

# Determination of smoke emission from manufactured solid fuels for domestic use —

## Part 1: General method for determination of smoke emission rate

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# Committees responsible for this British Standard

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- Association of British Solid Fuel Appliances Manufacturers
- British Coal Corporation
- British Foundry Association
- Department of Health
- Department of the Environment (Her Majesty’s Inspectorate of Pollution)
- Department of Trade and Industry (Warren Spring Laboratory)
- Low Temperature Coal Distillers’ Association of Great Britain Ltd.
- METCOM
- Solid Smokeless Fuels Federation

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## Foreword

This Part of BS 3841 has been prepared under the direction of the Solid Mineral Fuels Standards Policy Committee. Together with BS 3841-2:1994 it supersedes BS 3841:1972 which is withdrawn.

The Clean Air Act 1956 [1], modified and extended by the Clean Air Act 1968 [2], was introduced to control air pollution in the United Kingdom.

Under Section 11 of the 1956 Act, local authorities are empowered, subject to confirmation by the Minister, to set up smoke control areas in which it is an offence to emit smoke from a building. The only defences against prosecution under the Act are that the smoke is produced from an authorized fuel, that authorized fuels are not available or that the smoke is from an exempted appliance.

An exempted appliance is defined by Section 11(4) of the 1956 Act as one which can be operated for burning a fuel other than an authorized fuel without producing any smoke or a substantial quantity of smoke.

An authorized fuel is defined in Section 34(1) of the 1956 Act as a fuel declared by regulations of the Minister to be an authorized fuel for the purposes of this Act. In 1956 a number of classes of solid smokeless fuel, both manufactured and natural, which pre-dated the Act were declared to be authorized fuels.

Subsequent development of other types of manufactured smokeless fuel for domestic purposes demonstrated the need for a standard procedure to establish their potential for smoke emission and to assess whether such fuels were suitable for authorization within the terms of the 1956 Act.

For this revision, BS 3841 has been divided into two Parts, Part 1 covering the fuel combustion procedure and Part 2 describing the smoke measurement equipment and its use. The main technical changes from the previous edition are as follows:

- a) extension of the test procedure to cover brown coal, lignite, peat and wood fuels;
- b) widening of the permitted tolerance in the second radiation peak for valid tests;
- c) modification of the refuelling procedure for long briquettes;
- d) provision of a suitable aerator to enable the gas ignition burner to burn natural gas;
- e) inclusion of the form of test report required;
- f) specification of a sampling method in a dilution tunnel as an alternative means of smoke measurement to the electrostatic precipitator;
- g) change of organic solvent for cleaning the precipitator;
- h) change of procedure for conditioning the precipitator; utilizing a constant temperature room (hot room);
- i) inclusion of safety precautions relating to the use of high voltage and of organic solvent in the operation of the precipitator.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

## Introduction

Smoke is defined in Section 34(1) of the Clean Air Act 1956 [1] as “including soot, ash, grit and gritty particles emitted in smoke”. This definition is modified by the 1968 Act [2] by the inclusion of fume. None of these terms is precisely defined within the Acts and therefore they are of little technical significance. It is clear from other parts of the Acts and related Statutory Instruments that smoke is to be assessed on the basis of its optical properties: it is often qualified by the use of “dark” or “black”. However, assessment of smoke emissions purely on the basis of light obscuration depends on many parameters including the particle size distribution of the emitted particles, their chemical composition and the lighting conditions at the time when the assessment is made (if it is in the open air). Assessment in these purely subjective terms is clearly unsatisfactory. Therefore, BS 3841 describes the gravimetric measurement of the particulate emission rate during a test carried out with the fire at an average radiation heat output chosen to be reasonably representative of normal domestic usage. Subsequently, an emission limit in gravimetric terms of 5 g/h was set by the Government.

The current test procedure relates particularly well to solid fuels manufactured from relatively high grade constituents. During recent years there have been many applications for the authorization of lower grade solid fuels such as peat, brown coal and fuels derived from waste materials such as wood waste, straw and paper.

This Part of BS 3841 describes a test procedure to provide the information necessary for a judgement to be made on the suitability of the fuel for classification as an authorized smokeless fuel on the basis of the 5 g/h emission limit and, if necessary, in terms of the concentration of particulate material emitted.

The procedure for authorization of a solid fuel is now well established. When a new solid smokeless fuel intended for use in a smoke control area has been developed, application is made to the Department of the Environment for authorization as a smokeless fuel. At this stage the smoke emission characteristics of a representative sample of the fuel would be determined in accordance with the procedure described in BS 3841. The average result of replicate determinations is compared with the emission limit.

The method is not suitable as a day-to-day quality control procedure because of its time-consuming nature and the expense incurred. Other procedures which are quicker and easier to carry out but possibly less precise have been developed for quality control purposes. Such methods are not absolute: the relationship between any such method and the reference method described in BS 3841 has to be determined and periodic checks and calibrations have to be carried out for each fuel.

## 1 Scope

This Part of BS 3841 describes a general method of carrying out a smoke emission test from a sample of a manufactured solid fuel intended for use in domestic fires.

## 2 References

### 2.1 Normative references

This Part of BS 3841 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Part of BS 3841 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

### 2.2 Informative references

This Part of BS 3841 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

## 3 Definitions

For the purposes of this Part of BS 3841 the definitions given in BS 1846-1:1968, BS 6100-1.5.1:1984 and BS 3323:1992 apply.

## 4 Principle

A specified ignition charge of the prepared fuel, the mass depending upon its bulk density, is charged into a standard design of open fire setting and ignited with gas. As the fuel burns the radiation heat output rises to a maximum (the first radiation peak) and then starts to drop. When it has fallen to a specified level a refuelling charge, again the mass depending upon the bulk density of the fuel, is added. The radiation heat output again rises to a maximum (the second radiation peak) and then starts to drop. The setting of the air control system of the fire is adjusted so that the value of the second radiation peak falls within the range 1.80 kW to 2.30 kW.

When the radiation heat output has fallen to a specified level after the second radiation peak a second refuelling charge, equal in mass to the first, is added to the fire. If the bulk density of the fuel is below  $480 \text{ kg/m}^3$ , a third refuelling charge, of the same mass as the first and second, is added after the radiation heat output has fallen to a specified level after the third radiation peak.

The mass of smoke emitted during the burning of the two, or three, refuelling charges is determined by one of the methods described in BS 3841-2 or by any other method which has been demonstrated to give equivalent results. The duration of the test period is taken as the time interval between the addition of the first refuelling charge and the falling of the radiation heat output to the level which is specified for refuelling, after the third or fourth radiation peak (depending upon whether there have been two or three refuelling charges). The result is expressed as the mass of smoke emitted per unit time, averaged over the duration of the test period.

NOTE Further information on the basis of the test method is given in Annex A.

## 5 Apparatus

**5.1 Smoke measurement equipment**, as required for the method of measurement of smoke emission rate (see 10.3.3).

**5.2 BCURA (British Coal Utilization Research Association) quadrant radiometer<sup>1)</sup>**, for measuring the radiation heat output from the fire. The radiometer shall consist of the upper section of a hemispherical cage fitted with a matched set of radiometer elements. The calibration factor  $F$ , in kilowatts per millivolt, is initially provided by the supplier of the radiometer and shall be redetermined at intervals not exceeding 24 months.

**5.3 Balance**, for weighing the fuel, with a capacity of at least 10 kg and an accuracy of  $\pm 0.01 \text{ kg}$ .

**5.4 Calibrated dry gas meter**, for measuring the total volume of gas supplied to the ignition burner, with an accuracy of  $\pm 0.1 \text{ dm}^3$ . The calibration shall be traceable to national standards and shall be carried out under the pressure conditions of the test.

**5.5 Indicating gas flowmeter**, for checking the rate of flow of gas supplied to the ignition burner, with a range of  $0.04 \text{ dm}^3/\text{s}$  to  $0.4 \text{ dm}^3/\text{s}$ .

**5.6 Manometer**, for measuring the pressure of the gas supply to the ignition burner, with a range covering 0 kPa to 2.5 kPa and an accuracy of  $\pm 0.0025 \text{ kPa}$ .

**5.7 Thermocouple or other temperature measurement device**, for measuring the temperature of the gas supply to the ignition burner, with a calibration traceable to national standards.

**5.8 Poker**, for de-ashing the fire, with a diameter of not more than 10 mm at the end which is inserted into the fire.

**5.9 Timing device**, accurate to within  $\pm 1 \text{ s}$  over the duration of the test.

## 6 Test chimney and setting

### 6.1 Test chimney

The test chimney shall be constructed in accordance with Figure 1. The chimney shall terminate within the test laboratory at a height of  $4\,570 \text{ mm} \pm 25 \text{ mm}$  above finished hearth level.

An extraction system shall be provided for collecting the flue gas from the top of the chimney and discharging it to outside air.

NOTE The design of the system depends on the method of smoke measurement: the arrangements when using the electrostatic precipitator and dilution tunnel methods are described in 3.2.1 and 4.2.11 respectively of BS 3841-2:1994.

### 6.2 Test setting

The test setting shall be constructed as shown in Figure 2. The fireback shall conform to BS 1251:1987.

NOTE 1 The number of parts of the fireback is left to individual choice.

The rear surface of the throat shall be formed above the fireback in the manner shown in Figure 2, i.e. without a smoke shelf. The line of the upper surface of the fireback shall be followed for approximately 100 mm and the throat then sloped off at an angle of approximately  $45^\circ$  to meet the brickwork at the rear of the chimney, yielding a throat width of approximately 115 mm.

<sup>1)</sup> For information on the availability of BCURA radiometers and calibrated radiometer elements write to Customer Services, Information, BSI, Linford Wood, Milton Keynes MK14 6LE.