

METHODS FOR THE SIZE ANALYSIS OF COAL AND COKE

B.S. 1293 & 2074 : 1965



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THIS BRITISH STANDARD, having been approved by the Solid Fuel Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 17th December, 1965.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

A complete list of British Standards, numbering over 4000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, price 15s. The B.S. Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

- B.S. 410. Test sieves.
- B.S. 792. Mild steel dustbins.
- B.S. 1016. Methods for the analysis and testing of coal and coke.
Part 13. Tests special to coke.
- B.S. 1017. The sampling of coal and coke.
Part 1. Sampling of coal.
Part 2. Sampling of coke.
- B.S. 1796. Methods for the use of British Standard fineness test sieves.
- B.S. 3142. Manufactured solid smokeless fuels for household use.
- B.S. 3323. Glossary of coal terms.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following B.S.I. references relate to the work on this standard:
Committee references SFE/45 and SFE/45/10
Draft for comment D64/1313

CONTENTS

Co-operating organizations	Page 4
Foreword	5

METHODS**SECTION ONE : GENERAL**

1. Scope	5
2. Introduction	5
3. Definitions	6
4. Precision	9

SECTION TWO : SIZE ANALYSIS OF COAL

5. Sampling	12
6. Procedure	15
7. Reporting of results	23
8. Preparation of samples for other purposes	23

SECTION THREE : SIZE ANALYSIS OF COKE

9. Sampling	27
10. Procedure	29
11. Reporting of results	31
12. Preparation of samples for other purposes	32

APPENDICES

A. Methods of checking sampling precision	34
B. Apparatus	41
C. Alternative forms of presentation of size analyses of coke	46

FIGURES

1. Nomogram for compounding sample for shatter or micum test	48
2. Test sieving machine for coke, side elevation	49
3. Vibrating-test sieving machine for coke	50
4. Test on sieving machine	51
5. Cumulative size distribution curve for run-of-oven coke	52

B.S. 1293 & 2074 : 1965

CO-OPERATING ORGANIZATIONS

The Solid Fuel Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- Association of Boiler Setters, Chimney and Furnace Constructors
- * Association of British Chemical Manufacturers
- Association of Consulting Engineers
- British Cast Iron Research Association
- British Chemical Plant Manufacturers' Association
- * British Coal Utilisation Research Association
- * British Coke Research Association
- * British Coking Industry Association
- British Electrical and Allied Manufacturers' Association
- * British Iron and Steel Federation
- British Ironfounders' Association
- British Mechanical Engineering Federation
- Chamber of Coal Traders
- Coal Utilisation Council
- * Coke Oven Managers' Association
- * Combustion Engineering Association
- * Confederation of British Industry
- Council of Ironfoundry Associations
- * Electricity Council, the Generating Board and Area Boards in England and Wales
- * Gas Council
- Heating and Ventilating Contractors Association
- * Imperial Chemical Industries Limited
- * Institute of British Foundrymen
- * Institute of Fuel
- Institution of Chemical Engineers
- * Institution of Gas Engineers
- Institution of Heating and Ventilating Engineers
- * Institution of Mechanical Engineers
- Iron and Steel Institute
- Low Temperature Coal Distillers' Association of Great Britain, Ltd.
- Ministry of Housing and Local Government
- Ministry of Power
- Ministry of Public Building and Works
- * National Coal Board
- Society of British Gas Industries
- Water-tube Boilermakers' Association
- Women's Advisory Council on Solid Fuel

The scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this standard:

- British Coal Exporters' Federation
- Cement Makers' Federation
- Coal Preparation Plant Association
- Institution of Electrical Engineers
- London Coal Exporters Association
- London Transport Board
- Society of Chemical Industry
- Solid Smokeless Fuels Federation
- South Wales Institute of Engineers

BRITISH STANDARD METHODS FOR THE SIZE ANALYSIS OF COAL AND COKE

FOREWORD

Since the publication in 1946 of B.S. 1293, 'Screen analysis of coal (other than pulverized coal) for performance and efficiency tests on industrial plant', and in 1954 of B.S. 2074, 'Size analysis of coke', evidence has been accumulated to show that some modification of the methods of size analysis described in these specifications, particularly in relation to the selection of samples, would be justified. The opportunity has therefore been taken, not only to revise these specifications and to incorporate them in a single British Standard, but also to provide the basis for international consideration of the techniques under the aegis of the International Organization for Standardization (ISO).

Section One of the present standard is of general application, Section Two deals with the size analysis of coal, originally in B.S. 1293, and Section Three with the size analysis of coke, originally in B.S. 2074.

METHODS

SECTION ONE: GENERAL

1. SCOPE

This British Standard describes the methods to be used for the size analysis of coal and coke.

2. INTRODUCTION

The methods for the size analysis of coal given in Section Two are based on those in B.S. 1293, but the opportunity has been taken of extending the specification to cover the size analysis of coal less than $\frac{3}{4}$ in top size. Further work has been carried out on the accuracy of sieving and on the size of sample needed.

This specification now covers all sizing tests that may be required and may be used equally to obtain complete size analysis of a run-of-mine coal or to determine the amount of undersize in a graded product. The size analysis of pulverized coal is not dealt with specifically as no sampling specification for such material is in existence. However, the procedures describing the use of fine mesh sieves are applicable and may be used.

In the course of a general review of the British Standards dealing with test methods for coal and coke, it was decided that the methods for size analysis and for the relevant sampling procedures should in future be incorporated in B.S. 1016 and B.S. 1017 respectively. The first stage of this process took place in March 1977 with the deletion of Clause 5 from this standard upon the publication of B.S. 1017 : Part 1 : 1977.

Although the methods of sampling recommended are based on those given in B.S. 1017*, attention is drawn to the precautions and differences necessary to ensure that degradation is reduced to a minimum during handling of the coal.

The methods for the size analysis of coke given in Section Three have similarly been modified as a result of extensive experimental work.

These two sections have been presented as far as practicable in the same

* B.S. 1017, 'The sampling of coal and coke', Part 1, 'Sampling of coal', Part 2, 'Sampling of coke'.

layout and information relating to both sections has been included in Section One and in the appendices.

3. DEFINITIONS

For the purposes of this standard the following definitions apply:

3.1 Sampling terms.

Unit of coal or coke. A supply of fuel (coal or coke) is regarded as made up of a series of units, some or all of which are selected for sampling so that each sample represents a particular unit. When a sample representative of a complete consignment is taken, the consignment itself is the unit.

Isolated consignment. A single consignment of fuel considered in isolation from any other consignment.

Increment. The quantity of fuel taken by a single operation of the sampling implement.

Sample. The total quantity of fuel collected over the sampling period from the unit whose properties are to be determined.

Sub-sample. Part of the sample consisting of a number of increments spaced evenly over the unit.

Regular sampling. The sampling of the same fuel received regularly at a given point. There are two forms of regular sampling, namely continuous sampling and intermittent sampling.

Continuous sampling. Taking a sample from each unit so that increments are taken at regular intervals whenever the fuel is handled at the point of sampling.

Intermittent sampling. Taking samples only from certain units of the fuel.

Replicate sampling. Taking each sample in a number of sub-samples, by putting increments in turn into different containers, in order to estimate the precision of sampling and size analysis.

Duplicate sampling. Taking each sample in two sub-samples, by putting alternate increments into two different containers, in order to estimate the precision of sampling and size analysis.

Sampling accuracy. The measure of the closeness with which a single sample represents the unit of fuel from which it is taken (see 'Accuracy').

Sample division. The process whereby a representative part of the sample is retained and the remainder rejected.

3.2 Statistical terms.

Accuracy (of a result). The closeness of agreement between an experimental result and the true value.

Accuracy (of a method). A measure of the ability of a method to provide accurate results, i.e. results which are close to the true value and free from bias. The accuracy of a method must not be confused with its precision (q.v.).

Precision. A measure of the ability of a method to yield reproducible results. If the method is precise, the standard deviation (q.v.) of a number of independent results obtained by the method is small.

A determination may be made with great precision, and the standard deviation of a number of determinations on the same consignment of fuel may therefore be low, but the results will only be accurate if they are free from bias (q.v.).

Bias. The tendency in some part of the procedure to obtain a value which is either persistently higher or persistently lower than the correct value.

If there is any possibility of bias, the words 'precision' and 'precise' are used instead of 'accuracy' and 'accurate'.

Range. The difference between the greatest and least values of a number of results.

Deviation. The difference between an experimental result and an arbitrary central value, usually the experimental mean value.

Variance. A measure of accuracy or precision, calculated as the sum of squares of deviations from the mean divided by one less than the number of results.

Standard deviation. A measure of accuracy or precision, calculated as the square root of the variance.

Numerical value of precision. For the purpose of this specification the numerical value of precision is taken to be ' $\pm 2 \times$ standard deviation'. This means that, if there is a 'normal' distribution of errors, the experimental results from a number of independent samples should agree with the mean value to within the stated precision in at least 95 cases out of 100.

Numerical value of bias. The numerical value of the difference between the true value and the average result obtained from a large number of determinations using a biased method.

3.3 General terms.

Screening: screens. The commercial operation of separating the smaller pieces of fuel from the larger by shaking or rolling the fuel over a surface provided with appropriately sized apertures; the screens used for that purpose.

Sieving: sieves. The laboratory or test operation of size analysis; the sieves used for that purpose.

NOTE. All references in this specification to sieves and sieving should be construed as references to British Standard sieves which fulfil the requirements of B.S. 410*.

Grading: graded fuel, sized fuel. The commercial operation of sorting fuel between two screens: fuel which has been so separated between specified size limits.

* B.S. 410, 'Test sieves'.

Nominal upper size. The smallest sieve size such that not more than 5 per cent of the fuel would be oversize.

Nominal lower size. The largest sieve size such that not more than 5 per cent of the fuel would be undersize.

Mean size. The calculated average size of the fuel (see Appendix C).

Size range. The range between the nominal upper size and the nominal lower size of the fuel (see Appendix C).

Hand placing. The operation in which the sieve remains stationary and each particle is handled; if a particle will, in some position and without forcing, pass through the sieve aperture, it is considered as undersize.

Hand shaking. The operation in which the test sieve is held in the hands, or suspended, and is shaken by hand at a rate just sufficient to cause the pieces of fuel to tumble or roll across the sieve.

Mechanical sieving. The operation in which a set of sieves is oscillated by mechanical means.

Wet sieving. A sieving operation in which liquid (usually water) is used to assist the passage of the undersize through the sieve apertures.

Dry sieving. Sieving without the aid of water.

3.4 Coal terms.

Large coal. Coal having a top size greater than 3 in*.

Small coal. Coal having a top size of 3 in or less*.

Run-of-mine coal. Coal as produced by mining operations and before preparation.

Through coal. Coal after passage through a screen of stated size.

Fines. Coal with a maximum particle size usually less than $\frac{1}{8}$ in (3.2 mm); also applied in a general sense to the content of fine material in a coal.

Pulverized coal. Coal reduced in size by grinding so that a high proportion will pass a fine sieve, e.g. a 200 mesh B.S. sieve.

3.5 Coke terms.

Oven coke. Coke produced by the carbonization of coal for the primary purpose of manufacturing coke.

Gas coke. Coke produced by the carbonization of coal for the primary purpose of manufacturing gas.

Low temperature coke. Coke produced by the carbonization of coal at low temperature, generally below 900°C.

Breeze. Coke of small size; the undersize remaining after separating the smallest size of graded coke.

* This definition is peculiar to this specification and differs from that in B.S. 1017, Part 1, which also differs from that given in B.S. 3323, 'Glossary of coal terms'.

4. PRECISION

4.1 Inherent bias. The sampling, preparation and sieving of samples of coal or coke will inevitably give rise to breakage, particularly in the larger sizes. This means that the proportions of the various sizes found in the sample will differ from those actually present in the main bulk of fuel from which the sample was taken. There is, therefore, an inherent bias in size analysis results and the terms 'precision' and 'precise' are used and not the terms 'accuracy' and 'accurate' (see Clause 3).

4.2 Levels of precision. The levels of precision selected are to some extent arbitrary, since the taking of more increments will normally give a better precision. Practical considerations, however, limit the number of increments that can be dealt with and it is necessary, therefore, to select a convenient number. The number chosen for the sampling of isolated consignments of coal in this standard is 40, as it has been shown that the errors due to sieving and sample division tend to offset the increase in precision that may be expected from increasing this number.

The levels of precision in Table 1, therefore, are those which should be obtained when testing the most difficult coals according to the procedures of Clauses 5 and 6. In the great majority of cases the precisions obtained will be much greater than those of Table 1 and, when replicate sampling procedures are used, Appendix 2A gives the method of calculating the precisions actually obtained.

TABLE 1. LEVELS OF PRECISION FOR SIZE ANALYSIS OF COAL

A. Cumulative percentage on one sieve.

Per cent oversize	<5	5-10	10-20	20-30	30-70	70-80	80-90	90-95	> 95
Precision	± 1.5	± 2.4	± 3.8	± 4.8	± 5.0	± 3.4	± 3.0	± 2.1	± 1.1

B. Percentage between two sieves.

Per cent in fraction	< 5	5-10	10-20	20-30	30-50
Precision	± 0.8	± 1.8	± 2.7	± 3.2	± 3.5

4.3 Sampling of coal. When sampling regular consignments of coal it is recommended that the precision to be aimed for should be twice that given in Table 1 (i.e. half the numerical values given). Special applications such as testing to a specification may require different standards and the method of duplicate sampling will permit the number of increments to be adjusted accordingly.

4.4 Sampling of coke. When a sample is taken from a consignment of coke, not all the fractions will be determined with the same precision, the fractions of greatest and least physical size usually being determined with greater precision than the middle sizes.

Again, practical considerations limit the weight of coke that can be dealt with and hence the number of increments, so that it is necessary to effect a compromise between the weight of sample and the precision desired.

Moreover, it is not possible to obtain a high precision for size analysis without taking a great weight of coke, the words 'high' and 'great' being used in a general sense.

The levels of precision given in Table 2 therefore are not regarded as those which would be desirable, so much as those which are practicable. Table 2a relates to the precisions of the cumulative percentages which should be obtained when sampling an isolated consignment, taking the numbers of increments specified in Table 8 and using the procedures of Clauses 9 and 10. Tables 2b and c relate to fractional percentages and mean sizes respectively.

Since the numbers of increments are based on the highest variances observed, in the majority of cases the precisions obtained will be better than those given in Table 2. When replicate sampling is used, Appendix A gives a method of calculating the precisions actually obtained.

When sampling regular consignments it is recommended that the precision to be aimed for should be twice that of Table 2, i.e. half the numerical values given, but initially the same number of increments, i.e. as given in Table 8, should be taken.

Special applications, such as testing to a specification, may require different standards and the methods of duplicate sampling will permit the number of increments to be adjusted to give the standard desired.

TABLE 2. LEVELS OF PRECISION FOR SIZE ANALYSIS OF COKE

A. Cumulative percentage on one sieve.

Per cent	0-5	5-10	10-20	20-40	40-50	50-60	60-70	70-80	80-90	90-95	95-100
Precision	3.5	4.0	4.5	5.0	4.5	4.0	3.5	3.0	2.5	1.5	1.0

B. Percentage between two sieves.

Per cent	0-5	5-10	10-20	20-30	30-50
Precision	(a) 1.8 (b) 2.5	(a) 2.0 (b) 2.8	3.2	3.5	(a) 3.5 (b) 5.0

(a) if middle dimension of fraction is less than or equal to the mean size.

(b) if middle dimension of fraction is more than the mean size.

C. Mean size.

Mean size (inches)	Up to 1	1-2	2 and over
Precision	0.03	0.10	0.28

4.5 Effects of breakage. The size distribution of coal or coke is continually changing during handling and transport and the considerable breakage which can occur, especially in the sizes greater than 2 in, should always be borne in mind when any decisions are taken or interpretations placed on the size analysis of these fuels. A size analysis can only refer to the size of the fuel at the point where the sample was taken.

B.S. 1293 & 2074 :

SECTION TWO: SIZE ANALYSIS OF COAL

5. SAMPLING

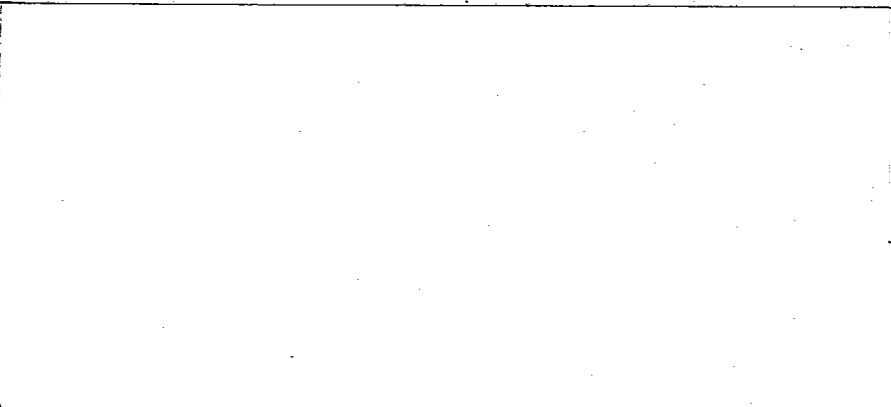
See B.S. 1017 : Part 1*.



*B.S. 1017, Sampling of coal and coke', Part 1, 'Sampling of coal'

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*B.S. 1017, Sampling of coal and coke', Part 1, 'Sampling of coal'

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See B.S. 1017 : Part 1*.



See B.S. 1017 : Part 1*.



*B.S. 1017, Sampling of coal and coke', Part 1, 'Sampling of coal.'

6. PROCEDURE

6.1 Preparation of sample for sieving. If the coal is wet, dry the sample to prevent fine coal adhering to the larger particles during the sieving operation. For graded coals, air-drying is the most convenient procedure, but for coals containing a large proportion of wet fines, spread the sample in a thin layer and dry in an oven at a temperature not exceeding 105°C. Allow the coal to cool to room temperature before weighing†.

6.2 Sample division. If the weight of undersize passing a particular screen is greatly in excess of that given in Table 5, it may be reduced by sample division to the figure given.

* Dustbins complying with B.S. 792, 'Mild steel dustbins', are recommended.

† Low rank coals which have been dried at a temperature of 105°C will pick up moisture during and after cooling. It is necessary to ensure that such coals are in equilibrium with the atmosphere before weighing; this may take several hours.

TABLE 5. MINIMUM WEIGHT OF UNDERSIZE TO BE RETAINED

Size of coal	Weight
Through 1½ in	400 lb (180 kg)
Through 1 in	150 lb (70 kg)
Through ½ in	32 lb (16 kg)
Through ¼ in	4 lb (2 kg)
Through ⅜ in	2 lb (1 kg)
Through ⅙ in (6 mesh B.S.)	½ lb (250 g)

The undersize may be reduced in weight by means of a mechanical sample divider or riffle, provided that size degradation is avoided. If the coal is too large to be passed through a mechanical sample divider or riffle, a sub-sample of suitable weight shall be carefully taken by increments ('shovels-full') from the pile using a shovel or sampling scoop. If, for example, the weight of material is to be reduced to one-half, alternate increments are put into two different piles, one forming the sub-sample, the other being rejected. For a sub-sample one-third of the weight of the original material, every third increment is kept and the others rejected. The increments taken in forming the pile retained for further sizing shall not be less than 40.

A simple scheme of working through the heap should be devised to ensure that the sub-sample does not contain an undue preponderance of coal from one side or section of the original pile. Weigh the reject material before disposal so that the gain or loss in weight of the complete size analysis may be determined.

Samples of wet or dry fines, taken according to Subclause 5.2, will generally be larger than is required for the size analysis. Samples of dry fines, after air-drying, if necessary, and mixing, may be reduced to the appropriate weight given in Table 5 by means of a mechanical sample divider or riffle. For wet fines, spread the gross sample on a clean flat surface, form into a cake, 1 in to 2 in thick, and extract a 2 kg sub-sample by taking not less than 50 increments evenly spread over the cake, using a small sampling scoop. If the sample is to be dry sieved, dry the sub-sample in an oven at a temperature of 105°C to 110°C. Allow the coal to cool to ambient temperature*. Mix and reduce to the appropriate weight given in Table 5 by means of a mechanical sample divider or a riffle.

The methods of sample division should be checked by the procedure described in Appendix B10 of B.S. 1017, Part 1, to ensure that the variance of sieving and sample division adopted for this specification are not exceeded. The values of this variance are given in Table 6.

* Low rank coals which have been dried at a temperature of 105°C will pick up moisture during and after cooling. It is necessary to ensure that such coals are in equilibrium with the atmosphere before weighing; this may take several hours.