TECHNICAL REPORT

ISO/TR 17252

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Fire tests — Applicability of reaction to fire tests to fire modelling and fire safety engineering

Essais au feu — Applicabilité des résultats de l'essai de réaction au feu aux techniques de modélisation et de sécurité contre l'incendie

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Foreword

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

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

In exceptional circumstances, 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), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 17252 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Introduction

There is a current trend towards performance-based approaches in national building regulations. This trend has seen rapid advancement internationally in the development of fire safety engineering (FSE). This has been supported by the application of fire modelling over the last five years, as marked by the publication of ISO/TR 13387-1, ISO/TR 13387-2, ISO/TR 13387-3, ISO/TR 13387-4, ISO/TR 13387-5, ISO/TR 13387-6, ISO/TR 13387-7 and ISO/TR 13387-8. The development of ISO/TR 13387-1, ISO/TR 13387-2, ISO/TR 13387-3, ISO/TR 13387-4, ISO/TR 13387-5, ISO/TR 13387-6, ISO/TR 13387-7 and ISO/TR 13387-8, as well as activities carried out nationally, have clearly identified that there are inconsistencies between the requirements of FSE (including the application of fire modelling) and the data reported from standard tests and ad hoc experiments.

This Technical Report is intended to assist in the development of an internationally consistent approach to the support of FSE by giving guidance on appropriate fire test methods that, where possible, have the primary function of fire safety regulations for the use of construction products.

It examines all of the current reaction to fire test methods and provides information to support the use of the data that the tests provide for FSE and fire modelling.

Fire tests — Applicability of reaction to fire tests to fire modelling and fire safety engineering

1 Scope

This Technical Report gives guidelines on the applicability of the current reaction to fire tests to fire safety engineering (FSE) and fire modelling. It also gives general guidance on the type of data needed for FSE calculations and fire modelling.

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 13943, *Fire safety — Vocabulary*

3 Terms and definitions

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

3.1
design fire
quantitative description of assumed fire characteristics within the design fire scenario

3.2
design fire scenario
specific fire scenario on which an analysis will be conducted

3.3
fire scenario
qualitative description of the course of a fire with time, identifying key events that characterize the fire and differentiate it from other possible fires

4 Symbols and abbreviated terms

FSE Fire safety engineering

Q is the heat release rate (MW)

Q_0 is the reference heat release rate, often taken to be 1 MW

t_g is the characteristic time to reach heat release rate, Q_0 (s)

5 Fire initiation and growth

5.1 Design fires and design fire scenarios

5.1.1 Background

5.1.1.1 Design fire scenarios are at the core of the FSE methodology described in all parts of ISO/TR 13387. An additional series of International Standards, ISO 16734, ISO 16736, ISO 16737 and ISO TS 16732, extend and implement these concepts.

The methodology is based upon analysing particular design fire scenarios and then drawing inferences from the results with regard to the adequacy of the proposed fire safety system to meet the performance criteria that have been defined. Identification of the appropriate scenarios requiring analysis is crucial to the fulfilment of fire safety performance objectives for buildings.

The characterization of a design fire scenario for analysis purposes should involve a description of such things as fire initiation, growth and extinction of fire, together with the likely smoke and fire spread routes under a defined set of conditions. This might include consideration of such conditions as diverse combinations of outcomes or events of different fire safety subsystems [see ISO/TR 13387 (all parts)], different internal ventilation conditions and different external environmental conditions. The consequences of each design fire scenario need to be considered. It is important to realize that smouldering fires may have the potential to cause a large number of fatalities in certain occupancies such as residential buildings.

5.1.1.2 Examples of typical design fire scenarios include:

- room fire (corner, ceiling, wall, floor);
- fire in stairwells;
- single burning item fire (furniture, wastepaper basket, fittings);
- developing fire (smoke extraction);
- cable tray or duct fire;
- roof fire (underside);
- cavity fire (wall, façade, plenum);
- fire in underground transportation system;
- arson:
  1) internal,
  2) external;
- fire in neighbouring building;
- fire in external fuel package(s);
- fire on roof;
- fire on façade;
- subterranean fire;

- forest fire or wildfire;
- fire in tunnel(s).

5.1.1.3 Following identification of the relevant design fire scenarios, it is necessary to describe the assumed characteristics of the fire on which the design will be based. These fire characteristics are defined as the design fire and usually require quantification of the following variables with respect to time:

- heat release rate [HRR (peak, mean, etc.)];
- toxic species production rate;
- smoke production rate (SPR);
- fire size (including flame length);
- time to key events such as flashover;
- other factors such as temperature, emissivity and location.

5.1.1.4 The fire characteristics listed above are influenced by a number of factors, which include:

- internal ventilation conditions (e.g. building air handling system);
- external environmental conditions;
- type, size and location(s) of ignition source;
- distribution and type(s) of fuel;
- fire load density;
- geometry of enclosure;
- ignitability of fuel;
- rate of heat release characteristics;
- ventilation [status of doors and/or windows (open or closed)];
- external heat flux;
- exposed surface area.

Additionally, events can modify the design fire and these are typically accounted for in an FSE approach to design. For example, the breakage of a window will alter the ventilation conditions and will influence the design fire. The incorporation of active fire protection measures into a design will also impact upon the design fire. It is therefore important that the effects of suppression systems, smoke control systems and intervention by the fire service be considered when appropriate.

5.1.2 Design fire types

For design purposes, an exponential or power-law rate of fire growth is often used. The most commonly used relationship is the *t*-squared fire growth rate given by Equation (1):

$$Q = Q_0 \left(t / t_g \right)^2 \quad (1)$$

where the growth time, t_g, is the time to reach heat release rate, Q_0.

In addition, when the fuel package for a particular design fire scenario is well defined and unlikely to change significantly during the life of the building, the actual burning characteristics of the fuel package can be used as the design fire. In such cases, oxygen consumption calorimetry, for example ISO 9705, is useful for providing quantitative data.

In some cases, it is now possible to predict the fire growth behaviour using calculation and modelling methods. For such approaches, the validation and verification of the approach will be an important consideration and will be very dependent upon the quality and reliability of the input data, whether it is generated from test methods or material data.

The concept of the reference scenario is not particularly new, but has gained prominence recently with the new developments within Europe. A reference scenario is basically intended to be representative of the application of products in buildings on an experimental scale. It should be representative of a specific hazard scenario and as such, needs to be fully defined in terms of the physical geometry of the space, the properties of the boundaries, the locations of openings and the fire source. Products can be performance tested within an appropriate reference scenario and in some cases, it could be argued that this type of test is the only means of producing reliable performance data. Examples of reference scenarios include the room corner test, a façade test, a horizontal duct test, a stairwell test and a roof test.

5.2 Sensitivity analysis in the design process

5.2.1 The design fire characteristics will have a major impact upon many aspects of the design since they form the input into many of the deterministic quantitative design calculations carried out in FSE design. A sensitivity analysis can be defined as the calculation of changes in outputs for variations in an input parameter of interest. It may be possible to deal with the uncertainties associated with the deterministic design by taking a conservative approach. However, the judgement of conservatism is very subjective. A worst-case design fire in terms of maximum size or growth rate will typically also be the worst case for:

— effect of smoke control system;

— effect of suppression systems on fire growth;

— time to structural failure;

— time and extent of fire spread within and from enclosure;

— fire service extinguishing capacity.

5.2.2 However, the same design fire may represent the best-case test for:

— time of activation of alarm system;

— time of activation of smoke control systems;

— time of activation of smoke and fire barriers;

— time of activation of suppression systems.

A sensitivity study should, therefore, be carried out on the consequences of the choice of design fire on the different parts of the quantitative assessment.

The objective of a sensitivity study is to establish the impact on the output parameter(s) caused by variation(s) in the input parameter(s); it is not intended to check the accuracy of the results.

If a single assumption is shown to be critical to the design and potentially the level of safety, consideration should be given to providing a degree of redundancy in the design or to carrying out a probabilistic study.

5.3 Limits of applicability

Empirically-based calculation methods and other types of approach to FSE design are generally assumed to be adequate provided that the approaches are used within their stated limits of applicability. However, if an approach is used outside of its limits of applicability, it is important that it be assessed on a theoretical basis and/or by comparison with experimental data. In such cases, it is usual to include some suitable safety factors in the analysis.

6 Sources of data for input into design

A systematic review of the current ISO/TC 92 reaction to fire test methods has been carried out. The outcome is summarized in Annex A in standardized tabular templates that make the extraction of the key information clear and simple to retrieve. This summary information should make the task of the application of test data within design approaches more robust as the limitations of the test methods and data are more visible to the user.

Summary sheets for the following International Standards are included in Annex A:

ISO 1182
ISO 1716
ISO 5657
ISO 5658-2
ISO 5658-4
ISO 5660-1
ISO 5660-2
ISO 9239-1
ISO 9705
ISO 11925-2
ISO 13784-1
ISO 13784-2
ISO 13785-1
ISO 13785-2
ISO/TR 14696

7 Application of test results

7.1 Repeatability and reproducibility

Information associated with the repeatability and reproducibility of test data is determined through inter-laboratory trials in accordance with ISO 5725 (all parts). However, the repeatability and reproducibility data relate only to the specific version of the test method and protocols that were used in the trial. If the test method is subsequently updated, then the repeatability and reproducibility data may only be considered to be, at best, indicative of performance. Therefore, in cases where the repeatability and reproducibility are important parameters in relation to the specific application of the test data, efforts should be made in establishing the relevance to the particular version of the test method used to generate the test data.

7.2 Heat flux measurements

Many of the reaction to fire test methods use heat flux meters to calibrate and/or set the incident radiant heat flux to the surface of the test specimens. The methodology for calibrating these gauges is provided in ISO 14934 (all parts). It is important to understand that whilst ISO 14934 provides for traceability of the calibrations to a primary calibration standard, the accuracy and relevance of the measurements should be carefully considered, especially if the values are to be used as input data for mathematical modelling and/or as part of an FSE design. In particular, consideration should be given to characterization of the radiative and convective contributions to the heat transfer and the importance of spectral characteristics.

7.3 Limiting factors affecting experimental quantification of fire growth

7.3.1 General

Fire tests do not typically simulate all aspects of a real fire. Typically, they have been designed to assess product or material characteristics in a well-defined methodology to enable direct comparison of fire performance parameters. The fire performance parameters that are measured are considered to be relevant to particular fire hazards and as such should be useable within modelling methods to predict larger scale and/or real-scale fire growth.

7.3.2 Heat release rate

Data from the cone calorimeter may be used to predict the heat release rate from lining products. However, selection of the incident radiant heat flux levels appropriate to a specific scenario will require consideration. In addition, for scenarios or orientations for which the conditions are vitiated, e.g. ceiling fires, the heat release rates resulting from the cone calorimeter tests will tend to be overestimated. However, the resulting smoke production rates will tend to be underestimated. Below concentrations of 15 % oxygen, the smoke yield tends to increase significantly.

Results from large-scale experimental fire test data may be used as a direct source of heat release data for fire models provided that the limitations of the tests are considered. Much information is available on burning rates for single items under free-burning or well-ventilated conditions in large enclosures. However, consideration should be given to inclusion, or not, of the effects of:

— radiative feedback from the hot smoke layer or from enclosure surface(s);

— limited supply of oxygen due to ventilation conditions or flames becoming immersed in the layer of combustion products;

— interaction between objects, in particular, their orientation and storage configuration.

7.3.3 Smoke production rate

As a large-scale fire develops and becomes more complex, the correlation between optical density of smoke in the small-scale and large-scale tests tends to break down. This is because the ventilation conditions and heat transfer can have a major impact on the smoke production.

NOTE None of the ISO/TC 92/SC 1 fire test methods provides any quantification of the irritancy of smoke.

7.3.4 Flame spread

Simply, flame spread can be divided into two categories:

— opposed flow or counter-current flame spread;

— wind-aided or concurrent flame spread.

In terms of direct measurements, the ISO/TC 92/SC 1 test methods relate predominantly to opposed-flow flame spread under a well-defined externally applied radiant heat exposure.

7.3.5 Ignition

Ignition of a solid material or product is generally the point at which the flow of volatiles from the surface is sufficient to enable a flame to persist. This is the starting point of any of the fire test methods that have been developed in ISO/TC 92/SC 1. Some of the test methods can be used to attempt to quantify the ignition characteristics of the material or product, whilst others simply ensure that the incident heat flux is sufficient to cause ignition for many materials or products. Whichever case is relevant, it is important that the externally applied heat flux and the external conditions be well characterized (e.g. ventilation conditions). This is certainly believed to be the case for the smaller scale test methods such as the cone calorimeter, however, the ignition sources are far less well characterized in relation to the large-scale test methods, such as the ISO 9705 test.

7.4 Differences between testing conditions and real fire scenarios

There can be significant differences between testing conditions and real fire scenarios. Some of the most obvious differences are itemized below, however, it should be realized that this list is not exhaustive.

— Conditioning

Fire test specimens are generally "conditioned" prior to the test. This means that the specimens are kept in a constant environment of temperature and humidity for the period of time required to produce constant mass. That is, the moisture content and any other properties that may vary depending upon the humidity and temperature have stabilized. These conditions are unlikely to reproduce realistic conditions, but do seek to maintain a constant basis from which to compare the fire performance of different products.

— Ageing effects

Typically, specimens for fire tests are delivered from the manufacturer's production line to the test laboratory. It is unusual, but not impossible, for any account to be taken of factors such as washing, durability, UV light stability, humidity, leaching of additives, wear and weathering. Clearly these factors may have some influence upon the performance of materials and products during their lifetime, but the importance of any influence will depend upon the type of product.

— Mounting and fixing

The performance of a product within a test is dependent upon the mounting and fixing arrangements used in the test and their relationship to the realistic applications of the products. Factors that should be considered when carrying out tests include types of substrate, presence or absence of an air gap directly behind the product, the location and type of joints, edge details and fixing details.

— Thermal attack

The thermal attack in terms of the imposed heat flux to the specimen surface in a test is reasonably well characterized. As already mentioned, the thermal attack is better defined in some of the test methods than in others, and the significant challenge rests with the fire safety engineer to determine how relevant the test results and conditions are in relation to the problem that should be solved.

8 Product family behaviours

There are some product family behaviours that are important to recognize and that will provide a significant challenge to some types of mathematical modelling approaches. These behaviours include melting, shrinking, slumping, dripping, spalling, charring, delaminating and intumescing. It may be the case that some of these types of behaviour can only be accommodated through empirical models in the short term, but it is clearly for the fire safety engineer to judge the relevance of these behaviours within the context of the design.

The importance of these behaviours, in particular test methods, is discussed in Annex A. In general, the effects of softening and melting are most apparent in tests where the specimen is in vertical orientation. As a result of movement of the specimen from its test position, the data produced is of limited validity.

The collapse of a thermoplastic foamed product or the expansion of an intumescent product in any test orientation changes the position of the product surface in relation to the heat source and it needs to be considered in any use of the data.

Annex A
(informative)

Review of fire test International Standards

A.1 Summary sheet for ISO 1182

1 International Standard ISO 1182			
2 Scope Method of test for determining the non-combustibility performance, under specified conditions, of homogeneous building products and substantial components of non-homogeneous building products.			
3 Application The test method is used for selection of construction products which, whilst not completely inert, produce only a very limited amount of heat and flame when exposed to temperatures of approximately 750 °C.			
4 Other related standards: none.			
5 Summary test information			
Thermal exposure	**Radiant** Vertical tube furnace	**Flame**	**Other**
6 Description The test apparatus consists of a furnace comprising essentially a refractory tube surrounded by a heating coil and enclosed in an insulated surround. A cone-shaped airflow stabilizer is attached to the base of the furnace and a draught shield to its top. The furnace is stabilized at 750 °C before test, thereafter the corresponding power input is kept constant throughout the test. A small cylindrical shaped specimen is placed in the centre of the furnace.			
7 Duration of exposure The test is carried out until final temperature equilibrium has been reached in the furnace, or for 60 min.			
8 Specimen details			

General application	Homogeneous building products and substantial components of non-homogeneous building products, as defined in the standard (i.e. ISO 1182).		
Height of specimen	(50 ± 3) mm, if the thickness of the material is different from (50 ± 3) mm, specimens of height (50 ± 3) mm are made by using a sufficient number of layers of the material and/or by adjustment of the material thickness.		
Specimen diameter	(45, +0, –2) mm		
Specimen preparation	The layers of the material occupy a horizontal position in the specimen and are held together firmly, without compression, by means of two fine steel wires to prevent air gaps between layers.		
Specimen conditioning	**Temp.** (23 ± 2) °C	**Humidity** (50 ± 5) %	**Other** To constant mass, followed by a drying procedure.

Burning characteristics considered	**Dripping**	**Flowing droplets**	**Falling debris**	**Delamination**	**Other**
(yes or no)	No	No	No	No	

Number of tests required and criteria for tests	Five tests
Method of reporting results	Test report containing the essential information as required by the standard (i.e. ISO 1182).

Any other information/comments

A suitable data acquisition system is normally adapted by the testing laboratory.

9 Experimental variations (non-standard application)

Comments

The test is a "pass/fail" test in relation to acceptance criteria originally laid down in earlier versions of the standard (i.e. ISO 1182) and later specified in other standards/regulations. Any experimental variation is of very limited value.

10 Experimental measurements (standard application)

Standard measurements	**Mass loss**	**Flaming**	**Temperature**
	Percentage of initial mass of the specimen	Yes	In the furnace

Any other information

Comments on applicability of this test method to end-use scenarios

Non-combustibility is a product characteristic, which is independent of the end use of the product.

Product family behaviours

In general, such construction products which, whilst not completely inert, contain a limited amount of organic material, show a limited temperature rise, flaming and mass loss in the test.

A.2 Summary sheet for ISO 1716

1 International Standard ISO 1716

2 Scope

Method of test for the determination of the heat of combustion of building products at constant volume in a bomb calorimeter.

3 Application

The test method is used to assess the potential fire load (expressed in MJ/kg or MJ/m^2) of the product.

4 Other related standards: None

5 Summary test information

Ignition source

Type	Electric firing wire
Size of source	
Location (in relation to specimen)	Touching
Thermal exposure	Explosive atmosphere of oxygen

6 Description

A powdered specimen of specified mass is burned under standardized conditions, at constant volume, in an atmosphere of oxygen, in a bomb calorimeter. The heat of combustion determined under these conditions is calculated on the basis of the observed temperature rise, taking into account heat losses and the latent heat of vaporization of water. The test determines an absolute value of a product and does not take into account any inherent variability of the product.

7 Duration of exposure

Until complete combustion of the specimen has taken place. This normally happens within a short period (a few minutes) after the electric circuit, to cause combustion, is closed.

8 Specimen details

General application	A product is evaluated through each of its components. If the product is homogeneous, the specimen is composed of the product. If the product is not homogeneous, each individual component part of that product is tested separately.		
Mass of specimen	0,5 g		
Sample preparation	The sample obtained is ground to produce a powdered test sample.		
Sample conditioning	**Temp.** (23 ± 2) °C	**Humidity** (50 ± 5) %	**Other** To constant mass.
Number of tests required and criteria for tests	Three tests. Validity of the test results is assessed against criteria for repeat tests.		
Method of reporting results	Test report containing the essential information as required by the standard (i.e. ISO 1716).		

Any other information/comments

Test processes may be automated in designs of commercially available equipment.

9 Experimental measurements (standard application)		
Standard measurements	**Gross heat of combustion** Expressed in MJ/kg or MJ/m^2.	**Net heat of combustion (when required)** Calculation described in Annex A of ISO 1716.
Limitations/ validity of results	Limited validity if incomplete combustion of the specimen occurs.	
Any other information		
Comments on applicability of this test method to end-use scenarios Heat of combustion is a product characteristic, which is independent of the end use of the product.		
Product family behaviours In general, such construction products which, whilst not completely inert, contain a limited organic material, have low values for the gross heat of combustion PCS ($<$ 3 MJ/kg). Heat of combustion values for different products may be found in literature, such as fire handbooks.		

A.3 Summary sheet for ISO 5657

<table>
<tr><td colspan="4">1 International Standard ISO 5657</td></tr>
<tr><td colspan="4">2 Scope
A method for examining the ignition characteristics of the exposed surfaces of specimens of essentially flat materials, and of composites of assemblies not exceeding 70 mm in thickness, when placed horizontally and subjected to specified levels of thermal irradiance.
Annex A gives a commentary on the text and guidance notes for operators.</td></tr>
<tr><td colspan="4">3 Application
The test method is applicable to essentially flat building products. This ignitability test is designed to assess the possibility of secondary ignition by radiative heat transfer. Specimens of the product are mounted horizontally and exposed to thermal radiation on their upper surface; the selected levels of constant irradiance are within the range of 10 kW/m^2 to 70 kW/m^2.</td></tr>
<tr><td colspan="4">4 Other related standards: ISO/TR 11925-1.</td></tr>
<tr><td colspan="4">5 Summary test information</td></tr>
<tr><td colspan="4">Ignition source</td></tr>
<tr><td>Pilot
Yes</td><td>Spark
No</td><td colspan="2">Burner
Propane/air mixture:
19–20 ml/min propane,
160–180 ml/min air.</td></tr>
<tr><td>Size of pilot burner</td><td colspan="3">Approximately 15 mm long flame.</td></tr>
<tr><td>Location (in relation to specimen)</td><td colspan="3">Pilot flame (which issues horizontally from a stainless steel nozzle) is applied to a position 10 mm above the centre of the specimen surface. This flame is not present continuously but is positioned on a dipping mechanism such that it is only present for 1 s in every 4 s.
A secondary ignition source is also provided adjacent to the turnaround point of the pilot flame tube; this source can be a gas flame, hot wire or spark ignitor. It should be capable of re-igniting the pilot flame if it is extinguished.</td></tr>
<tr><td>Thermal exposure</td><td>Radiant
10–70 kW/m^2</td><td colspan="2">Flame
0,05 kW</td></tr>
<tr><td colspan="4">6 Description
The radiator is in the shape of a truncated cone with an upper diameter of (66 ± 1) mm and a lower diameter of (200 ± 3) mm. The cone consists of a heating element of nominal rating 3 kW. The height of the cone is 75 mm.
The specimen is mounted on a pressure plate which keeps the specimen in the vicinity of the cone heater during the test, which results in a partially closed system (i.e. limited ventilation).</td></tr>
<tr><td colspan="4">7 Duration of exposure
At each irradiance, the duration of exposure is a maximum of 15 min.
Where sustained ignition occurs, the time in seconds is reported for any specimen.</td></tr>
</table>

<table>
<tr><td colspan="6">8 Specimen details</td></tr>
<tr><td>General application</td><td colspan="5">Although the test method and equipment have been designed to examine flat surfaces, a limited amount of surface irregularity can be accepted. The test specimens are representative of the surface of the material to be tested.
No meaningful results can be expected with products that intumesce considerably, i.e. more than 22 mm increase in surface height.</td></tr>
<tr><td>Specimen orientation</td><td colspan="5">Horizontal</td></tr>
<tr><td>Thickness of specimen</td><td colspan="5">Materials and composites of thickness that is 70 mm or less are tested using their full thickness.
For materials and composites of thickness that is greater than 70 mm, the unexposed face may be cut away to reduce the thickness to 70 (+0, −3) mm.</td></tr>
<tr><td>Specimen dimensions
Five at each level of irradiance and for each different exposed surface</td><td colspan="2">Width
165 (+0,-5) mm</td><td colspan="2">Length
165 (+0,-5) mm</td><td>Other</td></tr>
<tr><td>Specimen preparation</td><td colspan="5">Specimens are carefully mounted to ensure that they represent the building product in practice.
When cutting specimens from products with irregular surfaces, the highest point on the surface is arranged to occur at the centre of the specimen.</td></tr>
<tr><td>Substrate details</td><td colspan="2">Width</td><td colspan="2">Length</td><td>Fixing method/spacing, etc.</td></tr>
<tr><td></td><td colspan="2">165 (+0,-5) mm</td><td colspan="2">165 (+0,-5) mm</td><td>As recommended by the manufacturer</td></tr>
<tr><td>Specimen conditioning</td><td>Temperature
(23 ± 2) °C</td><td>Humidity
(50 ± 5) %</td><td colspan="3">Other
To constant mass.</td></tr>
<tr><td></td><td>Dripping</td><td>Flowing droplets</td><td>Falling debris</td><td>Delamination</td><td>Other</td></tr>
<tr><td>Burning characteristics considered
(yes or no)</td><td>No</td><td>No</td><td>No</td><td>No</td><td>Softening, foaming, spalling, shrinking</td></tr>
<tr><td>Number of tests required and criteria for test</td><td colspan="5">Five specimens at each level of irradiance selected and for each different exposed surface.</td></tr>
<tr><td>Method of reporting results</td><td colspan="5">Results reported in the form of computer-generated reports containing essential information as required by the standard (i.e. ISO 5657). This report contains a full description of the product tested, including details of any surface treatment.</td></tr>
<tr><td colspan="6">Any other information/comments
Where a product is normally backed by air, the specimen is backed by an air gap in the test, where practicable.
Special procedures are used for testing products with reflective coatings; i.e. application of a coating of carbon black and prevention of the contact of this surface with the pilot flame mechanism.</td></tr>
</table>

9 Experimental measurements (standard application)								
Standard measurements	**Time to ignition** Yes	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Rise in temperature	**Others** Observation of glowing decomposition						
Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**			
Damage to specimen	Observations							
Precision of data	**Reproducibility**				**Repeatability**			
Time to sustained surface ignition	8–75 s % of mean 18–54				4–50 s % of mean 9–37			
Calibration details	Use of special calibration board of ceramic fibre of density 200 ± 50 kg/m^3. Calibrate cone heater to produce irradiances of 10, 20, 30, 40, 50, 60 and 70 kW/m^2. Check every 50 operating hours at 30 kW/m^2, so that deviation is not more than 0,6 kW/m^2.							
Inaccuracies in measurements	Results on shiny surfaces should be treated with caution. Similarly, for materials that intumesce considerably.							
Limitations/ validity of results	The present test does not consider the ability to ignite by flame contact alone, without impressed radiation.							
Any other information Some products (such as flame-retardant plastics) show relatively greater variation in ignition times at lower irradiances.								
Comments on applicability of this test method to end-use scenarios The test has particular relevance for fire initiation, spread and growth situations, where a fire having grown to a certain point, a new phase of spread or growth is possible if ignition by radiation can bring fuel hitherto uninvolved into play. Ignition by radiation is clearly an important consideration where protection against fire spread is being sought by spatial separation.								

A.4 Summary sheet for ISO 5658-2

1 International Standard ISO 5658-2			
2 Scope A method of test for measuring the lateral spread of flame along the surface of a specimen of a product orientated in the vertical position. It provides data suitable for comparing the performance of essentially flat materials, composites or assemblies, which are used primarily as the exposed surfaces of walls.			
3 Application The method is applicable to the measurement and description of the properties of materials, products and assemblies in response to radiative heat in the presence of a pilot flame under controlled laboratory conditions.			
4 Other related standards: ISO/TS 5658-1 and ISO 5658-4.			
5 Summary test information **Ignition source**			
Pilot source Yes	**Spark**	**Burner** Propane/air burner	**Single electrode spark**
Size of source	230 mm long flame		
Location (in relation to specimen)	Vertically orientated 10 mm from hot end of specimen and impinging on the specimen surface.		
Thermal exposure	**Radiant** 480 mm × 280 mm panel fuelled by gas/air mixture giving heat flux of 50 kW/m^2 at hot end of specimen; natural gas, methane or propane may be used to fuel panel.	**Flame**	**Other**
6 Description Radiant panel is mounted vertically at an angle of 15° to the specimen surface. Area of irradiance is 0,020 m^2. Heat flux decreases from 50 kW/m^2 at hot end of specimen to 1,5 kW/m^2 at cool end.			
7 Duration of exposure Radiant panel and pilot burner are applied for whole test (i.e. 30 min, or 10 min if specimen fails to ignite during this initial period).			
8 Sample details			
General application	Product is tested on that face which will normally be exposed in end-use. If both faces may be exposed in use, then both faces are tested. Products suitable for testing are essentially flat. If the face of the product contains a surface that is specifically directional (e.g. corrugations, grain, or machine-induced horizontal or vertical orientation), the product is tested in both directions.		
Sample orientation	Vertical		
Thickness of sample	Up to 70 mm		

<table>
<tr><td>Sample dimensions</td><td colspan="2">Width
155 mm + 0,–5 mm</td><td colspan="2">Length
800 mm + 0,–5 mm</td><td colspan="2">Other</td></tr>
<tr><td>Sample preparation</td><td colspan="6">Specimen may be mounted (wrapped in aluminium foil) against a non-combustible backing-board (e.g. 25 mm oven-dry calcium silicate board of density (950 ± 100) kg/m^3). Alternatively it may be tested mounted on a substrate or in front of an air gap. Substrate can be a standard reference type (as in EN 13238) or as in end use.</td></tr>
<tr><td>Substrate details</td><td colspan="2">Width
155 mm</td><td colspan="2">Length
800 mm</td><td colspan="2">Fixing method/spacing, etc.
With or without adhesive, or with mechanical fixings</td></tr>
<tr><td>Sample conditioning</td><td>Temp.
(23 ± 2) °C</td><td>Humidity
(50 ± 5) %</td><td colspan="4">Other
To constant mass
Backing boards and spacers are conditioned for at least 12 h before their use with conditioned specimens.</td></tr>
<tr><td>Burning characteristics considered
(yes or no)</td><td>Dripping
Yes</td><td>Flowing droplets
Yes</td><td>Falling debris
Yes</td><td colspan="2">Delamination
Yes</td><td>Other
Flaming drips, spalling, flashing</td></tr>
<tr><td>Number of tests required and criteria for test</td><td colspan="6">Six specimens to be provided.
Three specimens to be tested for each potentially exposed surface or orientation.
NOTE 1 With specimens which could be exposed from either side and also having directional irregularities on one side only, at least nine specimens will be needed.
NOTE 2 Record time of arrival of the flame front at each 50 mm position.
NOTE 3 Also, record both time and position along centreline of specimen at which flame ceases to advance.</td></tr>
<tr><td>Method of reporting results</td><td colspan="6">Results are tabulated in computer-generated reports.
Derivations are made from heat flux profile and data expressed as:
— average heat for sustained burning (HSB);
— critical heat flux at extinguishment (CIE).</td></tr>
<tr><td colspan="7">Any other information/comments
Average of the results of (a) and of (b) for three specimens tested is calculated.</td></tr>
</table>

9 Experimental measurements (standard application)

Standard measurements	Time to ignition	Rise in temperature	Heat release	Total heat released	Smoke	CO	CO_2	O_2	Thermocouple readings in duct
	Yes	No	No	No	No	No	No	No	No

Others commonly measured	Mass loss	Others				
Damage to sample	Unusual behaviour is reported.	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**

Precision data	Reproducibility	
	HSB 22–76 % CIE 33–105 %	**Repeatability**
Calibration details	Heat flux profile measured along calcium silicate calibration board at 100 mm intervals. Heat flux profile (50 kW/m^2 to 1,5 kW/m^2) determined monthly. Daily verification also required at positions 50 mm and 350 mm from exposed end.	HSB 9–43 % CIE 9–95 %
Inaccuracies in measurements		
Limitations/ validity of results		

Any other information

Temperature measurements are made in a hood fitted over the radiant panel in the IMO version of this test, i.e. International Maritime Organization Resolution A.653 (16).

Comments on applicability of this test method to end-use scenarios

Flame spread mode is opposed-flow and may be assumed to be relevant to flame spread that occurs at the top of walls in rooms and corridors.

Product behaviour

The test specimen size is limited to a maximum thickness of 70 mm. There are therefore difficulties in testing some products in end-use conditions. Particular problems occur with: profiled products; sandwich panels and thick insulation products and products installed with an air gap.

Thermoplastics cause difficulty if the flame front is not established before they melt or distort away from the specimen holder.

NOTE Annex F of ISO 5658-2 contains a procedure for testing plastic piping.

10 Experimental variations (non-standard application)

Variations	Irradiance level	Burner output	Oxygen level	Sample mass	Preheat	Other

Comments

A.5 Summary sheet for ISO 5658-4

<table>
<tr><td colspan="4">1 International Standard ISO 5658-4</td></tr>
<tr><td colspan="4">2 Scope
This part of ISO 5658 specifies an intermediate-scale method of test for measuring the vertical spread (upward and downward) of flame over a specimen of a product orientated in the vertical position. A measure of lateral spread can also be obtained. This part of ISO 5658 provides data suitable for comparing the performance of materials, composites or assemblies, which are used as the exposed surfaces of walls or other vertically orientated products in construction applications. Some products with profiled surfaces can also be tested with a modified procedure representative of the end-use conditions of the product.
Upward flame spread is not limited to surfaces that are vertical. It is recognized that an enhanced form of upward, wind-aided flame spread can also occur on surfaces at an angle greater than 20° from the horizontal without any external ventilation. This type of flame spread can occur in both planar sloping surfaces and stepped surfaces such as stairs. Flame spread in these situations can become very rapid and can cause serious problems in escape ways such as staircases. When assessing stepped or sloping surface materials, it may be more appropriate to use a vertical flame test rather than a test in which the specimen is horizontal.</td></tr>
<tr><td colspan="4">3 Application
This method is applicable to the measurement and description of the properties of materials, products, composites or assemblies in response to radiative heat in the presence of non-impinging pilot flames under controlled laboratory conditions. The heat source may be considered to represent a single burning item such as a wastepaper bin or an upholstered chair within an enclosure, and this scenario would generally be considered to apply during the early stage of a fire (see ISO/TR 11696-1 and ISO/TR 11696-2).</td></tr>
<tr><td colspan="4">4 Other related standards: ISO/TS 5658-1 and ISO 5658-2.</td></tr>
<tr><td colspan="4">5 Summary test information</td></tr>
<tr><td colspan="4">Ignition source</td></tr>
<tr><td>Pilot
Yes</td><td>Spark
No</td><td>Burner
160 mm stainless steel tube, 10 mm internal diameter, with 15 evenly spaced 1 mm diameter holes. Propane flow 0,6 l/min.</td><td>Single electrode spark
No</td></tr>
<tr><td>Size of source</td><td colspan="3">15 mm × 23 mm long flames</td></tr>
<tr><td>Location (in relation to specimen)</td><td colspan="3">480 mm from base of specimen and 140 mm from edge of specimen. The pilot flames are approximately 2 mm from surface of specimen.</td></tr>
<tr><td>Thermal exposure</td><td>Radiant
480 mm × 280 mm panel fuelled by gas/air mixture giving heat flux of 40 kW/m^2 at height of 300 mm from base of specimen. Natural gas, methane or propane may be used to fuel the panel.</td><td>Flame</td><td>Other</td></tr>
</table>

6 Description Radiant panel is mounted vertically at an angle of 35° to the specimen surface. Heat flux decreases from 40 kW/m^2 at hottest part of exposure area to 5 kW/m^2 at cooler parts of the exposed area. Total area exposed is approximately 0,4 m^2.				
7 Duration of exposure Radiant panel and pilot burner are applied for whole of test (i.e. 30 min, or 20 min if specimen fails to ignite during this initial period).				
8 Specimen details				
General application	A product having one of the following surface characteristics is suitable for evaluation by this method: a) an essentially flat, exposed surface; b) a surface irregularity which is evenly distributed over the exposed surface provided that any cracks, fissures or holes do not exceed 8 mm in width or 10 mm in depth and the total area of such cracks, fissures or holes at the surface does not exceed 30 % of a representative area of 155 mm^2 of the exposed surface; c) products with profiled surfaces (e.g. ducting, panels, and pipes) may also be tested in end-use conditions but it should be recognized that flame spread rates and distances are not directly comparable to those obtained from essentially flat products.			
Specimen orientation	Vertical. The product is tested on that face which will normally be exposed in practice.			
Thickness of specimen	End-use thickness (up to 300 mm)			
Specimen dimensions	**Width** (1 025 ± 25) mm		**Length** (1 525 ± 25) mm	**Other**
Specimen preparation	Specimen assembled in specimen holder: a) with backing board (± substrate); b) without substrate or backing board; c) with backing board and spacers forming an air gap.			
Substrate details	**Width** 1 025 mm		**Length** 1 525 mm	**Fixing method/spacing, etc.** With or without adhesive or with mechanical fixings
Specimen conditioning	**Temp.** (23 ± 2) °C	**Humidity** (50 ± 5) %	**Other** a) For at least 4 d to constant mass; b) for at least 3 weeks. Backing boards and spacers are conditioned for at least 2 d under same conditions as test specimens.	

Burning characteristics considered (yes or no)	Dripping	Flowing droplets	Falling debris	Delamination	Other
	Yes	Yes	Yes	Yes	Flaming drips, spalling, flashing, smouldering, glowing

Number of tests required and criteria for test	Three specimens to be tested for each potentially exposed surface or orientation. Record ignition time and time of arrival of any sustained flame (vertical or lateral) at the reference lines on specimen surface.
Method of reporting results	Results are tabulated in computer-generated reports. Derivations may be made to obtain average flame spread rates (vertical and lateral).

Any other information/comments

Video recording of test may be used to verify times of flame front at the reference lines.

9 Experimental measurements (standard application)

Standard measurements	**Time to ignition**	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Yes	No	No	Optional	No	No	No	Optional
	Rise in temperature	**Others**						
	No							

Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**
	No	No	No	No	No	

Damage to specimen	Burned area and type of damage is recorded.	
Precision data	**Reproducibility**	**Repeatability**
	Time to ignition 28–133 % (average 59 %) Area of flame spread 0–61 % (average 31 %)	Time to ignition 12–46 % (average 26 %) Area of flame spread 0–36 % (average 17 %)
Calibration details	Heat flux is measured at five positions along a calcium silicate calibration board monthly. Daily verification as required at two of these positions.	
Inaccuracies in measurements		
Limitations/ validity of results	There is only one test condition in the standard (i.e. ISO 5658-4), i.e. 40 kW/m^2 near the base of the specimen reducing to zero at the top. Other furnace positions can be used to obtain different heat flux exposures, but these are not standardized. For most testing, test specimens should be substantially flat, although linear products such as pipes may be evaluated. Profiled products are difficult to test. Effluent analysis (i.e. heat release, smoke, toxic gases) is not standardized.	

Any other information

In the pre-normative EC research project (Roland), temperature and smoke measurements were also made in the exhaust duct.

Comments on applicability of this test method to end-use scenarios

The fire model represents a single burning item attack on the wall of a well-ventilated enclosure, which may be small or large. The specimen is sufficiently large to allow some end-use fixings (e.g. joints, air gaps) to be incorporated into the test specimen.

<table>
<tr><td colspan="7">10 Experimental variations (non-standard application)</td></tr>
<tr><td>Variations</td><td>Irradiance level</td><td>Burner output</td><td>Oxygen level</td><td>Specimen mass</td><td>Preheat</td><td>Other
Non-flat products may also be tested (e.g. pultruded profiles, thermoplastic pipes).</td></tr>
<tr><td colspan="7">Comments
Angle of radiant panel may be varied to create either higher or lower fluxes than 40 kW/m² on surface of test specimen.
Pilot burner may be modified to give flame impingement in test procedure.</td></tr>
</table>

Method of reporting results	Time histories	Mean value	Other
	Yes	Yes	Photographs, videotape.

A.6 Summary sheet for ISO 5660-1, ISO 5660-2

<table>
<tr><td colspan="6">1 International Standards ISO 5660-1, ISO 5660-2</td></tr>
<tr><td colspan="6">2 Scope
A method for assessing the heat release rate of essentially flat products exposed to controlled levels of radiant heating with or without an igniter. The specimen is exposed in the horizontal orientation. Products with surface irregularities may be tested according to specific requirements.</td></tr>
<tr><td colspan="6">3 Application
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.</td></tr>
<tr><td colspan="6">4 Other related standards: ISO/TR 5660-3, ISO 17554, ISO 13927 and ISO 11907-4.</td></tr>
<tr><td colspan="6">5 Summary test information</td></tr>
<tr><td colspan="6">Ignition source</td></tr>
<tr><td>Type</td><td>Pilot</td><td>Spark
Repetitive</td><td>Burner</td><td colspan="2">Single electrode spark</td></tr>
<tr><td>Size of source</td><td colspan="5">Spark plug with a gap of 3 mm.</td></tr>
<tr><td>Location (in relation to sample)</td><td colspan="5">Horizontal orientation of the spark gap is 13 mm above the centre of the specimen.
Regarding vertical orientation, the spark gap is located in the specimen face plane and 5 mm above the top of the holder.</td></tr>
<tr><td>Thermal exposure</td><td colspan="2">Radiant
Cone-shaped electrical radiator</td><td>Flame</td><td colspan="2">Other</td></tr>
<tr><td colspan="6">6 Description
External electrical radiant cone-shaped heater. Temperature of the heater is pre-set before the test and kept constant throughout the test. Used in either the horizontal (normative) or vertical (alternative) orientation.
Tests can be carried out in the range of 10 to 100 kW/m^2.</td></tr>
<tr><td colspan="6">7 Duration of exposure
For 30 min plus 2 min of additional data correction, or until specimen burns out totally, or until oxygen concentration keeps within 100 ppm for 10 min.</td></tr>
<tr><td colspan="6">8 Sample details</td></tr>
<tr><td>General application</td><td colspan="5">Solid (An application to liquid sample is being considered by IEC TC89.)</td></tr>
<tr><td>Thickness of sample</td><td colspan="5">50 mm or less are tested using their full thickness more than 50 mm are reduced to (50, +0, -3) mm.</td></tr>
<tr><td>Sample dimensions</td><td colspan="2">Width
(100, +0, –5) mm</td><td colspan="2">Length
(100, +0, –5) mm</td><td>Other</td></tr>
<tr><td>Sample preparation</td><td colspan="5">Sample tested as a representation of end-use application. Specimen wrapped in a single layer of aluminium foil and placed on refractory fibre blanket.</td></tr>
<tr><td>Sample conditioning</td><td>Temp.
(23 ± 2) °C</td><td>Humidity
(50 ± 5) %</td><td colspan="3">Other
To constant mass</td></tr>
</table>

Burning characteristics considered	**Dripping**	**Flowing droplets**	**Falling debris**	**Delamination**	
(yes or no)	No	No	No	No	Other
Number of tests required and criteria for test	Minimum three tests in each heating condition. The 180 s mean heat release rate readings are compared for the three specimens. If the main readings differ by more than 10 % from the arithmetic mean of the three readings, a further set of three specimens are tested. In such case, all six are reported.				
Method of reporting results	Results reported in the form of computer-generated reports containing essential information as required by the standards (i.e. ISO 5660-1, ISO 5660-2).				

Any other information/comments

The calculation of heat release rate is reliant upon data processing software. There is no guidance offered or suggested for verifying the software.

9 Experimental variations (non-standard application)

Variations	**Irradiance level**	**Burner output**	**Oxygen level**	**Sample mass**	**Preheat**	**Other**
Open air (fully ventilated condition)	Yes	Not applicable	Open air	Measured during test	No	With or without a spark ignitor

Comments

The area around the cone heater is freely ventilated and therefore oxygen is not restricted in the standard apparatus.

10 Experimental measurements (standard application)

Standard measurements	**Time to ignition**	**Heat release rate**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Yes	Yes	Yes	Yes	Optional	Optional	Mandatory	
	Rise in temperature In the exhaust duct	**Others** Exhaust gas volume flow rate Mass loss rate						

Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**
	Mandatory	In ISO 5660-2	Optional	Optional		
Limitations/ validity of results	Limited validity if specimen melts to cause overflow out of the trays, if spalling occurs; or if the specimen swells (dimensionally unstable) and touches the spark igniter or heater base plate.					

Any other information

Comments on applicability of this test method to end-use scenarios

Does not take into account fixing details, joints and edges finishes, since the specimen is too small to accommodate such fixings.

Sample size is small compared with end-use application.

Product family behaviour

Products with a thin surface coating or finish may exhibit a very rapid rise in heat release rate. This is characterized by sharp peaks in heat release and smoke production versus time curves, which can be difficult to capture and are dependent upon the scan rate used for collecting the data.

Thermoplastic foams (e.g. typically used as insulation material) may melt when exposed to the cone heater. They tend to shrink away from the cone heater, into the bottom of the specimen holder. The incident irradiance at the bottom of the specimen holder is lower than the value fixed at the location of the original specimen surface.

Products and/or materials that intumesce and/or swell when exposed to an incident radiant heat flux are tested in a lower position relative to the cone heater. The incident radiant heat flux at the lower position is measured prior to the test. However, as the product intumesces or swells, then the incident radiant heat flux will vary.

A.7 Summary sheet for ISO 9239-1

<table>
<tr><td colspan="5">1 International Standard ISO 9239-1</td></tr>
<tr><td colspan="5">2 Scope
A method for assessing the wind-opposed burning behaviour and spread of flame of horizontally mounted floorings exposed to a heat flux gradient in a test chamber, when ignited with pilot flames.</td></tr>
<tr><td colspan="5">3 Application
The method is applicable to all types of flooring under end-use conditions.</td></tr>
<tr><td colspan="5">4 Other related standards: ISO 9239-2.</td></tr>
<tr><td colspan="5">5 Summary test information</td></tr>
<tr><td colspan="5">Ignition source</td></tr>
<tr><td>Pilot
Yes</td><td>Spark</td><td colspan="2">Burner
Propane line burner</td><td>Single electrode spark</td></tr>
<tr><td>Size of source</td><td colspan="4">250 mm wide</td></tr>
<tr><td>Location (in relation to sample)</td><td colspan="4">3 mm above edge of specimen holder</td></tr>
<tr><td>Thermal exposure</td><td>Radiant
300 mm × 450 mm panel fuelled by propane giving 11 kW/m^2 at hot end of specimen; area of irradiance is 0,242 m^2.</td><td colspan="2">Flame</td><td>Other</td></tr>
<tr><td colspan="5">6 Description
Flames from lower line of holes in pilot burner impinge on specimen 10 mm from zero point.
Radiant heat panel is placed over test specimen with its longer dimension at 30° to horizontal plane.</td></tr>
<tr><td colspan="5">7 Duration of exposure
Radiant panel is applied for whole test (i.e. 30 min or longer period if specified by sponsor of test).
During first 2 min, pilot burner is not applied. It is then applied to specimen for 10 min before withdrawal and extinguishing.</td></tr>
<tr><td colspan="5">8 Sample details</td></tr>
<tr><td>General application</td><td colspan="4">Test specimens are representative of flooring in its end use.</td></tr>
<tr><td>Sample orientation</td><td colspan="4">Horizontal</td></tr>
<tr><td>Thickness of sample</td><td colspan="4">Maximum 40 mm</td></tr>
<tr><td>Sample dimensions</td><td>Width
230 mm</td><td colspan="2">Length
1 050 mm</td><td>Other</td></tr>
<tr><td>Sample preparation</td><td colspan="4">Specimen is mounted on a substrate that simulates actual floor (see EN 13238) and actual installation practice.</td></tr>
</table>

<table>
<tr><td>Substrate details</td><td colspan="3">Width
230 mm</td><td colspan="3">Length
1 050 mm</td><td colspan="2">Fixing method/ spacing, etc.
With or without adhesive and/or underlay</td></tr>
<tr><td>Sample conditioning</td><td>Temp.
(23 ± 2) °C</td><td>Humidity
(50 ± 5) %</td><td colspan="6">Other
To constant mass, or minimum 2 weeks</td></tr>
<tr><td>Burning characteristics considered
(yes or no)</td><td>Dripping
No</td><td>Flowing droplets
No</td><td>Falling debris
No</td><td>Delamination
No</td><td colspan="4">Other
Flame spread</td></tr>
<tr><td>Number of tests required and criteria for test</td><td colspan="8">Minimum four tests.
Test one specimen in one direction and one specimen in direction perpendicular to first. Test which yields lowest critical heat flux at extinguishment (CHF) and/or heat flux after period of 30 min (HF-30) value(s) is repeated twice in that direction.</td></tr>
<tr><td>Method of reporting results</td><td colspan="8">Results are tabulated in computer-generated reports.</td></tr>
<tr><td colspan="9">Any other information/comments</td></tr>
</table>

<table>
<tr><td colspan="9">9 Experimental measurements (standard application)</td></tr>
<tr><td>Standard measurements</td><td>Time to ignition</td><td>Heat release</td><td>Total heat released</td><td>Smoke
Yes, if required</td><td>CO</td><td>CO_2</td><td>O_2</td><td>Thermocouple readings in duct
Yes, if required</td></tr>
<tr><td></td><td>Rise in temperature</td><td colspan="7">Others</td></tr>
<tr><td>Others commonly measured</td><td>Mass loss</td><td>Smoke
Yes, if required</td><td>CO</td><td>CO_2</td><td>Heat of combustion</td><td colspan="3">Others
Flame spread</td></tr>
<tr><td>Damage to sample</td><td colspan="8"></td></tr>
<tr><td rowspan="2">Precision data</td><td colspan="4">Reproducibility</td><td colspan="4">Repeatability</td></tr>
<tr><td colspan="4">CHF (or HF-30) 5–47 %</td><td colspan="4">CHF (or HF-30) 2–21 %</td></tr>
<tr><td>Calibration details</td><td colspan="8">Heat flux profile (11 kW/m^2–1 kW/m^2) is determined after each essential change or once per month.</td></tr>
<tr><td>Inaccuracies in measurements</td><td colspan="8"></td></tr>
<tr><td>Limitations/ validity of results</td><td colspan="8"></td></tr>
<tr><td colspan="9">Any other information</td></tr>
<tr><td colspan="9">Comments on applicability of this test method to end-use scenarios
Related ASTM test method validated by room/corridor tests in USA.</td></tr>
</table>

<table>
<tr><td colspan="7">Product family behaviours

There is only one test condition using 11 kW/m^2 irradiance at hot end of test specimen. This is partly compensated by development of ISO 9239-2, which uses 25 kW/m^2 at hot end of test specimen.

The maximum thickness of test specimen is typically limited to 38 mm. However, with modification to the specimen holder, a specimen thickness of up to 100 mm can be accommodated. The test may be used to test the upper layer of floorings, but it is not suitable for testing floor assemblies.

Some floorings do not ignite at 11 kW/m^2 (even with the impinging line-type pilot burner). For these products, the performance is described as CHF $>$ 11kW/m^2.</td></tr>
<tr><td colspan="7">10 Experimental variations (non-standard application)</td></tr>
<tr><td>Variations</td><td>Irradiance level</td><td>Burner output</td><td>Oxygen level</td><td>Sample mass</td><td>Preheat</td><td>Other</td></tr>
<tr><td colspan="7">Comments</td></tr>
<tr><td rowspan="2">Method of reporting results</td><td colspan="2">Time histories</td><td colspan="2">Mean value</td><td colspan="2">Other</td></tr>
<tr><td colspan="2">Light attenuation by smoke and integral of the product of light attenuation and time.</td><td colspan="2"></td><td colspan="2">CHF (critical heat flux at extinguishment) or
HF-30 (heat flux after period of 30 min).</td></tr>
</table>

A.8 Summary sheet for ISO 9705

<table>
<tr><td colspan="4">1 International Standard ISO 9705</td></tr>
<tr><td colspan="4">2 Scope
ISO 9705 specifies a test method that simulates a fire that, under well-ventilated conditions, starts in a corner of a small room with a single open doorway.
The method is intended to evaluate the contribution to fire growth provided by a surface product using a specified ignition source.
A standard ignition source is specified, but other alternatives are allowed. It should, however, be noted that the type, position and heat output of the ignition source will considerably influence the fire growth.
The method is especially suitable for products that for some reason cannot be tested in a small laboratory scale, for example thermoplastic materials, the effect of an insulating substrate, joints and surfaces with great irregularity.
A test performed in accordance with the method specified in ISO 9705 provides data for the early stages of a fire from ignition up to flashover.
The method is not intended to evaluate the fire resistance of a product</td></tr>
<tr><td colspan="4">3 Application
Wall and ceiling linings under end-use conditions</td></tr>
<tr><td colspan="4">4 Other related standards: ISO/TR 9705-2.</td></tr>
<tr><td colspan="4">5 Summary test information</td></tr>
<tr><td colspan="4">Ignition source</td></tr>
<tr><td>Pilot</td><td>Spark</td><td>Burner
Ignition source is identical to heat source</td><td>Single electrode spark</td></tr>
<tr><td>Size of source</td><td colspan="3">Sandbox burner of 100 kW or 300 kW as standard ignition source. Other sources possible.</td></tr>
<tr><td>Location (in relation to sample)</td><td colspan="3">In the corner of the room.</td></tr>
<tr><td>Thermal exposure</td><td>Radiant</td><td>Flame
Diffusion flame</td><td>Other
Remark: Total heat flux mapping has been performed. Reported in ISO/TR 9705-2.</td></tr>
<tr><td colspan="4">6 Description
Standard ignition source is a sandbox burner of 17 cm × 17 cm.
Other ignition sources possible.</td></tr>
<tr><td colspan="4">7 Duration of exposure
10 min 100 kW and 10 min 300 kW for the standard ignition sequence. Other alternatives possible.</td></tr>
</table>

<table>
<tr><th colspan="5">8 Sample details</th></tr>
<tr><td>General application</td><td colspan="4">Sample is mounted on wall and ceiling of a room with a door opening. The wall with the door opening is not mounted with the test sample.</td></tr>
<tr><td>Sample orientation</td><td colspan="4">Vertical and horizontal under the ceiling.</td></tr>
<tr><td>Thickness of sample</td><td colspan="4">See sample preparation.</td></tr>
<tr><td>Sample dimensions</td><td colspan="2">Width</td><td colspan="1">Length</td><td>Other</td></tr>
<tr><td></td><td colspan="2"></td><td></td><td>Room dimensions are 3,6 m× 2,4 m × 2,4 m (length by width by height).</td></tr>
<tr><td>Sample preparation</td><td colspan="4">The following information about sample preparation is reproduced from the standard (i.e. ISO 9705).

The product to be tested is, as far as possible, mounted in the same way as in practical use.

NOTE In the standard specimen configuration, three walls and the ceiling are covered with the product. Alternative specimen configurations are given in Annex G of ISO 9705.

In cases where the product to be tested is in board form, the normal width, length and thickness of the boards are used as far as possible.

The product is attached either to a substrate or directly to the interior of the fire room. The mounting technique (for example, nailing, gluing, using a support system), as far as possible conforms to that used for the product. The mounting technique is clearly stated in the report, particularly if the mounting technique used improves the physical behaviour of the specimen during the test.

Thin surface materials, thermoplastic products that melt, paints and varnishes are, depending on their end use, applied to one of the following substrates:

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

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

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

e) the actual substrate if its thermal properties differ significantly from those of substrates a) to d), for example steel, mineral wool.

NOTE A suitable thickness for substrates a) to d) is 9 mm to 13 mm.

Paints and varnishes are applied to one of the substrates listed above at the application rate specified by the client.</td></tr>
<tr><td>Substrate details</td><td>Width

See above.</td><td>Length

See above.</td><td colspan="2">Fixing method/spacing, etc.

See sample preparation.</td></tr>
</table>

Sample conditioning	**Temp.**	**Humidity**	**Other**		
	(23 ± 2) °C	(50 ± 5) %	Equilibrium is deemed to be reached when a representative piece of the specimen has achieved constant mass.[1)] NOTE For wood-based products and products where vaporization of solvents can occur, a conditioning time of at least four weeks can be required.		
Burning characteristics considered	**Dripping**	**Flowing droplets**	**Falling debris**	**Delamination**	**Other**
(yes or no)	Yes	Yes	Yes	Yes	Cracking, melting to some extent, expansion, bowing, or distortion.
Number of tests required and criteria for test	One test				
Method of reporting results	Descriptive information, numerical results (scalar and vector data), graphical results, photographs and visual observation.				
Any other information/comments					

9 Experimental measurements (standard application)

Standard measurements	**Time to ignition**	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Yes*	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Rise in temperature	**Others**						
	Not used in standard procedure.	Flame spread by using a drawn grid on the material surface, total heat flux by total heat flux meters, flow measurement in door opening, temperatures inside the room, surface temperatures. *e.g. by HRR step						

Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**
	No	Yes	Yes	Yes	No	Content of combustion gases e.g. HCl, HCN, NOx etc.
Damage to sample	Observations are made after the testing.					

Precision data	**Reproducibility**	**Repeatability**
	Available in ISO/TR 9705-2	Available in ISO/TR 9705-2

1) 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.

Calibration details	Heat release by propane calibration, smoke system by calibration filter, gas analysis by reference gases, heat flux meter, pressure transducers, temperature, flow meters by weighing mass loss.					
Inaccuracies in measurements	Uncertainty analysis available					
Limitations/ validity of results						
Any other information						
Comments on applicability of this test method to end-use scenarios The test method is a full-scale test representing a room scenario.						
10 Experimental variations (non-standard application)						
Variations	**Irradiance level**	**Burner output**	**Oxygen level**	**Sample mass**	**Preheat**	**Other**
Burner level is changed after 10 min from 100 kW to 300 kW in the standard procedure.	Other levels of burner will produce different heat flux exposures.	Other burners and burner levels can be used.	Ventilation into the room can be changed for research purposes.	Not applicable	None	HRR range is 0–2 MW.
Comments						
Method of reporting results	**Time histories**	**Mean value**	**Other**			
	Yes	Yes	Photographs, videotape.			

A.9 Summary sheet for ISO 11925-2

<table>
<tr><td colspan="6">1 International Standard ISO 11925-2</td></tr>
<tr><td colspan="6">2 Scope
A method for determining the ignitability of building products by direct small flame impingement under zero impressed irradiance using specimens tested in a vertical orientation.
Products which melt and shrink away from the flame without being ignited may be addressed by the additional procedure given in Annex A of ISO 11925-2.</td></tr>
<tr><td colspan="6">3 Application
The test method is used to assess the ignitability of a product under test and relates to the accidental ignition of a small flame in fire.</td></tr>
<tr><td colspan="6">4 Other related standards: None</td></tr>
<tr><td colspan="6">5 Summary test information</td></tr>
<tr><td colspan="6">Ignition source</td></tr>
<tr><td>Type</td><td>Pilot</td><td>Spark</td><td colspan="2">Burner</td><td>Single electrode spark</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Yes</td><td></td></tr>
<tr><td>Size of source</td><td colspan="5">Small flame</td></tr>
<tr><td>Location (in relation to sample)</td><td colspan="5">Vertical orientation</td></tr>
<tr><td></td><td colspan="5">Surface, applied 40 mm above bottom edge of specimen for all thicknesses.
Edge (centre of bottom edge) applied 1,5 mm behind front surface, for products > 3 mm thickness, apply flame to midpoint of bottom.
For multilayer products > 10 mm, product is rotated 90° on vertical axis and flame is applied to bottom edge of centreline of underside of each different layer.</td></tr>
<tr><td>Thermal exposure</td><td colspan="2">Radiant</td><td colspan="2">Flame
Yes</td><td>Other</td></tr>
<tr><td colspan="6">6 Description
Small propane-fuelled flame 20 mm in height is applied in the vertical direction to a specimen.</td></tr>
<tr><td colspan="6">7 Duration of exposure
When flame is applied for 15 s and then removed, total test duration is 20 s.
When flame is applied for 30 s and then removed, total test duration is 60 s.</td></tr>
<tr><td colspan="6">8 Sample details</td></tr>
<tr><td>General application</td><td colspan="5">Solid</td></tr>
<tr><td>Thickness of sample</td><td colspan="5">60 mm or less are tested using their full thickness;
more than 60 mm are reduced to (60, +0, –1) mm by cutting away unexposed surface.</td></tr>
<tr><td></td><td colspan="5"></td></tr>
<tr><td>Sample dimensions</td><td colspan="2">Width</td><td colspan="2">Length</td><td>Other</td></tr>
<tr><td></td><td colspan="2">(90, +0, –1)mm</td><td colspan="2">(250, +0, –1)mm</td><td></td></tr>
<tr><td>Sample preparation</td><td colspan="5">Sample tested as supplied</td></tr>
</table>

Sample conditioning	**Temp.** (23 ± 2) °C	**Humidity** (50 ± 5) %	**Other** To constant mass		
Burning characteristics considered	**Dripping**	**Flowing droplets**	**Falling debris**	**Delamination**	**Other**
(yes or no)	Yes	Yes	Yes	Yes	Ignition occurs; flame height to 150 mm and time this occurs; whether or not ignition of filter paper occurs.
Number of tests required and criteria for test	Minimum 6 tests (3 lengthwise and 3 crosswise)				
Method of reporting results	Results reported in the form of report containing essential information as required by the standard (i.e. ISO 11925-2).				

Any other information/comments

Additional test done if requested and if melting and shrinking, but no ignition, occurs.

9 Experimental variations (non-standard application)

Variations	**Irradiance level**	**Burner output**	**Oxygen level**	**Sample mass**	**Preheat**	**Other**

Comments

In Annex A of ISO 11925-2, flame is applied to specimen (250 mm wide × 180 mm long) at bottom edge for 5 s, application is repeated until end of specimen is reached. Flame application follows the burnt edge as specimen shrinks and melts back. Assess whether flame reaches 150 mm within 20 s from start of flame. Presence of droplets/particles and their duration of flaming, if any.

10 Experimental measurements (standard application)

Standard measurements	**Time to ignition**	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Rise in temperature	**Others** Flame height to 150 mm within 20 s						
Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**		**Others**	

Any other information: observations of physical behaviour of the specimen

Limitations/ validity of results	Valid to small flame ignition only. No time to ignition is measured in the test, only time to 150 mm. Indication of ease of flame spread on ignition by small flame.

Comments on applicability of this test method to end-use scenarios

Presence of flaming droplets/particles is assessed when exposed to small flame.

Sample size is small compared with end-use application.

Impact of joints and fixings not easily assessed.

Multilayer specimen can be assessed, but see second list item.

A.10 Summary sheet for ISO 13784-1

<table>
<tr><td colspan="5">1 International Standard ISO 13784-1</td></tr>
<tr><td colspan="5">2 Scope
This part of ISO 13784 specifies a method of test for determining the reaction to fire behaviour of sandwich panel building systems and the resulting flame spread on or within the sandwich panel building construction, when exposed to heat from a simulated internal fire with flames impinging directly on the internal corner of the sandwich panel building construction.
The test method described is applicable to both freestanding self-supporting and frame-supported sandwich panel systems. This part of ISO 13784 is not intended to apply to sandwich panel products which are glued, nailed, bonded, or similarly supported by an underlying wall or ceiling construction. For products used as internal linings, the ISO 9705 test method should be used.
This part of ISO 13784 provides for small-room testing of sandwich panel building systems. For large-room testing of sandwich panel building systems, ISO 13784-2 should be used.
This method is not intended to evaluate the fire resistance of a product, which should be tested by other means.
NOTE Because of their design, some systems may be unsuitable for testing with ISO 13784-1. These systems may be suitable for testing with ISO 13784-2 and the latter test method should be considered. In this case the field of application of the test report might be restricted.</td></tr>
<tr><td colspan="5">3 Application
Sandwich panel systems (freestanding and frame-supported).</td></tr>
<tr><td colspan="5">4 Other related standards: ISO 9705, ISO 13784-2, ISO 13943 and IEC 60584-2.</td></tr>
<tr><td colspan="5">5 Summary test information</td></tr>
<tr><td colspan="5">Ignition source</td></tr>
<tr><td>Pilot</td><td>Spark</td><td colspan="2">Burner
Ignition source is identical to heat source.</td><td>Single electrode spark</td></tr>
<tr><td>Size of source</td><td colspan="4">Sand box burner of 100 kW or 300 kW as standard ignition source.</td></tr>
<tr><td>Location (in relation to specimen)</td><td colspan="4">In the corner of the room.</td></tr>
<tr><td>Thermal exposure</td><td>Radiant</td><td>Flame
Diffusion flame</td><td colspan="2">Other</td></tr>
<tr><td colspan="5">6 Description
Standard ignition source is a sandbox burner of 170 mm × 170 mm.</td></tr>
<tr><td colspan="5">7 Duration of exposure
10 min at 100 kW and then 10 min at 300 kW for the standard ignition sequence.</td></tr>
<tr><td colspan="5">8 Specimen details</td></tr>
<tr><td>General application</td><td colspan="4">The test specimen used consists of the requisite number of panels required by the test method to be performed. In all cases, the test specimen is representative of that used in practice, both in construction and materials. All constructional details of joints, fixings, etc., are reproduced and positioned in the test specimen as in practice. If the investigated type of sandwich panel is used in practice with an inside or outside structural framework, this is also to be used in the test.</td></tr>
<tr><td>Specimen orientation</td><td colspan="4">Vertical and horizontal</td></tr>
</table>

Thickness of specimen	See specimen preparation		
Specimen dimensions	**Width**	**Length**	**Other** Room dimensions are 3,6 m × 2,4 m × 2,4 m (length by width by height, internal dimensions). Doorway is 0,8 m wide by 2 m high.
Specimen preparation	The following information about specimen preparation is taken from ISO 13784-1. The test specimen used consists of the requisite number of panels required by the test method to be performed. In all cases, the test specimen is representative of that used in practice, both in construction and materials. All constructional details of joints, fixings etc., are reproduced and positioned in the test specimen as in practice. If the investigated type of sandwich panel is used in practice with an inside or outside structural framework, this is also to be used in the test. NOTE 1 The test specimen should be built by those suitably qualified in the construction of this type of structure. NOTE 2 If in practice ceiling panels are different than wall panels, a test can be performed with the correct combination of wall and ceiling panels. If the sandwich panel building system is intended to be used with decorative paint or film facings, these are present on the test specimen.		
Substrate details	**Width** See above	**Length** See above	**Fixing method/spacing, etc.** See specimen preparation
Specimen conditioning	**Temp.**	**Humidity**	**Other**
	10–30 °C before test		
Number of tests required and criteria for test	One test		
Method of reporting results	Descriptive information, numerical results (scalar and vector data), graphical results, photographs and visual observation.		

Any other information/comments

None

9 Experimental measurements (standard application)

Standard measurements	**Time to ignition**	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Yes*	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Rise in temperature of specimen Optional	**Others** Flame spread by using a drawn grid on the material surface, total heat flux by total heat flux meters, flow measurement in door opening, temperatures inside the room, surface temperatures. *e.g. by HRR step						

<table>
<tr><td>Others commonly measured</td><td>Mass loss

No</td><td>Smoke

Yes</td><td>CO

Yes</td><td>CO_2

Yes</td><td>Heat of combustion

No</td><td colspan="2">Others
Content of combustion gases, e.g. HCl, HCN, NOx.</td></tr>
<tr><td colspan="2">Burning characteristics considered
(yes or no)</td><td>Dripping

Yes</td><td>Falling debris

Yes</td><td colspan="2">Delamination

Yes</td><td colspan="2">Other
Cracking, melting to some extent, expansion, bowing, distortion.</td></tr>
<tr><td>Damage to specimen</td><td colspan="7">Observations are made after the testing.</td></tr>
<tr><td rowspan="2">Precision data</td><td colspan="4">Reproducibility</td><td colspan="3">Repeatability</td></tr>
<tr><td colspan="4">Not available</td><td colspan="3">Not available</td></tr>
<tr><td>Calibration
details</td><td colspan="7">Heat release by propane calibration,
smoke system by calibration filter,
gas analysis by reference gases,
heat flux meter,
pressure transducers,
temperature,
flow meters by weighing mass loss.</td></tr>
<tr><td>Inaccuracies in measurements</td><td colspan="7"></td></tr>
<tr><td>Limitations/ validity of results</td><td colspan="7"></td></tr>
<tr><td colspan="8">Any other information</td></tr>
<tr><td colspan="8">10 Experimental variations (non-standard application)</td></tr>
<tr><td>Variations

Burner level is changed after 10 min from 100 kW to 300 kW in the standard procedure.</td><td>Irradiance level</td><td>Burner output</td><td>Oxygen level

Ventilation into the room can be changed for research purposes.</td><td>Specimen mass</td><td>Preheat</td><td colspan="2">Other
HRR range is 0–2 MW. Under larger calorimeter, it can be increased.</td></tr>
<tr><td colspan="8">Comments</td></tr>
<tr><td rowspan="2" colspan="2">Method of reporting results</td><td colspan="2">Time histories</td><td colspan="2">Mean value</td><td colspan="2">Other</td></tr>
<tr><td colspan="2">Yes</td><td colspan="2">Yes</td><td colspan="2">Photographs, videotape.</td></tr>
</table>

A.11 Summary sheet for ISO 13784-2

1 International Standard ISO 13784-2				
2 Scope This part of ISO 13784 specifies a method of test for determining the reaction to fire behaviour of sandwich panel building systems and the resulting flame spread on or within the sandwich panel building construction, when exposed to heat from a simulated internal fire with flames impinging directly on the internal corner of the sandwich panel building construction. The test method described is applicable to both freestanding self-supporting and frame-supported sandwich panel systems. This part of ISO 13784 provides for large-room testing of sandwich panel building systems. For small-room testing of sandwich panel building systems, ISO 13784-1 is used. The test method described is only applicable to sandwich panel wall and ceiling or roof constructions. This method is not intended to evaluate the fire resistance of a product, which should be tested by other means.				
3 Application Sandwich panel systems (freestanding and frame supported)				
4 Other related standards: ISO 9705, ISO/TR 9705-2, ISO 13784-1, ISO 13943 and IEC 60584-2.				
5 Summary test information				
Ignition source				
Pilot	**Spark**	**Burner** Ignition source is identical to heat source.	**Single electrode spark**	
Size of source	Sandbox burner of 100 kW, 300 kW and 600 kW as standard ignition source.			
Location (in relation to specimen)	In the corner of the room (unless steel structure is in the corner, then at closest joint).			
Thermal exposure	**Radiant**	**Flame** Diffusion flame	**Other**	
6 Description Standard ignition source is a sandbox burner of 300 mm × 300 mm.				
7 Duration of exposure 5 min at 100 kW, 5 min at 300 kW and 5 min at 600 kW for the standard ignition sequence.				

<table>
<tr><td colspan="5">8 Specimen details</td></tr>
<tr><td>General application</td><td colspan="4">The test specimen used consists of the requisite number of panels required by the test method to be performed. In all cases, the test specimen is representative of that used in practice, both in construction and materials. All constructional details of joints, fixings, etc., are reproduced and positioned in the test specimen as in practice. If the investigated type of sandwich panel is used in practice with an inside or outside structural framework, this is also to be used in the test.
NOTE 1 The test specimen should be built by those suitably qualified in the construction of this type of structure.
NOTE 2 If in practice ceiling panels are different than wall panels, a test can be performed with the correct combination of wall and ceiling panels.
If the sandwich panel building system is intended to be used with decorative paint or film facings, these are present on the test specimen.</td></tr>
<tr><td>Specimen orientation</td><td colspan="4">Vertical and horizontal</td></tr>
<tr><td>Thickness of specimen</td><td colspan="4">See specimen preparation.</td></tr>
<tr><td>Specimen dimensions</td><td colspan="2">Width</td><td>Length</td><td>Other
Room dimensions are 4,8 m × 4,8 m × 4 m (length by width by height, internal dimensions).
Door is 4,8 m × 2,8 m.</td></tr>
<tr><td>Specimen preparation</td><td colspan="4">The following information about specimen preparation is taken from ISO 13784-2.
The test specimen used consists of the requisite number of panels required by the test method to be performed. In all cases, the test specimen is representative of that used in practice, both in construction and materials. All constructional details of joints, fixings etc., are reproduced and positioned in the test specimen as in practice. If the investigated type of sandwich panel is used in practice with an inside or outside structural framework, this is also to be used in the test.
NOTE 1 The test specimen should be built by those suitably qualified in the construction of this type of structure.
NOTE 2 If in practice ceiling panels are different than wall panels, a test can be performed with the correct combination of wall and ceiling panels.
If the sandwich panel building system is intended to be used with decorative paint or film facings, these are present on the test specimen.</td></tr>
<tr><td>Substrate details</td><td>Width
See above</td><td>Length
See above</td><td colspan="2">Fixing method/spacing, etc.
See specimen preparation</td></tr>
<tr><td>Specimen conditioning</td><td>Temperature</td><td>Humidity</td><td colspan="2">Other</td></tr>
<tr><td></td><td>10-30 °C before test</td><td></td><td colspan="2"></td></tr>
<tr><td>Number of tests required and criteria for test</td><td colspan="4">One test</td></tr>
<tr><td>Method of reporting results</td><td colspan="4">Descriptive information, numerical results (scalar and vector data), graphical results, photographs and visual observation.</td></tr>
<tr><td colspan="5">Any other information/comments</td></tr>
</table>

9 Experimental measurements (standard application)								
Standard measurements	**Time to ignition** Visual	**Heat release** No	**Total heat released** No	**Smoke** Visual	CO No	CO_2 No	O_2 No	**Thermocouple readings in duct** No
	Rise in temperature of specimen Optional	**Others** Flame spread by using a drawn grid on the material surface, total heat flux by total heat flux meters, flow measurement in door opening, temperatures inside the room, surface temperatures.						

Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**
	No	No	No	No	No	

Burning characteristics considered (yes or no)	**Dripping**	**Falling debris**	**Delamination**	**Other**
	Yes	Yes	Yes	Cracking, melting to some extent, expansion, bowing, distortion.

Damage to specimen	Observations are made after testing.	
Precision data	**Reproducibility**	**Repeatability**
	Not available	Not available
Calibration details	Heat flux meter, temperature, flow meters by weighing mass loss.	
Inaccuracies in measurements		
Limitations/ validity of results		

Any other information

None

Experimental variations (non-standard application)						
Variations Burner level is changed after 5 min from 100 to 300 kW in the standard procedure. Then after another 5 min from 300 to 600 kW.	**Irradiance level**	**Burner output**	**Oxygen level** Ventilation into the room can be changed for research purposes.	**Specimen mass**	**Preheat**	**Other**

Comments

Method of reporting results	**Time histories**	**Mean value**	**Other**
	Yes	No	Photographs, videotape.

A.12 Summary sheet for ISO 13785-1

1 International Standard ISO 13785-1

2 Scope

ISO 13785-1 specifies a screening method for determining the reaction to fire of materials and constructions of façades or claddings when exposed to heat from a simulated external fire with flames impinging directly upon a façade. It is the intention that ISO 13785-1 can be used by producers to reduce the burden of testing in ISO 13785-2 by eliminating those systems which fail in ISO 13785-1.

The behaviour of the façade panel construction and the resulting flame spread on or within the façade construction is studied.

The test method applies only to façades and claddings that are not freestanding and that are used by adding to an existing external wall.

The test method only applies to vertical elements and does not apply to determination of the structural strength of the façade or cladding.

3 Application

Materials and construction of façades or cladding.

4 Other related standards: ISO 13943, ISO 554, ISO/TR 3814, ISO 9705, ISO 13785-2 and IEC 60584-2.

5 Summary test information

Ignition source

Pilot	Spark	Burner	Single electrode spark
		Ignition source is identical to heat source.	

Size of source	The fire source is a propane gas burner with a right-angle top surface layer of a porous, inert material (e.g. sand). The size of the burner is 1,2 m × 0,1 m × 0,15 m. The construction is such that an even gas flow is achieved over the entire opening area. The heat output from the burner is (100 ± 5) kW throughout the test. The burner heat release rate is calculated by multiplying the gas flow with the heat of combustion of propane. A value of 46,4 kJ/g is used.
Location (in relation to specimen)	The burner is placed on the floor lengthwise below the test specimen with the ends of the burner lined up with the edges of the test specimen. The back wall of the burner is in contact with the sample holder.

Thermal exposure	Radiant	Flame	Other
		Diffusion flame	

6 Description

The size of the burner is 1,2 m × 0,1 m × 0,15 m. The burner heat release rate is calculated by multiplying the gas flow with the heat of combustion of propane. A value of 46,4 kJ/g is used.

7 Duration of exposure

30 min at 100 kW.

8 Specimen details

General application	Both in construction and materials, the test specimen is representative of the system used in practice. The application of the material to the test rig corresponds to the practical manner. All constructional details of joints, fixings, etc., are detailed and positioned in the test specimen as in practice.
Specimen orientation	Vertical

Thickness of specimen	See specimen preparation		
Specimen dimensions	**Width** See preparation	**Length** See preparation	**Other**
Specimen preparation	The following information about specimen preparation is taken from ISO 13785-1. Both in construction and materials, the test specimen is representative of the system used in practice. The application of the material to the test rig corresponds to the practical manner. All constructional details of joints, fixings, etc. are detailed and positioned in the test specimen as in practice. NOTE The test specimen should be built by persons suitably qualified in the construction of this type of structure in practice. The test specimen consists of sufficient cladding or façade panels together with battens and insulation where appropriate to cover two areas: 1,2 m wide and 2,4 m high and 0,6 m wide and 2,4 m high. The joints where used in practice and fixings are installed in end-use condition into the test specimen. The test specimen is incorporated in a central horizontal joint at mid-height and a central vertical joint. The bottom edge of the specimen is closed by the method normally used for the incorporation of window casements.		
Substrate details	**Width** See above	**Length** See above	**Fixing method/spacing, etc.** See specimen preparation
Specimen conditioning	**Temp.** (23 ± 2) °C	**Humidity** (50 ± 5) %	**Other** Specimens containing hygroscopic material are conditioned before the test to a constant mass at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %. NOTE These requirements correspond to the recommended atmosphere given in ISO 554. Specimens of non-hygroscopic material are stored in this environment for at least 48 h prior to the test.
Number of tests required and criteria for test	One test		
Method of reporting results	Descriptive information, numerical results (scalar and vector data), graphical results, photographs, visual observation.		
Any other information/comments			

9 Experimental measurements (standard application)

Standard measurements	**Time to ignition**	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Visual	No	No	Visual	No	No	No	No

	Rise in temperature of specimen	**Others**
	Yes	Flame spread by using a drawn grid on the material surface, total heat flux by total heat flux meters, surface and gas temperatures.

Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**
	No	No	No	No	No	

Burning characteristics considered (yes or no)	**Dripping**	**Falling debris**	**Delamination**	**Other**
	Yes	Yes	Yes	Cracking, melting to some extent, expansion, bowing, distortion.

Damage to specimen	Observations are made after testing.	
Precision data	**Reproducibility**	**Repeatability**
	Not available	Not available
Calibration details	Heat flux meter, temperature, flow meters by weighing mass loss.	
Inaccuracies in measurements		
Limitations/ validity of results		
Any other information		

10 Experimental variations (non-standard application)

Variations	**Irradiance level**	**Burner output**	**Oxygen level**	**Specimen mass**	**Preheat**	**Other**

Comments

Method of reporting results	**Time histories**	**Mean value**	**Other**
	Yes	No	Photographs, videotape.

A.13 Summary sheet for ISO 13785-2

1 International Standard ISO 13785-2

2 Scope

ISO 13785-2 specifies a test method for determining the reaction to fire of materials and construction of façade claddings when exposed to heat and flames from a simulated interior compartment fire with flames emerging through a window opening and impinging directly on the façade. The information generated from this test may also be applicable to the scenario of an external fire impinging on a façade; however, the results may not be applicable for all fire exposure conditions.

The method applies only to façades and claddings that are non-load-bearing. No attempt is made to determine the structural strength of the façade or cladding.

The test is not intended to determine the fire behaviour of a given building façade. Details such as balconies, windows, window shutters, curtains, etc. are not considered in this test. This test therefore does not include the risk of fire spread e.g. through the window details of the façade system as it is only constructed as a façade wall. There is clear evidence that an internal corner (also called a re-entrant corner) configuration produces a more intense fire exposure than a flat façade. The most commonly encountered internal re-entrant corner is with an angle of 90°. The test façade specimen therefore contains an internal corner with a re-entrant angle of 90°.

The test method described is intended to evaluate the inclusion of combustible components within façades and claddings of buildings which are otherwise of non-combustible construction.

3 Application

Materials and constructions of façade or claddings.

4 Other related standards: ISO 13943, ISO 554, ISO/TR 3814, ISO 9705 and ISO 13785-1.

5 Summary test information

Ignition source

Pilot	**Spark**	**Burner**	**Single electrode spark**
		Ignition source is identical to heat source.	

Size of source	The standard source of fuel used in the combustion chamber is propane. An example for the standard propane ignition source is given in Annex A of ISO 13785-2. Other choices of fuel are specified in Annex B, but the amount of smoke generated should not obstruct visual observation of the performance of the façade assembly, and the fuel has to conform to ISO 13785-2, 6.2 to 6.5. The duration of full fire exposure in the calibration test is 15 min, during which flames emerging from the opening impinge on the outer face of the cladding. Full fire exposure is preceded by 4 min to 6 min of a gradual increase in fire intensity. The full fire exposure is followed by a gradual decrease in intensity of 4 min to 6 min. The total test duration is between 23 min and 27 min.
Location (in relation to specimen)	The combustion chamber has only one opening in the main façade that allows for entry of air for combustion and that vents flames onto the façade. It is from here that the flames are directed at the sample.

Thermal exposure	**Radiant**	**Flame**	**Other**
		Diffusion flame	

6 Description			
During full fire exposure in the calibration test the front face of the façade is subjected to a total heat flux of (55 ± 5) kW/m^2 measured by the total heat flux meter 0,5 m vertically above the centre of the window opening (see Figure 2 of ISO 13785-2). The total heat flux at 1,5 m above the window opening is (35 ± 5) kW/m^2 (see ISO 13785-2, 5.2). NOTE The total heat fluxes may be calculated as an average over the 15 min when flames emerge from the opening. During full fire exposure in the calibration test, the temperature measured by each of the three thermocouples placed at the window opening (see ISO 13785-2, 8.2) is above 800 °C, calculated as an average over the 15 min duration (see ISO 13785-2, 5.2).			
7 Duration of exposure			
15 min.			
8 Specimen details			
General application	The test specimen is installed in accordance with manufacturer's instructions. The test specimen is representative of a façade used in practice, both in construction and materials.		
Specimen orientation	Vertical		
Thickness of specimen	See specimen preparation		
Specimen dimensions	**Width** See preparation	**Length** See preparation	**Other**
Specimen preparation	The following information about specimen preparation is taken from ISO 13785-2. The test specimen extends from the bottom of the window opening to a minimum height of 4,0 m above the top of the window opening. The minimum widths of the test specimen on the main and wing façades are 3,0 m and 1,2 m, respectively. The specimen is constructed so that a re-entrant corner is fabricated between the main façade and the wing façade. Once completed and installed in the test facility, the horizontal distance to the wing façade of the specimen from the (vertical) edge of the window opening is ⩽ 50 mm. The test specimen includes an opening coincident with the opening in the combustion chamber. Constructional details of the window opening, including the lintel and the jambs, are as in end-use practice. The test specimen is representative of a complete non-loadbearing exterior wall assembly, but the interior finish is not required. If horizontal joints are normally incorporated in the exterior wall assembly, the test specimen incorporates a horizontal joint. The joint is located above the window opening and within 3,0 m vertical distance from the top of the window opening. The horizontal joint extends from the main façade onto the wing façade. NOTE 1 Window details one level above the opening are not included. This means that the risk of fire spread through these details is not included in this test. If vertical joints are normally incorporated in the exterior wall assembly, the test specimen incorporates a vertical joint. The joint is located within 0,25 m of the horizontal centre of the window opening. The joint extends from the top of the window opening to a horizontal joint as specified in ISO 13785-2, 7.9, or to a minimum vertical distance of 3,0 m. NOTE 2 The test specimen is built by persons suitably qualified in construction of this type of structure in practice.		

	NOTE 3 The lintel of the façade at the window opening is constructed as in normal practice for this type of assembly. NOTE 4 The lintel of ventilated façade systems is constructed with openings as in normal practice for the type of façade assembly.		
Substrate details	**Width** See above	**Length** See above	**Fixing method/spacing, etc.** See specimen preparation
Specimen conditioning	**Temp.**	**Humidity**	**Other**
	10–30 °C		Test specimens are left to stand following installation on the test facility for a period sufficient for all the components to cure before being subjected to test. The ambient temperature during the conditioning is not less than 10 °C and not greater than 30 °C. The duration of the conditioning period conforms to the manufacturer’s instructions for curing. During curing, the test specimen is protected from precipitation and kept within the temperature range specified by the manufacturer(s) for curing components.
Number of tests required and criteria for test	One test		
Method of reporting results	Descriptive information, numerical results (scalar and vector data), graphical results, photographs and visual observation.		
Any other information/comments			

9 Experimental measurements (standard application)

Standard measurements	**Time to ignition** Visual	**Heat release** No	**Total heat released** No	**Smoke** Visual	CO No	CO_2 No	O_2 No	**Thermocouple readings in duct** No
	Rise in temperature of specimen Yes	**Others** Flame spread, total heat flux by total heat flux meters, surface and gas temperatures						
Others commonly measured	**Mass loss** No	**Smoke** No	CO No	CO_2 No	**Heat of combustion** No	**Others**		

Burning characteristics considered **(yes or no)**	**Dripping** Yes	**Falling debris** Yes	**Delamination** Yes	**Other** Cracking, melting to some extent, expansion, bowing, distortion.
Damage to specimen	Observations are made after the testing.			
Precision data	**Reproducibility**	**Repeatability**		
	Not available	Not available		

Calibration details	Heat flux meter, temperature, flow meters by weighing mass loss.					
Inaccuracies in measurements						
Limitations/ validity of results						
Any other information						
12 Experimental variations (non-standard application)						
Variations Other sources, such as wood and liquid fuels, are allowed.	**Irradiance level**	**Burner output**	**Oxygen level**	**Specimen mass**	**Preheat**	**Other**
Comments						
Method of reporting results	**Time histories**	**Mean value**	**Other**			
	Yes	N	Photographs, videotape.			

A.14 Summary sheet for ISO/TR 14696

1 International Standard ISO/TR 14696				
2 Scope ISO/TR 14696 provides 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 ISO/TR 14696. Smoke development is quantified by measuring the obscuration of light by the combustion product stream. Samples 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 sample is tested in thicknesses and configurations representative of actual end product or system uses. Other parameters and values needed in computer fire models can be determined. Examples are: effective heat of combustion, surface temperature, ignition temperature, temperature gradients in the sample, combustion gas yields, heat of gasification and flame spread.				
3 Application This test method has been developed for material, product or assembly evaluations, mathematical modelling and design purposes. The sample is tested in thicknesses and configurations representative of actual end product or system uses.				
4 Other related standards: ISO 5657, ISO 5660-1, ISO 9705 and ISO/IEC Guide 52.				
5 Summary test information				
Ignition source				
Pilot Hot wire	**Spark**	**Burner**	**Single electrode spark**	
Size of source	Two wires (1 m each) stretching along the lower and upper edges of a 1 m × 1 m sample. Wires are 0,81 mm diameter nickel chromium wires. A gas-fired radiant panel produces a heat flux to the sample.			
Location (in relation to sample)	One wire is positioned horizontally, spanning the full width of the sample, 80 mm above the bottom exposed edge of the sample and 15 mm from the sample surface. The other wire is positioned horizontally, spanning the full width of the sample, 20 mm above the top exposed edge of the sample and 15 mm from the sample's vertical plane.			
Thermal exposure	**Radiant** Radiant panel	**Flame**	**Other** Hot wire surface ignites pyrolysis gases when they reach the concentration required for ignition.	
6 Description See above				
7 Duration of exposure Until sustained flaming occurs. Wires are turned on again if the flames go out.				

8 Sample details			
General application	Sample is inserted into a sample holder.		
Sample orientation	Vertical		
Thickness of sample	Actual thickness up to 150 mm. Thicker samples can be accommodated in a thicker holder.		
Sample dimensions	**Width** 1 m	**Length** 1 m	**Other**
Sample preparation	Samples are representative of the construction of the end-use product. Materials and assemblies of normal thickness ⩽ 150 mm are tested in their full thickness. If a product is designed to normally have joints in a field application, then that sample incorporates the joint detail. The joint is centred in the sample's vertical or horizontal centreline as appropriate. The sample is also tested without a joint detail if the design does not include a joint. The edges of the sample are covered with 12 mm ceramic wool blanket to eliminate the gap between the holder and the sample.		

Substrate details	**Width** 1 m	**Length** 1 m	**Fixing method/spacing, etc.** A retainer frame fastened to the holder is typically used to hold the sample in position against the holder lip.
Sample conditioning	**Temp.** (23 ± 3) °C	**Humidity** (50 ± 5) %	**Other**

Burning characteristics considered **(yes or no)**	**Dripping** Yes	**Flowing droplets** Yes	**Falling debris** Yes	**Delamination** Yes	**Other** Cracking, melting to some extent, expansion, bowing, distortion.

Number of tests required and criteria for test	Three tests required. Usually (unless otherwise required) data are collected until 2 min after sustained flaming occurs on the unexposed side of the specimen.
Method of reporting results	Descriptive information, numerical results (mostly scalar values), graphical results and descriptive results, including photographs and videotape.
Any other information/comments	

9 Experimental measurements (standard application)								
Standard measurements	**Time to ignition**	**Heat release**	**Total heat released**	**Smoke**	CO	CO_2	O_2	**Thermocouple readings in duct**
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Rise in temperature of specimen	**Others** Mass loss rate						

Others commonly measured	**Mass loss**	**Smoke**	CO	CO_2	**Heat of combustion**	**Others**
		Yes			Yes	Ignition temperature, surface temperature.

Damage to sample	Observations are made.	
	Reproducibility	**Repeatability**
Precision data	Not available	Not available
Calibration details	Heat flux/distance relationship, heat release, mass loss (weighing platform), smoke system, gas analysis, heat flux meter, pressure transducers, pyrometer–emissivity adjustment.	

Uncertainties in measurements	No information
Limitations/ validity of results	The test data may have limited validity if any of the following occur: — the sample melts sufficiently to overflow the drip tray; — explosive spalling occurs.

Any other information

Comments on applicability of this test method to end-use scenarios

Edge and size effects are small in comparison to small-scale tests. Materials and assemblies can be tested in end-use configuration. Actual performance of samples during test (cracking, spalling, expansion, etc.) is taken into account.

10 Experimental variations (non-standard application)

Variations	**Irradiance level**	**Burner output**	**Oxygen level**	**Sample mass**	**Preheat**	**Other**
	0-50 kW/m^2	Radiant panel output changes during tests to maintain constant surface temperature	Ambient around sample	0-50 kg (1 g accuracy) (depending on scale capacity)	Sample is exposed to heat flux instantly by opening the water cooled shield	HRR range is 0–2 MW

Comments

Method of reporting results	**Time histories**	**Mean value**	**Other**
	Yes	Yes	Photographs, videotape.

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