

British Standard Methods of testing

Plastics

Part 1. Thermal properties

Method 141. Determination of flammability by oxygen index

[ISO title: Plastics — Determination of flammability by oxygen index]

Méthodes d'essai des plastiques

Partie 1. Caractéristiques thermiques

Méthode 141. Essais de réaction au feu — Détermination de l'indice d'oxygène

Verfahren zur Prüfung von Kunststoffen

Teil 1. Thermische Eigenschaften

Verfahren 141. Bestimmung der Entflammbarkeit über die Sauerstoffzahl

IMPORTANT NOTE. Before reading this method it is essential to read BS 2782, Part 0, Introduction, issued separately.

THESE SMALL SCALE LABORATORY TESTS ARE PRIMARILY FOR ASSISTANCE IN MONITORING CONSISTENCY OF PRODUCTION AND ARE NOT FOR USE AS A SOLE MEANS OF ASSESSING THE POTENTIAL FIRE HAZARD OF A MATERIAL IN USE.

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National foreword

This method has been prepared under the direction of the Plastics Standards Committee and is identical with ISO 4589-1984 'Plastics — Determination of flammability by oxygen index', published by the International Organization for Standardization (ISO).

It supersedes BS 2782 : Part 1 : Methods 141A to 141D : 1978, which are withdrawn, and gives a scope and choice of procedures from which equivalent methods are available as follows.

Method 141A is directly superseded by Method 141 when using test specimen I (see table 2) and procedure A (see 8.2). This is the preferred method for moulding materials and should be designated Method 141/I/A.

Method 141B is directly superseded by Method 141 when using test specimen IV and procedure A. This is the preferred method for self-supporting moulding or sheet materials for electrical purposes and should be designated Method 141/IV/A.

Method 141C is directly superseded by Method 141 when using test specimen III and procedure A, except that the maximum specimen thickness is increased to 10.5 mm. This is the preferred method for self-supporting sheet materials and should be designated Method 141/III/A.

Method 141D is directly superseded by Method 141 when using test specimen IV and procedure B. This is the method preferred in the UK for materials for electric cable insulation or sheath and should be designated Method 141/IV/B.

Other combinations of test specimen and procedure may be used and should be designated by 'Method 141/Test specimen form (see table 2)/Procedure' (A or B, see 8.2). In the absence of specified suffixes the appropriate test specimen form and procedure should be adopted in accordance with table 2 and 8.2.

The test procedure and the method of calculating results differ from those of Methods 141A to 141D : 1978, but are expected to produce comparable data with less overall practical effort.

The scope of this method has been extended to include the testing of:

- (a) cellular materials, having an apparent density of at least 100 kg/m³ (reference to Method 141 without further qualification implies use of test specimen form II and procedure A); and
- (b) flexible film or sheet (reference to Method 141 without further qualification implies use of test specimen form V and procedure B).

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'this method'.

Cross-references

International standards	Corresponding British Standards
	BS 2782 Methods of testing plastics
ISO 291-1977	Part 0 : 1982 Introduction (Appendix A is identical)
ISO 293-1974	Method 901A : 1977 Compression moulding test specimens of thermoplastic materials (Identical)
ISO 294-1975	Method 910A : 1977 Injection moulding test specimens of thermoplastic materials (Identical)
ISO 295-1974	Method 902A : 1977 Compression moulding test specimens of thermosetting materials (Identical)
ISO 845-1977	
Text covering rigid cellular materials	BS 4370 Methods of test for rigid cellular materials Part 1 : 1968 Methods 1 to 5 (Technically equivalent)
Text covering flexible cellular materials	BS 4443 Methods of test for flexible cellular materials Part 1 : 1979 Methods 1 to 6 (Technically equivalent)
ISO 2859-1974	BS 6000 : 1972 Guide to use of BS 6001. Sampling procedures and tables for inspection by attributes (Technically equivalent)
	BS 6001 Sampling procedures for inspection by attributes Part 1 : 1972 Specification for sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection (Technically equivalent)

Cross-references**International standards**

ISO 5725-1981

Corresponding British Standards

BS 5497 Precision of test methods

Part 1 : 1979 Guide for the determination of repeatability and reproducibility for a standard test method
(Technically equivalent)

The Technical Committee has reviewed the provisions of ISO 3167, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this method.

ISO 4893 and ISO 6400, which are referred to for information purposes only, have not yet been published but are supported by the Technical Committee in principle pending publication.

There is no corresponding British Standard for ISO 2818-1980, but the provisions of BS 2782 : Method 930A : 1977 'Preparation of test specimens by machining', which is identical with the 1974 edition of ISO 2818, are acceptable for use in conjunction with this method.

There is no corresponding British Standard for ISO 3582 which is referred to for information purposes only.

Warning note. This British Standard method, which is identical with ISO 4589, does not necessarily detail all the precautions necessary to meet the requirements of the Health and Safety at Work etc. Act 1974. Attention should be paid to any appropriate safety precautions and the method should be operated only by trained personnel.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

0 Introduction

This International Standard has been prepared to rationalize procedures developed independently for similar methods of test by various national standards bodies.

1 Scope and field of application

This International Standard 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/m³. The methods may also be applicable to some cellular materials having an apparent density of less than 100 kg/m³. A method is provided for testing flexible sheet or film materials while supported vertically.

Oxygen index results obtained using the methods described in this International Standard 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. Such requirements should be referred to in other standards. 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 International Standard 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/m³, attention is drawn to the method of ISO 3582 for testing horizontal burning characteristics.

2 References

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

ISO 293, *Plastics — Compression moulding test specimens of thermoplastic materials.*

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

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

ISO 845, *Cellular plastics and rubbers — Determination of density.*

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

ISO 2859, *Applications of statistical methods — Sampling procedures and tables of inspection by attributes.*

ISO 3167, *Plastics — Preparation and use of multi-purpose test specimens.*

ISO 3582, *Cellular plastic and cellular rubber materials — Laboratory assessment of horizontal burning characteristics of small specimens subjected to a small flame.*

ISO 4893, *Plastics — Preparation of test specimens from thermosetting materials by injection moulding.*¹⁾

ISO 5725, *Precision of test methods — Determination of repeatability and reproducibility.*

ISO 6400, *Plastics — Test specimens from semi-crystalline thermoplastic moulding materials by compression moulding — Preparation of reference test specimens with a reproducible state.*¹⁾

1) At present at the stage of draft.

3 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 at which the burning behaviour of 50 % of specimens representing the material under test would exceed at least one of the specified limits for burning.

4 Definition

For the purposes of this International Standard, the following definition applies.

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

5 Apparatus

The following apparatus shall be arranged as indicated by the diagrams in figures 1 and 2 as appropriate:

5.1 Test chimney: a heat-resistant glass tube supported vertically on a base through which oxygen-containing gas mixtures can be introduced.

The preferred dimensions of the chimney are 450 mm minimum height and 75 mm minimum diameter cylindrical bore. 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 a flow rate within the chimney of 30 mm/s (see the note). 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 means for distributing evenly the gas mixture entering the chimney. The preferred means comprises solid glass beads of between 3 and 5 mm diameter, in a layer between 80 and 100 mm deep. Other means, 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.

NOTE — For tubes of 75 to 100 mm diameter, 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.

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 be smooth to minimize induction of turbulence in the rising flow of gas.

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 % 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 — It should not be assumed that bottled oxygen or nitrogen will always contain $<0,1$ % (m/m) of water; moisture contents of 0,003 % to 0,01 % (m/m) are typical for commercial supplies as filled bottles >98 % (m/m) pure, but as such bottled gases are depressured 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 establishing the concentration of oxygen in the gas mixture entering the chimney with an accuracy of $\pm 0,5$ % (V/V) of the mixture and for adjusting the concentration with a precision of $\pm 0,1$ % (V/V) of the mixture when the gas velocity through the chimney is 40 ± 10 mm/s at 23 ± 2 °C.

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

NOTE — 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; or
- 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 compounded 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 ± 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 ± 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 $\pm 0,2$ 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 — 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.

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.

Table 1 — Equipment calibration frequencies

Item	Maximum period
Gas-flow rate controls	6 months
Oxygen concentration controls	6 months
Gas system joints (as required by clause A.2 in annex A)	
a) for joints disturbed during use or cleaning of the apparatus	24 h
b) for undisturbed joints	6 months

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.

NOTE — 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.

7.2 Test specimen dimensions and their preparation

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

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

Note the position and orientation of test specimens with respect to any asymmetry in the sample material.

NOTES

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

2 In the absence of a relevant material specification, one or more procedures from ISO 293, ISO 294, ISO 295, ISO 2818, ISO 3167, ISO 4893 or ISO 6400 may be used.

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

Table 2 — Test specimen dimensions

Test specimen form ¹⁾	Dimensions			Typical use
	Length mm	Width mm	Thickness mm	
I	80 to 150	$10 \pm 0,5$	$4 \pm 0,25$	For moulding materials
II	80 to 150	$10 \pm 0,5$	$10 \pm 0,5$	For cellular materials
III ²⁾	80 to 150	$10 \pm 0,5$	$< 10,5$	For sheet materials "as received"
IV	70 to 150	$6,5 \pm 0,5$	$3 \pm 0,25$	Alternative size for self-supporting moulding or sheet materials, for electrical purposes
V ²⁾	$140 \begin{smallmatrix} 0 \\ -5 \end{smallmatrix}$	$52 \pm 0,5$	$< 10,5$	For flexible film or sheet

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.