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Fourth edition
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Cellular plastics — Determination of horizontal burning characteristics of small specimens subjected to a small flame

Plastiques alvéolaires — Détermination des caractéristiques de combustion de petites éprouvettes en position horizontale, soumises à une petite flamme

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

This fourth edition cancels and replaces the third edition (ISO 9772:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— better definitions of positions of specimen on wire mesh and of burner have been provided;

— requirements for materials that show different damaged lengths on top and bottom faces of the specimen have been specified;

— dimensions of cotton indicator have been reduced;

— reference to ASTM E2016 has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Cellular plastics are widely used in products for packaging, building, housing, industry and transport, in various applications. The burning behaviour of cellular plastics is a concern for the fire safety of these products. This document gives a method for the determination of the burning behaviour of cellular plastics using a small flame source.

The burning behaviour of cellular plastics is influenced by the test specimen orientation (vertical or horizontal). This method of test evaluates specimens which are oriented horizontally.

The method described is also intended as a pre-selection test for materials used for components of devices and appliances. The final acceptance of the material is dependent upon its use in complete equipment that conforms with the standards applicable to such equipment.

It should be noted that the test results obtained by the test specified in this document alone cannot represent all the aspects of the fire hazard of cellular plastics in end-use conditions.

Cellular plastics — Determination of horizontal burning characteristics of small specimens subjected to a small flame

1 Scope

1.1 This document specifies a small-scale laboratory screening procedure for comparing the relative burning characteristics of horizontally oriented, small cellular plastic specimens having a density less than 250 $kg \cdot m^{-3}$ determined in accordance with ISO 845, when exposed to a small-flame ignition source.

NOTE Another International Standard which covers flexible cellular plastic and cellular rubber is ISO 3582[2].

1.2 This method of test is intended for quality assurance and limited product evaluation of cellular plastic materials under controlled laboratory conditions, and is not intended to assess the fire behaviour of, for example, building materials or furnishings under actual fire conditions.

1.3 The optional classification system described in Annex A is intended for the pre-selection of cellular plastic materials for products, including the determination of the ranges of material parameters that give the same classification (see 6.1).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 845, *Cellular plastics and rubbers — Determination of apparent density*

ISO 1923, *Cellular plastics and rubbers — Determination of linear dimensions*

ISO 10093:2020, *Plastics — Fire tests — Standard ignition sources*

ISO 13943, *Fire safety — Vocabulary*

ASTM E2016, *Standard Specification for Industrial Woven Wire Cloth*

IEC 60695-11-3, *Fire hazard testing — Part 11-3: Test flames — 500 W flames — Apparatus and confirmational test methods*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
afterflame
flame that persists after the ignition source has been removed

[SOURCE: ISO 13943:2017, 3.11]

3.2
afterflame time
length of time for which an *afterflame* (3.1) persists under specified conditions

[SOURCE: ISO 13943:2017, 3.12]

3.3
afterglow
persistence of glowing combustion after both removal of the ignition source and the cessation of any flaming combustion

[SOURCE: ISO 13943:2017, 3.13]

3.4
afterglow time
length of time for which an *afterglow* (3.3) persists under specified conditions

[SOURCE: ISO 13943:2017, 3.14]

3.5
extended application of test results
process of predicting a test result, on the basis of one or more existing test results obtained by the same test, for a product for which a property and/or the intended end-use application(s) are subject to variation

3.6
draught-free environment
space in which the results of experiments are not significantly affected by the local air speed

4 Significance of test

4.1 Tests conducted on a material under the conditions specified can be of considerable value when comparing the horizontal burning characteristics of different materials, controlling manufacturing processes or assessing any changes in formulation or treatment prior to use.

4.2 Assessment of fire hazard requires consideration of factors such as fuel contribution, intensity of burning (rate of heat release) and products of combustion, as well as environmental factors such as intensity of source, orientation of exposed material and ventilation conditions.

4.3 The horizontal burning characteristics, as measured by this test procedure, might be affected by factors such as density, any anisotropy of the cellular material, its melting characteristics, its colour and its thickness.

4.4 Certain materials might shrink from the applied flame without igniting. In this event, the test results are not valid, and additional test specimens are required to obtain 10 valid test results. If this proves impossible due to non-ignition of all the specimens, then this test is not suitable for these materials.

4.5 The horizontal burning characteristics of some cellular plastic materials might change with time, and tests are therefore conducted before and after heat ageing.

5 Apparatus

5.1 A **laboratory fume hood**, having an inside volume of at least 0,5 m^3 is used. The chamber shall permit observation of tests in progress and shall provide a draught-free environment whilst allowing normal thermal circulation of air past the test specimen during burning. The inside surfaces of the chamber shall be of a dark colour. When a light meter, facing towards the rear of the chamber, is positioned in place of the test specimen, the recorded light level shall be less than 20 lux.

For safety and convenience, this enclosure (which can be completely closed) shall be fitted with an extraction device, such as an exhaust fan, to remove products of combustion that might be toxic. The extraction device shall be turned off during the test and turned on again immediately after the test to remove the fire effluents. A positive closing damper might be needed.

NOTE The amount of oxygen available to support combustion is naturally important for the conduct of these flame tests. For tests conducted by this method when burning times are protracted, chamber sizes greater than 0,5 m^3 might be needed to provide reproducible results.

5.2 **P/PF2 laboratory burner**, as specified in ISO 10093. The burner shall be the diffusion flame burner specified in ISO 10093:2020, 11.3, having a barrel length of (100 ± 10) mm and an internal diameter of (9,5 ± 0,3) mm. The barrel shall not be equipped with an end attachment, such as a stabilizer.

5.3 The burner shall be fitted with a **burner wing top**, having an opening of internal length (48 ± 1) mm and internal width (1,3 ± 0,05) mm (see Figure 1).

To ensure the wing top opening is uniform in width, one option is to slide a (1,3 ± 0,05) mm steel wire or spacer along its length.

5.4 The **support gauze** shall be a wire cloth of plain weave, approximately 215 mm long by 75 mm wide, as shown in Figure 2. It shall consist of (6,4 ± 0,5) mm mesh gauze constructed of (0,9 ± 0,1) mm diameter stainless steel, plain or low carbon steel wire. The cloth-mesh and wire diameter shall be determined as described in the Standard Specification for Industrial Woven Wire Cloth, ASTM E2016.

5.5 The **gauge-support holder** shall consist of two laboratory ring stands with clamps adjustable to the desired angles and heights. The gauze-support holder shall be constructed from aluminium or steel and shall satisfy the following conditions:

— the long axis of the gauze shall be maintained to within 1° of the horizontal;

— the nearest end of the specimen shall be (13 ± 1) mm above the burner wing top (see Figure 2);

— the space both above and below the specimen shall not be obstructed;

— a means shall be provided for positioning the burner in the correct location relative to the specimen, preferably with a sliding mechanism and a stop to allow fast movement of the burner flame towards and away from the specimen;

— the gauze shall be equidistant from the front and back, and from both sides, of the test chamber, and shall be (175 ± 25) mm above the cotton indicator base-board (see Figure 2).

5.6 There shall be two timing devices, each of which reads to within 1 s or less.

5.7 A **measuring scale** graduated in millimetres, shall be used to measure the length, width and thickness of the test specimen.

5.8 The **gas supply** shall consist of technical-grade methane gas with a purity of at least 98 % and having a heat content of (37 ± 1) $MJ \cdot m^{-3}$, with regulator and meter to ensure uniform gas flow.

Other gas mixtures having a heat content of approximately (37 ± 1) $MJ \cdot m^{-3}$ or propane having a heat content of (94 ± 2) $MJ \cdot m^{-3}$ have been shown to provide similar results when using the procedure of Clause 8. In cases of dispute, however, technical-grade methane shall be used.

5.9 A **manometer and gas flow meter**, calibrated for the gas used and capable of reading the values shown in Table 1 shall be used.

5.10 A **cotton indicator**, consisting of a pad of dry, absorbent 100 % cotton measuring approximately 75 mm long, 75 mm wide and 6 mm thick and having a mass of approximately 0,18 g, shall be used.

5.11 A **desiccator**, containing anhydrous calcium chloride or another drying agent which can be maintained at (23 ± 2) °C and gives a relative humidity not exceeding 20 % shall be used.

5.12 A **conditioning room or chamber**, capable of being maintained at (23 ± 2) °C and a relative humidity of (50 ± 10) % shall be used.

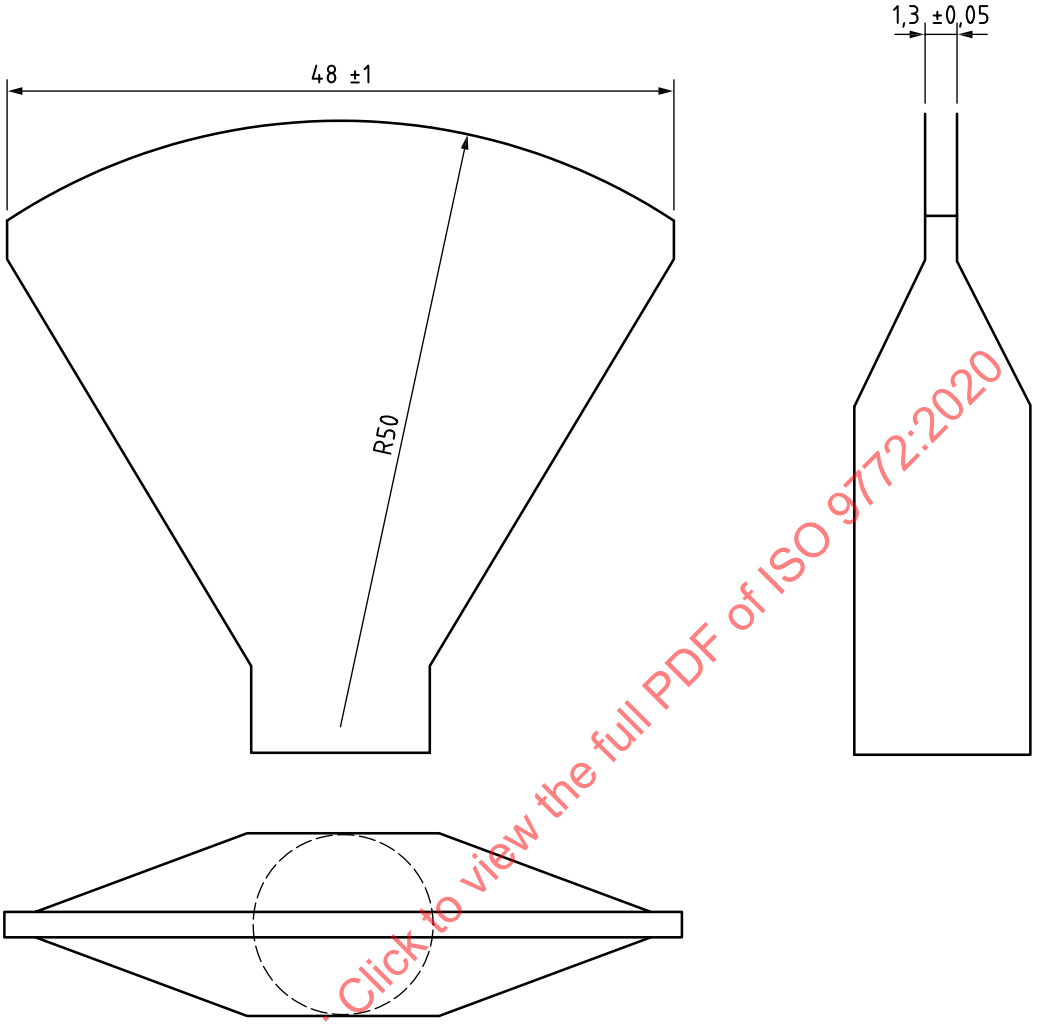
5.13 An **air-circulating oven**, giving a minimum of five air-changes per hour, and capable of being maintained at (70 ± 2) °C or another agreed temperature shall be used.

5.14 A **dial-gauge micrometer**, for measuring the specimen thickness, with a 650 mm^2 pressure foot exerting a pressure of (0,175 ± 0,035) kPa shall be used.

5.15 A **cotton indicator base-board**, measuring approximately 215 mm long and 75 mm wide and having a height such that the distance between the support gauze and the top of the base-board is (175 ± 25) mm shall be used.

The cotton indicator base-board shall be made of non-combustible board having a dry density of (850 ± 200) $kg \cdot m^{-3}$. It shall not be made of metal.

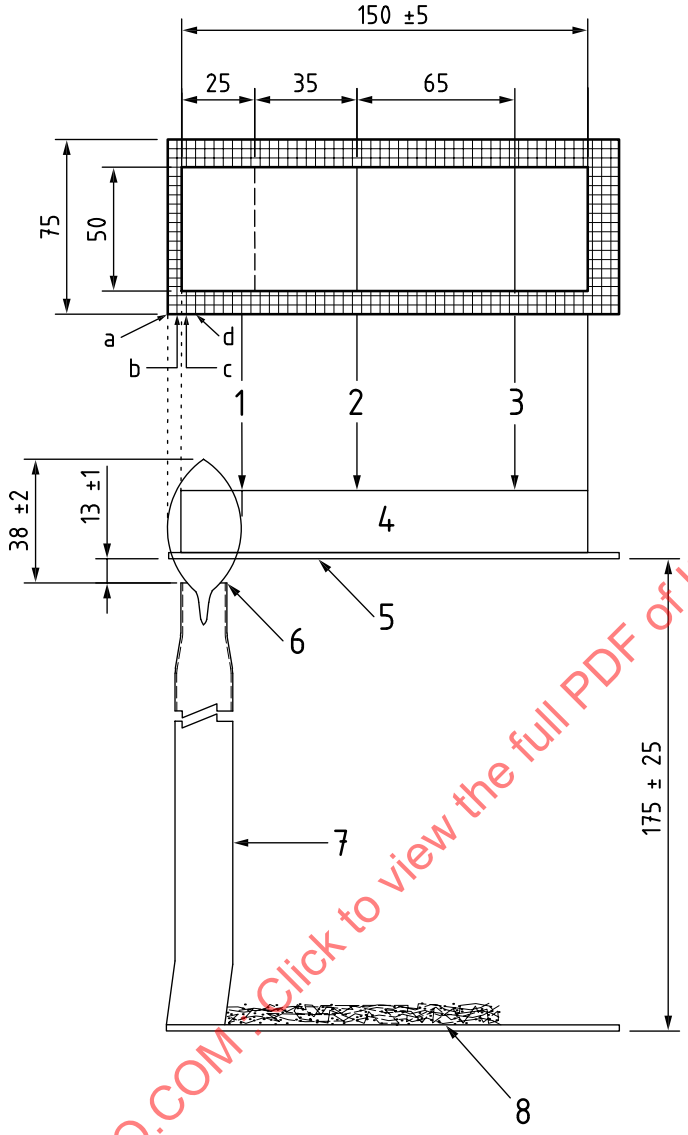
Dimensions in millimetres



NOTE Material: copper or stainless steel.

Figure 1 — Burner wing top

Dimensions in millimetres



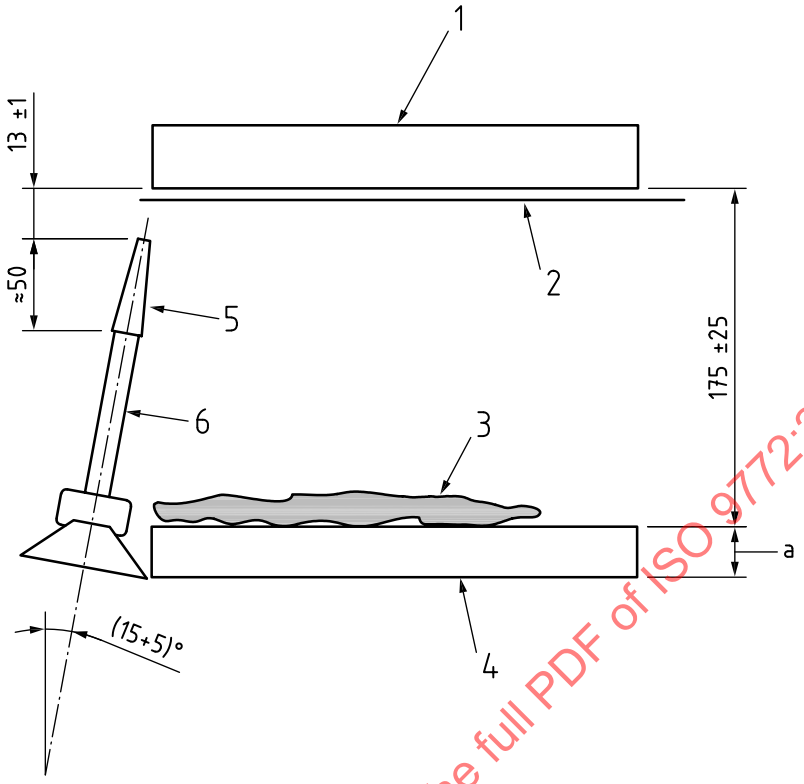
Key

1	25 mm mark	5	wire hardware cloth
2	60 mm mark	6	burner wing tip
3	125 mm mark	7	barrel
4	foam specimen	8	cotton indicator (approximately 7 mm 5 x 75 mm x 6 mm, 0,18 g)

a, b, c, d Represent the 1st, 2nd, 3rd and 4th vertical wires, respectively.

Figure 2 — Test specimen and support gauze

Dimensions in millimetres



Key

1 test specimen
2 support gauze
3 cotton indicator
4 cotton indicator base-board
5 burner wing top
6 burner
a Height of cotton indicator base-board.

Figure 3 — Position of cotton indicator below support gauze

6 Specimens

6.1 Extended application of test results

6.1.1 It is possible that the results of tests carried out on test specimens taken from materials of the same polymer composition but of different densities, colours and thicknesses will be different. For materials of the same polymer composition with properties which vary over a range, the test specimens shall be representative of the whole range.

6.1.2 Test specimens with densities at the extremes of the range shall be tested and, if the test results yield the same flame test classification, all specimens within the range shall be considered representative of the range. If the burning characteristics are not essentially the same, the results of the evaluation shall be considered to apply only to materials with the densities tested. Additional test specimens with intermediate densities shall be tested to determine the range of applicability.

6.1.3 Burning behaviour is likely to be affected by the level and nature of pigment content in the test specimen, and for each individual type of pigment, the flammability is likely to range between that

corresponding to the highest level and that corresponding to no pigment being present. Testing as follows is required in order to cover the range of burning behaviour. The test specimens shall be those that:

a) contain no colouring (natural);

b) contain the highest level of organic pigments;

c) contain the highest level of inorganic pigments;

d) contain the highest level of carbon black (if carbon black is one of the additives in a pigment package)

e) contain pigments which are known to adversely affect the flammability characteristics.

6.2 Preparation of specimens

6.2.1 All specimens shall be cut from a representative sample of the material (sheets or end products). After any cutting operation, care shall be taken to remove all dust and any particles from the surface. Cut edges shall have a smooth finish.

6.2.1.1 The density of the specimens shall be determined in accordance with ISO 845.

6.2.2 The standard test specimen shall be (150 ± 10) mm long by (50 ± 1) mm wide. Materials supplied in thicknesses over 13 mm shall be cut to (13 ± 1) mm thickness with any skin on one side. Materials supplied in thicknesses of 13 mm or less shall be tested at the thickness supplied, without removing any skin (see 6.2.5). When testing materials with adhesive applied, specimens having adhesive on one side only shall be used (see 6.2.5).

NOTE Tests made on test specimens taken from the same material but of different thicknesses or directions of anisotropy are not comparable.

6.2.3 Prepare a minimum of 20 specimens for the test. This includes 10 additional specimens in the event that the situation described in 4.4, 4.5 or A.3 is encountered.

6.2.4 Mark each specimen across its width with lines at 25 mm, 60 mm and 125 mm from one end, referred to hereafter as gauge marks (see Figure 2).

6.2.5 Test specimens with a high-density exterior (skin) on one side shall be tested with this side facing down. Test specimens with adhesive on one side shall be tested with this side facing up.

7 Conditioning

7.1 Specimens

7.1.1 The specimens shall not be conditioned until at least 24 h after their fabrication.

7.1.2 Condition two sets of five specimens for at least 48 h at (23 ± 2) °C and (50 ± 5) % relative humidity. One set is for possible retests as described in 4.4, 4.5 or A.3.

7.1.3 Condition two sets of five specimens for (168 ± 2) h at (70 ± 2) °C and then place them in a desiccator (5.11) for at least 4 h to cool to room temperature. One set is for possible retests as described in 4.4, 4.5 or A.3.

Other heat-ageing times and temperatures are acceptable for use if agreeable to all parties.

7.1.4 All test specimens shall be tested in laboratory atmospheres of 15 °C to 35 °C and 45 % to 75 % relative humidity.

7.2 Cotton indicator

Condition an adequate supply of cotton indicator (5.10) in a desiccator (5.11) for at least 48 h prior to use.

8 Test procedure

8.1 Adjustment of the flame

8.1.1 Ensure that the fume hood fan is off.

8.1.2 Prior to each test, the support gauge shall be cleaned, and any residue of previous tests shall be removed.

8.1.3 Adjust the gas flow rate and line pressure to the values shown in Table 1 for the gas supply (5.8), using the arrangement shown in Figure 4. In a position remote from the specimen support, adjust the burner (5.2) with its wing top (5.3) attached to provide a blue flame (38 ± 2) mm high when measured in subdued light. The flame is obtained by adjusting the gas flow rate and the air port of the burner until a (38 ± 2) mm high yellow-tipped blue flame is produced and then increasing the air supply until the yellow tip just disappears. Measure the height of the flame again and, if necessary, readjust.

When using propane, adjust the gas flow rate and line pressure to the values shown in Table 1. The flame will have a yellow tip.

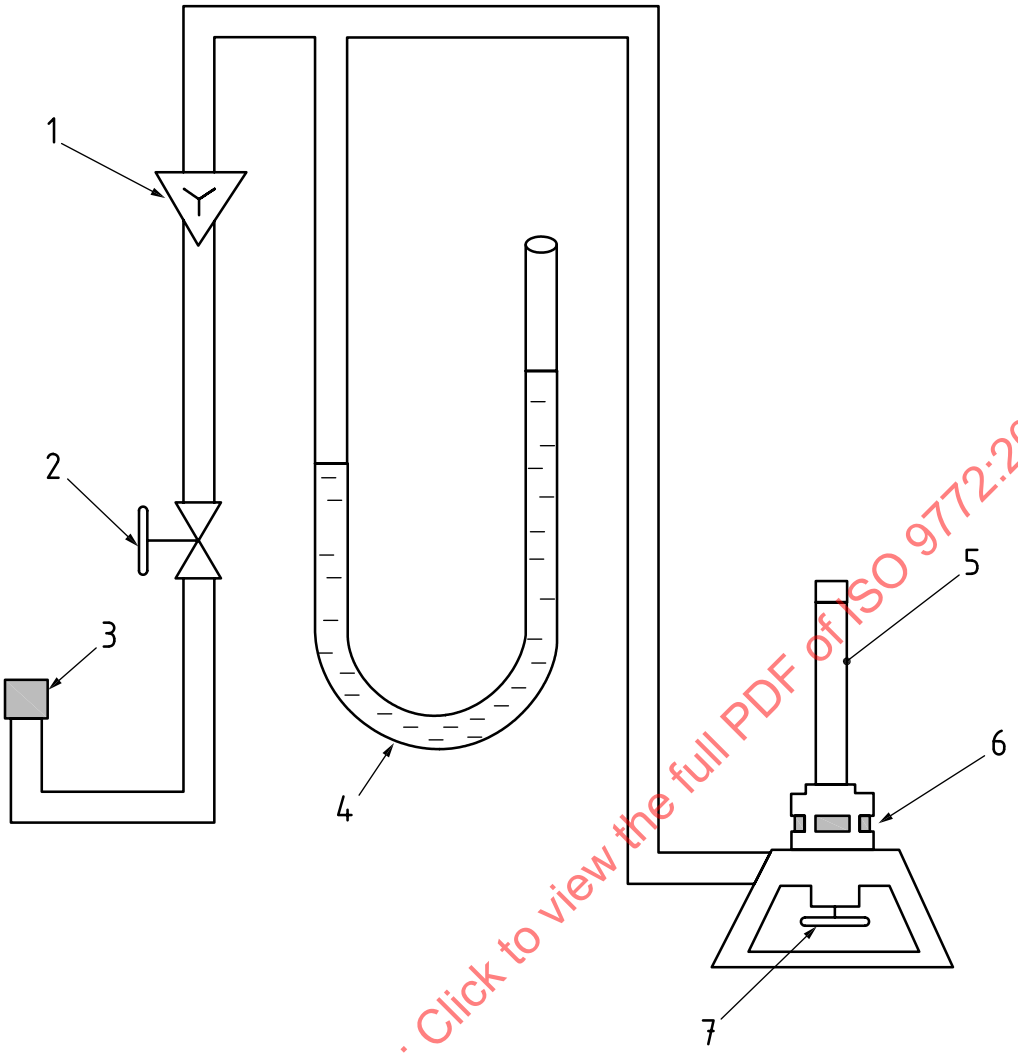
NOTE A flame that is not uniform and has higher ends can be caused by a wing top opening that is not spaced properly. To ensure the wing top opening is uniform in width, one option is to slide a (1,3 ± 0,05) mm steel wire or spacer along its length..

Table 1 — Gas sources

Gas	Approximate heat content	Flow rate	Line back-pressure[a]
	MJ/m^3	ml/min	mm H_2O column
Methane[b]	37 ± 1	965 ± 30	50 ± 10
Propane	94 ± 2	380 ± 15	25 ± 5

[a] The needle valve of the burner shall be adjusted to provide the line back-pressure indicated.

[b] Natural gas having a heat content of (37 ± 1) MJ/m^3 has been found to produce similar results.



Key

1 flow meter
2 control valve
3 fuel-gas source
4 manometer
5 burner
6 adjustable air inlet
7 needle valve adjustment

Figure 4 — Burner supply arrangement

8.2 Adjustment of specimen support

Place a clean specimen support gauze in the holder in such a way that the lower surface of the test specimen will be (13 ± 1) mm above the tip of the burner wing top as shown in Figure 2. The relative positions of burner and holder shall be such that, when the test specimen is in position, one edge of the flame will extend in to the test specimen as shown in Figure 2. The centre of the wing top shall be directly under the longitudinal axis of the test specimen.

8.3 Positioning of cotton indicator

Remove sufficient cotton indicator (5.10) from the desiccator (5.11) and thin to an area approximately 75 mm × 75 mm and maximum uncompressed thickness of 6 mm. Position the cotton under the support gauze as shown in Figure 2 and Figure 3.

8.4 Positioning of specimen

Place a test specimen on the support gauze in such a manner that:

— the surface on which the gauge marks have been made is uppermost;

— the end nearest to the 60 mm gauge mark is between the 2nd and 3rd vertical wire from the left of the rectangular wire cloth (see b and c in Figure 2) when the set-up is viewed from the top (refer to the top-view of the set-up in Figure 2);

— its longitudinal axis is parallel to, and vertically above, that of the support gauze.

NOTE Stoppers are useful as references to fix the position of the specimen on the wire mesh.

8.5 Burning procedure

8.5.1 Place the burner quickly in position under the test specimen so that the inner edge of the burner wing-tip is in line with the outer edge of the test specimen as shown in Figure 2 and simultaneously start the first timing device (see 5.6). The burner shall be inclined at (15 ± 5)° to the vertical in order to avoid debris falling from the test specimen dropping on to the burner.

8.5.2 Immediately close the front panel of the fume hood, if not already closed, so that there is only a small air gap, for example height (50 ± 10) mm, along the base of the panel.

8.5.3 After 60 s, remove the burner a distance of 100 mm or greater from the specimen.

8.5.4 Start the second timing device when the test specimen flame reaches the 25 mm gauge mark, whether the burning is on the bottom, top or edge of the specimen.

8.5.5 Stop the first timing device when the flame or glowing combustion front reaches the 60 mm gauge mark, or when the specimen ceases to burn or glow before reaching the 60 mm gauge mark.

8.5.6 Stop the second timing device when the flame or glowing combustion front reaches the 125 mm gauge mark, or when the specimen ceases to burn before reaching the 125 mm gauge mark.

8.5.7 Observe whether the cotton indicator was ignited by flaming drips.

8.5.8 Ignore drips falling into the burner unless a visible change occurs in the flame. In this case, abandon the test on this specimen and, after cleaning the burner and wing top, substitute a new test specimen.

8.5.9 Switch on the fume-hood fan and, after exhausting all fumes, remove the test specimen and the support gauze.

8.6 Measurements

8.6.1 The distance burnt (L_d) is the distance between the 25 mm gauge mark and the point where the flame or glowing combustion front stopped, expressed in millimetres. If the flame front went out before the 25 mm mark, record that $L_d = 0$.

8.6.2 The burning time (t_b) is the time measured by the second timing device, in seconds, from when the flame or glowing combustion front passed the 25 mm gauge mark, until the flame front stopped or passed the 125 mm gauge mark.

8.6.3 The elapsed time (t_e) is the time measured by the first timing device if the flame or glowing combustion front did not pass the 60 mm gauge mark, recorded as the time, in seconds, that the specimen continued to flame or to glow after the 60 s flame application. This is a combination of the afterflame time and afterglow time.

8.6.4 When using the classification system indicated in Annex A, the afterflame time and afterglow time shall be recorded individually by using the first timing device.

8.7 Preparation for the next test

8.7.1 If reusing the support gauze, burn and clean off any residues remaining and allow it to cool to room temperature before reuse.

8.7.2 Examine the burner and wing top for cleanliness and clean if necessary.

8.7.3 Check the support gauge (see 8.1.2) and the flame (see 8.1.3) at least once every five tests.

8.7.4 Switch off the fume-hood exhaust fan and repeat the procedure in 8.2 to 8.5 for the next test specimen.

9 Calculations

9.1 If the flame or glowing combustion front passed the 125 mm gauge mark, calculate the burning rate v, from Formula (1):

$$v/\mathrm{mm{\cdot}min^{-1}} = 6\ 000/(t_b/\mathrm{s}) \quad (1)$$

where t_b is the burning time.

9.2 If the flame or glowing combustion front did not pass the 125 mm gauge mark but did pass the 60 mm gauge mark, calculate the burning rate v, from Formula (2):

$$v/\mathrm{mm{\cdot}min^{-1}} = \left[60 \times (L_d/\mathrm{mm})\right]/(t_b/\mathrm{s}) \quad (2)$$

where

L_d is the distance burnt;

t_b is the burning time.

9.3 Calculate and record the average value of v from tests on five test specimens, for each conditioning treatment.

10 Precision

11 Test report

The test report shall include the following particulars:

a) a reference to this document, i.e. ISO 9772:2020;

b) a complete identification of the material tested, including the manufacturer's name, number or code;

c) the nominal apparent density;

d) the thickness, determined by ISO 1923, to the nearest millimetre, of the test specimen;

e) the presence or absence of skins;

f) the presence or absence of adhesive;

g) the direction of any anisotropy relative to the test specimen dimensions;

h) the conditioning treatment used (see 7.1.2 and 7.1.3);

i) details of any treatment prior to testing, other than cutting, trimming and conditioning;

j) the individual test values, including:

- distance burnt (L_d),
- burning time (t_b),
- elapsed time (t_e),
- afterflame time (for Annex A only),
- afterglow time (for Annex A only),
- burning rate (v) (also for the HBF classification in Annex A),
- whether the cotton indicator was ignited,
- the gas used, if different from methane,
- details of any abnormal burning behaviour;