INTERNATIONAL STANDARD

ISO 4589-2

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Plastics — Determination of burning behaviour by oxygen index —

Part 2: Ambient-temperature test

Plastiques — Détermination du comportement au feu au moyen de l'indice d'oxygène —

Partie 2: Essai à la température ambiante

Reference number
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Annexes

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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 4589-2 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

Together with parts 1 and 3 (see below), this part of ISO 4589 cancels and replaces ISO 4589:1984.

This revision has been prepared to introduce the following changes relative to the 1984 edition:

a) to amplify the requirements for equipment calibration (see clause 6 and annex A);

b) to reduce the permissible deviations for the gas flow rate through the chimney at 40 mm/s from ± 10 mm/s to ± 2 mm/s;

c) to introduce a relatively short procedure, as procedure C, intended for use for comparison purposes, to determine whether or not the oxygen index of a material lies above a specified minimum value;

d) to introduce a new specimen (form VI) and a corresponding procedure for testing of thin films. Precision data for the new procedure are given in an informative annex.

ISO 4589 consists of the following parts, under the general title *Plastics — Determination of burning behaviour by oxygen index*:

— *Part 1: Guidance*

— *Part 2: Ambient-temperature test*

— *Part 3: Elevated-temperature test*

Annexes A and B form an integral part of this part of ISO 4589. Annexes C and D are for information only.

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Plastics — Determination of burning behaviour by oxygen index —

Part 2:
Ambient-temperature test

1 Scope

This part of ISO 4589 specifies methods for determining the minimum concentration of oxygen, in admixture with nitrogen, that will support combustion of small vertical test specimens under specified test conditions. The results are defined as oxygen index values.

Methods are provided for testing materials that are self-supporting in the form of vertical bars or sheet up to 10,5 mm thick. These methods are suitable for solid, laminated or cellular materials characterized by an apparent density greater than 100 kg/m^3. The methods may also be applicable to some cellular materials having an apparent density of less than 100 kg/m^3. A method is provided for testing flexible sheet or film materials while supported vertically.

For comparative purposes, a procedure is provided for determining whether or not the oxygen index of a material lies above some specified minimum value.

Oxygen index results obtained using the methods described in this part of ISO 4589 can provide a sensitive measure of the burning characteristics of materials under certain controlled laboratory conditions, and hence may be useful for quality control purposes. The results obtained are dependent upon the shape, orientation and isolation of the test specimen and the conditions of ignition. For particular materials or applications, it may be necessary or appropriate to specify different test conditions. Results obtained from test specimens of differing thickness or by using different ignition procedures may not be comparable and no correlation with flammability behaviour under other fire conditions is implied.

Results obtained in accordance with this part of ISO 4589-2 must not be used to describe or appraise the fire hazard presented by a particular material or shape under actual fire conditions, unless used as one element of a fire risk assessment that takes into account all of the factors pertinent to the assessment of the fire hazard of a particular application for the material.

NOTES

1 It may not be possible to apply these methods satisfactorily to materials that exhibit high levels of shrinkage when heated, e.g. highly oriented thin film.

2 For assessing the flame propagation properties of cellular materials of density < 100 kg/m^3, attention is drawn to the method of ISO 3582:1978, *Cellular plastic and cellular rubber materials — Laboratory assessment of horizontal burning characteristics of small specimens subjected to a small flame*, for testing horizontal burning characteristics.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 4589. 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 4589 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 293:1986, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294:1995, *Plastics — Injection moulding of test specimens of thermoplastic materials.*

ISO 295:1991, *Plastics — Compression moulding of test specimens of thermosetting materials.*

ISO 2818:1994, *Plastics — Preparation of test specimens by machining.*

ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

ISO 2859-2:1985, *Sampling procedures for inspection by attributes — Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection.*

ISO 3167:1993, *Plastics — Multipurpose test specimens.*

3 Definition

For the purposes of this part of ISO 4589, the following definition applies.

3.1 oxygen index: The minimum concentration of oxygen, by volume percentage, in a mixture of oxygen and nitrogen introduced at 23 °C ± 2 °C that will just support combustion of a material under specified test conditions.

4 Principle

A small test specimen is supported vertically in a mixture of oxygen and nitrogen flowing upwards through a transparent chimney. The upper end of the specimen is ignited and the subsequent burning behaviour of the specimen is observed to compare the period for which burning continues, or the length of specimen burnt, with specified limits for such burning. By testing a series of specimens in different oxygen concentrations, the minimum oxygen concentration is estimated (see 8.6).

Alternatively, for comparison with a specified minimum oxygen index value, three test specimens are tested using the relevant oxygen concentration, at least two of which are required to extinguish before any relevant burning criterion is exceeded.

5 Apparatus

5.1 Test chimney, consisting of a heat-resistant glass tube supported vertically on a base through which oxygen-containing gas mixtures can be introduced (see figures 1 and 2).

The preferred dimensions of the chimney are 450 mm minimum height and 95 mm minimum diameter.

The upper outlet shall be restricted as necessary by an overhead cap having an outlet small enough to produce an exhaust velocity of at least 90 mm/s from that outlet.

NOTE 3 A cap converging to an outlet of 40 mm diameter at a level at least 10 mm above the top of the cylindrical chimney has been found satisfactory.

Chimneys of other dimensions, with or without restricted outlets, may be used, if shown to give equivalent results. The bottom of the chimney, or the base upon which the chimney is supported, shall incorporate a device for distributing evenly the gas mixture entering the chimney. The preferred device comprises a suitable diffuser and a mixing chamber with metal foil. Other devices, such as radial manifolds, may be used, if shown to give equivalent results. A porous screen may be mounted below the level of the specimen holder, to prevent falling combustion debris from fouling the gas entry and distribution paths.

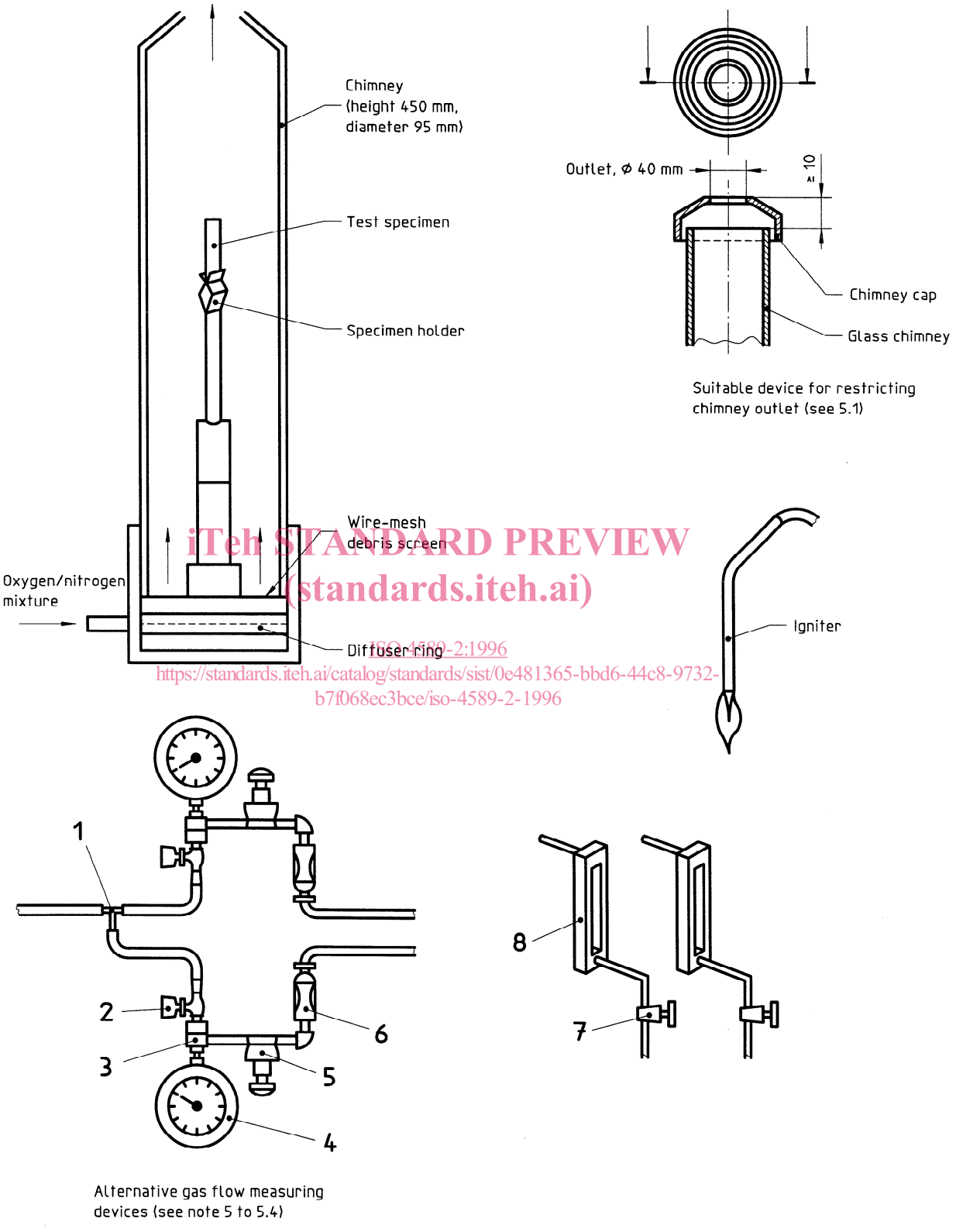
The chimney support may incorporate a levelling device and indicator, to facilitate vertical alignment of the chimney and a test specimen supported therein. A dark background may be provided to facilitate observation of flames within the chimney.

5.2 Test specimen holder, suitable for supporting a specimen vertically in the centre of the chimney.

For self-supporting materials, the specimen shall be held by a small clamp which is at least 15 mm away from the nearest point at which the specimen may burn before the extent-of-burning criterion is exceeded. For supported film or sheet test specimens, the specimen shall be supported by both vertical edges in a frame equivalent to that illustrated by figure 2, with reference marks at 20 mm and 100 mm below the top of the frame.

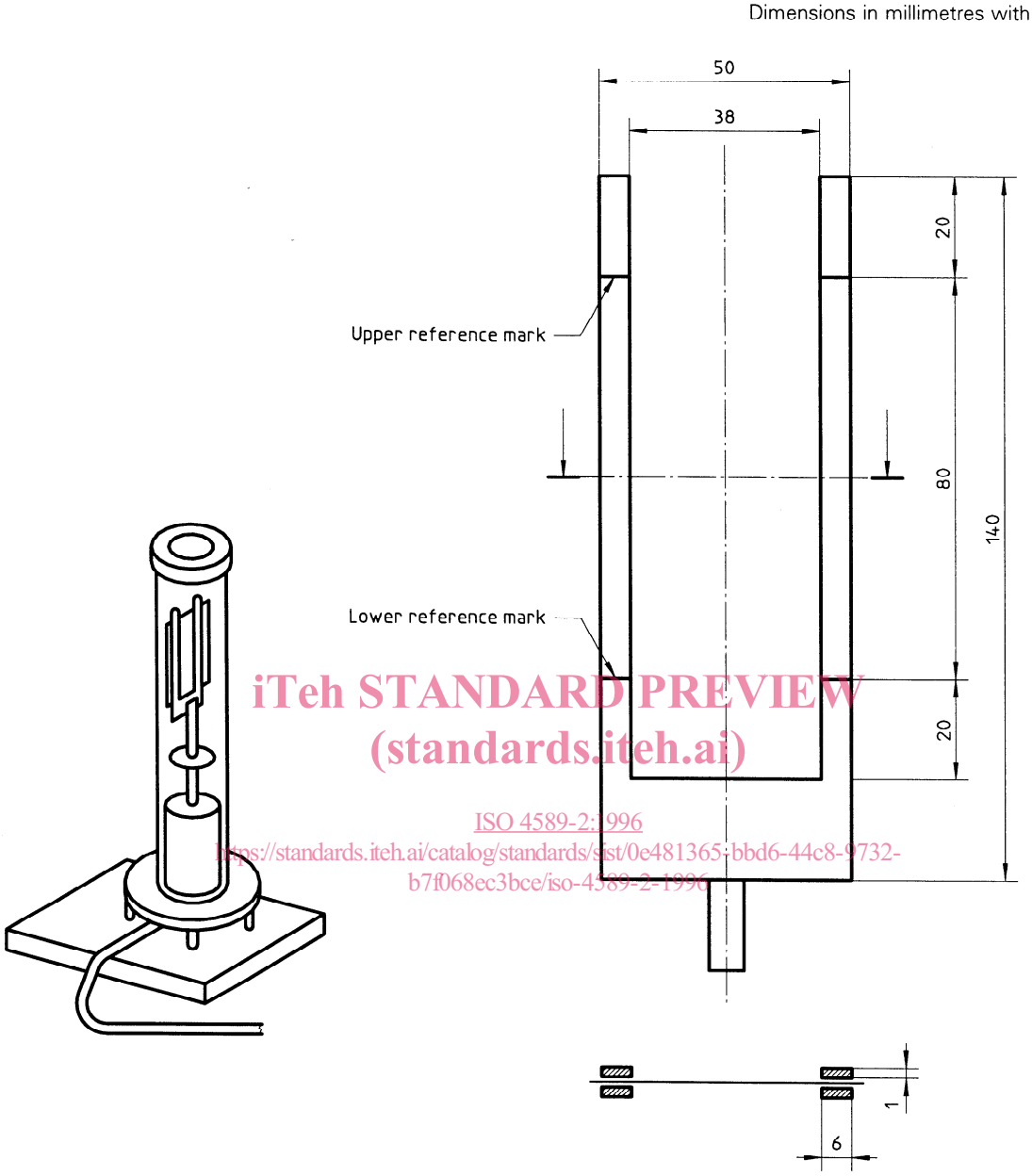
The profile of the holder and its support should preferably be smooth to minimize induction of turbulence in the rising flow gas.

Dimensions in millimetres



1 Gas premixing point
2 Cut-off valve
3 Orifice in holder
4 Pressure gauge
5 Precision pressure regulator
6 Filter
7 Needle valve
8 Gas flow meter

Figure 1 — Diagram of typical apparatus for determination of oxygen index



NOTE — The test specimen is held securely along both upright edges between forks made of stainless steel.

Figure 2 — Support frame for non-self-supporting test specimens

5.3 Gas supplies, comprising pressurized sources of oxygen and/or nitrogen not less than 98 % (*m/m*) pure and/or clean air [containing 20,9 % (*V/V*) oxygen], as appropriate.

The moisture content of the gas mixture entering the chimney shall be < 0,1 % (*m/m*), unless the results have been shown to be insensitive to higher moisture levels in the gas mixture. The gas supply system shall incorporate a drying device, or provision for monitoring or sampling the gas supply for moisture content, unless the moisture content of the gas supplies is known to be acceptable.

The constituent gas supply lines shall be linked in a manner which thoroughly mixes the gases, before they enter the gas distribution device at the base of the chimney, so that the variation in oxygen concentration in the gas mixture rising in the chimney, below the level of the test specimen, is < 0,2 % (*V/V*).

NOTE 4 It should not be assumed that bottled oxygen or nitrogen will always contain < 0,1 % (*m/m*) of water; moisture contents of 0,003 % (*m/m*) to 0,01 % (*m/m*) are typical for commercial supplies as filled bottles of purity ⩾ 98 % (*m/m*), but as such bottled gases are depressurized to below about 1 MPa, the moisture content of the gas drawn off may rise above 0,1 % (*m/m*).

5.4 Gas measurement and control devices, suitable for measuring the concentration of oxygen in the gas mixture entering the chimney with an accuracy of ± 0,5 % (*V/V*) of the mixture and for adjusting the concentration with a precision of ± 0,1 % (*V/V*) of the mixture when the gas velocity through the chimney is 40 mm/s ± 2 mm/s at 23 °C ± 2 °C.

Means shall be provided for checking or ensuring that the temperature of the gas mixture entering the chimney is 23 °C ± 2 °C. If this involves an internal probe, its position and profile shall be designed to minimize induction of turbulence within the chimney.

NOTE 5 Systems of measurement and control that have proved satisfactory include the following:

a) needle valves on individual and mixed gas supply lines, a paramagnetic oxygen analyser that continuously samples the mixed gas, and a flowmeter to indicate when the gas flow through the chimney is within the required limits;

b) calibrated orifices, gas pressure regulators and pressure gauges on the individual gas supply lines;

c) needle valves and calibrated flowmeters on the individual gas supply lines.

Systems b) and c) may require calibration after assembly to ensure that the cumulative errors of the component parts do not exceed the requirements of 5.4.

5.5 Flame igniter, comprising a tube that can be inserted into the chimney to apply to the test specimen a flame issuing from an outlet of 2 mm ± 1 mm diameter at the end of the tube.

The flame fuel shall be propane, without premixed air. The fuel supply shall be adjusted so that the flame will project 16 mm ± 4 mm vertically downwards from the outlet when the tube is vertical within the chimney and the flame is burning within the chimney atmosphere.

5.6 Timing device, capable of measuring periods up to 5 min with an accuracy of ± 0,5 s.

5.7 Fume extraction system, providing sufficient ventilation or exhaust to remove fumes or soot expelled from the chimney without disrupting the gas flow rate or temperatures in the chimney.

NOTE 6 If soot-generating materials are being tested, the glass chimney may require cleaning to maintain good visibility, and the gas inlets, or inlet screen, and temperature sensor (if fitted) may also require cleaning to function properly. Suitable precautions should be taken to protect personnel from noxious materials or burns during testing or cleaning operations.

5.8 Tool for preparing rolled film, consisting of a stainless-steel rod of 2 mm diameter, with a slit in one end (see figure 3).

6 Calibration of equipment

For compliance with this method, calibrate the equipment periodically in accordance with the instructions given in annex A so that the maximum interval between recalibration and use complies with the periods stated in table 1.

7 Preparation of test specimens

7.1 Sampling

Obtain a sample sufficient for preparation of at least 15 test specimens. The sample shall be taken, if relevant, in accordance with the material specification, otherwise in accordance with ISO 2859-1 or ISO 2859-2, as applicable.

NOTE 7 For a material for which the oxygen index is known to within ± 2, 15 test specimens may be sufficient. For materials of unknown oxygen index, or which exhibit erratic burning characteristics, between 15 and 30 test specimens may be required.

Table 1 — Equipment calibration frequencies

Item	Maximum period
Gas system joints (as required by clause A.1 in annex A)	
a) for joints disturbed during use or cleaning of the apparatus	Immediately
b) for undisturbed equipment	6 months
Cast PMMA sample	1 month
Gas flow rate controls	6 months
Oxygen concentration controls	6 months

Dimensions in millimetres

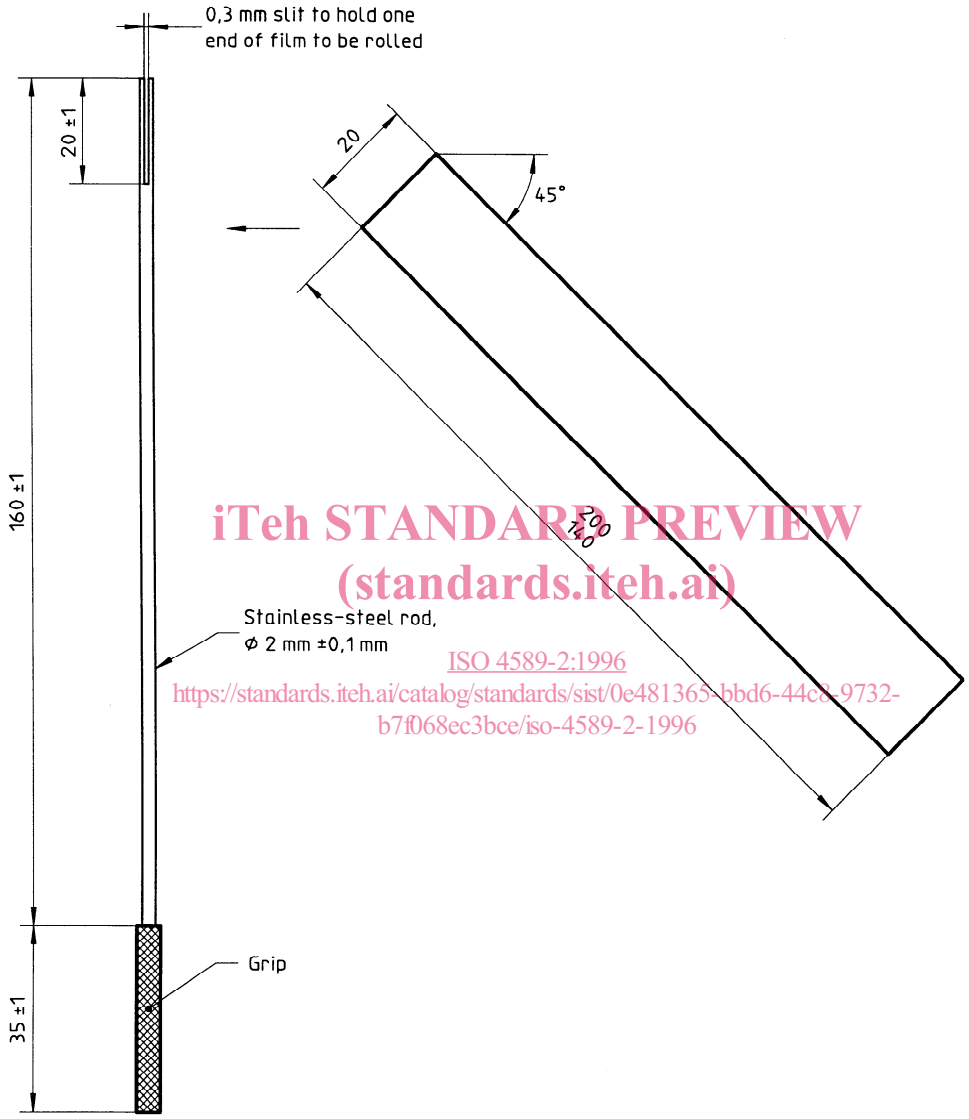


Figure 3 — Tool for preparing rolled-film specimens

7.2 Test specimen dimensions and preparation

Using, if applicable, procedures that comply with the appropriate material specification (see note 8) or ISO methods (see note 9) for specimen preparation, mould or cut test specimens that satisfy the dimensions specified for the most appropriate specimen form given in table 2.

To prepare a rolled specimen from a thin film, use the tool described in 5.8. Insert one corner of the film into the slit and then wind the film round the rod in a spiral of 45°. Ensure that the 45° angle is maintained during the winding process so that the film reaches exactly to the end of the tool, to produce a test piece of the correct length, as shown in figure 3. After the winding is finished, tape the last end of the roll while the material is still on the stainless steel rod to prevent loosening. Then pull the rod out of the rolled film. Cut off the rolled film at a distance of 20 mm from the top end (see figure 4).

Ensure that the surfaces of the specimens are clean and free from flaws that could affect burning behaviour, e.g. peripheral moulding flash or burrs from machining.

Note the position and orientation of test specimens with respect to any asymmetry in the sample material (see note 10).

NOTES

8 Some material specifications may require choice and identification of the "state of the test specimen" used; e.g. in a "defined state" or a "basic state" for a styrene-based polymer or copolymer.

9 In the absence of a relevant specification, one or more procedures from ISO 293, ISO 294, ISO 295, ISO 2818 or ISO 3167 may be used.

10 Oxygen index results may be significantly affected by differences in ease of ignition or burning behaviour, due to material inhomogeneity (e.g. different levels of shrinkage when heated for specimens cut in different directions from asymmetrically oriented thermoplastics film).

11 If a thin film burns in such a manner that erratic combustion behaviour including heat shrinkage and fluctuation of data results, the specimen form VI, i.e. a rolled film, should preferably be used. It gives reproducible results, similar to those given by specimen form I. Precision data obtained by interlaboratory trials on specimen form VI are given in annex D.

Table 2 — Test specimen dimensions

Test specimen form[1)]	Dimensions			Typical use
	Length mm	Width mm	Thickness mm	
I	80 to 150	10 ± 0,5	4 ± 0,25	For moulding materials
II	80 to 150	10 ± 0,5	10 ± 0,5	For cellular materials
III[2)]	80 to 150	10 ± 0,5	⩽ 10,5	For sheet materials "as received"
IV	70 to 150	6,5 ± 0,5	3 ± 0,25	Alternative size for self-supporting moulding or sheet materials, for electrical purposes
V[2)]	140 $^{0}_{-5}$	52 ± 0,5	⩽ 10,5	For flexible film or sheet
VI[3)]	140 to 200	20	0,02 to 0,10[4)]	For thin film "as received"; limited to the film that can be rolled by the specified rod[4)]

1) Test specimens of forms I, II, III and IV are suitable for materials that are self-supporting at these dimensions. Test specimens of form V are suitable for materials that require support during testing.

2) Results obtained using form III or form V test specimens may only be comparable for specimens of the same form and thickness. It is assumed that the amount of variation in thickness for such materials will be controlled by other standards.

3) The test specimen of form VI is suitable for a thin film that is self-supporting when it is rolled. Dimensions in the table are of an original film from which the rolled form is made. See 7.2 for the preparation of rolled film.

4) The film is limited to thicknesses that can be rolled by the specified rod (see figure 3). If the film is very thin, it may be necessary to combine two or more films together in the preparation of the rolled film so as to obtain results similar to those normally obtained with specimen form VI.