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“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड़ नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartrhari—Nitisatakam
“Knowledge is such a treasure which cannot be stolen”
Indian Standard

DIRECT REDUCED IRON — DETERMINATION OF APPARENT DENSITY AND WATER ABSORPTION OF HOT BRIQUETTED IRON (HBI)

ICS 73.060.10
NATIONAL FOREWORD

This Indian Standard which is identical with ISO 15968 : 2000 'Direct reduced iron — Determination of apparent density and water absorption of hot briquetted iron (HBI)' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Sponge Iron and Smelting Reduction Sectional Committee and approval of the Metallurgical Engineering Division Council.

The text of ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appear to the following International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated:

<table>
<thead>
<tr>
<th>International Standard</th>
<th>Corresponding Indian Standard</th>
<th>Degree of Equivalence</th>
</tr>
</thead>
</table>

ISO 3082 : 2009 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 11323 : 1996 Iron ores — Vocabulary

The technical committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

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</table>

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'.

1) Since revised in 2007.
2) Since revised in 2010.
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.

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

\[ \rho_a \]

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.

**Key**

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

**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 \( m_4(1) \ldots m_4(6) \)); 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, \( \rho_a \), assuming density of water to be 1 g/cm³, is given by the formulae

\[
\rho_a = \frac{m_1}{(m_4 - m_3)}
\]  

(1)

b) Wire suspension method

\[
\rho_a = \frac{m_1}{m_4}
\]  

(2)

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

\[
a = \left(\frac{m_2 - m_1}{m_1}\right) \times 100
\]  

(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/cm³. 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.
Annex A
(normative)

Operating procedure steps for the determination of apparent density of HBI

Dry the briquettes to constant mass at 105°C ±5°C
(usually about 1 h)

Cool to room temperature, remove any adhering dust and weigh dry briquettes in air - mass $m_1$

Submerge briquettes in water at 22 °C ±5 °C and allow them to remain immersed until air bubbling ceases (about 1 h)

Remove the soaked briquettes from the vessel, surface dry and weigh in air - mass $m_2$

Place a vessel containing water at 22 °C ±5 °C on a top-loading balance and tare to zero

**Basket suspension method**

Suspend empty basket in water and weigh - mass $m_3$

Place soaked briquettes in basket in water and weigh - mass $m_4$

**Wire suspension method**

Suspend each soaked briquette of the test portion in water and weigh - mass $m_4$

($m_{4(1)} + m_{4(2)} + ... + m_{4(6)}$)

assuming water density to be 1.0 g/cm$^3$

Apparent density $\rho_a = \frac{m_1}{m_2 - m_3}$

Apparent density $\rho_a = \frac{m_1}{m_4}$
Annex B
(normative)

Flowsheet showing procedure for acceptance of test results

Start with independent duplicate results

- \(|X_1 - X_2| \leq r\)
  - Yes: \(\bar{X} = (X_1 + X_2) / 2\)
  - No: One more determination

- \(X_{\text{max}} - X_{\text{min}} \leq 1.2 \times r\)
  - Yes: \(\bar{X} = (X_1 + X_2 + X_3) / 3\)
  - No: One more determination

- \(X_{\text{max}} - X_{\text{min}} \leq 1.3 \times r\)
  - Yes: \(\bar{X} = (X_1 + X_2 + X_3 + X_4) / 4\)
  - No: \(\bar{X} = \text{median}\{X_1, X_2, X_3, X_4\}\)
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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of ‘BIS Catalogue’ and ‘Standards: Monthly Additions’.

This Indian Standard has been developed from Doc No.: MTD 30 (5059).

Amendments Issued Since Publication

<table>
<thead>
<tr>
<th>Amendment No.</th>
<th>Date of Issue</th>
<th>Text Affected</th>
</tr>
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<tbody>
<tr>
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