SLOVENSKI STANDARD

SIST ISO 5660-1

prva izdaja
avgust 1995

Požarni preskusi - Reakcija materialov na ogenj - 1. del: Hitrost sproščanja toplote gradbenih izdelkov (Metoda konusnega kalorimetra) (prevzet standard ISO 5660-1:1993 in ISO 5660-1:1993/Cor.1:1993 z metodo platnice)

Fire tests - Reaction to fire - Part 1: Rate of heat release from building products (Cone calorimeter method)

Essais au feu - Réaction au feu - Partie 1: Débit calorifique des produits du bâtiment (Méthode au calorimètre conique)

Deskriptorji: gradbeništvo, požarna zaščita, gradbeni izdelki, požarni preskusi, odziv na ogenj, hitrost sproščanja toplote, konusni kalorimeter

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Referenčna številka
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Nadaljevanje na straneh od II do III, i do iv, 1 do 31 in v popravku

UVOD

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PREDGOVOR

Mednarodni standard ISO 5660-1:1993 in tehnični popravek 1:1993 je pripravil tehnični odbor Mednarodne organizacije za standardizacijo ISO/TC 92 Požarni preskusi gradbenih materialov, elementov in konstrukcij, pododbor SC 1 Reakcija materialov na ogenj.

Odločitev za prevzem tega standarda in tehničnega popravka je sprejel tehnični odbor USM/TC POO Požarno preskušanje materialov in konstrukcij.

Ta slovenski standard je dne 1995 -..-.. odobril direktor USM.

ZVEZE S STANDARDI

S prevzemom tega mednarodnega standarda veljajo naslednje zveze:

SIST ISO 3261:1995 (sl)	Požarni preskusi - Slovar
SIST ISO 8421-1:1995 (sl)	Požarna zaščita - Slovar - 1. del: Splošni izrazi in pojavi pri požaru
SIST ISO 8421-2:1995 (sl)	Požarna zaščita - Slovar - 2. del: Požarna zaščita konstrukcij

OSNOVA ZA IZDAJO STANDARDA

Prevzem standarda ISO 5660-1:1993 in tehničnega popravka ISO 5660-1:1993/Cor.1:1993

OPOMBI

- Povsod, kjer se v besedilu standarda uporablja izraz mednarodni standard , pomeni to v SIST ISO 5660-1:1995 slovenski standard .
- Uvod in predgovor nista sestavni del standarda.

VSEBINA **Stran**

Tehnični popravek 1 - Ref. No. ISO 5660-1:1993/Cor.1:1993

Po mnenju Ministrstva za informiranje Republike Slovenije z dne 18. februarja 1992, štev. 23/96-92, spada ta publikacija med proizvode informativne narave iz 13. točke tarifne številke 3, za katere se plačuje 5-odstotni davek.

INTERNATIONAL STANDARD

ISO 5660-1

First edition
1993-06-01

Fire tests – Reaction to fire –

Part 1:
Rate of heat release from building products (Cone calorimeter method)

Essais au feu – Réaction au feu –

Partie 1: Débit calorifique des produits du bâtiment (Méthode au calorimètre conique)

Reference number
ISO 5660-1:1993 (E)

Contents

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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 5660-1 was prepared by Technical Committee ISO/TC 92, *Fire tests on building materials, components and structures*, Sub-Committee SC 1, *Reaction to fire*.

ISO 5660 consists of the following parts, under the general title *Fire tests – Reaction to fire*:

- *Part 1: Rate of heat release from building products (Cone calorimeter method)*
- *Part 2: Dynamic smoke measurement*
- *Part 3: Burning rate of building products*

Annexes A to G 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 and a spark. 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 heat release rates 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 heat release rate is defined in ISO/IEC 52 Guide as the calorific energy released per unit time by a material during combustion under specified test conditions. It is one of the fundamental properties of fire and should almost always be taken into account in any assessment of fire hazard since it significantly affects the development of fire in a building.

This test is based on part of the ASTM standard E 1354. However, not all the equipment in E 1354 is the subject of this International Standard. Some of the additional instrumentation, in particular that measuring the properties of smoke and its rate of production, is the subject of discussion in ISO/TC 92.

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

Fire tests – Reaction to fire –

Part 1:
Rate of heat release from building products (Cone calorimeter method)

1 Scope

This International Standard specifies a method for assessing the heat release rate of essentially flat products exposed to controlled levels of radiant heating with or without an external igniter. The rate of heat release is determined by measurement of the oxygen consumption derived from the oxygen concentration and the flow rate in the combustion product stream. The time to ignition (sustained flaming) is also measured in this test. Products with surface irregularities may be tested according to specific requirements.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 5660. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 5660 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 554:1976, *Standard atmospheres for conditioning and/or testing – Specifications.*

ISO/TR 3814:1989, *Tests for measuring "reaction-to-fire" of building materials – Their development and application.*

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

3 Definitions

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

3.1 assembly: Fabrication of materials or composites, for example sandwich panels.

NOTE 1 This may include an air gap.

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

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

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

3.5 ignition: Onset of sustained flaming as defined in 3.12.

3.6 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.

NOTE 2 Convective heating is negligible in the horizontal specimen orientation. In the vertical orientation, it is small, but not negligible. Despite this contribution from convective heating, the term "irradiance" is used instead of "heat flux" throughout this International Standard as it best indicates the essentially radiative mode of heat transfer.

3.7 material: Single substance or uniformly dispersed mixture, for example metal, stone, timber, concrete, mineral fibre, polymers.

3.8 orientation: Plane in which the exposed face of the specimen is located during testing, either vertical or horizontally face upwards

3.9 oxygen consumption principle: Proportional relationship between the mass of oxygen consumed during combustion and the heat released.

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

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

NOTE 3 This may include an air gap.

3.12 sustained flaming: Existence of flame on or over the surface of the specimen for periods of over 4 s.

3.13 transitory flaming: Existence of flame on or over the surface of the specimen for periods of between 1 and 4 s.

4 Symbols

A_s initially exposed surface area of the specimen, expressed in square metres (m²)

C calibration constant for oxygen consumption analysis, expressed in (m·kg·K)$^{1/2}$

Δh_c net heat of combustion, expressed in kilojoules per gram (kJ/g)

$\Delta h_{c,eff}$ effective net heat of combustion, expressed in kilojoules per gram (kJ/g)

m mass of the specimen, expressed in kilograms (kg)

m_f mass of the specimen at the end of the test, expressed in kilograms (kg)

m_i mass of the specimen at sustained flaming, expressed in kilograms (kg)

$\dot{m}$ mass loss rate of the specimen, expressed in kilograms per second (kg/s)

$\dot{m}_e$ mass flow rate in exhaust duct, expressed in kilograms per second (kg/s)

Δp orifice meter pressure differential, expressed in pascals (Pa)

$\dot{q}$ heat release rate, expressed in kilowatts (kW)

$\dot{q}''$ heat release rate per unit area, expressed in kilowatts per square metre (kW/m²)

$\dot{q}''_{max}$ maximum value of the heat release rate, expressed in kilowatts per square metre (kW/m²)

$\dot{q}''_{180}$ the average heat release rate over the period starting at t_{ig} and ending 180 s later, expressed in kilowatts per square metre (kW/m²)

$\dot{q}''_{300}$ the average heat release rate over the period starting at t_{ig} and ending 300 s later, expressed in kilowatts per square metre (kW/m²)

q''_{tot} the total heat released during the entire test, expressed in megajoules per square metre (MJ/m²)

r_O stoichiometric oxygen/fuel mass ratio

t time, expressed in seconds (s)

t_d delay time of the oxygen analyser, expressed in seconds (s)

t_{ig} time to ignition (sustained flaming), expressed in seconds (s)

Δt sampling time intervals, expressed in seconds (s)

T_e absolute temperature of gas at the orifice meter, expressed in kelvin (K)

x_{O_2} oxygen analyser reading, mole fraction of oxygen

$x^0_{O_2}$ initial value of oxygen analyser reading

$x^1_{O_2}$ oxygen analyser reading, before delay time correction

5 Principle

This test method is based on the observation that, generally, the net heat of combustion is proportional to the amount of oxygen required for combustion. The relationship is that approximately $13,1 \times 10^3$ kJ of heat are released per kilogram of oxygen consumed. Specimens in the test are burned in ambient air conditions, while being subjected to a predetermined external irradiance within the range 0 kW/m² to 100 kW/m² and measurements are made of oxygen concentrations and exhaust gas flow rates.

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. These properties are determined on small representative specimens.

6 Apparatus

6.1 General

The test apparatus shall be constructed as shown in figure 5; a cross-section through the heater is shown in figure 1 and an exploded view of horizontal and vertical orientations are given in figures 7 and 8. Untoleranced dimensions specified as critical shall have a tolerance of ± 1 mm.

All other dimensions are recommended values and should be followed closely.

6.2 Cone-shaped radiant electric heater, capable of horizontal or vertical orientation. The active element of the heater shall consist of an electrical heater rod, rated at 5 000 W at 240 V[1)], tightly wound into the shape of a truncated cone (see figure 1). The heater shall be encased on the outside with a double-wall stainless steel cone, packed with a refractory fibre material of approximately 100 kg/m³ density. The irradiance from the heater shall be capable of being held at a preset level by means of a temperature controller and three, type K, stainless steel sheathed thermocouples, symmetrically disposed and in contact with, but not welded to, the heater element (see figure 1). The thermocouples shall be of equal length and wired in parallel to the temperature controller. Either 3 mm outside diameter sheathed thermocouples with exposed hot junction or 1,0 mm to 1,6 mm outside diameter sheathed thermocouples with unexposed hot junction may be used. The heater shall be hinged so that it can be swung into either a horizontal or vertical orientation. The heater shall be capable of producing irradiances on the surface of the specimen of up to 100 kW/m². The irradiance should be uniform within the central 50 mm × 50 mm area of the specimen, to within ± 2 % in the horizontal orientation and to within ± 10 % in the vertical orientation.

6.3 Temperature controller, capable of holding the element temperature steady to within ± 2 °C. A suitable system is a "3-term" controller (proportional, integral and derivative) and a thyristor unit capable of switching currents up to 25 A at 240 V. The controller should have a temperature input range of 0 °C to 1 000 °C, a set scale capable of being read to 2 °C or better and automatic cold junction compensation.

The thyristor unit shall be of the "zero-crossing" and not of the "phase-angle" type.

NOTE 4 A desirable feature is a control which, in the event of an open circuit in the thermocouple line, will either cause the power to fall to near the bottom of its range, or cut the power off.

The heater temperature shall be monitored by a meter capable of being read to ± 2 °C or better; it may either be separated or incorporated into the temperature controller.

6.4 Load cell, for measuring specimen mass loss. The load cell shall have an accuracy of 0,1 g and it should preferably have a measuring range of 500 g and a mechanical tare adjustment range of 3,5 kg.

6.5 Specimen holders, different for the two orientations.

6.5.1 The horizontal specimen holder is shown in figure 2. The bottom of the holder shall be lined with a layer of low density (nominal density 65 kg/m³) 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 25 mm by using the sliding cone height adjustment (see figure 1).

6.5.2 The vertical specimen holder is shown in figure 3 and includes a small drip tray to contain a limited amount of molten material. A specimen is installed in the vertical specimen holder by backing it with a layer of refractory fibre blanket (nominal density 65 kg/m³), the thickness of which depends on specimen thickness, but shall be at least 13 mm. A layer of rigid, ceramic fibre millboard shall be placed behind the fibre blanket layer. The millboard thickness shall be such that the entire assembly is rigidly bound together once the retaining spring clip is inserted behind the millboard. In the vertical orientation, the cone heater height is set so the centre lines up with the specimen centre.

6.6 Exhaust gas system, with flow measuring instrumentation.

6.6.1 The exhaust gas system shall consist of a high temperature centrifugal exhaust fan, a hood, intake and exhaust ducts for the fan and an orifice plate flow meter (see figure 4). The exhaust system shall be capable of developing flows from 0,012 m³/s to 0,035 m³/s.

6.6.2 A restrictive orifice with an internal diameter of 57 mm shall be located between the hood and the duct to promote mixing.

6.6.3 A ring sampler shall be located in the fan intake duct for gas sampling, 685 mm from the hood (see figure 5). The ring sampler shall contain 12 small holes to average the stream composition with the holes facing away from the flow to avoid soot clogging.

6.6.4 The temperature of the gas stream shall be measured using a 1,0 mm to 1,6 mm outside diameter sheathed-junction thermocouple or a 3 mm outside diameter exposed junction thermocouple positioned in the exhaust stack on the centre-line and 100 mm upstream from the measuring orifice plate.

1) This requires a 30 A supply.

6.6.5 The flow rate shall be determined by measuring the differential pressure across a sharp edge orifice (internal diameter 57 mm) in the exhaust stack, at least 350 mm downstream from the fan, if the latter is located as shown on figure 4.

6.6.6 The geometry of the exhaust system is not so critical. Where necessary, small deviations from the recommended dimensions given in figure 4 are allowed, for example, the inner diameter of the duct and the orifice plates can be slightly different. Also the fan does not need to be at the exact location as indicated on figure 4, but may be located further downstream allowing for a more common type of fan to be used. In this case, undisturbed inflow distance to the gas sampling probe and the measuring orifice shall be sufficient for the flow to be uniformly mixed.

6.7 Gas sampling apparatus

Gas sampling apparatus is shown in figure 6 and incorporates a pump, a filter to prevent entry of soot, a cold trap to remove most of the moisture, a by-pass system set to divert all flow except that required for the oxygen analyser, a further moisture trap and, if CO_2 is not measured, a trap for CO_2 removal.

NOTE 5 If an (optional) CO_2 analyser is used, the equations to calculate the rate of heat release can be different from those for the standard case (see clause 12 and annex F).

6.8 Ignition circuit

External ignition is accomplished by a spark plug powered from a 10 kV transformer. The spark plug shall have a gap of 3 mm. The transformer shall be of a type specifically designed for spark ignition use. The transformer shall have an isolated (unearthed) secondary to minimize interference with the data transmission lines. The electrode length and location of the spark plug shall be such that the spark gap is located 13 mm above the centre of the specimen in the horizontal orientation. In the vertical orientation, the spark plug shall be positioned so that the gap is located in the specimen face plane and 5 mm above the top of the holder.

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

6.10 Oxygen analyser, paramagnetic type, with a range of 0 % oxygen to 25 % oxygen. The analyser shall exhibit a linear response and drift of not more than ± 50 parts per million of oxygen (root-mean-square value) over a period of 30 min. Since oxygen analysers are sensitive to stream pressures, the stream pressure shall be regulated (upstream of the analyser) to allow for flow fluctuations and the readings from the analyser compensated with an absolute pressure regulator to allow for atmospheric pressure variations. The analyser and the absolute pressure regulator shall be located in a constant temperature environment. The oxygen analyser shall have a 10 % to 90 % of full-scale response time of less than 12 s.

6.11 Heat flux meter, of the Gardon (foil) or Schmidt-Boelter (thermopile) type with a design range of about 100 kW/m². The target receiving radiation, and possibly to a small extent convection, shall be flat, circular, of approximately 12,5 mm in diameter and coated with a durable matt black finish. The target shall be water-cooled.

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

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

This meter shall be used to calibrate the heater (figures 7 and 8). It shall be positioned at a location equivalent to the centre of the specimen face in either orientation during this calibration.

6.12 Calibration burner, constructed from a square-section brass tube with a square orifice covered with wire gauze through which the methane diffuses (figure 9). The tube is packed with ceramic fibre to improve uniformity of flow. The calibration burner is suitably connected to a metered supply of methane of at least 99,5 % purity.

6.13 Data collection and analysis system, having facilities for recording the output from the O_2 analyser, the orifice meter, the thermocouples and the load cell. The data collection system should have an accuracy corresponding to at least 50 parts per million of oxygen for the oxygen channel, 0,5 °C for the temperature measuring channels, and 0,01 % of full-scale instrument output for all other instrument channels. The system should be capable of recording data every 5 s for at least 1 h.

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 nor 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 square area of the exposed surface.

NOTE 6 When an exposed surface does not meet the requirements of either 7.1 a) or 7.1 b), the product may be tested in a modified form complying as nearly as possible with the requirements given in 7.1. The test report should state that the product has been tested in a modified form and clearly describe the modification.

7.2 Asymmetrical products

A product submitted for this test can have faces which differ or can 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, then both faces shall be tested.

7.3 Thin materials

This test method can prove unsuitable for excessively thin materials since insufficient data will be collected for the calculation of heat release rates. For some materials, reducing the data collection interval from 5 s to some shorter value can solve this problem.

7.4 Composite specimens

Composite specimens may be tested, provided they are prepared as specified in 8.3.

7.5 Dimensionally unstable materials

This test method can prove unsuitable for materials that change their dimensions substantially when exposed to the cone radiation, for example materials that intumesce or shrink away from the cone radiator, because the irradiance on the surface of the specimen at the time of ignition can differ significantly from that set initially. The precision of the method can be worse than that indicated in annex B for materials that behave in this way.

8 Specimen construction and preparation

8.1 Specimens

8.1.1 Unless otherwise specified, three specimens shall be tested at each level of irradiance selected and for each different exposed surface.

8.1.2 The specimens shall be representative of the product and shall be square with sides measuring $(100_{-5}^{\ 0})$ mm.

8.1.3 Products with normal thickness of 50 mm or less shall be tested using their full thickness.

8.1.4 For products with normal thickness of greater than 50 mm, the requisite specimens shall be obtained by cutting away the unexposed face to reduce the thickness to $(50_{-3}^{\ 0})$ mm.

8.1.5 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.

8.1.6 Assemblies shall be tested as specified in 8.1.3 or 8.1.4 as appropriate. However, where thin materials or composites are used in the fabrication of an assembly, the presence of air or an air gap or the nature of any underlying construction can significantly affect the ignition and burning characteristics of the exposed surface.

NOTE 7 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.

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, for example, bonded with the appropriate adhesive or mechanically fixed.

8.1.7 Products that are thinner than 6 mm shall be tested with a substrate representative of end-use conditions, such that the total specimen thickness is 6 mm or more. In the case of specimens of less than 6 mm in thickness and which would be used with an air space adjacent to the unexposed face, the specimens shall be mounted so that there is an air space of at least 12 mm between its unexposed face and the refractory fibre blanket.

NOTE 8 This can be achieved by the use of a metal spacer frame.

8.2 Conditioning of specimens

Before the test, specimens shall be conditioned to constant mass at a temperature of (23 ± 2) °C, and a relative humidity of (50 ± 5) % in accordance with ISO 554.

NOTE 9 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.

8.3 Preparation

A conditioned specimen shall be wrapped in a single layer of aluminium foil, of 0,03 mm to 0,05 mm thickness, with the shiny side towards the specimen, covering the unexposed surfaces.

Composite specimens shall be exposed in a manner typical of the end-use condition [for example, if used with an air gap (see 8.1.6), an air gap shall be included behind the specimen and within the aluminium foil]. They shall be