BRITISH STANDARD

BS 7530-2: 1995

CONFIRMED DECEMBER 2007

## Methods for

# Froth flotation testing of hard coal —

## Part 2: Evaluation of flotation characteristics

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee SFI/5, Coal preparation, upon which the following bodies were represented:

British Coal Corporation

Coal Preparation Plant Association

Low Temperature Coal Distillers' Association of Great Britain Ltd.

Minerals Engineering Society

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# Foreword

This Part of BS 7530 was prepared by Technical Committee SFI/5. It is one of two Parts giving methods for froth flotation testing of hard coal. BS 7530-1 sets out the procedure for a laboratory test to determine whether or not a coal is amenable to up-grading in quality by froth flotation.

It is accepted that variation of the many parameters in the froth flotation process can be used to effect the beneficiation of the product. This Part of this British Standard describes methods of applying certain test conditions to reveal the relative response of coals to the flotation process.

To facilitate the determination of how a particular coal will respond to froth flotation, a method of controlling the recovery of froth is used. This is done by inhibiting the process to a degree, determining the rate at which a coal reacts and by progressively sampling the froth. This method provides a basis to vary test parameters to explore any special flotation characteristics.

This standard is applicable to a wide range of coals and provides a method of comparison of flotation behaviour and will facilitate the exchange of information relating to specific performance. It is expected that the use of this method will provide a tool for comparison of flotation characteristics.

From the results of the standard test it is possible to draw evaluation curves similar to those obtained from float and sink testing of raw coal.

Because of the high reproducibility of results the test represents a reliable means of comparing the flotation response of different samples.

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**Summary of pages**

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, 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 Part of BS 7530 describes a laboratory method for evaluation of the froth flotation characteristics of hard coal, of particle size less than 0.5 mm. It is applicable to coal in powder form or in the form of a slurry.

## 2 References

### 2.1 Normative references

This Part of BS 7530 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 7530 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 7530 refers to other publications that provide information or guidance. The 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 7530, the definitions given in BS 3552 apply.

## 4 Principle

A test portion of coal is mixed with water to form a suspension in the flotation cell, or a test portion of slurry is added to the cell and diluted. A collector and frother are added, the suspension is conditioned and air is then introduced to the cell while agitation is maintained by means of an impeller.

To study differing flotation characteristics, the flotation operation is inhibited in two ways, relating to reagent dosage rate in the first stage of the test and to air flow rate in the second stage.

A number of froth increments are obtained which give spaced points for comparison.

## 5 Reagents

**5.1** *General.* Use only reagents of recognized analytical grade and only water conforming to grade 3 of BS 3978:1987.

**5.2** *Collector. n*-Dodecane used undiluted.

**5.3** *Frother.* Prepare a solution of 0.1 % (*V*/*V*) 4-methylpentan-2-ol (otherwise known as methyl isobutyl carbinol or MIBC) by diluting 1 ml of MIBC to 1 l using water (see **5.1**). All dosages of MIBC stated refer to this solution.

## 6 Apparatus

**6.1** *Flotation machine,* as described in **5.1** of BS 7530-1:1992, consisting of a mechanical impeller type flotation machine designed for laboratory scale flotation testing, comprising the following:

a) *a flotation cell*, of capacity 2.5 l to 10 l, made from an inert material such as stainless steel, glass or polymethyl methacrylate;

b) *an impeller assembly*, capable of being driven so that the periphery of the impeller moves at a speed of approximately 6 m/s. The impeller shall be positioned centrally with a clearance of 6 mm ± 1 mm above the bottom of the cell;

c) a means of supplying air to the impeller.

A typical flotation machine is shown in Figure 1 and Figure 2.

**6.2** *Air flowmeter,* with a needle valve to control the air flow rate to the flotation cell.

**6.3** *Constant level device,* for maintaining the pulp at a constant level during the test.

NOTE The level may be maintained by the manual addition of water.

**6.4** *Two scrapers,* for removing the froth from the entire surface of the pulp, including the area behind the standpipe.

**6.5** *Calibrated micro-syringe or micro-pipette.*

**6.6** *Containers,* capable of holding individual samples of froth and tailings.

**6.7** *Timing device,* accurate to ± 1 s and capable of being zeroed and started as required.

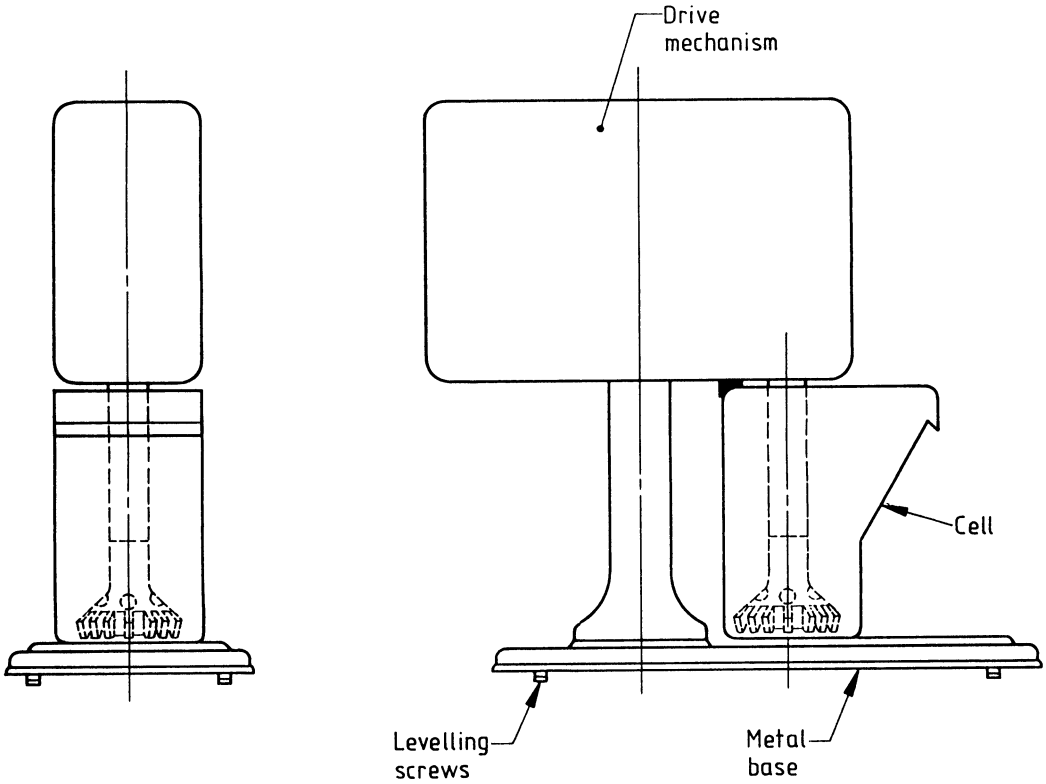


**Figure 1 — Typical flotation machine**

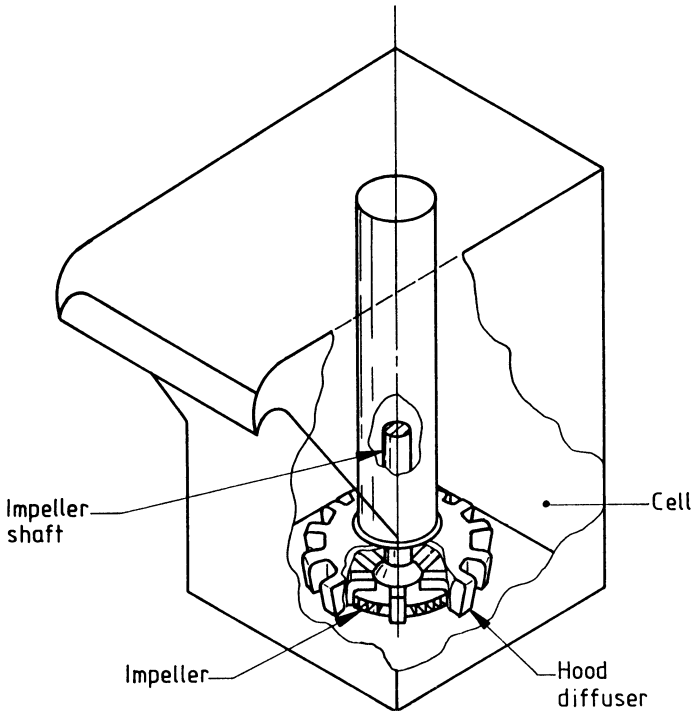


**Figure 2 — Detail of flotation cell and impeller**

## 7 Sampling and preparation of test sample

Take a gross sample which is at least five times the mass required for a single flotation test (see **9.1**).

Where the sample for flotation testing is obtained in slurry form, allow it to settle for at least 12 h and then remove the supernatant water. Mix the resulting thickened slurry and determine its solids content.

NOTE 1 The history and method of preparation of the sample can affect the flotation characteristics of the coal. The source of the sample should be recorded and care should be taken to ensure that samples for comparative tests are prepared in the same manner. Since replicate tests are required together with subsampling for size analysis and other tests, care should be taken in mixing and subdivision of the original sample. When applicable, sampling and division of samples should be carried out in accordance with BS 1017-1.

NOTE 2 The use of chemical additives to enhance the settlement of a slurry and the use of heat to drive off water should not be employed because such practices can affect the flotation characteristics of the coal.

## 8 Flotation test conditions

### 8.1 Test temperature

The test temperature shall be 20 °C ± 10 °C.

### 8.2 Impeller operating speed

The impeller operating speed shall be such as to give an air flow rate of $2\ l\ s^{-1} \cdot m^{-2}$ of the pulp surface area with the air inlet valve fully open; an impeller tip speed of approximately 6 m/s is usually suitable.

### 8.3 Air flow rate

The air inlet valve shall be used to control the air flow rate during the test over the required range of $0.25\ l.s^{-1} \cdot m^{-2}$ to $2.0\ l\ s^{-1}\ m^{-2}$ of pulp surface area (see **9.3.5**).

### 8.4 Pulp level

This shall be 20 mm ± 2 mm below the overflow lip of the cell when the impeller is rotating at the operating speed and the air inlet valve is closed.

## 9 Procedure

### 9.1 Test portion

If the feed sample is in powder form, calculate the mass of the test portion required from the measured volume of the flotation cell at the pulp level (see **8.4**) and the moisture content of the test sample (see BS 7530-1) to give a solids content of 100 g (dry basis) per litre of pulp.

In the case of a slurry, calculate the required mass of thickened slurry from the volume of the flotation cell at the pulp level (see **8.4**) and the solids content of the thickened slurry to give a solids content of 100 g (dry basis) per litre of pulp.

Weigh the test portion to the nearest 0.1 g.

### 9.2 Preparation

If the test portion is in powder form, half fill the flotation cell with water (see **5.1**) and start the impeller with the air inlet valve closed. Gradually add the test portion and top up to the required level with water. Then agitate for 10 min at the operating impeller speed with the air inlet valve closed.

If the test portion is a thickened slurry, transfer it to the cell and add water to the required level. Agitate for 2 min at the operating impeller speed with the air inlet valve closed.

### 9.3 Flotation test

**9.3.1** Carry out the following procedure seven times, collecting the seven froth concentrates in the same container.

Add *n*-dodecane (see **5.2**) at a dose rate of 90 ml/t of dry solids (based on the original feed mass) and condition for 1 min without air. Add the frother (see **5.3**) at a dose rate of 10 l/t of dry solids and condition for an additional 10 s without air. Open the air valve and control the air flow rate to $2\ l\ s^{-1}\ m^{-2}$ of pulp surface area.

Allow froth to build up for 30 s, then remove the froth concentrate for a further 1 min.

Close the air valve.

**9.3.2** Remove any froth remaining on the surface of the pulp, the standpipe and the cell walls and add this to the froth concentrates.

**9.3.3** Remove the tailings for analysis (designated tailings 1).

**9.3.4** Re-introduce the combined froth concentrates to the flotation cell and make up to the required level with water. Start the impeller with the air valve closed. Add *n*-dodecane at a dose rate of 180 ml/t, based on the original feed mass, and condition for 1 min with the air valve closed. Add the frother at a dose rate of 20 l/t and condition for an additional 10 s with the air valve closed.

**9.3.5** Collect nine froth concentrates in separate containers marked 1 to 9, over consecutive times as follows.

a) Open the air valve and adjust the flow rate to $0.25\ l\ s^{-1}\ m^{-2}$ of pulp surface area. Collect froth concentrate 1 in a container for 30 s. Change container and collect froth concentrate 2 for the following 30 s.

b) Change the container and adjust the air flow rate to $0.5\ l\ s^{-1}\ m^{-2}$ of pulp surface area. Collect froth concentrate 3 for 30 s. Change container and collect froth concentrate 4 for the following 30 s.

c) Change the container and adjust the air flow rate to 1 l $s^{-1}$ $m^{-2}$ of pulp surface area. Collect froth concentrate 5 for 60 s. Change the container and collect froth concentrate 6 for the following 60 s.

d) Change the container and adjust the air flow rate to 2 l $s^{-1}$ $m^{-2}$ of pulp surface area. Collect froth concentrate 7 for 60 s. Change the container and collect froth concentrate 8 for the following 60 s.

e) Change the container and collect froth concentrate 9 until flotation is completed.

**9.3.6** Remove the tailings for analysis (designated tailings 2).

**9.3.7** Dry, weigh and analyse all products in accordance with the relevant Parts of BS 1016.

NOTE 1 All reagent additions should be made below the surface of the pulp.

NOTE 2 All air flow rates should be ± 10 % of the stated value and adjustments to air flow rates made within 10 s.

NOTE 3 The recommended procedure for froth removal is as follows:

— use two froth scrapers;

— wipe the cell walls and standpipes at least once during each concentrate removal;

— remove froth from the surface approximately once every 15 s.

## 10 Presentation of results

Tabulate the percentage by mass of froth concentrate and tailings together with the results of ash determinations and/or other tests and calculate the results as shown in the example given in Table 1.

Present the results graphically by plotting the cumulative percentage by mass of froth concentrate/tailings versus cumulative percentage by mass of ash as shown in Figure 3 and/or by plotting the "Mayer curve" as shown in Figure 4.

## 11 Test report

The test report shall include the following:

a) the date of the test;

b) the complete identification of the sample;

c) the history of the sample;

d) reference to the method used, ie BS 7530-2;

e) the percentages by mass of froth concentrates and tailings;

f) the results for any other properties determined;

g) any unusual features noted during the tests;

h) any operation not specified in this standard or the standards to which reference is made, or regarded as optional.

**Table 1 —Example of presentation of froth flotation data and calculations for flotation characteristics curves**

| **SOURCE: Mansfield** | | | | | | **SAMPLE DATE: 24 March 1992** |
|---|---|---|---|---|---|---|
| **SIZE FRACTION: < 0.5 mm** | | | | | | |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| **Froth flotation product** | **Percentage by mass of concentrate /tailings** | **Percentage by mass of ash** | **Quantity of ash (2) × (3)[a]** | **Cumulative percentage by mass of concentrate/ tailings, Σ (2)** | **Cumulative quantity of ash, Σ (4)** | **Cumulative percentage of ash, (6) ÷ (5)** |
| | % | % | g × 100 | % | g × 100 | % |
| Froth 1 | 9.9 | 4.9 | 48.51 | 9.9 | 48.51 | 4.9 |
| Froth 2 | 16.1 | 5.0 | 80.50 | 26.0 | 129.01 | 5.0 |
| Froth 3 | 14.3 | 5.6 | 80.08 | 40.3 | 209.09 | 5.2 |
| Froth 4 | 7.4 | 6.2 | 45.88 | 47.7 | 254.97 | 5.3 |
| Froth 5 | 6.6 | 7.4 | 48.84 | 54.3 | 303.81 | 5.6 |
| Froth 6 | 2.5 | 9.4 | 23.50 | 56.8 | 327.31 | 5.8 |
| Froth 7 | 3.6 | 18.4 | 66.24 | 60.4 | 393.55 | 6.5 |
| Froth 8 | nil | — | | | | |
| Froth 9 | nil | — | | | | |
| Tailings 2 | 5.0 | 69.2 | 346.00 | 65.4 | 739.55 | 11.3 |
| Tailings 1 | 34.6 | 85.8 | 2 968.68 | 100.0 | 3 708.23 | 37.1 |
| Totals | 1 000 | 37.1 | 3 708.23 | | | |

NOTE Flotation complete after froth 7.

[a] Numbers in parentheses refer to column numbers in the table.

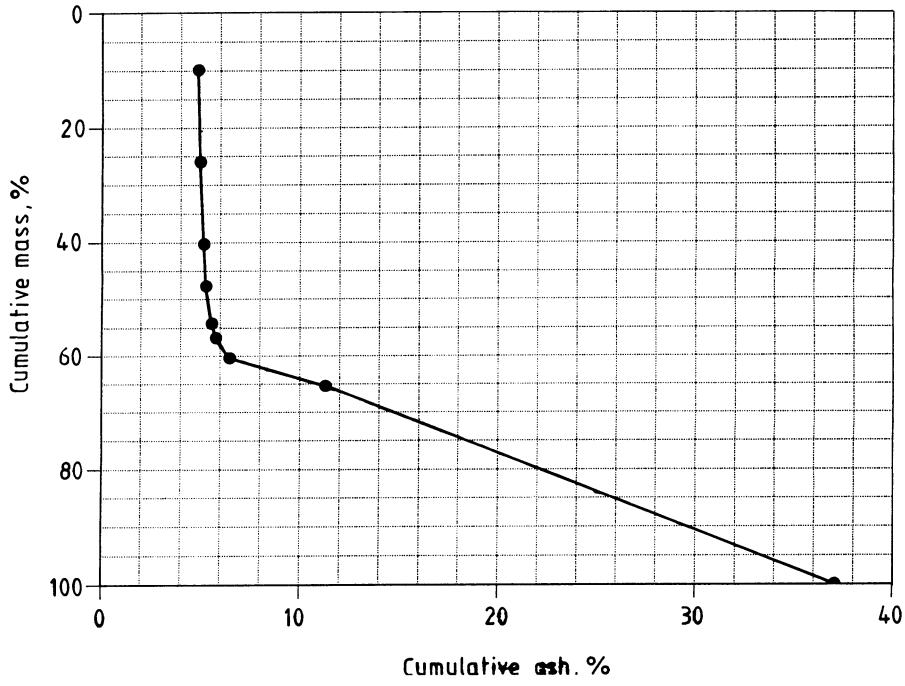


**Figure 3 — Example of plot of cumulative percentage by mass of froth concentrate/tailings versus cumulative percentage of ash using data from Table 1**

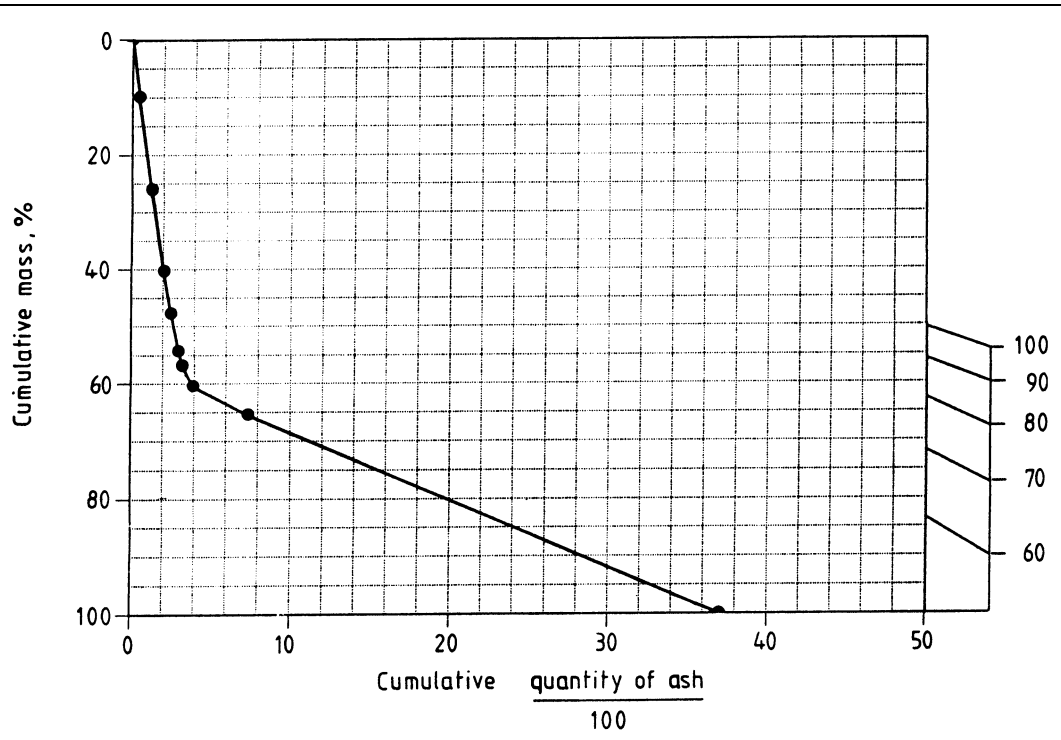


**Figure 4 — Example of plot of "Mayer curve" using data from Table 1**

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# List of references

## Normative references

### BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 1016, *Methods for analysis of coal and coke.*
BS 3552:1994, *Glossary of coal preparation terms.*
BS 3978:1987, *Specification for water for laboratory use.*
BS 7530, *Methods for froth flotation testing of hard coal.*
BS 7530-1:1992, *Laboratory procedure.*

## Informative references

### BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 1017, *Methods for sampling of coal and coke.*
BS 1017-1:1989, *Methods for sampling of coal.*

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