
**Direct reduced iron — Determination of
tumble strength of hot briquetted iron (HBI)**

Minerais de fer préréduits — Essai au tambour du fer briqueté à chaud



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Printed in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 15967 was prepared by Technical Committee ISO/TC 102, *Iron ore and direct reduced iron*, Subcommittee SC 5, *Physical testing of direct reduction feedstock and DRI*.

Annexes A and B form a normative part of this International Standard.

Introduction

The international trade of hot briquetted iron (HBI) as a merchant commodity is increasing rapidly and is expected to grow beyond 10 million tonnes per annum in the twenty-first century. This has led to the need for the development of test method standards for HBI.

This International Standard specifies a method for the determination of the tumble strength of HBI. The test gives a relative measure of the resistance of HBI to size degradation by impact and abrasion, following the same principle as the tumble test for iron ores (see ISO 3271). The level of degradation measured in the test has been found to be similar to that experienced by HBI during ship loading, transport and bulk materials handling operations.

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Direct reduced iron — Determination of tumble strength of hot briquetted iron (HBI)

WARNING — This International Standard may involve hazardous materials, operations and equipment. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

1 Scope

This International Standard specifies a method for the determination of the tumble strength of hot briquetted iron (HBI).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3310-1:2000, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*.

ISO 3310-2:1999, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*.

ISO 10835:1995, *Direct reduced iron — Sampling and sample preparation — Manual methods for reduced pellets and lump ores*.

ISO 11323:1996, *Iron ores — Vocabulary*.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 11323 and the following apply.

3.1

tumble index of HBI

relative measure of the tumble strength of the HBI expressed as the mass percentage of the + 6,3 mm size fraction following a tumble test

3.2

abrasion index of HBI

relative measure of the size degradation of the HBI by abrasion expressed as the mass percentage of the – 500 µm size fraction following a tumble test

4 Sampling and sample preparation

Sampling of a lot of HBI and sample preparation shall be in accordance with ISO 10835.

A test sample of at least 70 kg shall be obtained.

5 Test method

5.1 Principle

A 15 kg test portion is tumbled in a circular drum (internal diameter 1 000 mm and internal length 500 mm) for a total of 200 revolutions. This is intended to simulate the degradation of the HBI caused by typical ship loading, discharge and materials handling operations.

The product material is sieved with test sieves including sieves with square mesh apertures of 6,3 mm and 500 μm . The appropriate size fractions are weighed and tumble and abrasion indices calculated.

5.2 Apparatus

5.2.1 Test sieves, conforming to ISO 3310-1 or ISO 3310-2 and having square openings of the following nominal aperture size: 40 mm, 6,3 mm and 500 μm .

5.2.2 Weighing devices, having appropriate capacities, each having a sensitivity of 1 g or better.

5.2.3 Drying pan, having a smooth surface, free from contamination and capable of accommodating in a single layer the specified number of briquettes of the test portion prepared from the test sample.

5.2.4 Drying oven, equipped with a temperature indicator and a control device capable of regulating and maintaining the temperature in the oven at $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

5.2.5 Tumble test apparatus, a circular drum of internal diameter 1 000 mm and internal length 500 mm constructed of steel plate at least 5 mm in thickness, as shown in Figure 1. The drum shall be replaced whenever the thickness of the plate is reduced to 3 mm in any area.

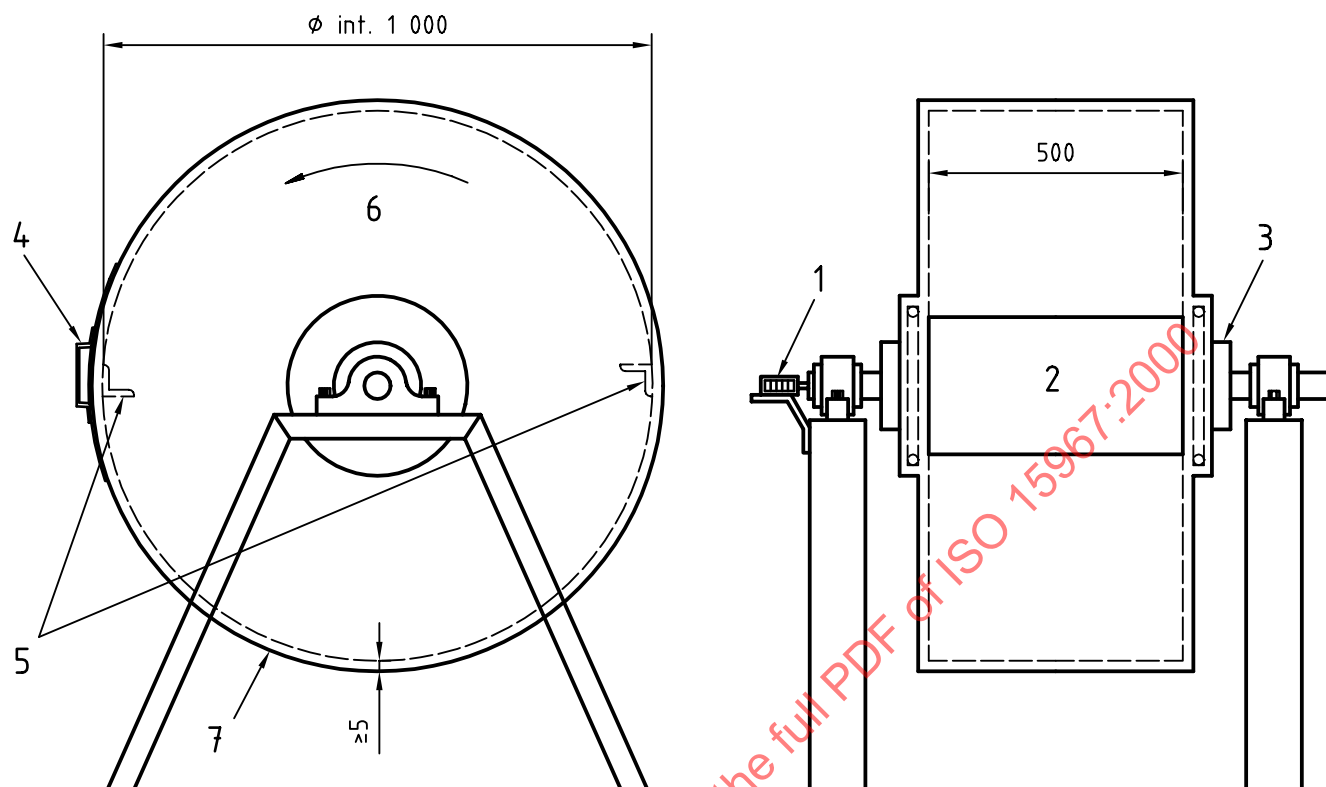
Two equally spaced steel angle lifters of section 50 mm $\times$ 50 mm of thickness 5 mm and length 500 mm shall be attached longitudinally inside the drum by welding in such a manner as to prevent the accumulation of material between the lifters and the drum. Each lifter shall be attached so that one leg of the angle points toward the axis of the drum, with its attached leg pointing away from the direction of rotation to provide an unobstructed shelf for lofting of the sample. The lifters shall be replaced when the width of the shelf is reduced by wear to less than 47 mm.

The door shall be constructed to fit the drum and form a smooth inner surface. During the test it shall be capable of being rigidly fastened and sealed to prevent loss of the sample.

The drum shall be rotated on stub axles attached to its ends by flanges welded so as to provide smooth inner surfaces.

The apparatus shall be fitted with a revolution counter and with an automatic device for stopping the drum after a predetermined number of revolutions. The apparatus shall operate on a minimum 1,5 kW power supply to ensure that the drum attains full speed in one revolution, rotates uniformly and stops within one revolution.

Dimensions in millimetres

**Key**

- | | |
|--------------------------------|-----------------------------|
| 1 Revolution counter | 4 Door with handle |
| 2 Door (not shown) | 5 Two lifters (50 × 50 × 5) |
| 3 Stub axle (no through shaft) | 6 Direction of rotation |
| | 7 Plate |

Figure 1 — Example of tumble test apparatus**5.3 Preparation of test portions**

Take the test sample obtained in clause 4, dry at $105^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 4 h and allow to cool to room temperature. Sieve the test sample by hand on a 40 mm test sieve, having a square aperture and conforming to test sieve standard specifications, discard any minus 40 mm material.

Spread the test sample on a smooth and flat plate to form a single layer of briquettes, in the shape of a rectangle. Prepare at least four test portions, each of approximately 15 kg, by taking at random single briquettes and placing them consecutively in four piles or containers.

Weigh each test portion and determine whether the test portion meets the mass tolerance of $15\text{ kg} \pm 0,5\text{ kg}$. Single briquette increments shall be added to the test portions from the remaining test sample or removed from the test portions and discarded to make up a weight of $15\text{ kg} \pm 0,5\text{ kg}$.

Take at random one test portion, weigh and record the mass, m_0 .

5.4 Procedure**5.4.1 General**

A schematic representation of the procedure is given in annex A.

5.4.2 Number of determinations

Start with duplicate determinations and if necessary make further determinations in accordance with the flowsheet presented in annex B.

5.4.3 Tumbling

Place the test portion carefully in the tumble drum (5.2.5). Tightly fasten the door and rotate the drum at $0,417 \text{ s}^{-1} \pm 0,016 \text{ s}^{-1}$ (25 rpm $\pm$ 1 rpm) for a total of 200 revolutions.

Carefully remove all material from the drum.

WARNING — Tumbling of HBI can be noisy and care must be taken to protect the hearing of the operator.

NOTE 1 It is recommended that putty or modelling clay be used to seal the door to prevent the loss of fines from the drum.

NOTE 2 After tumbling it is recommended that the tumble drum be kept at rest for at least 2 min to allow airborne dust to settle inside the drum.

5.4.4 Sieving

Sieve the HBI by hand on a 40 mm sieve to remove unbroken HBI and reduce the load on the smaller sieves.

Place the – 40 mm material on a nest of sieves which shall include a 6,3 mm and 500 μm sieve and shake for 1 min by hand. Mechanical sieving may be used provided that tests give results that are similar to those obtained by hand sieving, within the permissible tolerance of 2 % absolute.

Determine and record the mass of + 6,3 mm fraction, – 6,3 mm + 500 μm fraction and – 500 μm fraction.

5.4.5 Permissible loss of mass

The difference between the initial mass of the test portion and the total mass of the tumbled fractions shall not exceed 1 % of the initial mass of the test portion. If this difference exceeds 1 % the test shall be rejected.

5.5 Expression of results

The tumble index, T , and the abrasion index, A , expressed as percentages by mass, are calculated using the following formulae:

$$T = \frac{m_1}{m_0} \times 100 \quad (1)$$

$$A = \frac{m_0 - (m_1 + m_2)}{m_0} \times 100 \quad (2)$$

where:

m_0 is the mass, in grams, of the test portion as weighed out and placed in the tumble drum;

m_1 is the mass, in grams, of the + 6,3 mm fraction of the tumbled test portion;

m_2 is the mass, in grams, of the – 6,3 mm + 500 μm fraction of the tumbled test portion.

Retain each index to two decimal places for calculation of tolerances.

5.6 Number of tests and permissible tolerances

The test shall be carried out in duplicate. If the difference between the paired results does not exceed the permissible tolerance (r) given in Table 1, the mean value of the results shall be reported as the final result to one decimal place. If the difference between the paired results exceeds r , further test(s) shall be carried out in accordance with the flowsheet presented in annex B.

Table 1 — Permissible tolerance (95 % probability)

Tumble strength	Repeatability
Tumble index, T (+ 6,3 mm)	$r_T = 0,2 \%$
Abrasion index, A (– 500 μm)	$r_A = 0,12 \%$

5.7 Test report

The test report shall include the following information:

- name and address of testing laboratory;
- date of the test report;
- reference to this International Standard, i.e. ISO 15967;
- details necessary for the identification of the sample;
- results of the test, to one decimal place;
- any characteristics noticed during the test and any operations which may have had an influence on the results, e.g. scalping sieves used, loss of mass during the test;
- reference to verification activities.

6 Verification

Checks shall be carried out at regular intervals. The frequency of checking is a matter for each laboratory to determine. The following items shall be checked:

- drum condition;
- rotation speed and revolution counter;
- test sieves;
- weighing devices.

Appropriate records of all verification activities must be maintained.