

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

Part 2: Methods for measuring the smoke emission rate

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 Together with BS 3841-1:1993 it supersedes BS 3841:1972 which is withdrawn.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, Parts 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 (see Annex A);
- 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 20, 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.

0 Introduction

BS 3841-1 describes the general procedure to be adopted for measuring the smoke emissions from solid smokeless fuels. This Part of BS 3841 describes procedures for measuring the smoke emission rate (in g/h) under the combustion conditions specified in Part 1.

The electrostatic precipitator method was developed for the purpose of collecting and measuring the smoke from domestic appliances burning solid fuel. The precipitator collects the particulate matter from the total volume of flue gas produced by the fire during the test period. The total mass of smoke emitted during the test period is determined by weighing the precipitator at the beginning and end of the test.

The dilution tunnel method involves sampling isokinetically from a duct above the test chimney. This technique is widely used internationally.

Both methods have been shown to be capable of measuring in the range 0.5 g/h to 30 g/h. The two methods give results in close agreement (see Annex A).

1 Scope

This Part of BS 3841 describes an electrostatic precipitator method and a dilution tunnel method for measuring the smoke emission rate from a manufactured solid fuel tested in accordance with BS 3841-1:1994.

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 Electrostatic precipitator method for smoke emission rate measurement

3.1 Principle

The instrument used is an electrostatic precipitator developed for the purpose of collecting and measuring the smoke from domestic appliances burning solid fuel. It is placed on top of the laboratory test chimney and removes the smoke from the whole of the flue gas with minimal resistance to flow. The total mass of smoke emitted during a test period is determined by weighing the instrument at the beginning and the end of the test.

NOTE The precipitator has been shown to have the requisite efficiency of smoke collection for testing manufactured solid fuels in accordance with BS 3841-1 and was used in the experimental work leading to the formulation of BS 3841.

3.2 Apparatus

3.2.1 Electrostatic precipitator, comprising a single stage multi-tube unit, constructed as shown in Figure 1 to Figure 4. The main components of the assembly shall be as follows.

- a) *Collecting electrodes*. The collecting electrodes (1) (see Figure 1) shall be made of hexagonal tube of 0.7 mm thick aluminium alloy, having external dimensions of 30 mm across the flats, assembled in a honeycomb consisting of 85 passages, as shown in the plan view. By utilizing the outside of some of the tubes as collecting surfaces, the assembly shall be made up of 66 individual tubes, 457 mm long. The ends of the tubes shall be argon-arc welded together and the tube assembly shall be welded to a 356 mm diameter base plate and 330 mm diameter top plate. Both end plates shall be flanged and shall be of 1.6 mm thick aluminium alloy. A 102 mm high aluminium alloy skirt (2) of diameter 360 mm shall be bolted to the flange on the base plate. The skirt shall contain two 6 mm swages approximately 51 mm apart, the lower one being 29 mm from the base of the skirt.
- b) *Charged electrodes*. The charged electrodes (10) (see Figure 1) shall be made of hard-drawn stainless steel wire of 0.15 mm diameter, and shall pass along the vertical axis of each tube. They shall be spring loaded and shall be attached to suspension hooks (8) on a supporting framework at each end of the tube assembly.

c) *Supporting frames.* The supporting frames (4) and (5) shall be as shown in Figure 1 and Figure 2. Each frame shall be made up of 22 aluminium alloy strips of width 13 mm and thickness 1.6 mm. The strips shall be slotted together into a lattice (see Figure 2) resulting in 85 junctions at which the suspension hooks (8) clip on. The frames shall be strengthened by 12 mm × 12 mm aluminium angle of thickness 3 mm formed into a ring, butt welded and then welded round the periphery of the lattice. The top frame shall be attached to the main frame by 13 mm × 13 mm insulators, for example of compressed mica-filled phenolformaldehyde (3). For the lower supporting frame, the insulators shall be held at an angle of 45° to the vertical by mounting brackets made from 1.6 mm thick aluminium (6) and (7), the insulators passing through 32 mm diameter holes in the skirt.

NOTE Details of the method of fixing are shown in Figure 3. The precipitator shall be positioned for smoke collection as shown in Figure 4.

A 610 mm × 610 mm mild steel sealing plate shall be attached to the top of the square section test chimney to form the base of a safety cage. In the centre of this plate a hole shall be cut, 330 mm in diameter. A locating ring of internal diameter 370 mm shall be made up from 25 mm × 3 mm mild steel strip, located centrally on the base plate and fastened by a suitable means such as tack welding. When in position for smoke collection, the precipitator shall stand inside the locating ring.

A collecting hood shall be positioned above the precipitator and connected by ducting to a fan discharging to outside air. A damper shall be provided in the extraction ducting to enable the suction exerted by the fan to be varied.

3.2.2 Extra-high tension (EHT) power unit, capable of providing a continuously variable output voltage of 0 kV to 12 kV at 50 mA continuous rating. The output shall be d.c. negative to earth, with a ripple content of not more than 1 %. Meters shall be provided for reading the output voltage and the current on a meter scale of approximately 125 mm. The meters shall be at the final stage of the output of the circuit in order that internal tracking current, which increases with the usage of the equipment, is not measured. An overload protection device shall be incorporated to safeguard the components of the unit against short-circuiting at the output terminals. This device shall be so designed as to switch off the mains power supply to the unit and to provide an audible warning signal; an interlock shall be provided to ensure that the overload protection device cannot be reset until the voltage control has been returned to zero.

The leads from the power unit shall be connected to the electrostatic precipitator by means of suitably sized crocodile clips, the negative conductor being attached to the top supporting frame [see 3.2.1 c)] and the positive conductor, which is at earth potential, to the top plate [see 3.2.1 a)].

WARNING. It is essential that adequate precautions be taken to prevent personnel who are operating the equipment from coming into contact with the high voltage. Suitable equipment consists of an earthed metal cage with a gate, surrounding the precipitator when in position for smoke collection. With this method a safety lock should be attached to the gate in the cage, with an interlocking arrangement to the EHT unit which ensures that the unit can be turned on only when the gate is closed.

A reliable independent earth should be provided for the collecting hood in the flue gas extraction system (see 3.2.1) and for the safety cage described above. The EHT unit itself should be built into a totally enclosed cabinet which is also earthed.

3.2.3 Means for discharging the precipitator

NOTE This should preferably be an automatic shorting device, e.g. linked to the mechanism for opening the gate on the safety cage. Alternatively the precipitator may be discharged manually, a suitable design of earthing tool being shown in Figure 5.

3.2.4 Electrically heated, thermostatically controlled oven, for drying the precipitator and evaporating any residual solvent after cleaning (see 3.3.1). The oven shall be fitted with a control dial that indicates the set oven temperature within a range of at least 20 °C to 120 °C, with an accuracy of ± 2 K.

NOTE 1 Essential safety precautions for the design and use of the oven are given in 3.4.1.

NOTE 2 The most suitable size of oven depends on the number of test chimneys and the frequency of testing. It is recommended that the oven should be able to hold two precipitators per test chimney.

3.2.5 Temperature-controlled room (hot room), for conditioning the electrostatic precipitator before use (see 3.3.2). The room shall be heated by tubular electric convector heaters and shall be thermostatically controlled at an average temperature between 32 °C and 35 °C with a fluctuation of less than ± 3 K about the mean temperature.

The room shall have enough floor space for the balance specified in 3.2.6 and sufficient storage space for all the precipitators in regular use in the test laboratory.

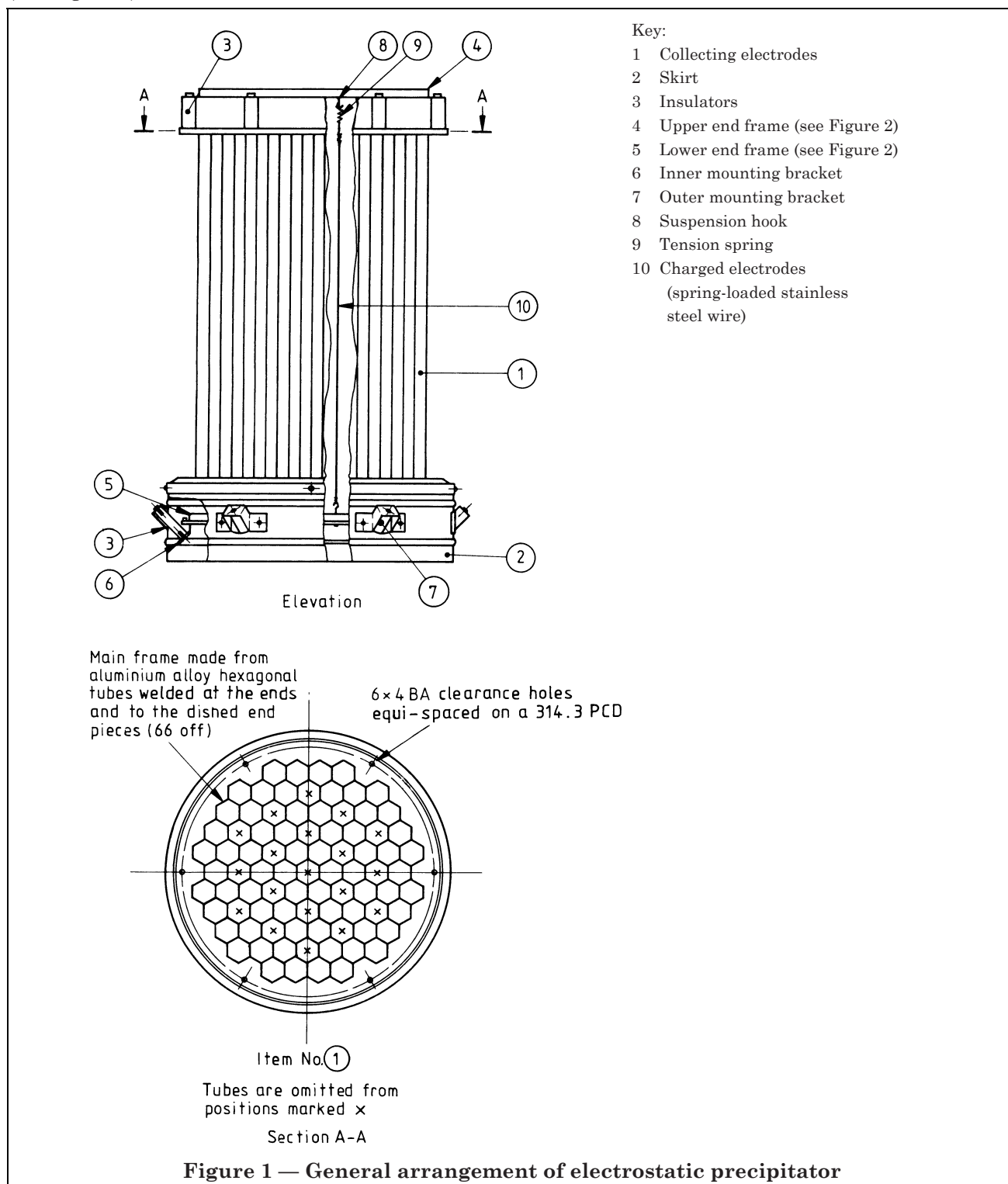
3.2.6 Balance, for weighing the precipitator, having a capacity of approximately 10 kg with an accuracy of ± 0.05 g. The balance shall be sited inside the hot room (3.2.5), in a position which is free from vibration and draughts.

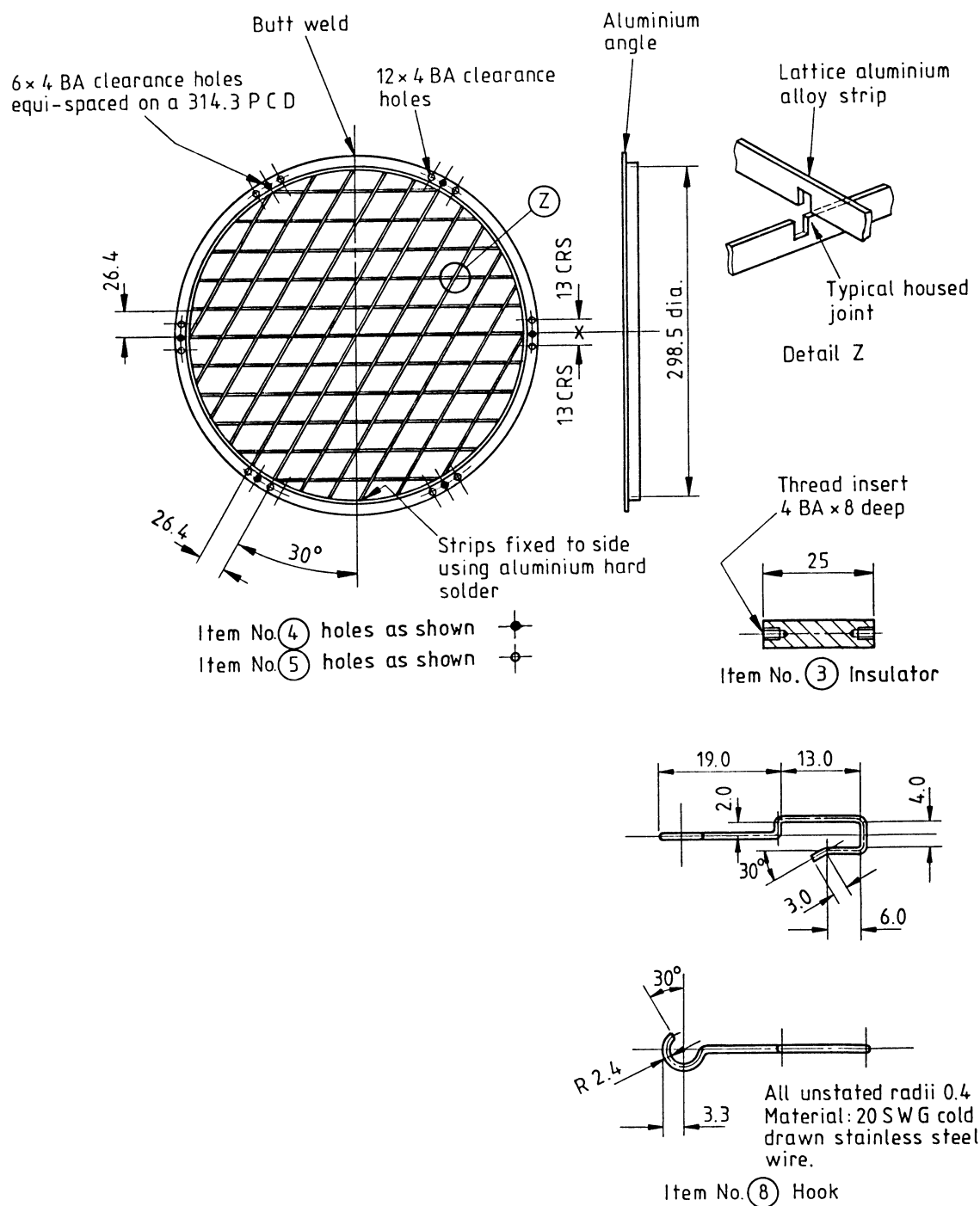
3.2.7 Pressure gauge, capable of measuring a pressure differential with respect to atmosphere in the range 0 kPa to 0.01 kPa with a minimum accuracy of ± 0.00025 kPa.

The gauge shall be connected to a static pressure tapping point in the flue just below the precipitator (see Figure 4).

3.2.8 High pressure water lance, for cleaning the precipitator.

NOTE A suitable design operates at approximately 7 000 kPa with a jet angle of 30° and has facilities for injecting detergent into the stream, the precipitator being washed on a sloping surface draining to waste.





NOTE 1 Lattice arrangement ensures that when frames are in position, the junctions are in line with the centres of the precipitator tubes.

NOTE 2 See Figure 1 for key.

Figure 2 — Supporting frame of electrostatic precipitator