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Coal — Froth flotation testing —

Part 2: Sequential evaluation

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Foreword

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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 document 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).

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

This second edition cancels and replaces the first edition (ISO 8858-2 2004), of which it constitutes a minor revision. The changes are as follows:

— updated title;
— document updated according to current ISO drafting rules.

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 a widespread application for the recovery of fine coal particles and their separation from unwanted mineral matter. The response of coal to the froth flotation process is measured initially by a laboratory scale test. ISO 8858-1 provides a means of evaluating the general flotation characteristics of a coal under a set of specified conditions and will not necessarily indicate the full potential of that coal. 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 document describes a procedure for the more complete determination of the flotation characteristics of a coal, using the apparatus and basic procedures described in ISO 8858-1. The purpose of this extended procedure is to provide information similar to that provided by the sink/float curve, which is the basis for density separations. The data obtained are expressed as a yield/ash curve. The information can be used to define the limitations on the cleaning of fine coal by froth flotation.

The procedures specified in this document are of practical significance in the development and evaluation of coal-preparation-plant flotation circuits, although engineering design aspects, such as flotation kinetics and the selection of size and type of cell, are not addressed.

The flotation response curve (yield/ash) indicates the maximum possible yield at any specified ash content. The general shape of the curve indicates the sensitivity of flotation performance to the nature of the coal and to operating conditions.

The procedure may be modified to test and compare the performance of different frother and collector types, the assessment of liberation by grinding, and the comparison of alternative feed size ranges. However, results of such tests should clearly indicate any use of non-standard procedures.

Coal — Froth flotation testing —

Part 2: Sequential evaluation

1 Scope

This document sets out a laboratory sequential procedure for the froth flotation testing of fine coal, e.g. coal having a particle size of less than 0,5 mm. The procedure provides a means of evaluating the flotation characteristics for coal (expressed as a yield/ash relationship) that can be expected from the froth flotation process.

This document does not apply to pulp samples that cannot be dewatered without the use of heat or chemical additives. This document does not apply to procedures for the investigation of flotation kinetics.

The test is not intended to provide plant design data.

This document is intended to be read in conjunction with ISO 8858-1.

2 Normative references

The following referenced documents are indispensable for the application 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 589, *Hard coal — Determination of total moisture*

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

ISO 1213-1, *Coal and coke — Vocabulary — Part 1: Terms relating to coal preparation*

ISO 1953, *Hard coal — Size analysis by sieving*

ISO 8858-1, *Hard coal — Froth flotation testing — Part 1: Laboratory procedure*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Principle

A sequence of laboratory flotation tests is carried out on a single coal sample, using a procedure based on that described in ISO 8858-1. Variations on that procedure are made to generate a number of products, by refloating concentrates and tailings a number of times. The masses and ash mas fractions of the various products are used to construct a yield/ash curve showing the flotation response.

5 Sample

The history and method of sampling and preparation of samples can affect the flotation characteristics of the coal considerably. The history of the sample should be recorded, and care should be taken to ensure that samples for comparison purposes are sampled and prepared in a similar manner and, where applicable, in accordance with the sampling and preparation procedures specified in ISO 13909-2, ISO 13909-4 and ISO 18283.

A size analysis of the sample shall be carried out in accordance with ISO 1953.

6 Apparatus

The apparatus shall be as specified in ISO 8858-1.

7 Flotation conditions

7.1 Collector dosage

To establish well-defined flotation response curves, it is necessary to extend the range of conditions specified in ISO 8858-1. Different coals will require different conditions to display the attainable range of yields and corresponding product ash levels. To obtain a preliminary guide to the appropriate flotation conditions for this extended test, it is recommended that a sample of the coal be first tested according to the procedure specified in ISO 8858-1.

NOTE It is suggested that the collector increments referred to in 8.3 be selected on the basis of the result of the ISO 8858-1 test in Table 1.

Table 1

ISO 8858-1 yield %	ISO 8858-1 suggested collector dosage (fraction of dosage used in ISO 8858-1)
< 40	As in ISO 8858-1 = 1 ml/kg
⩾ 40 < 60	25 % = 0,25 ml/kg
⩾ 60 ⩽80	10 % = 0,10 ml/kg
> 80	2,5 % = 0,025 ml/kg

The final result is largely independent of the selected increment size. Experienced operators may prefer to use other dosage rates.

7.2 Frother dosage

Frother addition at each stage may be made at approximately half the dosage specified in ISO 8858-1, i.e. at 0,05 ml of 4-methyl-2-pentanol (formerly called methyl isobutyl carbinol MIBC) (50 ml of 0,1 % aqueous solution) per kilogram of dry solids in the initial sample.

Frother dosages are not critical beyond the initial separation. Operator judgment may be used to maintain an adequate froth.

7.3 Solids content

The solids content for the first flotation stage shall be as specified in ISO 8858-1. For all subsequent stages, the mass of solids shall be that which results from the previous flotation stage.

7.4 Air flow rate

The air flow rate shall be as specified in ISO 8858-1.

7.5 Test temperature

The test temperature shall be as specified in ISO 8858-1 and shall be reported with the test results.

8 Procedure

8.1 Initial procedure

The moisture content, size analysis and other parameters specified in ISO 8858-1 shall be determined.

8.2 Initial separation

The initial separation shall be carried out generally following the principles given in ISO 8858-1 with the exceptions that:

a) no collector shall be used;

b) no conditioning time is required; and

c) no frother shall be used.

Both concentrate and tailings shall be retained as pulps for subsequent reflotation.

NOTE Experience has shown that omission of frother and collector permits selective recovery of low-ash rapid floating particles and better definition of the low-yield end of the curve.

To ensure that the cell volume for subsequent tests is not exceeded, care should be taken to use a minimum of wash water in collecting the two products.

8.3 Subsequent separations

After performing an initial flotation, the resultant tailings shall be successively refloated, generally following the procedure given in ISO 8858-1, with incremental collector addition to recover any floatable particles that may not have been collected with the concentrate. This process shall be continued until it is estimated that reflotation of the successive tailings fraction has resulted in nil or negligible concentrate mass (approxately less than 5 % of the initial feed sample mass).

Each concentrate fraction, resulting from these successive tailings flotations, shall then be refloated as many times as necessary, until further flotation does not result in additional removal of mineral matter (as judged by the presence of solids in the tailings), or the concentrate sample to be floated shall have nil or negligible mass (approximately less than 5 % of the initial feed sample mass).

After completion of these flotations, each concentrate shall be repeatedly refloated until all entrained mineral matter is removed. Each tailings fraction resulting from refloating of the concentrates shall then be subjected to further flotations until nil or negligible concentrate is produced.

Essentially, the initial feed mass is fractionated by successive re-flotations without subsequent recombination of individual concentrate or tailings fractions.

NOTE 1 It will be rare for any branch of the process sequence to require more than four flotation operations. Usually, two or three stages will suffice.

NOTE 2 For some coals, further testing can be required to achieve separations yielding down to 2 % of the initial feed mass.

8.4 Analysis of concentrate and tailings

All products may be filtered. All products shall be air-dried, their mass determined and analysed for moisture and ash as specified in ISO 589 and ISO 1171 respectively and reported on a dry basis.

Drying in an air oven at 40 °C may be carried out, provided that equilibration with ambient conditions is achieved before the mass is determined.

9 Calculation of results

The mass of reconstituted feed (m_R), in grams, shall be calculated on a dry basis from the following Formula (1):

$$m_R = \sum_{i=1}^{N} (m_C)_i + \sum_{j=1}^{M} (m_T)_j \quad (1)$$

where

N is the total number of concentrates;

$(m_C)_i$ is the mass of concentrate i, in grams;

M is the total number of tailings;

$(m_T)_j$ is the mass of tailing j, in grams.

The mass fraction distribution (D), expressed as a percent for a product is given by the following Formulae:

mass fraction distribution for concentrate i expressed as a percent,

$$D_i = 100(m_C)_i/m_R \quad (2)$$

mass fraction distribution for tailings j, expressed as a percent,

$$D_j = 100(m_T)_j/m_R \quad (3)$$

The distribution for all products (concentrate and tailings) and the ash mass fractions of each product shall be determined and the results listed in a single table in ascending order of ash mass fractions. Progressive cumulative distribution (i.e. yield) and corresponding cumulative ash mass fractions shall then be calculated according to the following Formulae:

Cumulative percentage yield ($Y_{cum,n}$) in the first n products,

$$Y_{cum,n} = \sum_{k=1}^{N} D_k \quad (4)$$

where D_k is the distribution to the kth product in the ordered list

Cumulative mass fraction of ash ($A_{cum,n}$) expressed as a percent of the first n products,

$$A_{cum,n} = \sum_{k=1}^{N} \frac{(D_k \times A_k)}{Y_{cum,n}} \quad (5)$$

where A_k is the ash mass fraction expressed as a percent, on a dry basis of the kth product in the ordered list

To determine a quantitative performance measure, organic efficiency and ash error may be used in accordance with ISO 7936.

10 Test report

The test report shall contain the following information:

a) a reference to this document, i.e. ISO 8858-2:2024;