# INTERNATIONAL STANDARD

# ISO 5657

Second edition
1997-12-15

## Reaction to fire tests — Ignitability of building products using a radiant heat source

*Essais de réaction au feu — Allumabilité des produits de bâtiment avec une source de chaleur rayonnante*



ISO 5657:1997(E)

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**Annexes**





International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

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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.

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.



International Standard ISO 5657 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommitte SC 1, *Reaction to fire*.

This second edition cancels and replaces the first edition (ISO 5657:1986), which has been technically revised.



Annexes A to E of this International Standard are for information only.

## Introduction

Fire is a complex phenomenon: its behaviour and its effects depend upon a number of interrelated factors. The behaviour of materials and products depends upon the characteristics of the fire, the method of use of the materials and the environment in which they are exposed. The philosophy of "reaction to fire" tests is explained in ISO/TR 3814.

A test such as is specified in this International Standard deals only with a simple representation of a particular aspect of the potential fire situation typified by a radiant heat source in the presence of a pilot flame; it cannot alone provide any direct guidance on behaviour or safety in fire. A test of this type may, however, be used for comparative purposes or to ensure the existence of a certain quality of performance (in this case ignitability) considered to have a bearing on fire performance generally. It would be wrong to attach any other meaning to performance in this test.



The term "ignitability" is defined in ISO/IEC Guide 52 as the measure of the ease with which a specimen can be ignited due to the influence of an external heat source, under specific test conditions. It is one of the first fire properties to be manifest and should almost always be taken into account in any assessment of fire hazard. It may not, however, be the main characteristic of the material which affects the subsequent development of fire in a building.



This test does not rely upon the use of asbestos-based materials.

# Reaction to fire tests — Ignitability of building products using a radiant heat source

**SAFETY WARNING - So that suitable precautions may be taken to safeguard health, the attention of all concerned in fire tests is drawn to the possibility that toxic or harmful gases may be evolved during exposure of test specimens. The advice on safety given in annex A clause A.7 should also be noted.**

## 1 Scope

This International Standard specifies a method for examining the ignition characteristics of the exposed surfaces of specimens of essentially flat materials, composites or assemblies not exceeding 70mm 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. Advice on the limitations of the test is given in annex B.



## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing.*

ISO/IEC Guide 52:1990, *Glossary of fire terms and definitions.*

ISO/TR 14697:1997, *Reaction to fire tests — Guidance on the choice of substrates for building products.*

## 3 Definitions

NOTE — See also A.1.

For the purposes of this International Standard, the definitions given in ISO/IEC Guide 52, together with the following, apply.

**3.1** **assembly**: Fabrication of materials and/or composites.

NOTE — This may include an air gap.

EXAMPLE — Sandwich panels.

**3.2** **composite**: Combination of materials which are generally recognised in building construction as discrete entities.

EXAMPLE — Coated or laminated materials.

**3.3** **essentially flat surface:** Surface whose irregularity from a plane does not exceed ± 1mm.

**3.4** **exposed surface**: That surface of the product subjected to the heating conditions of the test.

**3.5** **irradiance** (at a point of a surface): Quotient of the radiant flux incident on an infinitesimal element of surface containing the point, by the area of that element.

**3.6** **material**: Single substance or uniformly dispersed mixture.

EXAMPLES — Metal, stone, timber, concrete, mineral fibre, polymers.

**3.7** **plume ignition**: Inception of any flame in the plume above the specimen, sustained or transitory.

**3.8** **product**: Material, composite or assembly about which information is required.



**3.9** **specimen**: Representative piece of the product which is to be tested together with any substrate or treatment.



NOTE — This may include an air gap.

**3.10** **sustained surface ignition**: Inception of a flame on the surface of the specimen which is still present at the next application of the pilot flame (greater than 4s duration).

**3.11** **transitory surface ignition:** Inception of any flame on the surface of the specimen which is not present at the next application of the pilot flame (less than 4s duration).

## 4 Principles of the test

NOTE — See also A.2.

Specimens of the product are mounted horizontally and exposed to thermal radiation on their upper surface at selected levels of constant irradiance within the range 10 to 70kW/m².

A pilot flame is applied at regular intervals to a position 10mm above the centre of each specimen to ignite any volatile gases given off. The time at which sustained surface ignition occurs is reported.

NOTE 1 Information is given on the use of the apparatus to determine the ignitability of materials under higher irradiances in annex C.

NOTE 2 Other types of ignition which occur are reported in 11.5.

NOTE 3 Convection transfer may also make a very small contribution (not more than a few per cent) to the heating at the centre of a specimen and to the reading of the radiometer during the calibration procedure. However, the term irradiance is used throughout this International Standard as best indicating the essentially radiative mode of heat transfer.

## 5 Suitability of a product for testing

NOTE — See also A.3.

### 5.1 Surface characteristics

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

a) an essentially flat exposed surface; or

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

— at least 50% of the surface of a representative 150mm diameter area lies within a depth of 10mm from a plane taken across the highest points on the exposed surface, and/or

— for surfaces containing cracks, fissures or holes not exceeding 8mm in width nor 10mm in depth, the total area of such cracks, fissures or holes at the surface does not exceed 30% of a representative 150mm diameter area of the exposed surface.

**5.1.2** When an exposed surface does not meet the requirements of either 5.1.1a) or 5.1.1b), the product shall, if practicable, be tested in a modified form complying as nearly as possible with the requirements given in 5.1.1. The test report shall state that the product has been tested in a modified form and clearly describe the modification (see clause 13).



### 5.2 Asymmetrical products

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



## 6 Specimen construction and preparation

NOTE — See also A.4.

### 6.1 Specimens

**6.1.1** Five specimens shall be tested at each level of irradiance selected and for each different exposed surface.

**6.1.2** The specimens shall be representative of the product, square, with sides measuring $165^{+0}_{-5}$ mm.

**6.1.3** Materials and composites of thickness 70mm or less shall be tested using their full thickness.

**6.1.4** For materials and composites of thickness greater than 70mm, the requisite specimens shall be obtained by cutting away the unexposed face to reduce the thickness to $70^{+0}_{-3}$ mm.

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

**6.1.6** Assemblies shall be tested as specified in 6.1.3 or 6.1.4 as appropriate. However, where thin materials or composites are used in the fabrication of an assembly, the presence of air or an air gap and/or the nature of any underlying construction may significantly affect the ignition characteristics of the exposed surface. The influence of the underlying layers should be understood and care taken to ensure that the test result obtained on any assembly is relevant to its use in practice (see A.4.1).

When the product is a material or composite which would normally be attached to a well-defined substrate, then it shall be tested in conjunction with that substrate using the recommended fixing technique, e.g. bonded with the appropriate adhesive or mechanically fixed.

Alternatively, where the end-use substrate is non-combustible or of limited combustibility, then the material or composite may be tested using a reference substrate of a density less than the end-use substrate.

See ISO/TR14697 for advice on substrates.

## 6.2 Baseboards

**6.2.1** One baseboard will be required for each test specimen. However, since it will sometimes be possible to re-use the baseboard after test, the total number required will depend on the frequency of testing and the type of product being tested.

**6.2.2** The baseboards shall be square with sides measuring $165^{+0}_{-5}$ mm and shall be made of non-combustible insulation board of oven dry density (825 ± 125) kg/m³ and nominal thickness 6mm. The thermal inertia of these boards shall be nominally $9{,}0 \times 10^4$ $W^2s/m^4K^2$.

## 6.3 Conditioning of specimens



NOTE — See also A.4.3.

Before test, the specimens and baseboards shall be conditioned to constant mass[1)] at a temperature of (23 ± 2)°C and a relative humidity of (50 ± 5)% with free access of air to both sides.



## 6.4 Preparation

**6.4.1** A conditioned specimen shall be placed on a baseboard treated according to 6.3 and the combination shall be wrapped in one piece of aluminium foil of nominal thickness 0,02mm from which a circle 140mm diameter has been previously cut (see figure 1). The circular cut-out zone shall be centrally positioned over the upper surface of the specimen. After preparation, the specimen-baseboard combination shall be returned to the conditioning atmosphere until required for test.

**6.4.2** Where a product will normally be backed by air (see 6.1.6), then the specimen shall, where practicable, be backed by an air gap in the test. The air gap shall be formed by including a spacer between the specimen and the baseboard. The spacer shall consist of a piece of non-combustible insulation board of the same size and density as the baseboard, from the centre of which a circular area $140^{+0}_{-5}$ mm in diameter has been removed. The thickness of the spacer shall correspond to the size of the air gap, if this is known, except that the total thickness of the spacer plus specimen shall not exceed 70mm. If the size of the air gap is not known or the total thickness of the air gap plus specimen exceeds 70mm, then the specimen shall be tested with a spacer which will give a total thickness for the specimen and spacer of $70^{+0}_{-3}$ mm.

The spacer and baseboard shall be placed for at least 24h in an atmosphere at a temperature of (23 ± 2)°C and a relative humidity of (50 ± 5)%, with free access of air to both sides of each. The spacer shall

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

then be interposed between the baseboard and the specimen and the combination shall be wrapped in aluminium foil as described in 6.4.1. A clean spacer shall be used for each specimen tested. After preparation the combination shall be returned to the conditioning atmosphere until required for test.

**6.4.3** Baseboards and/or spacers used to back the specimens may be re-used if they are not contaminated. Immediately before re-use, however, they should have been in the conditioning atmosphere specified in 6.3 and 6.4.2 for at least 24h. If there is any doubt about the condition of a baseboard or spacer, it may be placed in a ventilated oven at a temperature of approximately 250°C for a period of 2h in an attempt to remove any volatile residue. If there is still any doubt about the condition, it shall be discarded.

### 6.5 Reflective coatings

In real fires, metallic coatings which tend to reflect heat may become coated with black soot or tarnish. When assessing the ignitability of materials with a reflective metallic coatings, the product should be assessed both in its virgin state and also with an applied thin coating of matt black water-based emulsion. Apply a coating of carbon black dispersed in organic solvent to give a coverage rate of 5g/m² of the carbon black. The coated specimen should then be prepared and tested according to the normal testing procedures in 6.4 and clause 11 respectively.

### 6.6 Dimensionally unstable materials

This test method may prove unsuitable for materials that change their dimensions substantially when exposed to radiant heat, for example, materials that intumesce or shrink away from the radiator. The irradiance on the surface of such materials may differ significantly from the irradiance set by the temperature controller, either greater or less depending upon the behaviour of the material, which could lead to a worse precision in the repeatability and reproducibility of the method than that indicated in annex D.



## 7 Test apparatus

All dimensions given in the following description of test apparatus are nominal unless tolerances are specified.

The test apparatus shall consist essentially of a support framework which clamps the test specimen horizontally between a pressing plate and a masking plate such that a defined area of the upper surface of the specimen is exposed to radiation. This radiation shall be provided by a radiator cone positioned above and supported from the specimen support framework. An automated pilot flame application mechanism shall be used to bring a test flame through the radiator cone to a position above the centre of the surface of the specimen. A specimen insertion and location tray shall be used to position the specimen accurately on the pressing plate of the specimen support framework and a screening plate shall be used to shield the surface of the specimen during its insertion into the apparatus.

A general arrangement of a suitable apparatus is shown in figure 2, with detailed drawings in figures 3 to 6.

### 7.1 Specimen support framework, masking plate and pressing plate

**7.1.1** The specimen support framework and the other parts of the system to hold the specimen in position shall be constructed from stainless steel. It shall consist of a rectangular base-frame made from 25mm x 25mm square tube of 1.5mm wall thickness and shall have overall dimensions of 275mm x 230mm. A horizontal masking plate, 220mm square and 4mm thick, shall be mounted centrally and

260mm above the top of the base-frame on four 16mm diameter legs positioned at the corners of the masking plate. A 150mm diameter circular opening shall be cut centrally in the masking plate, the edges of the hole being chamfered on the top surface of the plate at an angle of 45° and to a horizontal width of 4mm.

**7.1.2** Two vertical guide rods not less than 355mm long of 20mm diameter steel shall be mounted on the base-frame, one at the mid-length of each of the short sides of the frame. A horizontal adjustable bar 25mm x 25mm which can slide on the rods and be locked in position by bolts capable of being tightened by hand shall be mounted below the masking plate and between the vertical guide rods. A vertical central hole and sleeve in the adjustable bar shall be used to located a sliding vertical rod of 12mm diameter and 148mm long, surmounted by a 180mm square pressing plate 4mm thick. The pressing plate shall be pushed against the underside of the masking plate by the counterweighted pivot arm which shall be mounted below the adjustable horizontal bar and shall press against the bottom of the sliding vertical rod. This can be achieved by an arm about 320mm long.

It shall contain at one end a roller which shall bear against a boss on the bottom of the sliding vertical rod and at the other end an adjustable counterweight.

The counterweight shall be capable of compensating for different masses of specimens and of maintaining a force of approximately 20 N between the upper surface of the specimen and the masking plate. A counterweight of about 3kg has been found to be suitable. An adjustable stop shall be provided to limit upward movement of the pressing plate, due to collapse, softening or melting of the specimen during its exposure, to 5mm. Alternatively spacing blocks between the pressing plate and the masking plate may be used.



**7.1.3** Figure 3 shows details of the specimen support framework.



## 7.2 Radiator cone

**7.2.1** The radiator cone shall consist of a heating element, of nominal rating 3kW, contained within a stainless steel tube, approximately 3,500mm in length and 8,5mm in diameter, coiled into the shape of a truncated cone and fitted into a shade. The shade shall have an overall height of (75 ± 1)mm, an internal diameter of (66 ± 1)mm and an internal base diameter of (200 ± 3)mm. It shall consist of two layers of 1mm thick stainless steel with a 10mm thickness of ceramic fibre insulation of nominal density 100kg/m³ sandwiched between them. The heating element shall be fastened to the inside face of the shade by steel pins. At least four clamps shall be used, positioned equidistantly around the perimeter of the shade to prevent additional sagging of the lower coil below the base of the shade. (See figure 4b.)

The upper turn of the heating element shall not obstruct the area of the top aperture of the shade by more than 10% when projected vertically.

**7.2.2** The radiator cone shall be capable of providing irradiance in the range 10 to 70kW/m² at the centre of the aperture in the masking plate and in a reference plane coinciding with the underside of the masking plate, when measured as described in 10.2. The distribution of irradiance provided by the cone at the reference plane shall be such that the variation of irradiance within a circle of 50mm diameter, drawn from the centre of the masking plate aperture, shall be not more than ±3% of that at the centre; the variation of irradiance within a circle of 100mm diameter shall be not more than ±5% of that at the centre.

The distribution of irradiance shall be determined from readings at the centres of selected 10mm squares forming the grids shown in figure 4d). The tolerances given shall apply to the readings within the grid comprising all the squares shown in figure 4d).

For these measurements, the opening in the masking plate shall be completely filled; it is therefore advisable to employ a number of calibration boards of special horizontal shapes and sizes.

**7.2.3** The radiator cone shall be located and secured from the vertical guide rods of the specimen support framework by clamps which position the lower rim of the radiator cone shade (22 ± 1)mm above the upper surface of the masking plate.

**7.2.4** Details of the radiator cone are shown in figure 4b).

**7.2.5** The temperature of the radiator cone shall be controlled by reference to the reading of a thermocouple (primary thermocouple) (7.6) in close and stable thermal contact with the heater element tube. A second thermocouple (secondary thermocouple) shall be attached similarly, mounted in a diametrically opposite position. The thermocouples shall have a speed of response not slower than that of a thermocouple with insulated hot junction in a stainless steel sheath 1mm in diameter. Each thermocouple shall be attached to a coil of the heater element tube which places them between one-third and half way down from the top of the radiator cone. At least 8mm of the end of the thermocouple shall lie in a region of approximately uniform temperature.

A description of methods of attaching thermocouples which have been found satisfactory in practice is given in A.5.1.

### 7.3 Pilot flame application mechanism

NOTE — See also A.5.2.



**7.3.1** The apparatus shall be provided with a mechanism which is capable of bringing a pilot flame from a re-ignition position outside the radiator cone to the test position within the cone. The mechanism shall be capable to taking the pilot flame through the radiator cone and through the aperture in the masking plate to a maximum distance of 60mm below the underside of the masking plate.



**7.3.2** The pilot flame shall issue from a nozzle made of stainless steel as specified in figure 5, attached near the end of the pilot flame tube.

**7.3.3** The normal position of the pilot flame shall be above the radiator cone and clear of the plume of smoke or decomposition products which may rise through the top of the cone. When in this position the pilot flame nozzle shall be adjacent to a secondary ignition source[2)] having a heat output not greater than 50W which shall be capable of re-igniting the pilot flame should it be extinguished.

**7.3.4** The normal position of the pilot flame shall be such that the flame issues horizontally over the centre point of the aperture in the masking plate and perpendicular to the plane of movement of the pilot arm, with the centre of the orifice in the nozzle positioned (10 ± 1)mm above the underside of the masking plate.

**7.3.5** The application mechanism shall automatically bring the pilot flame to the "normal test position" once every $4^{+0,4}_{0}$ s. The pilot flame shall not take longer than 0,5s to travel from the opening at the top of the radiator shade to the test position where it shall remain for $1^{+0,1}_{0}$ s. The time taken for the pilot flame to travel back over the same distance shall not exceed 0,5s.

**7.3.6** The mechanism shall be provided with an adjustable stop which will restrict the lowest point of travel of the pilot flame to any position within the range from 20mm above the test position to 60mm below.

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2 The secondary ignition source can be a gas flame, hot wire or spark ignited. A propane flame 15mm long, from a nozzle with an internal diameter of 1mm to 2mm, has a heat output of approximately 50W.

**7.3.7** A suitable pilot flame application mechanism is shown in figures 6a), 6b) and 6c).

NOTE — The pilot flame application mechanism should be constructed to a close tolerance since minor changes in the dimensions can lead to changes to the timing as specified in 7.3.5. Small changes can, however, be accommodated by slight changes in the diameter of the slave roller.

### 7.4 Specimen insertion and location tray

**7.4.1** The specimen insertion and location tray shall be used to facilitate rapid insertion of the specimen on to the pressing plate and to locate accurately the exposed area of the specimen in relation to the aperture in the masking plate.

**7.4.2** It shall consist essentially of a flat metal plate having lugs on its upper surface to position and hold the specimen. Guides shall be fixed to the lower surface to locate the tray in the apparatus and a stop shall also be provided to bear against the pressing plate, thus limiting the distance of insertion. The tray should be provided with a handle to facilitate use.

**7.4.3** A suitable device is shown in figure 7.

### 7.5 Specimen screening plate

**7.5.1** The screening plate shall be designed to slide over the top of the masking plate during the period of insertion of the specimen, thus shielding the specimen from radiation until commencement of the test.



**7.5.2** The plate shall be made from 2mm-thick polished aluminium or stainless steel and shall have overall dimension which allow it to cover the masking plate. It should be provided with a stop, to limit its insertion against the masking plate, and a handle.



**7.5.3** A suitable design is shown in figure 8.

### 7.6 Temperature controller

The temperature controller for the radiator cone shall be of the proportional integral and derivative type ("3-term" controller) with thyristor stack fast-cycle or phase angle (see A.5.3) control of not less than 15A maximum rating. Capacity for adjustment of integral times between about 10s and 150s, and differential times between about 2s and 30s, shall be provided to permit reasonable matching with the response characteristics of the heater. The temperature at which the heater is to be controlled shall be set on a scale capable of being read to ±2°C. An input range of temperature of about 0°C to 1000°C is suitable. (An irradiance of 50kW/m² will be given by a heater temperature in the region of 800°C.) Automatic cold junction compensation for the thermocouple shall be provided.

Desirable features are a meter to indicate the output to the heater and a control which, in the event of an open circuit in the thermocouple line, will cause the temperature to fall to near the bottom of its range.

The monitor heater temperature, particularly to show the operator when the heater has attained temperature equilibrium, heater temperature shall be indicated by a meter capable of being read to ±2°C. This may be incorporated in the controller or separate.

### 7.7 Radiometer (heat flux meter)

The radiometer shall be of the Schmidt Boelter or Gardon type with a range of 0 to 70kW/m². The target receiving radiation, and possibly to a small extent convection, shall be flat, circular, not more than 10mm in diameter and coated with a durable matt black finish. The target shall be contained within a watercooled body the front face of which shall be of highly polished metal, flat, coinciding with the plane of the target and circular, with a diameter of about 25mm.

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

The calibration of the radiometer shall be checked whenever a recalibration of the apparatus is carried out (see 10.2), by comparison with an instrument held as a reference standard and not used for any other purpose. The reference standard instrument shall be fully calibrated at yearly intervals.

### 7.8 Millivolt measuring device

This shall be compatible with the output from the radiometer specified in 7.7. It shall have a full scale deflection, sensitivity and accuracy which enables the irradiance measure by the radiometer to be resolved to 0,5kW/m².

### 7.9 Secondary thermocouple monitoring device

To monitor the secondary thermocouple, an instrument is required with a resolution equivalent to ±2°C. This may read directly in temperature or in millivolts. Allowance or automatic compensation for cold junction temperature shall be made. If a separate device is used to monitor heater temperature, this may, with a suitable switch connection, also be used to monitor the secondary thermocouple.



### 7.10 Timing device (timer)

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



### 7.11 Air and propane supplies

Air and propane shall be fed to the pilot flame (see 7.3) via regulating valves, filters (if necessary), flow meters, non-return valves, a suitable junction connection and a flame arrester as shown in figure 10.

#### 7.11.1 Gas regulating valves

These shall be capable of adjusting the pressure and flow of propane and air to the pilot flame to the levels required by 9.2.

#### 7.11.2 Filters

Filters may need to be installed in the propane and/or air lines to avoid the readings of the flow-meters being affected by impurities (for example oil droplets) carried in the flow.

#### 7.11.3 Flow-meters

These shall be capable of measuring the flow-rates of propane and air to the pilot flame to an accuracy of at least 5%.

#### 7.11.4 Non-return valves

A suitable non-return valve shall be included in both air and propane lines, sited as close to the junction point as possible.