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Plastics -- Determination of burning behaviour by oxygen index -- Part 1: Guidance

Plastiques -- Détermination du comportement au feu au moyen de l'indice d'oxygène -- Partie 1: Guide

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INTERNATIONAL STANDARD

ISO 4589-1

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Plastics — Determination of burning behaviour by oxygen index —

Part 1:
Guidance

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

Partie 1: Guide

Reference number
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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 4589-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

Together with parts 2 and 3 (see below), this part of ISO 4589 cancels and replaces ISO 4589:1984, which has been technically revised.

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*

Annex A of this part of ISO 4589 is for information only.

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Introduction

The oxygen index (OI) test at ambient temperature was first described by Fenimore and Martin[2] in 1966. The first use of the method in standards was ASTM Standard Test Method D 2863:1970[6], and it has since been published in a wide range of national and international standards. It was published as ISO 4589 in 1984 and has now been revised as ISO 4589-2. The OI test at elevated temperatures is described in ISO 4589-3.

In the period since ASTM D 2863 became a standard, a considerable number of papers have been published about this test. An example is the review by Weil, Hirschler, *et al*[3] relating to the relevance of the test to real fire situations. Other papers have suggested empirical formulae relating OI to the amounts of added fire retardant, or describe practical investigations on the equipment performance (see Kanury[4]). A clear consensus on the value of the two variants of the test has emerged, however, and it is the purpose of this guidance document to discuss the use of the equipment and the applicability of both test methods.

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Plastics — Determination of burning behaviour by oxygen index —

Part 1:
Guidance

1 Scope

1.1 This part of ISO 4589 constitutes a guidance document for the OI test. It provides information to guide the reader in the use of the test procedures described in parts 2 and 3.

1.2 Part 2 describes a method for determining the minimum concentration of oxygen by percentage volume 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. The results are defined as OI values. For comparative purposes, a procedure is also provided for determining whether or not the OI of a material lies above some specified minimum value, which is particularly important for quality control purposes. There is also a procedure for the testing of thin films between 20 µm and 100 µm thickness.

1.3 Part 3 describes methods of carrying out the same determination over a range of temperatures typically between 25 °C and 150 °C (although temperatures up to 400 °C may be used). The results are defined as OI values at the test temperature. Part 3 also describes a method for determining the temperature at which the OI of the small vertical test specimens is 20,9. The result is defined as the flammability temperature. Part 3 is not applicable to materials having an OI value of less than 20,9 at 23 °C.

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 4589-2:1996, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test.*

ISO 4589-3:1996, *Plastics — Determination of burning behaviour by oxygen index — Part 3: Elevated-temperature test.*

3 Principles of the test

3.1 In part 2, the material can be tested either as a rigid specimen or as a flexible specimen in a specified holder which is mounted in a transparent chimney in which a mixture of oxygen and nitrogen flows upwards in a laminar flow pattern. After specimen conditioning, the test is carried out at room temperature. This constitutes the test in its simplest form. In the top-surface ignition procedure, the applied flame is allowed to impinge on the top surface of the specimen for a maximum time of 30 s coupled with periodic removal of the flame every 5 s to check if the specimen is burning. This also ensures that the specimen temperature does not rise excessively, since this would normally lower the OI value. In the propagating-ignition procedure, the flame is allowed to impinge to a depth of approximately 6 mm down the vertical sides of the specimen. In the thin-film procedure, the film is wrapped in a 45° spiral around a rod and taped, after which the rod is withdrawn and the top end of the specimen is cut off at a distance of 20 mm from the top.

3.2 In part 3, the material is tested in an identical manner, except that the test takes place in a heated column in which both the incoming gas and the gas passing up the column are heated. At the start of the test, the specimen and specimen holder are preheated in the gas flow for 240 s ± 10 s to allow them to reach temperature equilibrium prior to testing. The flame is applied for the same length of time as in part 2.

4 Applicability of the test

4.1 The test is used for the quality control of materials, particularly to check the incorporation of flame retardants in the material under test, and for research and development. This test, in isolation, is insufficient to evaluate the burning behaviour and should not be used for regulations relating to safety control and consumer protection. The test provides a sensitive measure of burning materials under controlled laboratory conditions. The results are dependent upon the specimen size, shape and orientation. Notwithstanding these restrictions, the OI test is widely used in the polymer industry as well as by cable-manufacturing companies and by those manufacturing flame retardants.

4.2 The elevated-temperature test (part 3) has the advantage of providing information on the effect of a range of temperatures on the OI value. Thus, the value of the test is enhanced over that of the single-point measurement at room temperature and gives a better understanding of the behaviour of materials over a temperature range. This is of particular value in detecting, for example, the loss of effectiveness of added flame retardant, which has been shown to be dramatic in certain cases. It is also useful in monitoring any chemical changes taking place at the higher temperatures which may serve to enhance or reduce the tendency to burn.

4.3 The flammability temperature test (part 3, annex B) provides a means for assessing the way in which materials behave in a normal atmosphere, by determining the temperature at which the OI of a specimen is 20,9.

4.4 Parts 2 and 3 may be used to compare the particular burning characteristics of a series of plastic materials. The burning characteristics of a material are complex, and one test alone is insufficient to evaluate the material behaviour. It should be stressed that a number of tests are required to describe all the burning characteristics of a material.

4.5 It is essential that these small-scale laboratory tests be regarded as material tests only. They are primarily for assistance in development, monitoring consistency and/or pre-selection of materials and **are not for use as the sole means of assessing the potential fire hazard of a material in use.**

4.6 The specific requirements of different industries have resulted in the issue of a number of similar standards, but they are not completely identical, often using different burners and conditions of ignition. These different burners and conditions may give different test results and care should be exercised in comparing results from these tests when conducted in accordance with different standards.

5 Specimen preparation

Specimen preparation should always be carried out carefully. It is important to ensure that the surfaces are clean and free from any flaws, as failure to observe these precautions can profoundly affect the burning behaviour. No short cuts should be taken in conditioning of specimens.

6 Apparatus

6.1 General

Several types of apparatus exist that meet the specifications of parts 2 and 3. Some models have flow meters, valves or oxygen analysers. Some models are modular and allow upgrading to a heated model at a later date. A full description can be found in clause 5 of parts 2 and 3.

6.2 Measuring device

A number of methods for measuring oxygen concentration are available. The standard indicates that measurement may be made either by the use of flow meters or by the use of an oxygen analyser. It is essential to use the proper calibration information for flow meters and to calibrate oxygen analysers using a standard gas. It is also necessary to check the overall equipment from time to time at the intervals specified in part 2 to ensure that there are no leaks in the system. This is critical if for any reason the equipment is dismantled and reassembled.

6.3 Column design

The recommended column size for the ambient test (part 2) is a minimum of 95 mm with a restricted aperture. The reason for this was clearly identified by the work of Wharton[5] who showed that there was entrainment of air from outside the column. In the case of part 3, it is recommended that a 75 mm minimum diameter column be used, again with a restricted aperture since entrainment of air was more of a problem in this equipment. Without the aperture, there would be errors introduced into the oxygen index values for particular materials. The preferred shape and size of the opening to eliminate this effect is given in parts 2 and 3.

6.4 Sample holder

There are two types of holder, depending on the specimen: one for rigid specimens, the other for flexible specimens. Care should be taken to ensure that the specimen holder cools to ambient temperature in part 2 testing. Alternatively, a second holder can be used.

NOTE — The elevated-temperature test (part 3) encounters a number of problems, one of which relates to the sample holder for flexible thermoplastic materials. The recommended wire cage support (see figure 7 of part 3) is not optimum for some products. 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 Operating conditions

7.1 Calibration

The importance of following the calibration procedures as specified in both part 2 and part 3 cannot be stressed too highly. It is recommended that a regular check be carried out by testing a specified material, such as PMMA, and that records of all values obtained should be kept. If there is any significant change in these values then the complete calibration procedure should be carried out to determine the cause of the change.

NOTE — The PMMA should be a non-modified transparent cast sheet based on a homopolymer of methyl methacrylate in accordance with ISO 7823-1[1]. Other PMMA sheets, such as cast sheets based on a copolymer of methyl methacrylate, and extruded or melt-calendered PMMA sheets, may give a different burning behaviour depending on the comonomer used, the composition and the molecular mass, since these characteristics affect melt behaviour during burning.

7.2 Flame application time

The conditions under which the flame is applied to the specimen should be carefully controlled. The reason for this caution is that the longer the flame is applied the higher the specimen temperature becomes. This will normally result in a fall in the OI value, since it is generally the case that the higher the temperature the lower the OI value obtained for most materials. The procedure used for applying the flame should be specified in the test report.

7.3 Gas flow

While early work indicated that the upward laminar flow in the column could be varied by ± 25 % (i.e. the linear velocity is 40 mm/s ± 10 mm/s) for the test conducted at room temperature, it has been clearly shown that such a wide variation could not be tolerated for the elevated-temperature test since the test requires a constant concentration of oxygen, which depends on flow and temperature. In part 3, both flow and temperature are therefore closely defined, flow being controlled to within ± 2 % (i.e. the linear velocity is 40 mm/s ± 0,8 mm/s). Tighter flow control is now also applicable for part 2 at ± 5 % (i.e. 40 mm/s ± 2 mm/s).