

Australian/New Zealand Standard™

Methods of test for determining combustion propagation characteristics of plastics

Method 2: Determination of minimum oxygen concentration for flame propagation following top surface ignition of vertically oriented specimens

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee BD/18, Fire Safety, to supersede AS 2122, *Combustion propagation characteristics of plastics, Part 2: Determination of minimum oxygen concentrations for flame propagation following top surface ignition of vertically oriented specimens*.

This test explores the minimum oxygen concentration necessary to just support flame propagation in test conditions of varying mixtures of oxygen and nitrogen. The test does not indicate the combustion propagation characteristics of the material at other oxygen concentrations or with the application of external heat energy.

The test has been found useful for quality control of materials, particularly in relation to the proof of the incorporation of flame retardants in the material under test. It has also been found useful in the research and development area. Guidance on the manner in which the results of this test method may be applied is given in Appendix B.

The combustion propagation characteristics of a material are complex and a series of tests would be required to specify all combustion characteristics of a material (e.g. ignitability, flame propagation, heat release, smoke release, toxicity and dripping behaviour). This test may be used to compare aspects of this particular combustion propagation characteristic of a series of plastics materials.

It must be stressed that this combustion propagation characteristics test will not indicate the fire hazard of a material in actual use. It is the manner in which the material is installed and the modification and/or fabrication which it undergoes in the production of the final product which determines the fire hazard of the material. This test may be used to specify a combustion propagation characteristic of a raw material in a product Standard.

This Method is based on ASTM D2863, *Standard method for test flammability of plastics using the oxygen index methods*; however, modifications have been incorporated as a result of work carried out by CSIRO, Division of Building Research*.

This Standard is technically similar to ISO 4589 *Plastics—Determination of burning behaviour by oxygen index*. Both methods yield, within experimental error, similar results.

* Information on the development of this method may be found in CSIRO, Division of Building Research, *Special Report 1977*, by G.C Ramsay and A.N. Souprounovich, *The Oxygen Index Test—Part 1*. See also SAA HB 37.0: *Handbook of Australian fire standards. Part 0: Fire test standards—Preparation, application and format*, for background information on firetests.

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 METHOD
1 SCOPE

This Standard specifies a test method for determining the minimum oxygen concentration for flame propagation for small specimens of plastics materials in a vertical configuration at the ambient temperature of the testing laboratory, when ignited at the top by surface ignition.

The method is suitable for testing various forms of plastics including film, fabric and cellular plastics. It is also suitable for testing certain non-plastics materials, e.g. fabrics made from natural fibres. Guidance on the manner in which the results of this method may be applied is given in Appendix B.

2 PRINCIPLE

The minimum concentration of oxygen in an upward flowing mixture of oxygen and nitrogen that will just support flame propagation is measured under equilibrium conditions. The balance between the heat from combustion of the specimen and the heat lost to the surroundings establishes the equilibrium. This point is approached from both sides of the critical oxygen concentration and a statistical method is used in its determination.

3 REFERENCED DOCUMENT

The following document is referred to in this Standard:

AS

1327 Standard environment for conditioning and testing plastics materials

4 APPLICATION

This method shall not be used as the sole criterion for the description or appraisal of the fire hazard of the material or product under actual fire conditions. In general, tests of this nature are considered unsuitable alone for use in regulations relating to safety control and consumer protection but find use in research and development, quality control, and material specifications.

5 APPARATUS AND REAGENTS

5.1 Apparatus

(a) Test chamber

NOTES:

- 1 During the course of combustion, gases or vapours, or both are evolved which may be hazardous to personnel. Adequate precautions should be taken to protect the operator.
- 2 To ensure removal of toxic fumes, soot and heat, the apparatus should be installed under an exhaust hood which should be of such power as to not alter the controlled flow of gases in the column or reduce the temperature, thus disturbing the heat balance.

- (b) *Test columns* Two columns are required, each consisting of a heat-resistant glass tube of minimum bore 75 mm and minimum height 450 mm. A column of bore 95 mm and 210 mm high with restricted upper opening of bore 50 mm has been found to give equivalent results. The bottom of the column or the base to which the tube is attached shall contain non-combustible material to mix and distribute evenly the gas mixture entering at the base or a suitable mixing chamber.

NOTE: Glass beads 3 to 5 mm in diameter in a bed 80 × 100 mm deep have been found suitable (see Figure 1). A wire screen above the non-combustible material is desirable to catch falling fragments and keep the base of the column clean.

(c) Specimen holder

- (i) *For self-supporting materials* Any small holding device which will support the specimen at its base and hold it vertically in the centre of the column is acceptable. A typical arrangement is shown in Figure 1.
- (ii) *For non-self-supporting materials* For materials such as film, thin sheet or fabrics the frame shown in Figure 2 shall be used.

- (d) *Gas control and measurement devices* Suitable control and measuring devices shall be incorporated so that the oxygen concentration and the total gas flow supplied to the test column can be controlled. For determining the percentage of oxygen in the mixed gas stream either a calibration of the control devices to within one unit per hundred units of full scale or an oxygen analyser shall be used. A paramagnetic oxygen analyser has been found to be satisfactory. Percent oxygen concentration may be calculated as follows:

$$O_2\% = (100 O_2)/(O_2 + N_2)$$

where O_2 is the volumetric flow rate of oxygen and N_2 is the corresponding volumetric flow rate of nitrogen.

- (e) *Igniter* A small coil of nichrome wire enclosed in a silica tube, mounted in a holder as shown in Figure 3 (see Appendix B for construction details). The igniter head shall be heated electrically to a point where a piece of silver foil (2 × 3 × 0.05 mm, melting point 950°C) melts in less than 5 s when placed on the silica tube. The current needed to achieve this result should be checked prior to testing a specimen and should be maintained to within ±0.1 A.

NOTE: Other suitable measuring devices may be used to ensure a minimum igniter temperature of 950°C.

- (f) *Timer* A stopwatch graduated to at least 0.5 s intervals.
- (g) *Thermometer* Range of 0–50°C and graduated to at least 0.5°C.

5.2 Reagents

A thermometer with commercial grade (or better) oxygen and nitrogen shall be used.

6 TEST SPECIMENS

6.1 Number and dimensions

- (a) **Number and dimensions** A sufficient number of test specimens (normally 20 to 25) shall be cut from the material to be tested. Test specimen dimensions shall be those specified in Table 1. If test specimens of dimensions other than those specified are used, different results may be obtained.
- (b) For Type A materials, where a thickness of 3.0 ± 0.5 mm is not available, test specimens of other thicknesses may be used, but comparisons shall be made only between test specimens of the same thickness.
- (c) For Type B test specimens, comparisons should only be made between materials of similar densities.
- (d) Type C materials shall be tested in the as-received thickness, but comparisons shall be made only between materials of the same thickness.

TABLE 1
TEST SPECIMEN DIMENSIONS

Type	Form	Width mm	Thickness mm	Length mm
A	Physically self-supporting	6.5 ± 0.5	3.0 ± 0.5	70 to 150
B	Cellular plastics (flexible or rigid)	12.5 ± 0.5	12.5 ± 0.5	125 to 150
C	Film or thin sheet	52.0 ± 0.5	As received	140 ± 5

6.2 Reference marks

- (a) Type A test specimens shall be marked 50 mm from the top.
- (b) Type B test specimens of thermoplastics materials that 'shrink' from the igniter shall be marked 20 mm and 95 mm from the top.
- (c) Other Type B test specimens shall be marked 75 mm from the top.
- (d) Type C test specimens shall be marked 20 mm and 120 mm from the top.

6.3 Directional properties

If there is any directional effect in the surface texture of the material, test specimens shall be tested in each direction. If there is anisotropy in the material, test specimens shall be tested in each direction. All surfaces of the test specimens shall be smooth and free from fuzz, burrs or cutting dust.

6.4 Conditioning

Unless otherwise agreed or specified, all test specimens shall be conditioned in accordance with AS 1327, at $23 \pm 2^\circ\text{C}$ and 50 ± 5 % relative humidity for a minimum period of 24 h and only moved to the testing location immediately prior to testing.

7 CALIBRATION OF GAS MEASURING DEVICES

Where flow control devices are used to determine the oxygen concentration in the atmosphere, these shall be calibrated at not less than six-monthly intervals against a water-sealed rotating drum meter (a wet-test meter) or other equivalent calibration device.

Where an oxygen analyser is used, standard oxygen/nitrogen mixtures shall be used for calibration.

8 TEST PROCEDURE

The procedure shall be as follows:

- (a) Each day after elimination of all the gas leaks from the system, check the calibration of the apparatus by the use of a material whose minimum oxygen concentration for flame propagation has been previously determined.
- (b) The specimen holder should be approximately concentric inside the glass column. Clamp a test specimen vertically in the specimen holder with the top of the test specimen at least 100 mm below the top of the open column. If a restricted opening column is used, the top of the test specimen should be at least 40 mm below the opening.
- (c) Ensure that the gas flow rate in the column is equivalent to 40 ± 10 mm/s calculated at 0°C and 101.3 kPa pressure.
- (d) The selection of the desired initial concentration of oxygen should be based on experience with similar materials. If there is no experience with similar materials, ignite a test specimen in the air and note the burning. If the specimen burns rapidly, a starting concentration of about 18% oxygen should be selected; however, if the specimen goes out, a concentration of about 25% oxygen or higher, depending upon the difficulty of ignition and time of burning, should be used.
- (e) Purge the system with the selected gas mixture for a minimum of 30 s and measure and record the temperature of the gas in the glass column.
- (f) Lower the igniter on to the test specimen, with the longer axes of the igniter head and test specimen cross-section coincident (see Figure 4), and the igniter held in contact at the top for the following period:
 - (i) For Type A test specimens the ignition time shall be 10 s. If this is insufficient, increase the time in increments of 5 s. Successive determinations on the same material shall use the same ignition time.

NOTE: For thermoplastics materials, ignition times greater than 30 s are wasteful of material.
 - (ii) For Type B test specimens that 'shrink' from the igniter head, pursue the retreating material to the 20 mm mark and then withdraw the igniter. Other Type B test specimens are usually well ignited in 2 to 5 s. In such cases, remove the igniter when the entire top surface is burning.
 - (iii) For Type C test specimens, move the igniter across the top to ensure that the entire top of the test specimen is burning. The test specimen is considered to be well alight when the flame front passes the 20 mm reference mark.

After ignition has been achieved, gently remove the igniter from the test specimen in order to avoid turbulence or adhesion of the molten material to the igniter, both of which may cause extinction of the flame.

Remove any residual material remaining on the silica tube before subsequent ignitions are carried out.