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**Hard coal — Determination of  
abrasiveness**

*Houille — Détermination de l'abrasivité*

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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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 27, *Solid mineral fuels*, Subcommittee SC 5, *Methods of analysis*.

This third edition cancels and replaces the second edition (ISO 12900:2015), of which it constitutes a minor revision to provide clarification on how to operate the abrasion test machine in [Clause 7](#).

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](http://www.iso.org/members.html).

## Introduction

The abrasiveness of coal is recognized as a factor in coal operations, from mining to utilization, requiring a standard method of measurement and evaluation, as some coals are more abrasive than others.

The interaction between coal and conveying, storage, and crushing equipment results in component wear. In particular, higher contact pressures in some coal pulverizers result in significant wear.

For the ranking or relative comparison of the abrasiveness of coals, a test was developed<sup>[1]</sup> which standardized the following equipment variables:

- a) test equipment dimensions and tolerances;
- b) speed of rotation of wearing components;
- c) properties of the wearing components;
- d) mass of the test portion;
- e) top particle size of the test portion;
- f) duration of the test.

The abrasiveness of coal is generally a function of two factors: the physical properties of the coal, in particular, moisture content, mineral content, and mineral characteristics<sup>[1][2][3][4][5][6]</sup>; the mechanics of the operations to which the coal is subjected.

NOTE Moisture contents over 10 % in the test sample after air-drying and laboratory equilibration might give anomalous results; the reason for this has not been established.

Wear on coal-pulverizing elements in industrial mills is influenced by the physical characteristics of the coal and its mineral constituents, the mechanical characteristics of the mill, including the milling pressures, alloy material properties and coal feed flow, and the operation of the mill. Abrasiveness as determined by this document has been demonstrated to provide initial empirical estimates of specific wear rates in certain types of industrial tube-ball mills, vertical spindle mills, and high-speed hammer mills<sup>[3][6]</sup>, with different coefficients for each mill type.

Abrasiveness as determined by this document might be of value in providing an initial estimate of the likely wear in other applications, giving the relative effect of different coals.

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# Hard coal — Determination of abrasiveness

## 1 Scope

This document describes a method for determining the abrasiveness of hard coal.

## 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 589, *Hard coal — Determination of total moisture*

ISO 3310-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

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

No terms and definitions are listed in this document.

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/>

## 4 Principle

Four standard steel blades are rotated under specified conditions in a 2 kg mass of prepared coal in a test machine. The abrasiveness is calculated from the mass of steel lost during the test.

## 5 Apparatus

**5.1 Abrasion test machine**, comprising the following components:

**5.1.1 Blades**, of the following types:

- a) **A set of four reference blades**<sup>1)</sup>, having a Vickers hardness of  $160 \pm 15$  when tested in accordance with ISO 6507-1. When new, the blades, machined with the bar rolling direction parallel to the line of the bolt holes, from a bar of carbon steel, shall have the shape, dimensions, and surface finish

1) Suitable blades are available from Mitsui Babcock Energy Ltd., Technology Centre, Renfrew, U.K. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products. Equivalent products may be used if they can be shown to lead to the same results.

shown in [Figure 1](#). To reduce the extent of varying hardness near the surface, care should be taken during machining to minimize surface distortion and heating of the blades. The blades shall be marked for identification.

A new set of blades shall be “run in” by carrying out a number of abrasiveness determinations on 2 kg test portions of the same coal until constant results (within the limits of repeatability, see [Clause 10](#)) are obtained.

When blades are not in use, they should be wrapped in a cloth containing a rust-preventive solution and stored in a desiccator. Immediately prior to use, the blades should be cleaned with a suitable solvent, e.g. methylated spirits, and allowed to air-dry in a desiccator.

The reference set of blades shall be discarded when any of the following conditions occurs:

- the wear on the leading edge or corners is greater than 3 mm;
- the blades cannot be correctly adjusted in the jig.

After a number of tests, the wearing surface of the blades might become rough, in which case each blade should be gently polished with a finegrained emery paper and reconditioned prior to further use.

Dimensions in millimetres

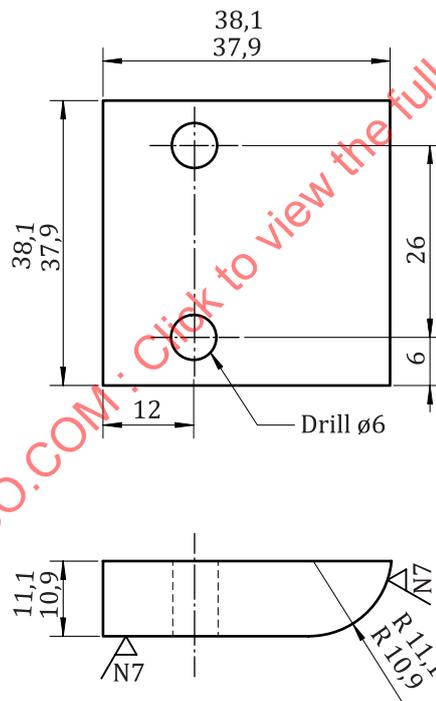


Figure 1 — Blades

- b) **A set of four working blades**, conforming to the requirements of [5.1.1](#) and checked successively against the reference blades when their original mass has decreased by 2 %, 3 %, 4 %, or more frequently if required.

The working set of blades shall be discarded when the results obtained on a sample using the working set differ, after a minimum of three determinations, by more than the limit of repeatability from the value obtained using the reference set.

After a number of tests, the wearing surface of the blades might become rough, in which case each blade should be gently polished with a finegrained emery paper and reconditioned prior to further use.

**5.1.2 Mill mortar**, having dimensions as shown in [Figure 2](#) and fitted with a dust-tight cover. The lower sections of the walls may be recessed to accommodate a replaceable liner. Hardened metal or hard metal plate is recommended for the mill mortar (or liner if fitted). The mill mortar shall be discarded (or a new liner fitted) when the tolerance shown in [Figure 2](#) is exceeded.

**5.1.3 Quadrant**, having four arms with elongated bolt holes for attachment and adjustment of the blades using round-head bolts, nuts, and spring washers. The quadrant shall be capable of being removed from the mill mortar (see [Figure 2](#)).

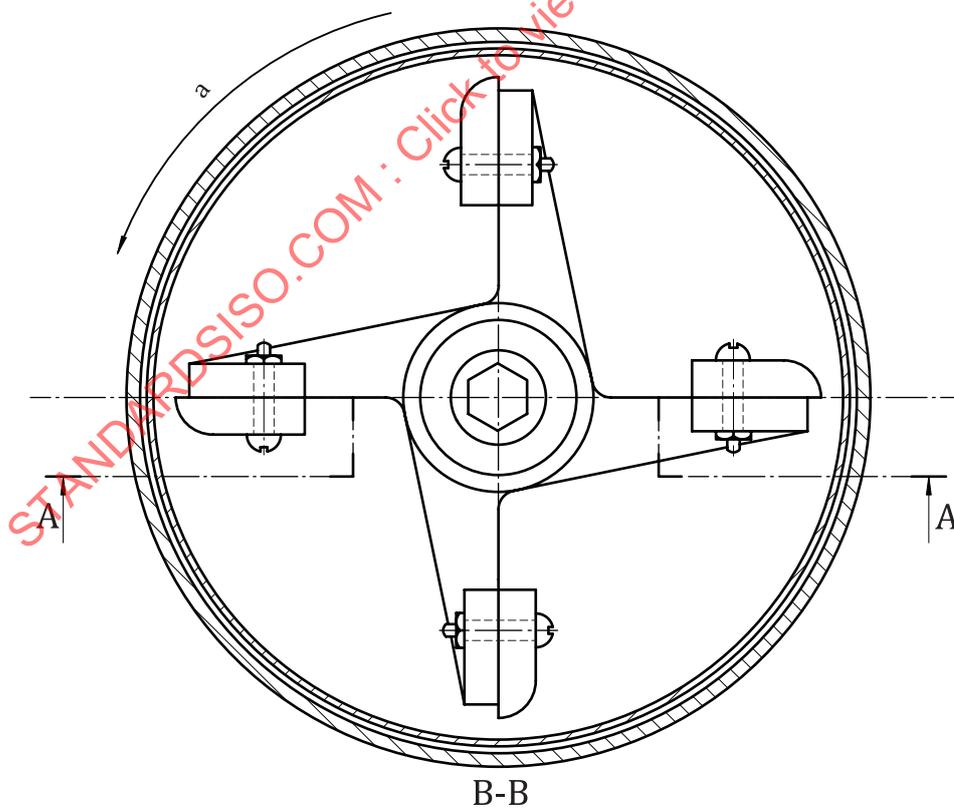
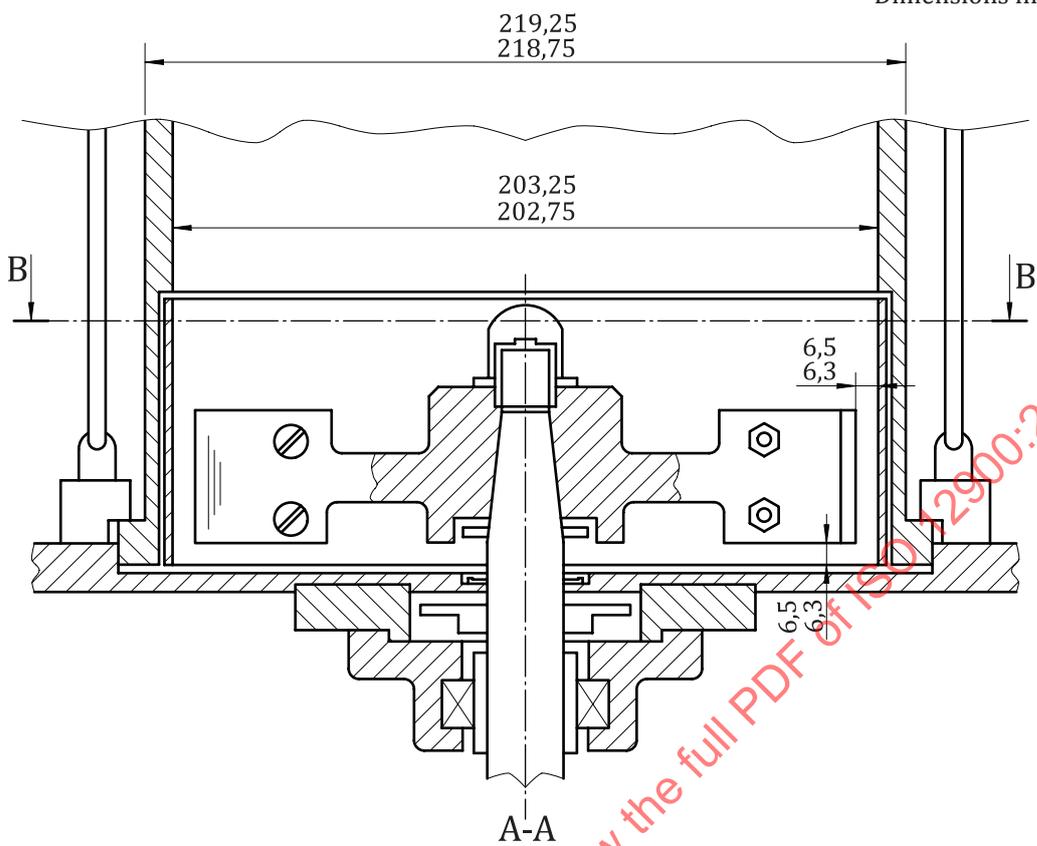
Some test machines have quadrants which are not removable. For these machines, the blades should be adjusted using suitable gauges so that the trailing and bottom edges are positioned  $(6,4 \pm 0,1)$  mm from the wall and bottom of the mill mortar.

**5.1.4 Drive**, for driving the quadrant at  $24,5 \text{ s}^{-1} \pm 0,5 \text{ s}^{-1}$  either directly or indirectly by a constant-speed electric motor. The shaft shall be fitted with a revolution counter and automatic cut-off switch.

NOTE A 2,5 kW motor is suitable. The drive can be above or below the mill mortar.

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Dimensions in millimetres



a Direction of rotation.

Figure 2 — Mill mortar and quadrant assembly

**5.1.5 Jig**, metal, (see [Figure 3](#)) to assist in attaching and adjusting the blades to the quadrant arms. The jig dimensions shall be such that, when the blades are secured on the quadrant arms so that they are touching the walls and bottom of the jig, they will have the correct clearances when the quadrant is replaced in the mill mortar. The clearance (6,3 mm to 6,5 mm) between the blades and the mill mortar shall be checked periodically using a limit gauge.

**5.2 Balance**, capable of weighing a mass of not less than 2 kg to within 1 g or better.

**5.3 Balance**, capable of weighing the blades to within 0,1 mg.

**5.4 Jaw crusher**, capable of reducing coal particles to less than 6,7 mm with minimum production of fines.

**5.5 Test sieves**, having apertures 6,7 mm, 16 mm, and 31,5 mm and conforming to the requirements of ISO 3310-1.

**5.6 Fine brass brush**, for cleaning blades.

## 6 Sample preparation

The test sample shall be of 6,7 mm nominal top size and shall have a fines content of not more than 30 % less than 1 mm.

The sample shall be taken in accordance with ISO 18283, ISO 13909-2, or ISO 13909-3 and be prepared in accordance with ISO 13909-4.

A suitable procedure, as shown in the flow diagram in [Figure 4](#), is as follows.

The sample is prepared to give 55 kg or more of material having a nominal top size of 31,5 mm. It is then air-dried.

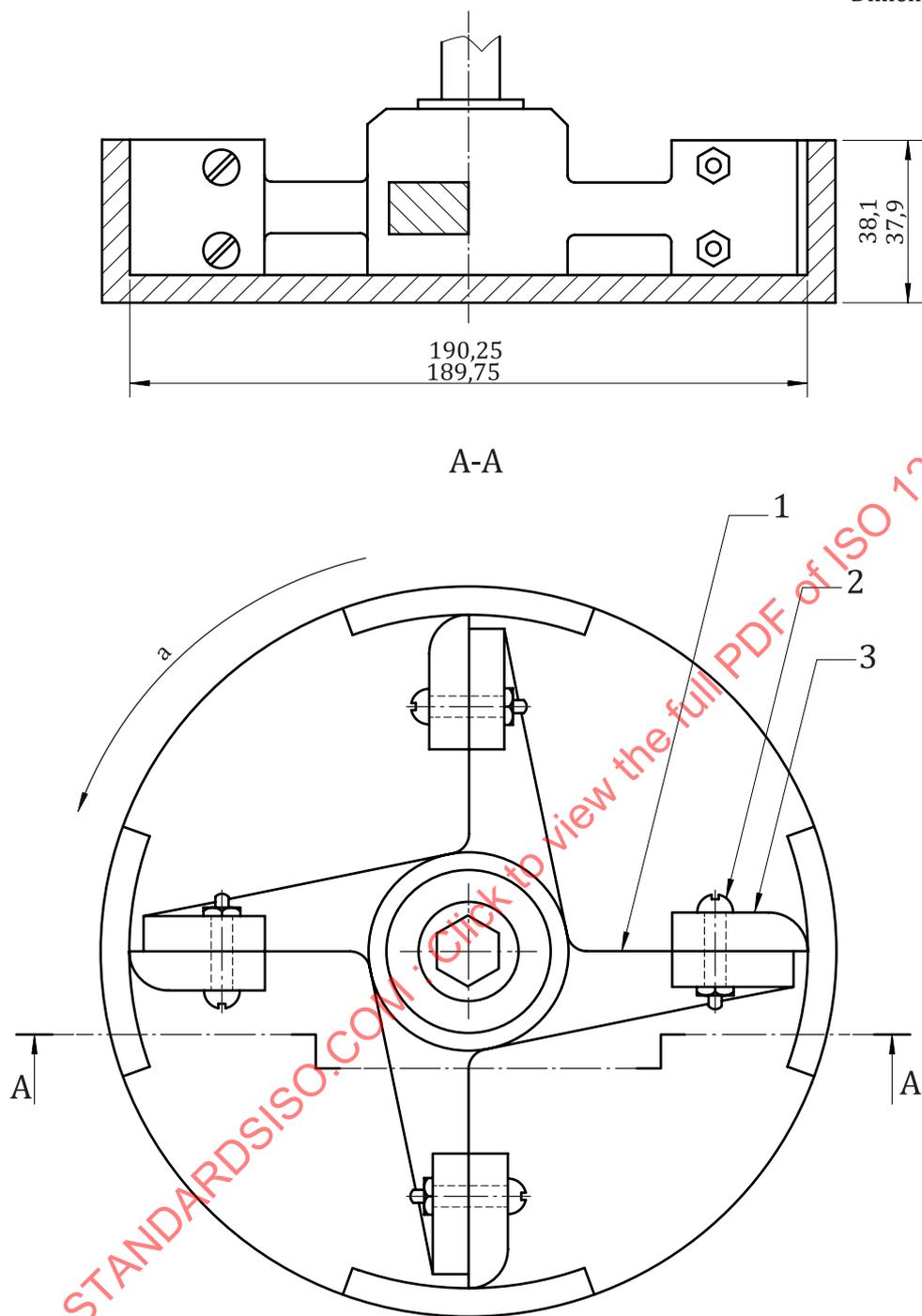
The air-dried sample is sieved using a 16 mm sieve. The fraction passing this sieve is set aside and the retained material is crushed (in one or more steps) to pass a 16 mm sieve.

If required, the sample of coal less than 16 mm may be divided, but to no less than 20 kg.

The sample is then sieved using a 6,7 mm sieve. The fraction passing this sieve is set aside and the retained material is crushed (in one or more steps) to pass a 6,7 mm sieve.

All the minus 6,7 mm coal is collected together and thoroughly mixed.

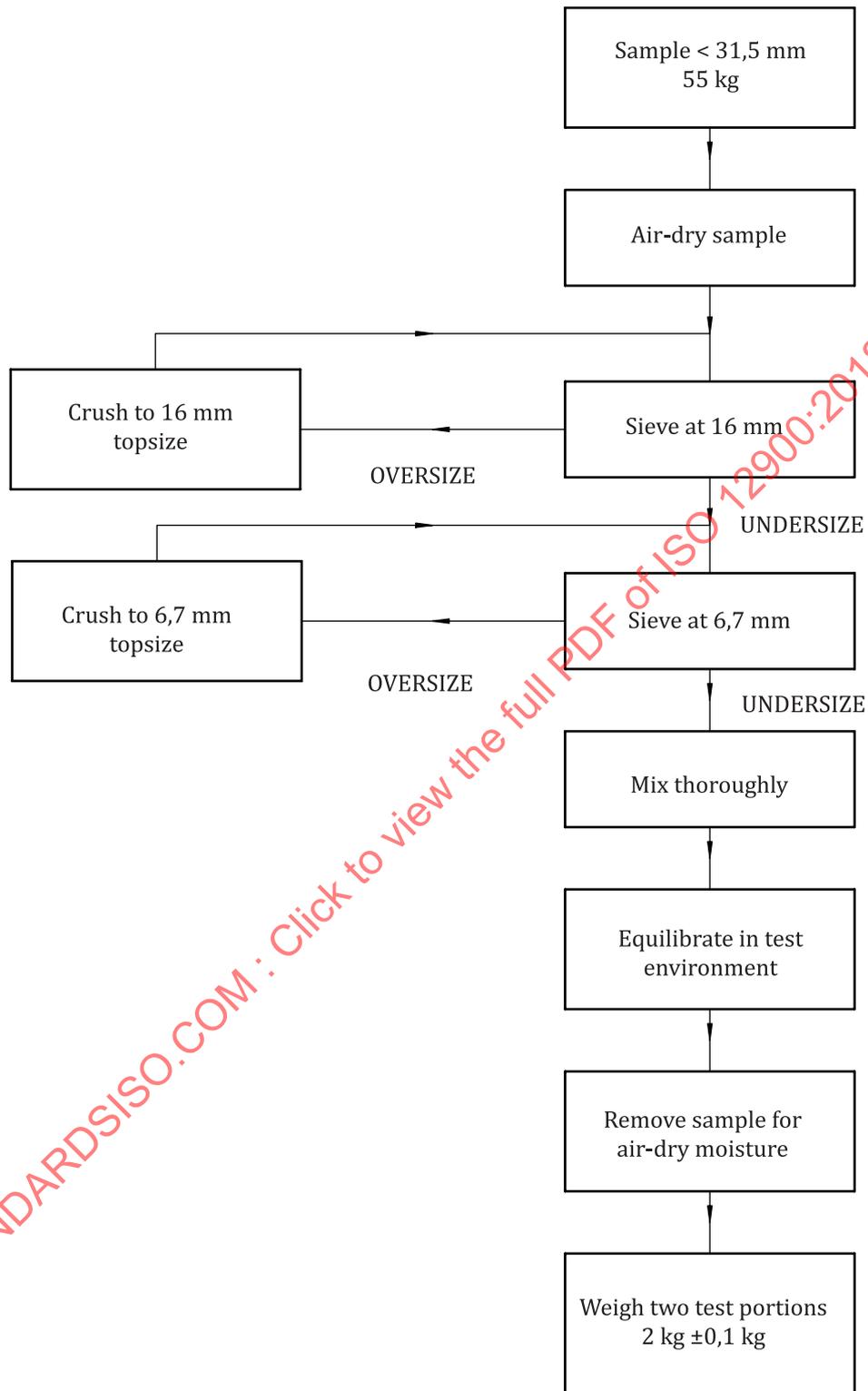
Dimensions in millimetres



**Key**

- 1 quadrant arm
- 2 retaining bolt
- 3 blades with curved edges
- a Direction of rotation.

**Figure 3 — Jig and location of blades**



**Figure 4 — Sample preparation: Flow diagram**

The sample is exposed in a thin layer for the minimum time necessary for the moisture content to reach equilibrium with the laboratory atmosphere.

## 7 Procedure

Inspect the mill mortar, quadrant arms, and blades and, if necessary, clean with a suitable solvent. Dry in a desiccator and weigh each blade to the nearest 0,1 mg.

NOTE A suitable solvent is methylated spirits.

Position the quadrant in the jig. Attach the blades to the quadrant using roundhead bolts, nuts, and spring washers. Ensure that the blades are just touching the walls and bottom of the jig and that the blades are mounted with the curved edges facing the direction of rotation. Tighten the nuts securely and check the adjustment. If necessary, adjust the blades.

Weigh out a  $1,5 \text{ kg} \pm 0,01 \text{ kg}$  sample and determine the total moisture content in accordance with ISO 589. Carry out the moisture determination concurrently with the abrasiveness determination.

Weigh out a  $2 \text{ kg} \pm 0,1 \text{ kg}$  test portion. Place the quadrant and blades in the mill mortar. Place the 2 kg test portion in the mill mortar and level the surface.

Fit and secure the cover. Set the automatic counter, start the motor, and allow it to trip at  $12\,000 \text{ revolutions} \pm 20 \text{ revolutions}$  at a quadrant speed of  $24,5 \text{ s}^{-1} \pm 0,5 \text{ s}^{-1}$ .

Remove the cover and the coal from the mill mortar. Remove the quadrant assembly and check that the blades are correctly positioned by replacing the quadrant and blades in the jig. If the blades have moved, repeat the entire test procedure with fresh test portions of coal, ensuring that the blades are firmly secured.

Remove the blades, allow them to cool, and carefully clean them using the brass brush and a suitable solvent. Dry the blades and store in a desiccator until ambient temperature is reached. Re-weigh each blade to the nearest 0,1 mg.

If the loss of mass of one blade repeatedly deviates by 20 % relative or more from the average loss of mass of all blades, the test should be discarded and the reason investigated.

Repeat the test using a duplicate test portion.

## 8 Calculation

The abrasiveness of the coal,  $A$ , in milligrams of metal lost per kilogram of coal, is calculated using [Formula \(1\)](#):

$$A = \frac{(m_1 - m_2) \times 10^3}{m_3} \quad (1)$$

where

$m_1$  is the total initial mass, in grams, of the four blades;

$m_2$  is the total final mass, in grams, of the four blades;

$m_3$  is the mass, in kilograms, of the test portion.

## 9 Reporting of results

Report the result as the mean of duplicate determinations to the nearest whole number.

## 10 Precision of the determination

The numerical values for repeatability and reproducibility should not exceed those given in [Table 1](#).