
**Hard coal — Froth flotation testing —
Part 1:
Laboratory procedure**

*Houille — Essais de flottation —
Partie 1: Méthode de laboratoire*

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	2
5 Reagents	2
6 Apparatus	2
7 Sampling	3
8 Flotation conditions	4
8.1 Operating temperature	4
8.2 Water	4
8.3 Solids content	4
8.4 Pulp level	4
8.5 Collector	4
8.6 Frother	4
8.7 Air flow rate	4
9 Procedure	4
10 Expression of results	6
11 Test report	6
Annex A (informative) Recommended layout of a form for a test report	13
Bibliography	14

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 27, *Solid mineral fuels*, Subcommittee SC 1, *Coal preparation: Terminology and performance*.

This second edition cancels and replaces the first edition (ISO 8858-1:1990), of which it constitutes a minor revision. It also incorporates the Technical Corrigendum ISO 8858-1:1990/Cor.1:2001.

A list of all parts in the ISO 8858 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The froth flotation of coal has widespread application for the concentration and separation of fine coal particles from mineral matter. The response of coal to the froth flotation process is initially measured by a laboratory scale test. Although the principles used for the laboratory tests are generally similar, the precise type of equipment and techniques used vary considerably.

The procedure for the laboratory froth flotation test sets out, in detail, the type of equipment to be used and the methods to be adopted. The purpose of this procedure is to provide a standard method of test by which a preliminary evaluation of the froth flotation characteristics of a coal can be compared. This need is particularly important for exploration programmes. This document also serves as an introduction for operators who are not familiar with the techniques (and problems) associated with the laboratory froth flotation of coals.

[Annex A](#) of this document is for information only.

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Hard coal — Froth flotation testing —

Part 1: Laboratory procedure

1 Scope

This document sets out a laboratory procedure for the froth flotation testing of fine coal, e.g. coal of particle size less than 0,5 mm. The procedure provides a means of evaluating the general flotation characteristics of a coal under a set of specified standard conditions, and will not necessarily indicate the full flotation potential of that coal.

The flotation characteristics of coals are sensitive to changes in flotation conditions. These conditions can be changed by varying basic parameters such as flotation time, reagent and dosage rate. Separate flotation tests are used to assess the effect of varying these parameters to determine the best flotation conditions for a particular coal. A method of evaluating flotation response will be given in a separate standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 565, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

ISO 648, *Laboratory glassware — Single-volume pipettes*

ISO 1171, *Solid mineral fuels — Determination of ash*

ISO 11722, *Solid mineral fuels — Hard coal — Determination of moisture in the general analysis test sample by drying in nitrogen*

ISO 1213-1, *Solid mineral fuels — Vocabulary — Part 1: Terms relating to coal preparation*

ISO 13909-1, *Hard coal and coke — Mechanical sampling — Part 1: General introduction*

ISO 13909-2, *Hard coal and coke — Mechanical sampling — Part 2: Coal — Sampling from moving streams*

ISO 13909-3, *Hard coal and coke — Mechanical sampling — Part 3: Coal — Sampling from stationary lots*

ISO 13909-4, *Hard coal and coke — Mechanical sampling — Part 4: Coal — Preparation of test samples*

ISO 18283, *Hard coal and coke — Manual sampling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1213-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

- 3.1 collector**
collecting agent
reagent added to a pulp to bring about adhesion between solid particles and air bubbles
- 3.2 flotation concentrate**
clean product recovered in froth flotation
- 3.3 conditioning**
preparatory stage in the flotation process in which the reagents are brought into intimate contact with the solids of the pulp
- 3.4 frother**
frothing agent
reagent used to control the size and stability of the air bubbles in the flotation process
- 3.5 froth flotation**
process for cleaning fine coal in which the coal, with the aid of a reagent or reagents, becomes attached to air bubbles in a liquid medium and floats as a froth
- 3.6 pulp**
mixture of solid particles and water
- 3.7 flotation tailings**
reject from froth flotation cells

4 Principle

Mixing of a coal sample with water to form a suspension in the flotation cell. Addition of collector and frother and introduction of air. Separate recovery of the concentrate and tailings and determination of the yield and ash of each.

NOTE 1 The use of chemical additives or heat can affect the flotation characteristics of the coal.

5 Reagents

During the analysis, use only reagents of recognized analytical grade and only distilled water or water of equivalent purity.

5.1 Collector, n-Dodecane.

5.2 Frother, Methyl iso-butyl carbinol (MIBC), (4-Methylpentan-2-ol), 0,14 % (V/V) aqueous solution.

6 Apparatus

The apparatus shall be a mechanical impeller type flotation machine (see [Figure 1](#)) with the following specifications.

6.1 Flotation cell manufactured from stainless steel.

[Figure 2](#) shows the dimensions of the flotation cell. The capacity of the cell with the deflector block and impeller in place is approximately 3,5 l.

It has been shown that the results obtained from laboratory froth flotation tests are very dependent on the procedure used to remove the concentrate from the surface of the pulp. For this reason, a deflector block manufactured from plastics material (see [Figure 3](#)) is used to guide the concentrate to a rectangular area in front of the impeller housing. The concentrate can then be removed by means of a scraper (see [Figure 4](#)) which is designed to cover the full width of the cell to a constant depth.

In order to establish the volume of pulp which can be contained in the flotation cell, the deflector block is fitted into the cell and water is added to the flotation cell to about 20 mm to 30 mm below the required pulp level. The impeller is started (air valve off) and additional water is added to the required mark (see [8.4](#)). The impeller is stopped, the deflector block removed, and the volume of water in the flotation cell is measured.

6.2 Impeller assembly, of stainless steel and capable of rotation at frequencies up to 1 500 revolutions per minute (equivalent to a speed of 5,7 m/s at the periphery). The dimensions of the impeller and diffuser are shown in [Figures 5](#) and [6](#).

The lower face of the impeller shall be positioned no more than 5 mm from the base of the cell.

Impellers constructed of other materials may be used, provided that it can be shown that the characteristics of flotation for the cell are similar to those obtained when a stainless steel impeller is used. To achieve this, different impeller rotational frequencies may be used if necessary.

6.3 Constant level control, maintaining the level of the pulp in the cell during the flotation test.

6.4 Scraper, of the design shown in [Figure 4](#). Its clearance at the sides of the cell shall be minimal and should not exceed 2 mm. The scraper shall be of such dimensions that it clears the pulp level (as defined in [8.4](#)) by not more than 2 mm.

6.5 Calibrated micro-syringe, for the addition of the collector ([5.1](#)).

6.6 Pipette, of capacity 25 ml, complying with ISO 648, for the addition of the frother solution ([5.2](#)).

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

6.8 Test sieves, complying with ISO 565, for the particle size analysis of the feed.

7 Sampling

The history and method of preparation of samples can affect considerably the flotation characteristics of the coal. The origin of the sample should be recorded and care should be taken to ensure that samples for comparison purposes are prepared in a similar manner. Since repeat tests are required together with sub-sampling for particle size and moisture determination, great care should be taken in mixing and subdivision of the original sample. Where applicable, all sampling and subdivision of samples shall be carried out in accordance with the procedures specified in ISO 13909-1 to ISO 13909-4 and ISO 18283 as appropriate.

The quantity of gross sample required is at least five times the quantity required for a single flotation test. The latter quantity can be determined by reference to [8.3](#).

Where the sample for flotation testing is obtained in pulp (or slurry) form, it will be necessary to separate the solids from the water before the procedures laid down in this document can be applied. Dewatering shall be by natural settlement followed by decantation and filtration. No chemicals or heat

shall be used in the dewatering process as they may affect the surface properties of the materials and change their flotation characteristics.

The results of the flotation test are influenced by the particle size and a complete particle size analysis of the coal, carried out according to ISO 1953, should be reported (see [Annex A](#)). A sub-sample should also be retained for the determination of ash and other parameters as required (see [9.2](#)).

8 Flotation conditions

8.1 Operating temperature

The operating temperature shall be $25\text{ °C} \pm 10\text{ °C}$.

8.2 Water

Water complying with [Clause 5](#) shall be used.

8.3 Solids content

The solids content of the sample to be tested shall be 100 g of solids (on a dry basis) per litre of pulp. For example, when the effective cell volume is 3,5 l the sample mass is 350 g of dry solids plus any associated moisture as previously determined, see [9.1](#).

8.4 Pulp level

The pulp level shall be $20\text{ mm} \pm 2\text{ mm}$ below the overflow lip of the cell when the impeller is rotating at 1 500 revolutions per minute and the air is off.

8.5 Collector

The quantity of collector ([5.1](#)) added shall be equivalent to 1 ml/kg of dry solids. For example, for a cell volume of 3,5 litres, a volume of 0,35 ml of collector will be required.

8.6 Frother

The quantity of frother ([5.2](#)) to be added shall be 0,1 ml of MIBC per kilogram of dry solids. For example, for a cell volume of 3,5 l, a volume of 25 ml of the solution ([5.2](#)) will be required.

8.7 Air flow rate

The air flow rate shall be $4\text{ l/min} \pm 0,4\text{ l/min}$. It is recommended that this flow rate be controlled by the use of a needle valve and measured by means of a flowmeter, and that a separate on/off valve be provided.

9 Procedure

9.1 From a representative sub-sample, determine the moisture content and ash percentage of the coal sample ([Clause 7](#)) by the procedures specified in ISO 11722 and ISO 1171 respectively. Calculate the mass of coal required for the flotation test from the measured cell volume ([6.1](#)) and the specified solids content of the sample to be tested ([8.3](#)).