INTERNATIONAL STANDARD

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Reaction to fire tests — Mass loss measurement

Essais de réaction au feu — Mesurage de la perte de masse

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Foreword

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

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

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

ISO 17554 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Reaction to fire tests — Mass loss measurement

1 Scope

This International Standard specifies a small-scale method for assessing the mass loss rate of essentially flat specimens exposed in the horizontal orientation to controlled levels of radiant heating with an external igniter under well-ventilated conditions. The mass loss rate is determined by measurement of the specimen mass and is derived numerically. The time to ignition (sustained flaming) is also measured in this test. Mass loss rate can be used as an indirect measure of heat release rate for many products. However some products, e.g. those with high water content, will have mass loss rates that are not so closely linked to heat release rates. Such products need to be tested in accordance with ISO 5660-1 for correct assessment of heat release.

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 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 13943:2000, *Fire safety — Vocabulary*

ISO/TR 14697:1997, *Fire tests — Guidance on the choice of substrates for building products*

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

3 Terms and definitions

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

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

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

3.3
ignition
onset of sustained flaming as defined in 3.9

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

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

3.5
material
single substance or uniformly dispersed mixture

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

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

3.7
product
material, composite or assembly about which information is required

3.8
specimen
representative piece of the product which is to be tested together with any substrate or treatment

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

3.9
sustained flaming
existence of flame on or over the surface of the specimen for periods of over 10 s

3.10
transitory flaming
existence of flame on or over the surface of the specimen for periods of between 1 s and 10 s

4 Symbols

Symbol	Designation	Unit
A_s	Initially exposed surface area of the specimen	m^2
M	Mass of the specimen	G
m_i	Mass of the specimen at the start of the test	g
m_f	Mass of the specimen at the end of the test	g
m_{10}	Mass of the specimen at 10 % of total mass loss	g
m_{90}	Mass of the specimen at 90 % of total mass loss	g
$\dot{m}$	Mass loss rate of the specimen	$g \cdot s^{-1}$
$\dot{m}_{max}$	Maximum value of the mass loss rate	$g \cdot s^{-1}$
$\dot{m}_{A,10\text{-}90}$	Average mass loss rate per unit area between 10 % and 90 % of mass loss	$g \cdot m^{2} \cdot s^{-1}$
$\dot{m}_{180}$	Average mass loss rate over the period starting at t_{ig} and ending 180 s later	$g \cdot s^{-1}$
$\dot{m}_{300}$	Average mass loss rate over the period starting at t_{ig} and ending 300 s later	$g \cdot s^{-1}$
T	Time	s
t_{ig}	Time to ignition (onset of sustained flaming)	s
Δt	Sampling time interval	s

5 Principle

The test method is used to assess the mass loss rate that the product undergoes under the test conditions. This rate is determined on small representative specimens burning in a well-ventilated environment.

6 Apparatus

6.1 General

The test apparatus shall consist essentially of the following components:

6.1.1 Cone-shaped radiant electrical heater.

6.1.2 Weighing device for measuring specimen mass.

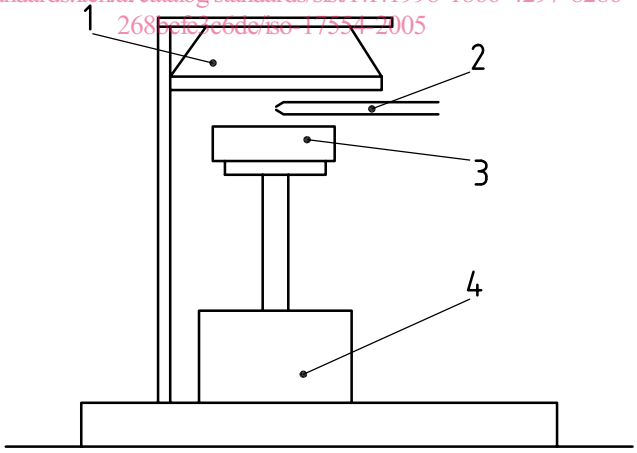
6.1.3 Specimen holder.

6.1.4 Spark ignition circuit.

6.1.5 Heat flux meters.

6.1.6 Data collection and analysis system.

A schematic representing the assembly is given in Figure 1. The apparatus should be located under a suitable exhaust system with a flow rate of less than 0,5 m^3/s. The individual components are described in detail in the following sections.



Key

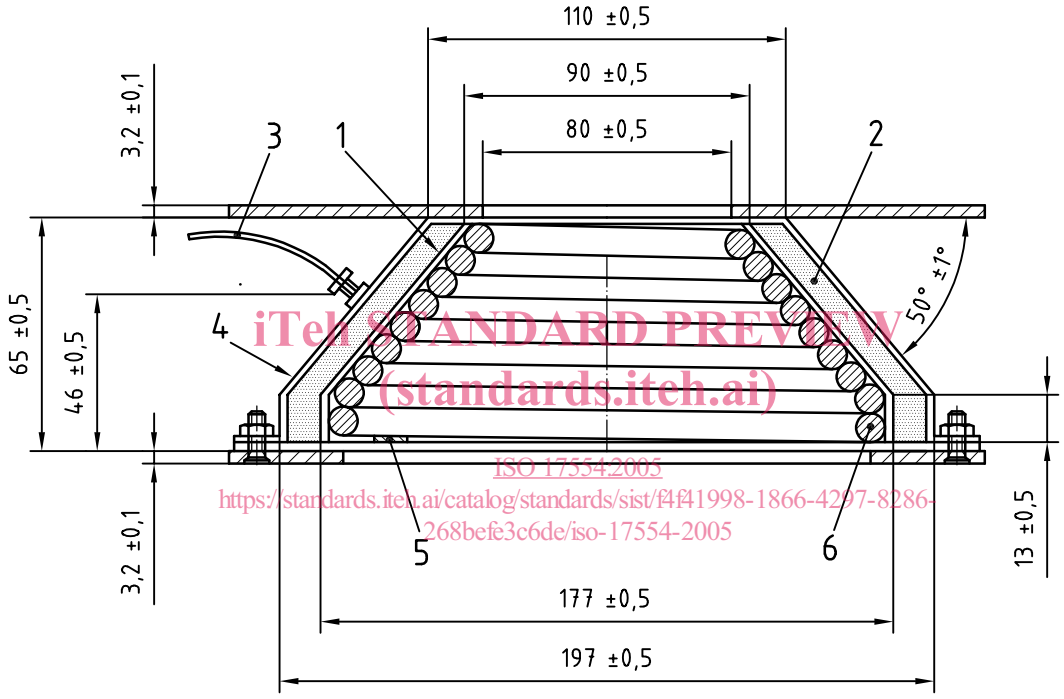
1 cone heater
2 spark igniter
3 specimen
4 load cell

Figure 1 — Schematic of apparatus

6.2 Cone-shaped radiant electrical heater

The active element of the heater shall consist of an electrical heater rod, capable of delivering 5 000 W at the operating voltage, tightly wound into the shape of a truncated cone (see Figure 2). The heater shall be encased on the outside with a double-wall stainless steel cone, filled with a refractory fibre blanket of nominal thickness 13 mm and nominal density 100 kg/m^3. The irradiance from the heater shall be maintained at a preset level by controlling the average temperature of three thermocouples, (type K, stainless-steel sheathed thermocouples, have proved suitable, but Inconel[1)] or other high performance materials are also acceptable) symmetrically disposed and in contact with, but not welded to, the heater element (see Figure 2). Either 3,0 mm outside-diameter sheathed thermocouples with an exposed hot junction or 1,0 mm to 1,6 mm outside-diameter sheathed thermocouples with an unexposed hot junction shall be used. The heater shall be capable of producing irradiances on the surface of the specimen of up to 100 kW/m^2. The irradiance shall be uniform within the central 50 mm × 50 mm area of the exposed specimen surface, to within ± 2 %.

Dimensions in millimetres



Key
1 inner shell
2 refractory fibre packing
3 thermocouple
4 outer shell
5 spacer block
6 heating element

Figure 2 — Conical heater assembly

6.3 Radiation shield

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

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

1) Inconel is an example of a suitable product available commercially. This information is given for the convenience of users of ISO 17554 and does not constitute an endorsement by ISO of this product.

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

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

6.4 Irradiance control

The irradiance control system shall be properly tuned so that it maintains the average temperature of the heater thermocouples during the calibration described in 10.1.1 at the preset level to within ± 10 °C.

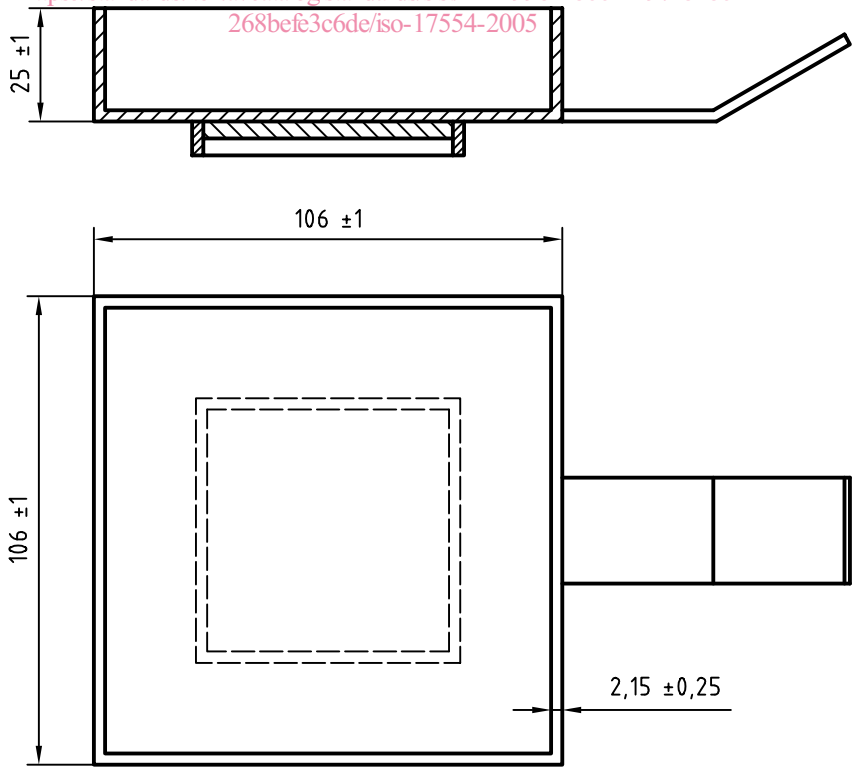
6.5 Weighing device

The weighing device shall have an accuracy of ± 0,1 g or better, measured according to the calibration procedure described in 10.2.1. The weighing device shall be capable of measuring the mass of specimens of at least 500 g. The weighing device shall have a 10 % to 90 % response time of 1 s to 4 s as determined according to the calibration described in 10.1.2. The output of the weighing device shall not drift by more than 1 g over a 30 min period, as determined with the calibration described in 10.1.3.

6.6 Specimen holder and retainer frame

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

Dimensions in millimetres

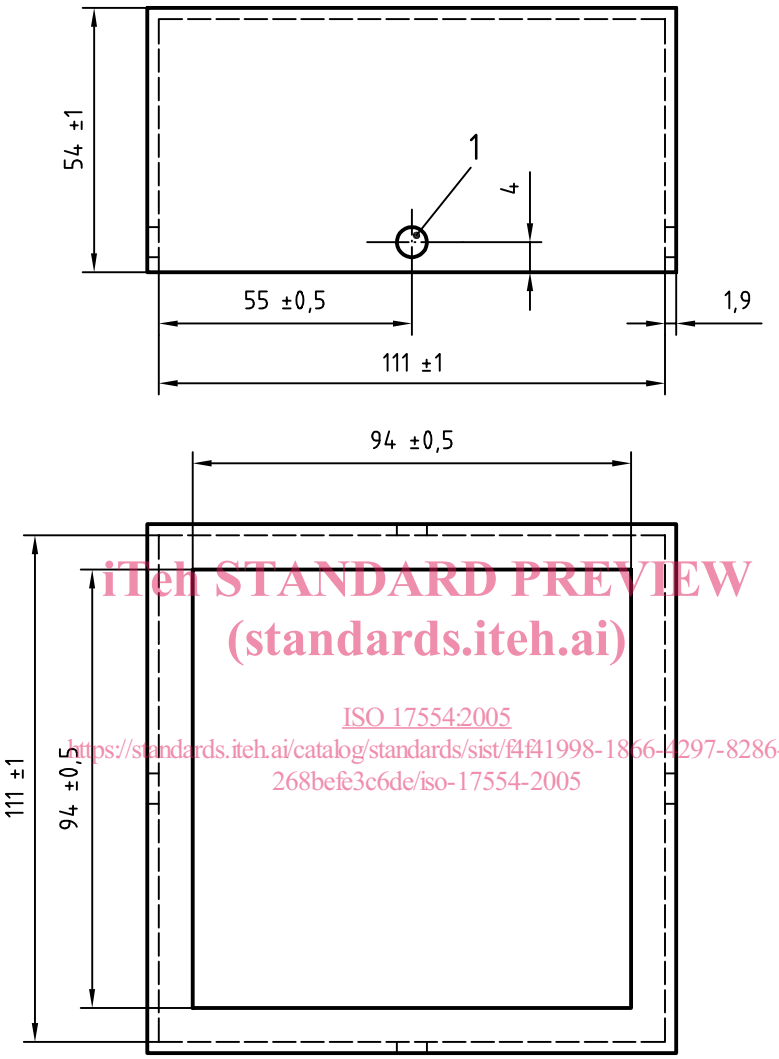


The thickness should be 2,4 ± 0,15.

Figure 3 — Specimen holder

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

Dimensions in millimetres



Key

1 10 × 32 tapped holes (X4)

Figure 4 — Specimen retainer frame

6.7 Ignition circuit

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

6.8 Ignition timer

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

6.9 Heat-flux meter

The working heat flux meter shall be used to calibrate the heater (see 10.2.2). It shall be positioned at a location equivalent to the centre of the specimen face during calibration.

This heat flux meter shall be of the Schmidt-Boelter (thermopile) type with a design range of (100 ± 10) kW/m^2. The target receiving the heat shall be flat, circular, of approximately 12,5 mm in diameter and coated with a durable matt black finish of surface emissivity, ε = 0,95 ± 0,05. The target shall be water-cooled. A cooling temperature, which could cause condensation of water on the target surface of the heat flux meter, shall not be used.

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

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

6.10 Data collection and analysis system

This system shall have facilities for recording the output from the weighing device. It shall have an accuracy corresponding to at least 0,01 % of the full-scale instrument output and at least 0,1 % for the measurement of time.

7 Suitability of a product for testing

7.1 Surface characteristics

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

a) an essentially flat exposed surface;

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

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

   2) for surfaces containing cracks, fissures or holes not exceeding 8 mm in width or 10 mm in depth, the total area of such cracks, fissures or holes at the surface does not exceed 30 % of a representative 100 mm^2 area of the exposed surface.

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

7.2 Asymmetrical products

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

7.3 Materials of short burning time

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