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Plastics — Determination of burning behaviour by oxygen index —

Part 3: Elevated-temperature test

Plastiques — Détermination du comportement au feu au moyen de l'indice d'oxygène —
Partie 3: Essai à haute température

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Foreword

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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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 4589-3:1996), which has been technically revised.

A list of all parts in the ISO 4589 series can be found on the ISO website.

Introduction

This document has been prepared to extend the methods available for the determination of flammability by oxygen index (OI) (see ISO 4589-2) to typical elevated temperatures to which a plastic material can be exposed in a service situation. It also provides a method for determining the temperature at which combustion of a small bar of material is just supported in air under certain test conditions; the resulting temperature is termed the flammability temperature.

This document is intended to be used in conjunction with ISO 4589-2 which describes the basic OI test method.

Results obtained in accordance with this document are not applicable 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 which takes into account all of the factors which are pertinent to the assessment of the fire hazard of a particular application for the material.

Plastics — Determination of burning behaviour by oxygen index —

Part 3: Elevated-temperature test

1 Scope

This document specifies methods for determining the minimum volume fraction of oxygen, in a mixture with nitrogen, that will support combustion of small vertical test specimens under specified test conditions over a range of temperatures between 25 °C and 150 °C. The range of temperatures is typically between 40 °C and 150 °C. The results are defined as temperature index values at the test temperature, which is typical of the practical temperature that a plastic material can experience in an overheated service situation.

Methods are provided for testing materials that are self-supporting at the test temperature in the form of vertical bars or sheet up to 10,5 mm thick. However, they are not applicable to form V which requires a supporting frame as defined in ISO 4589-2:2017, Table 2. These methods are suitable for solid, laminated or cellular materials characterized by an apparent density 100 kg/m^3 or higher. The methods are also 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.

This document also includes a method (see Annex A) for determining the temperature at which the OI of small vertical test specimens in air is 20,9 % under specified test conditions. The temperature at which this occurs is defined as the flammability temperature (FT) and the method is limited to the determination of temperatures less than 400 °C. The method is not applicable to materials having an OI of <20,9 %.

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

NOTE 2 For assessing the flame propagation properties of cellular materials of density <100 kg/m^3, attention is drawn to the method described in ISO 3582.

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 4589-1, *Plastics — Determination of burning behaviour by oxygen index — Part 1: General requirements*

ISO 4589-2:2017, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test*

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4589-1, ISO 13943 and the following apply.

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

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

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

3.1
flammability temperature
FT
temperature at which flaming combustion of a material is supported in air that has a volume fraction of oxygen of 20,9 %

3.2
temperature index
TI
minimum volume fraction of oxygen, in a mixture of oxygen and nitrogen, at a test temperature that supports flaming combustion of a material under specified test conditions

Note 1 to entry: The test temperature will typically be between 40 °C and 150 °C.

3.3
ignition
DEPRECATED: sustained ignition
⟨flaming combustion⟩ initiation of sustained flame

[SOURCE: ISO 13943:2008, 4.188]

4 Principle

A small test specimen is supported vertically in a mixture of oxygen and nitrogen flowing upwards through a transparent heated 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 volume fractions of oxygen, the minimum volume fraction of oxygen is estimated. General requirements for the apparatus and test method are given in ISO 4589-1.

5 Apparatus

5.1 Arrangement

The apparatus specified in 5.2 to 5.6 shall be arranged as indicated in Figures 1 to 4, as appropriate.

5.2 Test chimney

The test chimney shall consist of two concentric heat-resistant glass tubes supported vertically between an insulating top plate and a base through which oxygen-containing gas mixtures can be introduced. The chimney is provided with a heating element suitable for use in conjunction with a preheater for heating the incoming gas mixture. This is to maintain the test atmosphere within the inner tube in the vicinity of the test specimen at within ± 3 °C of any specific test temperature up to, and including 125 °C and at within ± 5 °C of any higher test temperature at which the equipment is intended to be used. The heating element shall not impede adequate observation of a test specimen under test.

The preferred dimensions of the inner tube are 450 mm to 500 mm minimum height, and 75 mm to 100 mm diameter cylindrical bore. The upper outlet should preferably be restricted as necessary by an overhead cap having an outlet small enough to produce an exhaust velocity of at least 90 mm/s at 23 °C ± 2 °C from a flow rate within the chimney of 40 mm/s at 23 °C ± 2 °C (see Note). The height of the outer tube should be similar to that of the inner tube, and the radial clearance between the inner and outer

tubes should be between 5 mm and 10 mm. 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 inner tube. A satisfactory means comprises beads of diameter between 3 mm and 5 mm in a layer between 80 mm and 100 mm deep. 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 test piece 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 piece supported therein. A dark background may be provided to facilitate observation of flames within the chimney.

NOTE For inner tubes of diameter 75 mm to 100 mm, a cap converging to an outlet of diameter 40 mm at a level at least 10 mm above the top of the cylindrical chimney is satisfactory. For such tubes also, an electrical-resistance heating element dissipating up to about 1 000 W and helically wound around the outer surface of the tube with a graded distribution of winding pitch so that the temperature is evenly distributed is suitable in conjunction with a preheater comprising a cylindrical ceramic body with longitudinal holes and containing a heating element dissipating up to about 1 000 W with regulating controls which can be operated separately from those of the heater windings on the chimney tube. If the target test condition is 150 °C or less, a preheater is not necessary; apparatus of more simple structure can be used.

5.3 Test specimen holder

The test specimen holder specified in ISO 4589-2:2017, 5.2 shall be used.

The transfer device (see Figure 4) can be used for moving a specimen loaded specimen holder into the test chimney.

5.4 Gas supplies

The gas supplies specified in ISO 4589-2:2017, 5.3 shall be used.

Because damage can occur to the chimney heater and preheater if energized while no gas flows through them, it is recommended that a gas-flow or pressure-sensing device is incorporated in the gas supply lines and is coupled to the heater power-control circuits.

To economize purified oxygen and nitrogen, it is recommended that an air pump is provided to supply air instead of oxygen and/or nitrogen, at the appropriate flow rate, during periods when specimens are not being tested.

5.5 Gas control devices

The gas supplies specified in ISO 4589-2:2017, 5.4 shall be used, except that the flow rate shall be 40 mm/s ± 0,8 mm/s at 23 °C.

A thermocouple (see Figure 1, Key 9) shall be provided for checking or ensuring that the temperature of the gas mixture in the chimney is in accordance with 5.2. 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 are listed in ISO 4589-2:2017, 5.4.

5.6 Oxygen analyser

The oxygen analyser specified in ISO 4589-2:2017, 5.5 shall be used.

5.7 Flame igniter

The flame igniter specified in ISO 4589-2:2017, 5.6 shall be used.

5.8 Timing device

The timing device specified in ISO 4589-2:2017, 5.7 shall be used.

5.9 Fume extraction system

The fume extraction system specified in ISO 4589-2:2017, 5.8 shall be used.

6 Calibration and maintenance of equipment

Calibrate and maintain the equipment periodically in accordance with the instructions given in ISO 4589-2:2017, Annex A so that the maximum interval between recalibration and use conforms to the periods stated in ISO 4589-2:2017, Table 1, except that the accuracy of checking the flow rate shall be ± 0,8 mm/s.

7 Preparation of test specimens

7.1 Sampling

Sampling shall be in accordance with ISO 4589-2:2017, 7.1.

For the flammability temperature procedure (see Annex A), at least 10 test specimens shall be provided. If a test specimen is not self-supporting at the temperature of the test, it shall be provided with external support by the use of a 0,55 mm ± 0,05 mm diameter nickel-chromium alloy wire with a maximum working temperature of 1 100 °C, and secured by ties of copper wire of 0,20 mm ± 0,02 mm diameter. These shall be positioned as shown in Figure 5. See Annex B for round-robin analysis of the effects of variation of the test specimen holder.

Another practice is to support the test piece between two capillary glass tubes, the assembly being lightly bound together with a single tie of fine nichrome or stainless-steel wire (nominally 200 µm gauge), and held in a small standard clamp. This non-standard practice should be used carefully and recorded in the test report.

7.2 Test specimen dimensions and preparation

With the exception of form V, test specimen dimensions shall conform to, and specimen preparation shall be in accordance with, ISO 4589-2:2017, 7.2.

7.3 Marking of test pieces

Marking of the test specimens shall be in accordance with ISO 4589-2:2017, 7.3.

7.4 Conditioning

Conditioning shall be in accordance with ISO 4589-2:2017, 7.4.

8 Procedure

8.1 Setting up the apparatus and test specimen

8.1.1 Position a temperature sensor in the position to be occupied by the top of a test specimen.

Adjust the electrical power to the chimney heater and preheater to give the test temperature, with the gas controls set to give a gas velocity within the chimney of 40 mm/s ± 0,8 mm/s at 23 °C. The flow rate shall be estimated by using the formula found in ISO 4589-2:2017, A.2.

8.1.2 Select an initial volume fraction of oxygen to be used. When possible, base this on experience of results for similar materials. Alternatively, try to ignite a test specimen in the chimney supplied with mixed gas and heated to the test temperature, and note the burning behaviour. If the specimen burns rapidly, select an initial volume fraction of about 18 % of oxygen; if the test specimen burns gently or unsteadily, select an initial oxygen volume fraction of about 21 %; if the specimen does not continue to burn in air, select an initial volume fraction of at least 25 %, depending upon the difficulty of ignition or the period of burning before extinguishing in air.

8.1.3 When the temperature in the test chimney is stable and in accordance with the limits given in 5.2, mount a specimen in the centre of the chimney so that the top of the specimen is at least 100 mm below the open top of the chimney, and the lowest exposed part of the specimen is at least 100 mm above the top of the gas distribution device at the base of the chimney.

8.1.4 Preheat the specimen for 240 s ± 10 s for it to reach a temperature within the applicable test temperature tolerance before ignition.

8.1.5 Set the gas mixing and flow controls so that an oxygen/nitrogen mixture at 23 °C, containing the desired volume fraction of oxygen, flows within the chimney at 40 mm/s ± 0,8 mm/s. Let the gas flow purge the chimney for at least 30 s prior to ignition of each specimen, and maintain the flow without change during ignition and combustion of each specimen. The flow rate shall be estimated by using the formula found in ISO 4589-2:2017, A.2.

Record the volume fraction of oxygen used, which is measured by an oxygen analyser or calculated in accordance with the formulae given in ISO 4589-2:2017, Annex B.

8.2 Igniting the test specimen

Ignite the specimen in accordance with ISO 4589-2:2017, 8.3 using procedure A or procedure B.

8.3 Assessing burning behaviour

The burning behaviour of individual test specimens shall be assessed in accordance with ISO 4589-2:2017, 8.4, except that the test temperature shall be determined by this document.

8.4 Selecting successive volume fractions of oxygen

The volume fraction of oxygen required for the purpose of 8.5 to 8.6 shall be calculated in accordance with ISO 4589-2:2017, Annex B.

Select successive volume fractions of oxygen in accordance with ISO 4589-2:2017, 8.5.

8.5 Determining the preliminary volume fraction of oxygen

Determine the preliminary volume fraction of oxygen in accordance with ISO 4589-2:2017, 8.6.