

British Standard Methods of testing

Plastics

Part 1. Thermal properties

Methods 143A and 143B. Determination of Flammability Temperature of materials

Méthodes d'essai des plastiques

Partie 1. Propriétés thermiques

Méthodes 143A et 143B. Détermination de la température d'inflammation
des matériaux

Verfahren zur Prüfung von Kunststoffen

Teil 1. Thermische Eigenschaften

Verfahren 143A und 143B. Bestimmung der Zündtemperatur von Werkstoffen

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

These small-scale laboratory tests are primarily for assistance in development and/or monitoring consistency of production of plastics materials and are not for use as a sole means of assessing the potential fire hazard of a material in use.

Contents

		Page
	5 Typical specimen holder and transfer tool showing the method for supporting the test specimen	10
	6 Method of test specimen support	11
Foreword	Front cover	
Committees responsible	Back page	
Methods		
1 Scope	2	
2 Definitions	2	
3 Principle	2	
4 Apparatus	2	
5 Calibration of equipment	3	
6 Test specimens	3	
7 Procedure for Method 143A. Measurement of Flammability Temperature	4	
8 Procedure for Method 143B. Comparison with a specified Flammability Temperature	5	
9 Test report	5	
Tables		
1 Criteria for establishing Flammability Temperature		
2 Dimensions of test specimen		
3 Alternative dimensions of sampled specimens		
Figures		
1 Typical test chimney	6	
2 Typical preheater and base assembly for test chimney	7	
3 Typical chimney outlet restrictor	8	
4 Typical apparatus for determining Flammability Temperature	9	

Foreword

These methods have been prepared under the direction of the Plastics Standards Policy Committee. They describe equipment and a basic procedure (Method 143A) 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 (FT). An abbreviated isothermal procedure (Method 143B) for assessing whether or not the FT of a material is above a particular temperature is also described.

The combustion conditions selected are specific to these particular tests, and correlation with flammability of a material under other conditions or in uncontrolled fires is not implied. The tests provide an indication of the ignitability of a material at elevated temperatures.

Methods 143A and 143B comprise a pair of a group of methods described in BS 2782 for determining the burning characteristics of plastics. The group includes Method 141, 'Determination of flammability by oxygen index', with which the methods described here have some features in common but their scope is not intended to be restricted thereto. Methods 143A and 143B have been developed from a method prepared by GEL/3/33 for testing materials for electric cables to encompass both plastics and rubbers. Again, Methods 143A and 143B are not necessarily restricted in scope even to these, but they are considered

to be applicable to such materials whether or not these materials are intended for electrical applications. These methods therefore are published as general methods in BS 2782 to enable cross-reference for testing not only electrical insulation materials or samples but also for a wider variety of purposes for which Method 143A may be suitable for research and development and for quality control purposes and Method 143B may be convenient for quality control purposes for assessing whether the FT of a material is above a specified minimum value.

Warning note. These methods do 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 methods should be operated only by trained personnel. In particular, provision should be made to protect personnel from fumes or burns which may evolve from burning or smouldering materials.

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

1 Scope

This method describes a procedure (Method 143A) for determining the temperature at which the oxygen index (see note 1) of small vertical test specimens in air is 20.9 under specified test conditions involving burning in air. The result is defined as the Flammability Temperature (FT) and the method is limited to the determination of results less than 400 °C.*

The method is suitable for testing plastics or other materials that are self-supporting in the form of vertical bars of 3.00 ± 0.25 mm thickness at room temperature although not necessarily self-supporting at the temperature of the test. The method includes provision for testing specimens of other dimensions when necessary, but results obtained from test specimens of differing thickness may not be comparable. The method is not applicable to materials having an oxygen index (see note 1) of ≤ 20.9 when measured at 23 °C.

FT results obtained using this method can provide a sensitive measure of the burning characteristics of materials under certain controlled laboratory conditions and hence may be useful for research and development or quality control purposes, but no correlation with flammability behaviour under other fire conditions is implied.

An abbreviated procedure for testing at a selected temperature (Method 143B) is also given for convenience in assessing whether or not the FT of a material is above a particular temperature.

NOTE 1. For the definition of oxygen index and for the method for determining oxygen index at 23 °C, see BS 2782 : Method 141.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back page.

2 Definitions

For the purposes of this standard the following definition applies.

Flammability Temperature (FT). The temperature at which combustion of a material is just supported in air under specified test conditions.

3 Principle

The temperature at which the oxygen index of a material in air flowing upwards in a test column is 20.9 is determined under equilibrium conditions of candle-like burning. The equilibrium is established by the relation between the heat generated from the combustion of a test piece and the heat lost to the surroundings as measured by one of two arbitrary criteria, namely a period of burning or a length of test piece burned.

The specific criteria, either of which may be exceeded to establish the FT, are given in table 1.

Table 1. Criteria for establishing Flammability Temperature		
Type of combustion	Period of burning after ignition	Length of test piece burnt after ignition
Flaming	s 180	mm 50

4 Apparatus

4.1 *General.* The following apparatus shall be arranged as shown in figures 1, 2, 3, 4 and 5 as applicable.

4.2 *Test chimney.* The test chimney (figure 1) shall comprise two concentric heat-resistant glass tubes, where the inner one has an internal diameter of 75 mm and a height of 450 mm and the outer one has an internal diameter of 95 mm and is the same height as the inner tube. A nickel chromium alloy wire†, complying with Class C5 of BS 115 : 1954, is wound on to the outer surface of the inner tube to form the chimney heater. The windings are graded, i.e. close together at the top becoming farther apart towards the bottom of the tube, to provide a minimum temperature gradient over the length of the space occupied by the test specimen. The outer tube serves to shield the inner tube from draughts. All gas entering the base of the inner tube passes through a preheater (figure 2) comprising a nickel chromium alloy wound element mounted in a coarse porous plug for discharging uniformly heated gas mixtures into the chimney. If the incoming gas mixture has not been premixed, for example is derived from separate oxygen and nitrogen supplies, the bottom of the inner tube, or the

* At temperatures above 300 °C it may not be possible to achieve the accuracy of temperature control stated in this method and the overall accuracy of the determination may be reduced.

† For information on the availability of wires referred to in this standard, apply to Central Enquiries Section, BSI, 389 Chiswick Road, Uxbridge, Middlesex, U.K. or to the nearest BSI branch office.

base to which it is attached, contains a non-combustible porous material to mix and distribute evenly the gases entering the tube. Glass beads of 3.5 mm diameter in a bed 80 mm to 100 mm deep have been found suitable but other mixing devices are acceptable.

Independent electrical regulating circuits shall be provided for the chimney heater and preheater and the test chimney shall contain a movable thermocouple by which the temperature of the space occupied by the test specimen can be monitored or controlled so that the temperature in the vicinity of the specimen position in the chimney corresponds to the specified value within the applicable tolerance given in appendix B of BS 2782 : Part 0 : 1982. A wire screen may be mounted above the porous plug but below the level of the test specimen holder, to prevent falling combustion debris from fouling the gas entry paths.

NOTE 1. 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.

The concentric glass cylinders are held in position at the top and bottom by end plates made of a material that is heat-resistant and electrically insulating, for example inorganic fibre-reinforced composite. Both plates are suitably grooved and positioned with tie rods. These rods are correctly tensioned to allow for expansion of the glass under the conditions of temperature used in the column.

The outlet of the chimney shall be restricted by a metal overhead cap which converges to an outlet of 40 ± 5 mm diameter, 10 mm to 20 mm above the top of the chimney. A typical device is shown in figure 3 to complement the typical apparatus shown in figure 4.

NOTE 2. The metal cap is used to prevent the possibility of ambient air entering the column from the top.

4.3 Test specimen holder. This shall comprise means for supporting a test specimen vertically in the centre of the chimney so that the lowest exposed part of the test specimen is at least 100 mm above the top of the gas preheater and the top of the test specimen is at least 100 mm below the top of the chimney. Any small holding device that will support the test specimen at its base and hold it vertically in the centre of the chimney, as shown in figure 4, is acceptable. A small spring clamp supported by a tube concentric with the chimney is a suitable device. The profile of the holder and its supports shall be smooth, to minimize induction of turbulence in the rising air.

NOTE. It is recommended that a test specimen holder transfer tool be used to position the test specimen holder inside the test chimney. A typical device is shown in figure 5.

4.4 Gas supplies

4.4.1 Air. The gas mixture required for the test chimney is clean, dry air. Air contains 20.9 % (V/V) oxygen. The moisture content of the air entering the test chimney shall be less than 0.5 % (m/m).

Metering and control devices shall be used which will measure and control the flow of air to comply with 7.2.

4.4.2 Propane. A supply of propane is required for the ignition source (see 4.5).

4.5 Ignition source. This shall comprise a tube that can be

inserted into the chimney to apply to the test piece a flame issuing from an outlet of 2 ± 1 mm internal diameter at the end of the tube. The fuel shall be propane, without premixed air. The fuel supply shall be adjusted so that a luminous flame will project to 16 ± 2 mm vertically downwards from the outlet when the tube is vertical and the flame is burning in still air outside the chimney.

4.6 Timing device. This shall be any device capable of measuring for at least 5 min and accurate to ± 0.2 s.

4.7 Fume extraction system. This shall comprise a hood or other facility installed above the chimney to provide just sufficient exhaust to ensure the removal of fumes, soot and other noxious products without interfering with the gas flow or temperature in the chimney.

NOTE. If soot-generating materials are being tested, the glass chimney may require cleaning to maintain good visibility. The temperature sensor and gas inlet bed or screen may also require cleaning to function properly. Adequate precautions should be taken to protect the operator from noxious materials or burns during testing or cleaning operations.

5 Calibration of equipment

5.1 Air flow rate indicator

The system for indicating the air flow rate through the chimney shall be checked at intervals of not more than 6 months, using a water-sealed rotating drum meter (wet test meter) or an equivalent device with an accuracy equivalent to ± 0.8 mm/s flow rate through the chimney. Routine checks shall be performed on all joints for leaks.

NOTE. Attention is drawn to the fact that the accuracy specified is more stringent than that required for the corresponding calibration of equipment in accordance with annex A of BS 2782 : Method 141 : 1986. This is because a closer tolerance on flow rate is considered to be necessary for testing materials at elevated temperatures in accordance with Methods 143A or 143B.

5.2 Temperature indicators

An independently calibrated instrument shall be used at intervals of not more than 6 months to check that temperature control and indicating devices enable the equipment to comply with 4.2.

6 Test specimens

6.1 Number and dimensions

For Method 143A (see clause 7), at least 10 test specimens shall be provided. For Method 143B (see clause 8), at least three test specimens shall be provided. The test specimens shall be moulded or cut from the material to be tested. Where this is not possible, for example with a cross-linked product, a moulded and cross-linked slab shall be prepared from material sampled during manufacture of the same production batch.

If possible, the dimensions of a test specimen shall comply with the limits given in table 2 (see note 1). Otherwise, for the purpose of testing moulded sheet of different thickness to that specified in table 2, or samples cut from finished articles (for example, extruded cable sheath) dimensions of a sampled specimen shall comply with the limits given in table 3.

Table 2. Dimensions of test specimen

Thickness	Width	Length
mm 3.0 ± 0.25	mm 6.5 ± 0.5	mm 70 to 150

Table 3. Alternative dimensions of sampled specimens (see note 1 to 6.1)

Thickness	Width	Length
mm ≤ 3.25	mm 6.5 ± 0.5	mm 70 to 150
> 3.25	As necessary to give a cross-sectional area of 20 ± 2 mm ² (see note 1 to 6.1)	

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 0.55 ± 0.05 mm diameter nickel chromium alloy wire complying with Class C5 of BS 115 : 1954 and secured by ties of copper wire of 0.20 ± 0.02 mm diameter. These shall be positioned as shown in figure 6.

NOTE 1. FT results from test specimens of differing dimensions may be different and therefore not comparable.

NOTE 2. For anisotropic materials, the direction of anisotropy may affect the result and should therefore be evaluated, unless a particular direction has previously been agreed upon.

6.2 Preparation

The edges of the test specimens shall be smooth and free from fuzz or burrs of material from machining or peripheral flash from moulding.

6.3 Marking

Test specimens shall be marked on at least two adjacent faces with transverse lines in a contrasting colour to assist in monitoring when the flame propagation exceeds the relevant criterion. If wet inks are used, the marks shall be allowed to dry prior to igniting the test specimen.

One mark shall be provided 50 mm from the upper end of the test specimen to be ignited.

6.4 Conditioning

Test specimens shall be conditioned at 23 ± 2 °C and (50 ± 5) % r.h. for at least 8 h immediately prior to use.

WARNING NOTE. Samples of cellular materials that initially may contain volatile flammable material, for example, expanded polystyrene produced by extrusion using a hydrocarbon as a blowing agent, should be purged of such volatile material prior to conditioning at 23 °C and 50 % r.h. Such test specimens may be purged satisfactorily by preconditioning in a suitable ventilated oven for 168 h. Larger blocks of such materials may require

longer pretreatment. It is essential that facilities for cutting specimens from cellular material that may contain volatile flammable material be adequate for the hazards involved.

NOTE. For many materials, less vigorous conditioning than that specified here would be sufficient and should be given in the appropriate British Standard.

7 Procedure for Method 143A. Measurement of Flammability Temperature

NOTE. For an abbreviated procedure to check for comparison with a specified FT value, see clause 8 (Method 143B).

7.1 Maintain the room or enclosure used for the test at ambient conditions of 23 ± 2 °C and (50 ± 5) % r.h., unless each test specimen is conditioned in accordance with 6.4 until immediately prior to use, in which case ambient humidity control to (50 ± 5) % r.h. is optional.

7.2 Set the flow controls so that air is flowing through the chimney at a mean gas velocity of 40 ± 0.8 mm/s when measured at 23 ± 2 °C. The test is then carried out using this setting.

NOTE. The mean gas velocity or flow rate (F) at 23 ± 2 °C may be estimated, in mm/s, from the following equation:

$$F = 1.27 \times 10^6 \left(\frac{V}{d^2} \right)$$

where

V is the total gas flow rate through the chimney (in L/s);

d is the internal diameter of the chimney (in mm).

7.3 Allow the gas mixture to flow for at least 30 s to purge the system.

7.4 Set the column temperature at a desired value using the column and preheater controls (see note). Using the thermocouple, adjust the controls to obtain a temperature gradient of less than 5 °C between the position of the top of the test specimen and 50 mm below this position. Resite the thermocouple 25 mm below the top of the test specimen. Allow the temperature to stabilize.

NOTE. The adjustment of these independent controls should be such that the preheater raises the incoming air temperature at the base of the column to approximately that of the column itself. The use of widely differing settings between preheater and column temperatures can contribute to variation in the FT value obtained.

7.5 Using a test specimen holder preheated to the column temperature, insert a test specimen in the test specimen holder and place this in the chimney using the transfer tool. With the thermocouple positioned so that it is immediately adjacent to, but not touching, the test specimen, as shown in figure 4, leave the apparatus for 240 ± 10 s, to permit temperature stabilization, and then record the indicated air temperature.

If the recorded air temperature after stabilization is greater than 10 °C different from the temperature set in 7.4, repeat the procedures of 7.4 and 7.5 (see notes). If otherwise, move the thermocouple away from the specimen and proceed immediately in accordance with 7.6.

NOTE 1. It may be helpful also to preheat the transfer tool if an excessive temperature difference is induced by a chilling effect from that tool.

NOTE 2. Use of periods other than 240 ± 10 s between introduction of the test specimen and the initial application of the igniter in accordance with 7.6 may lead to non-comparable results when testing materials for which the FT is sensitive to the period of exposure to elevated temperatures.

7.6 Apply the ignition source (see 4.5) so that approximately 6 mm of the flame impinges on the top of the test specimen. As the test specimen burns, lower the ignition source to maintain the flame impingement of approximately 6 mm. Apply the flame for 15 ± 1 s to ignite the test specimen. Upon removal of the ignition flame, start the timer.

7.7 Do not adjust any of the controls after ignition of the test specimen.

NOTE. It may be helpful to perform preliminary tests during which the temperature is varied to establish an approximate value for the FT. Results of such tests should not be included in the estimation of FT.

7.8 Observe the burning behaviour of the test specimen. Record whether the flame is extinguished before either of the relevant criteria from table 1 is satisfied, i.e. the minimum period of burning is exceeded or the minimum length of the test specimen is burnt. Alternatively, when either of the criteria is exceeded, snuff out the flame and record the response of the test specimen.

7.9 Remove the test specimen used and any debris.

7.10 Depending upon the behaviour of the preceding test specimens, select the temperature for the following burn. Reduce the temperature if the burning of the test specimen exceeded either the period or the length specified (see table 1) or increase the temperature if neither criterion was exceeded.

7.11 Continue repeating the procedure from 7.3 to 7.10 inclusive until the FT is established, to within an increment of 5°C , as the lowest column temperature as recorded in 7.5 at which the test specimen exceeds at least one of the test criteria.

NOTE. Increments of $> 5^\circ\text{C}$ may be used to establish an approximate value of FT.

7.12 Determine at least three values for the FT of the material by carrying out the procedure from 7.3 to 7.11 inclusive at least three times.

7.13 Calculate and record the FT of the material as the mean value of the three or more values determined in accordance with 7.12. Express it as the mean value when rounded to the nearest 1°C , with an exactly intermediate result being rounded downwards.

8 Procedure for Method 143B. Comparison with a specified Flammability Temperature

NOTE. If it is required to check, for example, that the FT of a material complies with a minimum specified value, then the following abbreviated procedure can be used. In case of dispute or for determining the actual FT of a material, however, attention is drawn to Method 143A.

8.1 Depending upon the results obtained (see 8.2), test up to three test specimens using the procedure given in 7.1 to 7.9 except that for the purposes of 7.5 the maximum acceptable temperature difference, from the specified value, is reduced from 10°C to 5°C .

8.2 If for at least two from three test specimens tested in accordance with 8.1 the flame is extinguished before either of the relevant criteria from table 1 is exceeded, record that the FT of the material is not less than the specified value.

9 Test report

The test report shall include the following information:

- (a) a reference to this British Standard and the method used, e.g. BS 2782 : Part 1 : Method 143A : 1989;
- (b) a statement that test results relate only to the behaviour of the test specimens under the conditions of this test and that these results must not be used to infer the fire hazards of the material in other forms or under other fire conditions;
- (c) identification of the material tested, including, where relevant, the type of material, previous history, and the test piece orientation with respect to any anisotropy in the material;
- (d) the test specimen dimensions;
- (e) the method of sample support, e.g. self-supporting or nickel chromium alloy wire;
- (f) for Method 143A, the FT;
- (g) for Method 143B, a statement to the effect that FT is or is not greater than the specified value of FT, as applicable;
- (h) a description of any relevant ancillary characteristics or behaviour such as charring, dripping, spalling, bending, erratic burning or afterglow;
- (j) any variations from the requirements of this method.