

Coal flow properties —

Part 1: Bin flow

ICS 73.040

National foreword

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Summary of pages

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Coal flow properties —

Part 1: **Bin flow**

Propriétés d'écoulement du charbon —

Partie 1: Écoulement d'une trémie



Contents

Page

Foreword.....	iv
1 Scope.....	1
2 Normative references	1
3 Terms and definitions	1
4 Notation.....	4
5 Sampling and sample preparation	5
5.1 Sampling	5
5.2 Sample preparation.....	5
5.2.1 General	5
5.2.2 Sample top size	6
5.2.3 Sample division	6
5.2.4 Moisture content	6
6 Determination of yield locus	6
6.1 Apparatus.....	6
6.2 Instantaneous yield locus	6
6.2.1 General	6
6.2.2 Preconsolidation of the sample.....	7
6.2.3 Shear consolidation.....	8
6.2.4 Shearing of the sample.....	9
6.2.5 Determination of the complete family of instantaneous yield loci	10
6.3 Other yield loci	10
6.3.1 High-pressure yield locus	10
6.3.2 Time yield locus	10
6.3.3 Temperature yield locus.....	12
6.3.4 Vibration yield locus	12
6.4 Reporting and presentation of results	12
6.4.1 General	12
6.4.2 Prorating procedure.....	13
6.4.3 Determination of the instantaneous flow function	13
6.5 Acceptance of results and precision of the determination	14
7 Determination of wall yield locus	15
7.1 Principle	15
7.2 Apparatus.....	15
7.3 Sample.....	15
7.4 Procedure.....	15
7.5 Calculations	16
7.6 Determination of wall friction angle (ϕ).....	17
7.7 Precision of determination.....	17
8 Determination of bulk density/compressibility	18
8.1 General	18
8.2 Apparatus.....	18
8.3 Sample.....	18
8.4 Procedure.....	18
8.5 Calculations	19
8.6 Presentation of results	19
8.7 Precision of determination.....	19
Annex A (informative) Bin design philosophy.....	23

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 15117-1 was prepared by Technical Committee ISO/TC 27, *Solid mineral fuels*, Subcommittee SC 1, *Coal preparation: Terminology and performance*.

ISO 15117 consists of the following parts, under the general title *Coal flow properties*:

- *Part 1: Bin flow*
- *Part 2: Rapid assessment*

Coal flow properties —

Part 1: Bin flow

1 Scope

This part of ISO 15117 sets out methods for the measurement of the flow properties of coal, primarily for the design of bins and chutes. It also provides some guidance on the presentation of these data for analysis and design.

This part of ISO 15117 consists of a bulk density test and a yield locus test giving information on material flow properties. It also describes a further test, called the wall yield locus, which measures the friction between coal and bin wall material.

Although this part of ISO 15117 is nominally for coal, the principles and apparatus may be used for coke and other semi-cohesive particulate materials where a knowledge of flow properties is required.

NOTE Some discussion of the relevance of coal flow properties to bin design philosophy is provided in Annex A.

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 1213-2:1992, *Solid mineral fuels — Vocabulary — Part 2: Terms relating to sampling, testing and analysis*

ISO 1953:1994, *Hard coal — Size analysis by sieving*

ISO 589:1981, *Hard coal — Determination of total moisture*

ISO 13909-2: 2002, *Hard coal and coke — Mechanical sampling — Part 2: Coal — Sampling from moving streams*

ISO 13909-4: 2001, *Hard coal and coke — Mechanical sampling — Part 4: Coal — Preparation of test samples*

ASTM D 6128-00, *Standard Test Method for Shear Testing of Bulk Solids Using the Jenike Shear Cell*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 1213-2 and those below apply.

NOTE In this part of ISO 15117, the terms pressure and stress are used synonymously because this convention is used in research and literature on this subject. Some other terms have not yet been standardized in the literature. These are listed below, together with a reference to the preferred nomenclature.

3.1

axi-symmetric flow

SEE mass flow

3.2

bulk density

the mass of a sample of particulate solid including moisture, divided by its total volume

NOTE The level of consolidation stress is critical to any measurement of bulk density.

3.3

bulk material

semi-cohesive particulate material such as coal and other minerals

3.4

cohesion

the shear stress at yield under zero normal stress

NOTE This parameter is not normally quantified.

3.5

compaction

the process of permanent volume reduction of a bulk material by application of a consolidating stress

3.6

consolidation

SEE compaction

3.7

core flow

SEE funnel flow

3.8

critical consolidation, in a shear cell

the state existing in a bulk sample within a shear cell when the cell stem travel becomes independent of applied shear force

NOTE Under these conditions, the bulk material is deforming without change in voidage. The material is said to be in its critical state.

3.9

critical state

SEE critical consolidation

3.10

critical pipe or rathole diameter

the diameter of a rathole or pipe at which the rathole or pipe becomes unstable

NOTE The critical rathole diameter varies with consolidation pressures.

3.11

effective angle of internal friction

δ

the angle with the horizontal axis of a line through the origin and tangent to the Mohr circle through the end point of the yield locus

See Figure 4.

NOTE The line through the origin is called the effective yield locus.

3.12

expanded flow

flow from a bin which has two distinct cross-section regimes

NOTE Funnel flow exists in the lower cylindrical section of the bin whereas mass flow exists in the conical outlet hopper or hoppers.

3.13**flow function, instantaneous****FF**

for a given bulk material, a plot of the unconfined yield strength σ_c versus the major consolidating pressure, values being obtained from the yield loci

NOTE This is a measure of the bulk strength or flowability of a bulk material, in a de-aerated state, when first loaded into a bin or consolidated in a shear cell.

3.14**flow function, time storage**

for a given bulk material, a measure of the increase in unconfined yield strength of material subjected to standard consolidation conditions for a defined time, typically 24 h to 48 h

3.15**funnel flow**

the flow that occurs during gravity storage when bulk material sloughs off the surface of the material and discharges through a vertical channel which forms within the material in the bin whenever material is drawn from the outlet

NOTE Material adjacent to the bin walls remains stationary.

3.16**hopper half-angle**

α

the angle between one wall of the hopper and the vertical

3.17**major consolidating pressure****major consolidating stress**

σ_1

the pressure given by the Mohr circle passing through the end point of the instantaneous yield locus and the tangent to the locus

See Figure 4.

3.18**mass flow**

the flow that occurs when bulk material is in motion at every point in a bin whenever material is drawn from the outlet

NOTE Mass flow is normally symmetric and is usually axi-symmetric in three dimensions in a conical hopper, or plane in two dimensions in a wedge hopper.

3.19**natural fines**

the fraction of the sample screened below 4 mm or 6 mm

3.20**particulate solid**

an assembly of solid particles having properties independent of the number of particles present

SEE **bulk material** (3.3).

3.21**plane flow**

SEE mass flow

3.22

shear apparatus

equipment for subjecting the material under test to shear deformation under conditions of controlled normal pressure

3.23

unconfined yield strength

σ_c
the major principal stress that must be applied tangentially to an unconfined surface to cause yielding

3.24

voidage or voids ratio

the volume of the voids within a quantity of bulk material, divided by total volume (voids plus solids)

3.25

yield locus, effective

see effective angle of internal friction

3.26

yield locus, instantaneous

the shear force versus normal force curve for plastic failure of an over-consolidated bulk material of given initial voidage; this defines conditions when material flow commences

3.27

yield locus, time

the shear force versus normal force curve for plastic failure of a bulk material after being held at rest under a standard pressure for a given time

3.28

yield locus, wall

ϕ
the locus of shear force versus applied normal force on a sample of bulk material moving in contact with a boundary surface or wall

NOTE This is the angle determined by the shear and normal force shown in Figure 10.

4 Notation

The following quantity symbols are used in this part of ISO 15117:

- F Unconfined yield force under instantaneous conditions
- h Compacted height, in bulk density test
- S Steady-state shear force during the “shear consolidation” phase of the shear test
- S_f Steady shear force obtained in the wall friction test
- S_t An uncorrected value of S determined from the shear test
- S_s The value of S selected for a particular level of consolidation, and used for prorating $(S_i)_t$ values
- $\overline{S_i}$ Maximum value of shear force obtained during the “sample shear” phase of the shear test
- $(\overline{S_i})_t$ An uncorrected value of S determined from the shear test
- $(\overline{S_i})_p$ A corrected value of S obtained using Equation (1)