

BRITISH STANDARD 3620 : 1963

[UDC 003.6 : 622.7-333 : 662.66]

Confirmed June 1987

Methods for the
Expression and Presentation of
Results of Coal Cleaning Tests

Confirmed

- APR 1993

BRITISH STANDARDS INSTITUTION

METHODS FOR THE
EXPRESSION AND
PRESENTATION OF RESULTS
OF COAL CLEANING TESTS

B.S. 3620 : 1963

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B.S. 3620 : 1963

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 4th June, 1963.

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.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review.

Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 9,000, fully indexed and with a note of the contents of each, will be found in the BSI Catalogue which may be purchased from BSI Sales Department. The Catalogue may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standard:

B.S. 3552. Glossary of terms used in coal preparation.

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 reference SFE/46 Draft for comment D 62/2643

CONTENTS

	Page
Co-operating organizations	4
Foreword	5

METHODS

1. Scope	5
2. Object	5
3. Definitions	5
4. Standard expression of efficiency	5
5. Tabulation and graphical presentation of test results	6
6. Size of coal	6
7. Multiple-product separations	6

APPENDICES

A. Methods for expressing efficiency	7
B. Recommended methods of presenting coal cleaning test data	9
Form 1. Tables for three-product separation	17
Form 2. Example for three-product separation	19
Form 3. Tables for two-product separation	21
Form 4. Example for two-product separation	23

FIGURES

1. Partition curves (three-product)	25
2. Ash error and organic efficiency	26
3. Correctly placed and misplaced material—high density cut	27
4. Correctly placed and misplaced material—low density cut	28

CO-OPERATING ORGANIZATIONS

The Gas Industry Standards Committee and the Solid Fuel Industry Standards Committee, under whose joint supervision this British Standard was prepared, consist 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 (Incorporated)
Association of Heating, Ventilating and Domestic Engineering Employers
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 Engineers' Association
British Iron and Steel Federation
British Ironfounders' Association
Chamber of Coal Traders
Coal Utilization Council
Coke Oven Managers' Association
Combustion Engineering Association
Council of Ironfoundry Associations
Electricity Council, the Generating Board and the Area Boards in England and Wales
Federation of British Industries
*Gas Council
Imperial Chemical Industries, Ltd.
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
Society of Chemical Industry
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 British Standard:

Coal Preparation Plant Association
Coal Preparation Society

BRITISH STANDARD METHODS FOR THE EXPRESSION AND PRESENTATION OF RESULTS OF COAL CLEANING TESTS

FOREWORD

This British Standard has been drawn up by a representative Committee under the authority of the Solid Fuel Industry Standards Committee.

The formulae, tables and graphs contained in this British Standard are identical with those recommended, after considerable discussion, by a Committee of the International Organization for Standardization (ISO).

It is expected that their general adoption will simplify the exchange of information relating to the efficiency and performance of coal preparation plant and that the accumulation of data resulting from their use on a variety of coals treated in different types of machine in different parts of the world may enable them to be simplified at a later date.

METHODS

SCOPE

1. This British Standard outlines the principles on which the expression of the efficiency of operation of coal cleaning plant should be based, recommends the criteria, coefficients and formulae to be used and also gives methods for the tabulation and graphical presentation of the test data.

OBJECT

2. Expressions of efficiency are required for:
- Indication of the accuracy (or inaccuracy) of a given separating operation on a particular coal.
 - Prediction of the probable results of treating different coals by a given separating operation.
 - Comparison of different separating processes.

DEFINITIONS

3. The terms used in this British Standard are defined in B.S. 3552, 'Glossary of terms used in coal preparation'.

STANDARD EXPRESSION OF EFFICIENCY

4. Many different formulae have been proposed to express different aspects of efficiency and those commonly used are listed in Appendix A. For the purpose of meeting the requirements stated in Clause 2 no one of these formulae, by itself, suffices.

For the standard expression of efficiency, the following four formulae should be used in conjunction:

- (i) *Separation density* expressed as (a) *Partition density* and/or (b) *Equal errors density*.
- (ii) *Total of correctly placed material* at the separation density, expressed as a percentage of the reconstituted feed, and where required the *Misplaced material* in each product at the separation density, expressed as a percentage of the product.
- (iii) *Ecart probable moyen* and *Imperfection*.
- (iv) *Ash error* or *Organic efficiency*.

TABULATION AND GRAPHICAL PRESENTATION OF TEST RESULTS

5. The formulae for the expression of efficiency are derived by a standard method of calculation from the basic test data; for convenience, the tables and graphs in which these data are presented should also follow a standard pattern.

Appendix B describes and exemplifies recommended methods for the tabulation and graphical presentation of test results.

SIZE OF COAL

6. In expressing efficiency, it is essential to state the nominal size limits of the coal to which the calculations refer.

MULTIPLE-PRODUCT SEPARATIONS

7. In multiple-product separations, the formulae should be expressed at each separation density (see also Appendix B2).

APPENDIX A

METHODS FOR EXPRESSING EFFICIENCY

Formula	Derived from	Remarks
(i) <i>Separation density</i>		Describes one characteristic of the separation, but does not indicate its accuracy.
a. Partition density	Partition curve	
b. Equal errors density	M-curve Washability curves	
(ii) <i>Misplaced material</i>	M-curve Washability curves	Measure of quantity misplaced (without reference to its quality) at the separation density.
(iii) <i>Total of correctly placed material</i>	M-curve Washability curves	Measure of quantity correctly placed (without reference to its quality) at the separation density.
(iv) <i>Ash error</i>	M-curve Washability curves	Reflects both the quantity and quality of misplaced material in terms of the specific property of coal (percentage of ash) which the separation is designed to control ; measures qualitative efficiency.
(v) <i>Yield loss</i>	M-curve Washability curves	Reflects both the quantity and quality of misplaced material and measures quantitative efficiency.
(vi) <i>Organic efficiency</i>	M-curve Washability curves	Related to yield loss but expressed as a percentage.
(vii) <i>Error area</i>	Partition curve	Measures quantity of misplaced material in terms of density.
(viii) <i>Partition coefficients</i>	Partition curve	Special applications only.
(ix) <i>Ecart probable moyen</i>	Partition curve	Gives an indication of the quantitative errors inherent in the separating process at a given separation density.
(x) <i>Imperfection</i>	Partition curve	Modification of <i>Ecart probable moyen</i> to include effect of varying separation density.
(xi) <i>Yield loss</i>	Product samples	States results without reference to accuracy of separation.

NOTES ON FORMULAE AND GENERAL DATA

NOTE 1. *M-curves* and *Washability curves* describe graphically the character of the raw coal and of the products in terms of weight and ash content. *Partition curves* describe only the products and in terms of weight and density; they can be constructed without the necessity to determine ash contents.

NOTE 2. *M-curves* have wider direct applications than *Washability curves*, especially, for example, in 3-product separations.

NOTE 3. The *Ecart probable moyen* and *Imperfection* reflect the influence of changes in the separation process rather than in the raw coal, in contrast to the formulae derived from *M-curves* or *Washability curves*, which reflect changes in the raw coal as well as in the separation process.

NOTE 4. The *Separation density*, although not a measure of efficiency, is an important characteristic of the separation and is essential to any comprehensive statement of the results of a given test.

NOTE 5. The *Misplaced material* and the *Total of correctly placed material* at the *Separation density*, the *Ash error*, the *Yield loss*, the *Organic efficiency* and the *Error area* can all be used for guarantee tests and occasional control tests to give an indication of the accuracy of a given separation on a given coal, and hence of economic efficiency; but they are of little value in the prediction of probable results of cleaning a range of coals by one specific process.

Partition coefficients, *Ecart probable moyen* and *Imperfection* are valuable for the purpose of prediction but do not give an adequate indication of the accuracy of a given separating operation on a particular coal.

APPENDIX B

RECOMMENDED METHODS OF PRESENTING COAL CLEANING
TEST DATA**B1. Description of the tables**

(i) Two sets of tables are required:

- a.* For three-product separation (Cleaned coal, middlings and discard).
- b.* For two-product separation (Cleaned coal and discard).

For convenience, an identical layout has been adopted for both sets of tables, but in those intended for use with two-product separations the columns which relate only to three-product separations have been struck through so as to avoid confusion.

(ii) Each set of tables is presented in two ways:

- a.* In blank—the tables would be printed in this way.
- b.* Completed, by way of example, by filling in the figures relating to the results of a test on a Baum jig washer.

(iii) For the test described in this example, the washer was supplied with coal sized 6 in-0. The figures used for (i) *b* refer to the fraction sized between $\frac{1}{2}$ in and $\frac{1}{2}$ mm. The fine material below $\frac{1}{2}$ mm was removed from the samples before carrying out float-and-sink tests, because this fine material presents difficulties in testing. Moreover, the jig is not expected to clean material smaller than $\frac{1}{2}$ mm.

(iv) For a full analysis of the test, tables similar to those given for the $\frac{1}{2}$ in- $\frac{1}{2}$ mm size would be required for the other sizes of the raw coal, in this instance, 6-2 in, 2-1 in, and 1- $\frac{1}{2}$ in. Such tables would enable the performance on the different sizes to be compared. By adding together the results on the four individual sizes, a further set of tables could be constructed representing the whole of the 6 in- $\frac{1}{2}$ mm coal.

(v) In this test, three products were made, cleaned coal, middlings and reject. The reject is the material removed by the primary reject elevator and the middlings is the reject from the secondary reject elevator. The table headed THREE-PRODUCT SEPARATION is built up from float-and-sink tests at various specific gravities from 1.30 to 2.00 on samples of each of these three products. Although intervals of 0.1 specific gravity have been used for the example, the same intervals will not necessarily be required in any specific test.

(vi) The figures in the table headed TWO-PRODUCT SEPARATION have been calculated from these same figures on the assumption that the products from

both elevators (i.e. the middlings and the reject) were combined so that there were two products only, cleaned coal and a single reject.

B2. Expression of efficiency in three-product separation

(i) Three-product separation may be regarded as a combination of two distinct two-product separations (i.e. a low-density cut and a high-density cut), whether these two stages are in fact carried out in different separating vessels or in different parts of the same vessel.

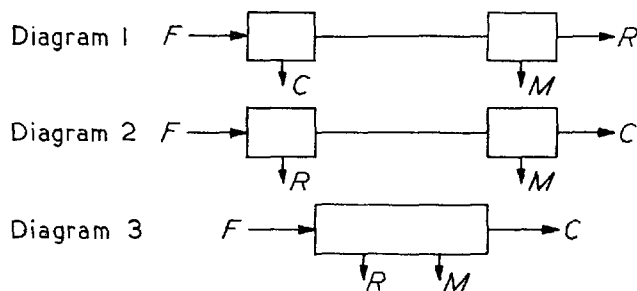
The following diagrams illustrate different combinations of the two stages, the symbols used being:

F = Feed (reconstituted raw coal).

C = Cleaned coal

R = Reject

M = Intermediate product (middlings).



Diagrams 1 and 2 are typical arrangements for a two-stage dense medium separation, the only difference being that the low-density cut comes first in Diagram 1 and second in Diagram 2.

Diagram 3 represents a normal three-product jig (or a three-product dense medium separation). The middlings M may be collected as a separate product, or recirculated, or otherwise dealt with; but, provided any recirculated middlings are included in the reconstituted feed F , the argument is unaffected.

(ii) The efficiency of a three-product separation may be calculated in two different ways:

Method A, by regarding it as two distinct and individual separations, each with its own feed;

Method B, by regarding it as a single comprehensive separation, the feed for which is the reconstituted raw coal.

In order to calculate the partition coefficients, the appropriate formulae for these two methods, for the combinations of plant illustrated in Diagrams 1 to 3, are as follows:

For Diagram 1. Method A, low-density cut $\frac{100 (M + R)}{C + M + R}$

high-density cut $\frac{100 R}{M + R}$

Method B, low-density cut $\frac{100 (M + R)}{C + M + R}$

high-density cut $\frac{100 R}{C + M + R}$

For Diagram 2. Method A, high-density cut $\frac{100 R}{C + M + R}$

low-density cut $\frac{100 M}{C + M}$

Method B, high-density cut $\frac{100 R}{C + M + R}$

low-density cut $\frac{100 M}{C + M + R}$

For Diagram 3. Method A, high-density cut $\frac{100 R}{C + M + R}$

low-density cut $\frac{100 M}{C + M}$

Method B, high-density cut $\frac{100 R}{C + M + R}$

low-density cut $\frac{100 (M + R)}{C + M + R}$

While for Method A the formulae are identical for Diagrams 2 and 3, in the latter case there is no sharp dividing line between the first and second cuts. The first (high-density) cut separates the reject R from the combination of the cleaned coal C and middlings M , and it is this combination which becomes the feed to the second stage of the separation.

Method A enables the efficiency of each of the two separations to be studied individually, for only the material actually admitted to the separation is included in the calculation. This is of advantage when considering the performance of each machine or stage in the separation process.