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Guide to

Determination and presentation of float and sink characteristics of raw coal and of products from coal preparation plants

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- Association of British Mining Equipment Companies
- British Coal Corporation
- Coal Preparation Plant Association
- Minerals Engineering Society

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Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Definitions	1
3 Sampling	1
4 Comprehensive plant efficiency tests	2
5 Size analysis	2
6 Pilot testing	3
7 Float and sink testing	3
8 Presentation of results	10
Appendix A Procedure for a centrifugal float and sink test	14
Appendix B Typical procedure for the treatment and testing of a sample of a raw coal	14
Appendix C Practical hints on float and sink testing	15
Figure 1 — Sectional elevation of a 2 L measuring vessel for the determination of relative density of solids in aqueous suspension	6
Figure 2 — Suitable cylindrical float and sink apparatus for separation of coarse size fractions	7
Figure 3 — Float and sink bench	8
Figure 4 — Suitable float and sink apparatus for separation of 4 mm to 0.5 mm size fractions	9
Figure 5 — Suitable float and sink apparatus for separation of size fractions finer than 0.5 mm	10
Figure 6 — Example of washability curves	12
Figure 7 — Example of M-curve	13
Figure 8 — Typical scheme for the treatment and testing of a sample of raw coal	16
Table 1 — Recommended minimum mass of raw coal for a given size fraction	1
Table 2 — Example of results of size analysis	2
Table 3 — Typical physical properties of organic liquids used in float and sink testing	4
Table 4 — Suitable solids for aqueous suspensions	5
Table 5 — Typical presentation of float and sink data and calculation for washability curves	11
Publications referred to	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Solid Mineral Fuels Standards Policy Committee. It is based on a draft International Standard, ISO/DIS 7936 which is being prepared by the International Organization for Standardization (ISO).

The results of float and sink tests, presented in tabular and graphical form, are the basis for the provision of washability data and are of use when designing and redesigning coal preparation plants and in predicting, controlling and assessing the performance of such plants. This British Standard provides guidance on float and sink testing, rather than specifying the full methods and the means of presenting the results, because of the various purposes for which the tests might be carried out and the wide range of conditions which might apply. It is essential that, before tests other than those for routine control purposes are to be carried out, detailed information concerning the size ranges and relative density fractions to be examined and the accuracy required is provided in order to establish the scope of the test.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, 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.

1 Scope

This British Standard provides guidance on the apparatus and procedures for separation methods, based on differences in relative density, for determining the float and sink characteristics of raw coal and of products from coal preparation plants. It also provides guidance on the presentation, in tabular and graphical form, of the results of such tests.

A procedure using a centrifuge to separate coals with a maximum particle size of less than 1 mm is described in Appendix A. A typical procedure for the treatment and testing of a sample of raw coal is described in Appendix B and some practical hints on float and sink testing are given in Appendix C.

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

2 Definitions

For the purposes of this British Standard the definitions given in BS 3323 and BS 3552 apply, together with the following.

2.1

top size

the size corresponding to the 5 percentile on the cumulative size distribution curve of a material, i.e. the size above which 5 % of the material is retained

2.2

bottom size

the size corresponding to the 95 percentile on the cumulative size distribution curve of a material, i.e. the size above which 95 % of the material is retained

3 Sampling

3.1 General

Sampling should be carried out in accordance with BS 1017-1.

The mass of the bulk sample, and consequently the degree of accuracy obtained in a float and sink test, may be varied according to the purpose for which the test is being carried out. The three main categories of tests are as follows:

- a) investigations of the characteristics of raw coal;
- b) comprehensive plant efficiency tests (see clause 4);
- c) plant control tests.

3.2 Raw coal

The mass of the bulk sample should be such that the number of discrete particles in any size fraction is not less than 2 000. A size fraction is defined by the aperture size of the square-hole sieve through which all the particles will just pass and the aperture size of the sieve on which they will all be retained.

Examples of size fractions are given in Table 1 together with the recommended minimum mass of each size fraction. The masses will generally be sufficient to ensure that there are at least 2 000 particles in each size fraction for raw coal, but some values have been adjusted to take account of practical considerations.

Table 1 — Recommended minimum mass of raw coal for a given size fraction

Size fraction	Mass of coal
mm	kg
< 250.0 ≥ 125.0	1 000
< 125.0 ≥ 63.0	350
< 63.0 ≥ 31.5	180
< 31.5 ≥ 16.0	90.0
< 16.0 ≥ 8.0	33.0
< 8.0 ≥ 4.0	7.0
< 4.0 ≥ 2.0	3.0
< 2.0 ≥ 1.0	1.5
< 1.0 ≥ 0.5	1.0
µm	
< 500 ≥ 63	0.5

In order that there is sufficient material for subsequent analysis, each relative density fraction should have a mass of at least 20 g and should contain at least 10 discrete particles. Because some coals give low yields in the intermediate relative density fractions, it may be necessary to take a much larger bulk sample than that based on the recommendations in Table 1.

Other size fractions, replacing or supplementing those in Table 1, may be chosen: the minimum mass for each size fraction will then depend on the number of separations to be made and the quantitative distribution of the components in terms of relative density.

It is better to take a bulk sample which is too large than to risk not having sufficient material. When testing coal that includes the larger sizes in Table 1, the bulk sample may have to be 10 tonnes or more. From a newly opened mine or a trial shaft, and in other similar circumstances, the mass of the bulk sample should always be at least 10 tonnes.

For bore cores it is usually impracticable to obtain the masses recommended in Table 1. For this reason, core plies or sections as large as possible should be selected and sub-division of a crushed ply or section prior to float and sink testing should be avoided.

Both the size distribution and the ash of the raw coal coming from a working coal face or a mine will vary during a shift as well as from day to day. It is essential that the duration of sampling should be long enough to cover such variations.

3.3 Plant products

The minimum mass of clean coal in a given size fraction should normally be 50 % greater than that for raw coal, to ensure that adequate amounts of misplaced material are available.

Since the relative densities of discard, middlings, etc. are greater than that of clean coal, the minimum mass of samples containing these components should be increased proportionately. This will ensure that these samples contain approximately the same number of particles as the corresponding clean coal sample and that consequently a similar degree of accuracy will be obtained in the test.

Samples should be taken as soon as possible after the material leaves the cleaning unit in order to minimize breakage and disintegration. Testing should then commence as soon as possible.

When sampling pulp, the mass of the (dried) solids should meet the recommendations in Table 1. Increments should be taken at regular time intervals over the total cross section of the pulp stream either manually or by mechanical means, using a sampling device having a capacity equal to at least twice the recommended minimum mass of increment. Care should be taken to ensure that none of the sample is lost by splashing.

3.4 Samples for plant control testing

Routine samples should be taken regularly for the purpose of determining the average efficiency of a cleaning plant. They may represent daily, weekly or even longer periods of operation. The mass taken may be less than that based on the recommendations in Table 1, depending on the reason for the test, but if any dispute arises concerning the accuracy of the results then the mass of the sample should meet all the relevant recommendations in 3.2 and 3.3.

4 Comprehensive plant efficiency tests

A comprehensive plant efficiency test involves a systematic mass balance of all materials entering and leaving the coal cleaning plant. In this case the mass and moisture content of the raw feed, the mass and moisture content "as weighed" of all cleaned products, discard, etc., and the volume and solids content of the effluent will have to be determined.

The mass of all materials is calculated to a uniform moisture basis and the raw coal feed entering the plant and the products leaving the plant are balanced against each other. The efficiency of the cleaning plant is assessed from the actual and theoretical yields and grades. The analysis of the raw coal feed derived by the computation from the masses and analyses of all the products is used for the calculation of the theoretical yields.

When a screen analysis of a plant product is made in connection with a cleaning plant efficiency test, it will be found that there is some material below the nominal bottom size being treated in the cleaning unit. The mass and particle size range of this undersize material should be recorded.

5 Size analysis

The sample should be spread out on an impervious base, preferably under shelter, and allowed to dry sufficiently for sieving purposes. It should then be sieved using a suitable range of aperture sizes. Typical size fractions are given in Table 2. Oversize material may be broken by hand or machine crushed according to the nominal top size required. If applicable, the relevant part of the crusher circuit in a preparation plant may be simulated.

Table 2 — Example of results of size analysis

Size fraction	Mass of size fraction	Cumulative oversize	Cumulative undersize
mm	%	% (m/m)	% (m/m)
≥ 125.0	Nil	Nil	100.0
< 125.0 ≥ 63.0	11.9	11.9	88.1
< 63.0 ≥ 31.5	12.1	24.0	76.0
< 31.5 ≥ 16.0	12.8	36.8	63.2
< 16.0 ≥ 8.0	15.7	52.5	47.5
< 8.0 ≥ 4.0	12.5	65.0	35.0
< 4.0 ≥ 2.0	10.2	75.2	24.8
< 2.0 ≥ 1.0	7.5	82.7	17.3
< 1.0 ≥ 0.5	5.6	88.3	11.7
< 0.5	11.7	100.0	Nil
Total	100.0		

The quantity of material passing the 63 mm aperture sieve is usually more than the amount required and can be divided before proceeding to the next sieve. Further division may be necessary before sieving on some of the smaller aperture sieves.

NOTE The above sieving process may be preceded by a sample treatment operation designed to simulate particle breakdown which may occur in a coal preparation plant.

If it is not possible to carry out efficient sizing by dry sieving due to fine particles adhering to larger particles, then wet sieving should be used to ensure that the fine particles are collected in the appropriate size fraction.

6 Pilot testing

Pilot testing is frequently carried out on a smaller sample in order to determine the pattern of behaviour which the bulk sample will follow. This knowledge enables the operator to plan the actual test in such a way that unnecessary operations are avoided so that the test is carried out more quickly and with less effort.

The pilot test, or previous experience, may indicate an advantage in commencing the separation at either the highest or lowest relative density. A sample which will give a high yield at either of these points should be separated at the point so that the bulk of the sample can be removed in one operation.

In cases where there is only a low yield in one or both of two consecutive relative density fractions in the pilot test, it is better to combine these fractions in the main test. Such a combination will not affect the outcome of the test and will often improve its accuracy and reduce the time and effort involved.

7 Float and sink testing

7.1 Float and sink medium

7.1.1 Basis for selection. The medium which is to be used for the separation may be a mixture of organic liquids, aqueous solutions of inorganic salts, or solids in aqueous suspensions. The choice of medium is governed to some extent by the bulk and particle size of the coal being tested, its rank, its relative density and the purpose for which the separation is being carried out. The most suitable range of relative densities¹⁾ for the test will have to be determined by trial and error but would normally include 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9 and 2.0. Relative densities lower than 1.3 and higher than 2.0 may be required. Additional separations at intermediate relative densities will be found useful if the cumulative ash is increasing rapidly in relation to the cumulative yield for successive relative density fractions. As stated in 3.2, each relative density fraction should weigh at least 20 g and should contain at least 10 discrete particles.

If it is known or suspected that the sample will disintegrate or otherwise react on contact with water or aqueous solutions, separations will have to be carried out using organic liquids. However, the fact that the raw coal will react with water will affect its behaviour in the cleaning process and any information which will provide guidance should be obtained for reference purposes.

7.1.2 Organic liquids. If the separation is critical, particularly for finer particle sizes, the use of organic liquids is preferred because of their low viscosity, their volatility and their inertness towards shales. Some organic liquids and their physical properties are listed in Table 3.

WARNINGS

- a) Many solvent vapours are toxic and present a serious health hazard. Adequate ventilation, preferably down-draught (see Figure 3), is essential. Avoidance of contact with the skin is also essential.
- b) Mixtures of air and light petroleum vapour are highly explosive.
- c) Some organic liquids may affect subsequent analyses.

For relative densities of 1.6 and lower, mixtures of tetrachloroethylene and one of the less dense liquids may be used. For relative densities of 1.6 to 2.9, mixtures of tetrachloroethylene and one of the more dense liquids may be used.

The following equation may be used for determining the volume of liquid required in formulating a mixture of the desired relative density.

$$V_m = \frac{V_t (d_t - d_p)}{d_m - d_p}$$

where

V_m is the volume (in litres) of the liquid with the higher relative density;

V_t is the volume of mixture desired (in litres);

d_m is the higher relative density (of one component);

d_t is the desired relative density of the mixture;

d_p is the lower relative density (of the other component).

It is important that the relative density of the resultant mixture is checked, for example by means of a hydrometer graduated in divisions of not more than 0.002.

¹⁾ All relative densities quoted in this standard are measured at 20 °C in relation to water at 20 °C.