INTERNATIONAL STANDARD

ISO 15968

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Direct reduced iron — Determination of apparent density and water absorption of hot briquetted iron (HBI)

Minerais du fer préréduits — Détermination de la masse volumique apparente et de l'absorption d'eau du fer briqueté à chaud

Reference number
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Contents

Page

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 15968 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 apparent density of HBI. The test gives a measurement of apparent density which is useful as a test of briquetting machine performance, as a measure of briquette quality, and may be used as part of a programme to certify that HBI meets the requirements of the International Maritime Organization (IMO) Code of Safe Practice for Solid Bulk Cargoes.

Direct reduced iron — Determination of apparent density and water absorption of hot briquetted iron (HBI)

CAUTION – 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 apparent density and water absorption 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 3082:—[1)], *Iron ores — Sampling and sample preparation procedures.*

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
open pores
those pores that are penetrated when immersed in water

3.2
closed pores
those pores that are not penetrated when immersed in water

1) To be published. (Revision of ISO 3082:1998)

3.3
apparent density
ρ_a
mass of the dry material divided by the **apparent volume** (3.4) of the material

3.4
apparent volume
volume of the material, as given by the mass of water displaced by the material that has been previously saturated in water

NOTE The apparent volume includes the volume of the solids, the volume of the **open pores** (3.1) and the **closed pores** (3.2).

3.5
water absorption
a
the mass of water absorbed into the **open pores** (3.1) of the dry material expressed as a percentage of the dry mass

4 Sampling and sample preparation

Sampling of a lot of HBI and sample preparation shall be carried out taking into account the general considerations and fundamentals given in ISO 3082 and ISO 10835.

A test sample of a sufficient quantity to provide at least 100 briquettes shall be obtained.

5 Test method

5.1 Principle

Dried briquettes are weighed in air and, after being soaked in water and surface-dried, are weighed again, first in air and then in water. The apparent density and water absorption are determined, by calculation, from the masses obtained.

5.2 Apparatus and materials

5.2.1 Test sieve, conforming to ISO 3310-1 or ISO 3310-2 and having square openings of 40 mm nominal aperture size.

5.2.2 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.

5.2.3 Drying oven, equipped with a temperature indicator and a control device capable of regulating and maintaining the temperature in the oven at 105 °C ± 5 °C.

5.2.4 Two vessels, for containing water, one for soaking the briquettes in water and the other for weighing soaked briquettes in water on a top loading balance. The second vessel shall be large enough to ensure that the suspended briquette, or wire basket holding the briquettes, is completely submerged and does not touch the sides or bottom of the vessel; e.g. a vessel 200 mm in diameter by 200 mm high is sufficient for the basket specified in 5.2.6.

5.2.5 Suspension device, to allow the test pieces to be suspended and weighed in water (see Figure 1).

5.2.6 Suspension wire or **wire basket,** to support the briquettes when suspended from the suspension device.

NOTE A wire basket 150 mm in diameter by 100 mm high is sufficient to hold a test portion of six typical briquettes.

5.2.7 Balance, top-loading, having a capacity of at least 4 kg, a readability of 0,1 g and a weighing platform on which to place and tare the vessel for weighing suspended, soaked briquettes.

5.2.8 Water, free from any impurity (for example dissolved air) that would significantly affect its density. In case of doubt, use distilled or de-ionized water or filtered tap water that has been freshly boiled.

5.2.9 Cloth or paper towel, to surface-dry the test piece.

5.2.10 Thermometer, to take the temperature of the water used for immersion.

5.3 Procedure

5.3.1 General

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

5.3.2 Number of determinations

Start with duplicate determinations and, if necessary, make further determination(s) in accordance with the flowsheet presented in annex B.

5.3.3 Preparation of test portions

Take the test sample obtained in clause 4 and sieve it 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.

Take the plus 40 mm material from the sieved test sample and spread it on a smooth and flat plate into a rectangle with a single layer of briquettes. Prepare four test portions, each of at least 6 briquettes, by taking at random single briquettes and placing them consecutively into four piles or containers.

5.3.4 Determination of mass of dry briquettes in air

Take at random one test portion.

The briquettes in the test portion may either all be tested at the same time or be tested individually in random order and the results averaged.

Dry the briquettes at 105 °C ± 5 °C to constant mass (this usually requires 1 h in a convection oven). The test portion is cooled in air to room temperature and any adhering dust removed from the individual briquettes with a soft brush or by gently blowing with compressed air. Weigh the test portion or each briquette to the nearest 0,1 g, to obtain the total mass, m_1, of all the dried briquettes in the test portion.

5.3.5 Soaking of briquettes

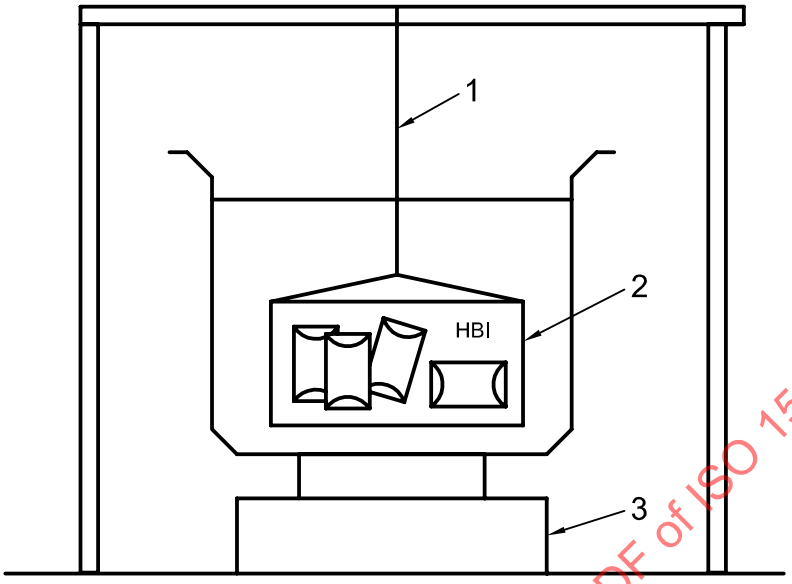
The dried briquettes from each test portion may be soaked individually or all at one time in a vessel containing water at a temperature of 22 °C ± 5 °C. Completely submerge them in the water to soak, and turn or agitate them occasionally to help remove air bubbles. Allow the briquettes to remain submerged until all air bubbling stops. This may take up to 1 h.

5.3.6 Determination of mass of surface-dried soaked briquettes in air

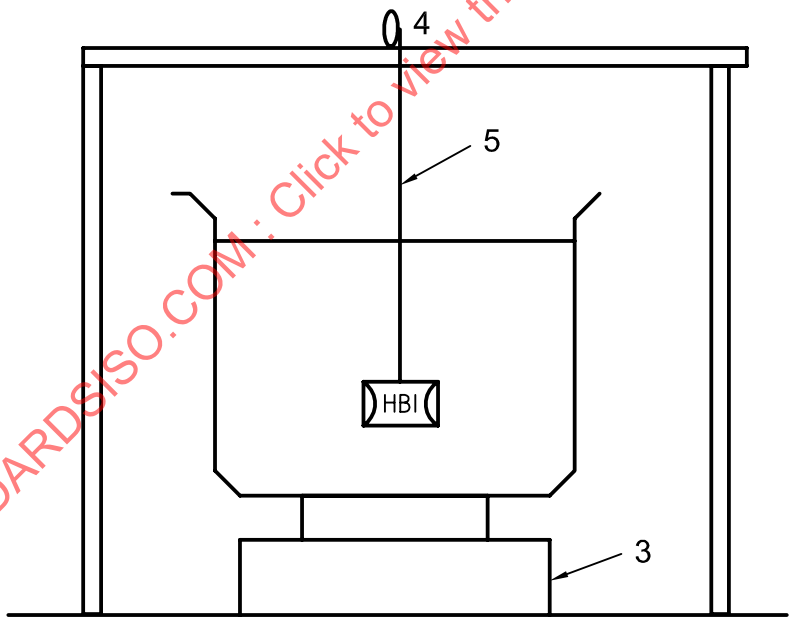
Remove the soaked briquettes from the vessel in which they have been immersed. Let them drain momentarily and then gently surface-dry them with paper towel (5.2.9) or a damp towel, taking care not to draw water out of any of the pores. Place them on the top-loading balance (5.2.7) and immediately weigh to obtain the total mass, m_2, of all the soaked briquettes in the test portion.

5.3.7 Determination of apparent density of soaked briquettes in water

Two methods, a) and b), are allowed for this step. See the examples shown in Figure 1.



a) Wire basket method



b) Wire suspension method

Key

1	Suspension wire	4	Wire tie post
2	Wire basket	5	Thin wire
3	Balance		

Figure 1 — Examples of apparent density apparatus

a) Testing of entire test portion — Wire basket method

See Figure 1 a).

Place a vessel containing water at 22 °C ± 5 °C on the top-loading balance and tare to zero. Note that the vessel shall have enough freeboard to accommodate the water that will be displaced by the test portion without overflowing (approximately 600 ml for six average-sized briquettes).

Suspend the empty wire basket (5.2.6) in the water and weigh to obtain its mass, m_3.

Vertically raise the wire basket out of the water and place each of the previously weighed, surface-dried, soaked briquettes in the basket, being careful not to splash any water out of the vessel. Lower the basket containing the briquettes back into the water. Ensure that the briquettes are completely submerged and that the cage hangs free and does not touch the sides or bottom of the vessel. There should be no air bubbling and the mass should be constant immediately to be recorded as mass, m_4.

b) Testing of individual briquettes of a test portion — Wire suspension method

See Figure 1 b).

Place a vessel containing water at 22 °C ± 5 °C on the top-loading balance and tare to zero. Suspend individually the previously weighed, surface-dried, soaked briquettes in the tared vessel. Completely submerge each briquette in the water, making sure that it hangs free and does not touch the sides or the bottom of the vessel. There should be no air bubbling and the mass should be constant immediately. Repeat for each briquette in the test portion (masses $m_{4(1)}$.....$m_{4(6)}$); calculate mass m_4 as the total of all the briquettes of a test portion.

5.4 Expression of results

5.4.1 Apparent density, ρ_a, assuming density of water to be 1 g/cm^3, is given by the formulae

a) Wire basket method $$\rho_a = \frac{m_1}{(m_4 - m_3)} \quad (1)$$

b) Wire suspension method $$\rho_a = \frac{m_1}{m_4} \quad (2)$$

5.4.2 The water absorption, a, expressed as percentage of the dry mass is given by the formula

$$a = \frac{(m_2 - m_1)}{m_1} \times 100 \quad (3)$$

where

m_1 is the mass in air, in grams, of the dried briquettes;

m_2 is the mass in air, in grams, of the surface-dried, soaked briquettes;

m_3 is the apparent mass in water, in grams, of the wire suspension basket. This is equivalent to the "apparent volume" of the basket. In the case of the wire suspension method, mass m_3 is negligible;

m_4 is the apparent mass in water, in grams, of the soaked briquettes. This is equivalent to the "apparent volume" of the briquettes.

Report the results of the density determinations of each test portion (at least six briquettes) to two decimal places. Compare test results to the permissible tolerance and calculate the average result, rounded to the nearest 0,1 g/cm^3. The result of the calculated average for water absorption is rounded to the nearest 0,1 %.

5.5 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 = 0,2, 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.

5.6 Test report

The test report shall include the following information:

a) name and address of the testing laboratory;

b) date and issue of the test report;

c) reference to this International Standard, i.e. ISO 15968;

d) details necessary for the identification of the sample;

e) the results obtained, expressed in accordance with 5.4;

f) drying time;

g) immersion period;

h) type and temperature of water;

i) details of any occurrence that may have affected the results;

j) reference to verification activities.

6 Verification

Regular checking of apparatus and procedure is essential to verify the test results. Checks shall be carried out at regular intervals. The frequency of checking using appropriate procedures is a matter for each laboratory to determine. The following items should be checked:

a) balance;

b) thermometer.

Appropriate records of verification activities shall be maintained.