INTERNATIONAL STANDARD

ISO 7215

Second edition
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Iron ores — Determination of relative reducibility

Minerais de fer — Détermination de la réductibilité relative

Reference number
ISO 7215:1995(E)

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.

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.

International Standard ISO 7215 was prepared by Technical Committee ISO/TC 102, *Iron ores*, Subcommittee SC 3, *Physical testing*.

This second edition cancels and replaces the first edition (ISO 7215:1985), clauses 6, 7 and 9 of which have been technically revised.

Annexes A and B of this International Standard are for information only.

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Introduction

The relative reducibility test method is one of several procedures used to evaluate the behaviour of natural and processed iron ores under specific conditions. The specific conditions involved in this test are: isothermal reduction; reduction in a fixed bed; reduction by means of carbon monoxide; a sample having a specified size range.

The results of this test should be considered in conjunction with the results of other tests, particularly those showing the physical behaviour of materials during reduction.

Annex A, giving mathematical derivations for formulae for relative reducibility, is included for information only.

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Iron ores — Determination of relative reducibility

1 Scope

This International Standard specifies a method for determining the reducibility in relative terms of natural and processed iron ores.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2597-1:1994, *Iron ores — Determination of total iron content — Part 1: Titrimetric method after tin(II) chloride reduction.*

ISO 3310-1:1990, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth.*

ISO 3310-2:1990, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate.*

ISO 9035:1989, *Iron ores — Determination of acid-soluble iron(II) content — Titrimetric method.*

ISO 9507:1990, *Iron ores — Determination of total iron content — Titanium(III) chloride reduction methods.*

ISO 9508:1990, *Iron ores — Determination of total iron content — Silver reduction titrimetric method.*

ISO 10836:1994, *Iron ores — Method of sampling and sample preparation for physical testing.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 reducibility: The ease with which oxygen combined with iron can be removed from natural or processed ores. [ISO 11323]

3.2 degree of reduction: The extent to which oxygen has been removed from iron oxides, expressed as the ratio of oxygen removed to oxygen originally combined with the iron.

3.3 relative reducibility test: An isothermal reduction test performed under specified conditions on a fixed bed of natural, processed or agglomerated ores to determine the final degree of reduction.

4 Principle

Using carbon monoxide, isothermal reduction of the test portion placed on a balance in a fixed bed at 900 °C for 3 h. Heating and cooling in an inert atmosphere.

Calculation of the degree of reduction from the loss in mass and the total iron and iron(II) contents of the test sample.

5 Reducing gas

Volumes and flow rates of gases used in this International Standard are measured at a temperature of 0 °C and at atmospheric pressure (101,325 kPa).

5.1 Composition

The reducing gas shall consist of:

CO	30 % (*V/V*) ± 1,0 % (*V/V*)
N_2	70 % (*V/V*) ± 1,0 % (*V/V*)

5.2 Purity

Impurities in the reducing gas shall not exceed:

H_2	0,2 % (*V/V*)
CO_2	0,2 % (*V/V*)
O_2	0,1 % (*V/V*)
H_2O	0,2 % (*V/V*)

Impurities in the heating gas (N_2) shall not exceed 0,1 % (*V/V*).

6 Apparatus

Ordinary laboratory equipment and

6.1 Test sieves, having square mesh apertures of the following nominal sizes and conforming to ISO 3310-1 or ISO 3310-2:

10,0 mm; 12,5 mm; 16,0 mm; 18,0 mm; 20,0 mm

6.2 Electrically heated reduction furnace, with tube assembly, gas supply and flow rate regulating system (see figure 1), and equipped with a balance permitting the oxygen loss of the sample to be read at any time during the test.

6.2.1 The tube assembly (see figure 2) shall consist of:

a) a reduction tube made of non-scaling, heat-resistant metal capable of withstanding a temperature greater than 910 °C and having an internal diameter of 75 mm ± 1 mm;

b) a perforated plate made of non-scaling, heat-resistant metal capable of withstanding a temperature greater than 910 °C, mounted within the reduction tube to support the test portion; the plate shall be 4 mm thick; the holes shall be 2 mm to 3 mm in diameter and the pitch between holes shall be 4 mm to 5 mm;

c) a frictionless connection between the gas supply and reduction tube which ensures linearity of weight loss determination;

d) a device to connect the reduction tube to the weighing device;

e) a heat exchange medium, for example alumina balls, placed in the bottom under the perforated plate of the reduction tube, to a depth of 100 mm, to preheat the gas.

6.2.2 The furnace, shall have a heating capacity sufficient to maintain the entire test portion and the gas entering the bed at 900 °C ± 10 °C.

6.2.3 The weighing device, shall be capable of weighing the reduction tube assembly, including the test portion, to an accuracy of 0,5 g. The weighing device shall be checked for accuracy and sensitivity at regular intervals.

7 Sampling and samples

7.1 Sample for relative reducibility test

The test sample shall be prepared in accordance with ISO 10836.

A quantity of sample sufficient to provide at least five 500 g portions shall be prepared. The sample shall be oven dried at 105 °C ± 5 °C to constant mass.

The gross sample taken for testing is repeatedly divided, extracting masses for the reserve sample, tumble test sample, etc., until a stage is reached where the mass retained just exceeds the minimum required for the preparation of the test sample for relative reducibility.

7.1.1 Pellets

The division of the gross sample by riffle shall proceed until the mass retained just exceeds 30 kg. This sample shall be dried at 105 °C ± 5 °C, sieved on 12,5 mm and 10,0 mm test sieves, discarding the + 12,5 mm − 10,0 mm fractions and retaining the − 12,5 mm + 10,0 mm fraction. A minimum of 2,5 kg shall be used for the relative reducibility test sample. From the test sample, four test portions and one chemical analysis sample, each having a mass of 0,5 kg shall be obtained.

7.1.2 Sinters and ores

The size fraction required is − 20,0 mm + 18,0 mm to be obtained by increment division. One 62,5 kg sample is set aside as the reserve sample and the other 62,5 kg sample shall be dried at 105 °C ± 5 °C and then further divided.

One sample (approximately 30 kg), to be used as the relative reducibility test sample, shall be sieved on 20,0 mm and 18,0 mm test sieves, discarding the + 20,0 mm − 18,0 mm fraction. The − 20,0 mm + 18,0 mm fraction shall be further divided using the increment division method to give a minimum of 2,5 kg for the relative reducibility test sample. From this test sample, four test portions and one chemical analysis sample, each having a mass of 0,5 kg shall be prepared.

7.2 Sample for chemical analysis

A 500 g test portion shall be reserved for the determination of total iron content and iron(II) content.

8 Test conditions

8.1 Flow rate of reducing gas

The reducing gas (clause 5) flow rate shall, during the test period, be maintained at 15 l/min ± 0,5 l/min.

8.2 Temperature of test

The reducing gas shall be preheated before entering the test portion to maintain the test portion at 900 °C ± 10 °C during the entire test period.

9 Procedure

9.1 Number of determinations

Carry out the test in duplicate on one ore sample.

9.2 Other determinations

Simultaneously with the test, determine the total iron content in accordance with ISO 2597, ISO 9507 or ISO 9508 and the iron(II) content in accordance with ISO 9035.

9.3 Test portion

Weigh, to the nearest 1 g, approximately 500 g (± 1 particle) of the test sample (mass m_0).

9.4 Reduction

Place the test portion in the reduction tube such that the surface is even.

Close the top of the reduction tube (6.2.1) ensuring that the thermocouple is at the central position of the test portion. Insert the reduction tube into the furnace (6.2) and suspend it centrally from the weighing device (6.2.3), ensuring that there is no contact with the furnace or heating elements. Connect the gas supply.

Pass a flow of N_2 through the reduction tube at a flow rate of approximately 5 l/min and start heating. When the temperature of the test portion approaches 900 °C increase the flow rate to 15 l/min and continue heating at 900 °C for 30 min. Record the mass of the test portion (mass m_1). Introduce the reducing gas to replace the N_2 at a flow rate of 15 l/min.

CAUTION — Carbon monoxide and the reducing gas, which contains carbon monoxide, are toxic and therefore hazardous. During the following procedure, the testing shall be carried out in a well ventilated area or under a hood. Precautions, according to the safety codes of each country, should be taken for the safety of the operator.

At the end of 3 h of reduction, determine the mass of the test portion (mass m_2) and turn off the power. For safety reasons, introduce again, N_2 at a flow rate of 5 l/min to replace the reducing gas in the tube. Maintain the N_2 gas flow until the test portion is cooled to below 100 °C.

NOTES

1 If reduction versus time curves are required, record the mass of the test portion every 10 min during the first hour and every 15 min during the last two hours.

2 In the case of lump ores, the temperature of the test portion should be raised to 900 °C over more than 60 min to reduce decrepitation of the lump ore.

3 If physical tests, such as crushing strength, are to be performed on the reduced test portion, the flow of N_2 after reduction should be continued until the test portion reaches room temperature.

10 Expression of results

10.1 Calculation of degree of reduction

The degree of reduction attained after 3 h (referred to as the final degree of reduction), R_f, expressed as a percentage, is given by the equation[1]:

$$R_f = \left[\frac{m_1 - m_2}{m_0(0{,}430\ w_2 - 0{,}111\ w_1)} \right] \times 10^4$$

1) The derivation of the equation is given in annex A.

where

m_0 is the initial mass, in grams, of the test portion;

m_1 is the mass, in grams, of the test portion immediately before starting the reduction;

m_2 is the mass, in grams, of the test portion after 3 h of reduction;

w_1 is the iron(II) oxide content, as a percentage by mass, of the test sample prior to the test and is calculated from the iron(II) content by multiplying by a factor of 1,286, determined in accordance with ISO 9035;

w_2 is the total iron content, as a percentage by mass, of the test sample prior to the test, determined in accordance with ISO 2597, ISO 9507 or ISO 9508.

Record the final degree of reduction to one place of decimals.

10.2 Number of tests and repeatability

10.2.1 Number of tests

The reduction test shall be carried out in duplicate. If the difference between the paired results of R_f meets the repeatability limit given in 10.2.2, the test is terminated, if not, another duplicate test shall be carried out.

10.2.2 Repeatability

For a paired result, the difference between the two individual results shall be less than 3 % absolute for pellets and less than 5 % absolute for sinter.

NOTE 4 A repeatability limit for lump ore is not specified, because of the inherent heterogeneity, which varies for different ores.

10.3 Calculation of final results

The final degree of reduction, R_f, expressed as a percentage, shall be reported as the arithmetic mean of all test results, rounded to the nearest whole number.

11 Test report

The test report shall include the following information:

a) reference to this International Standard;

b) description of the test sample;

c) number of tests and final degree or reduction, R_f;

d) total iron and iron(II) contents of the test sample;

e) type of sieve used.

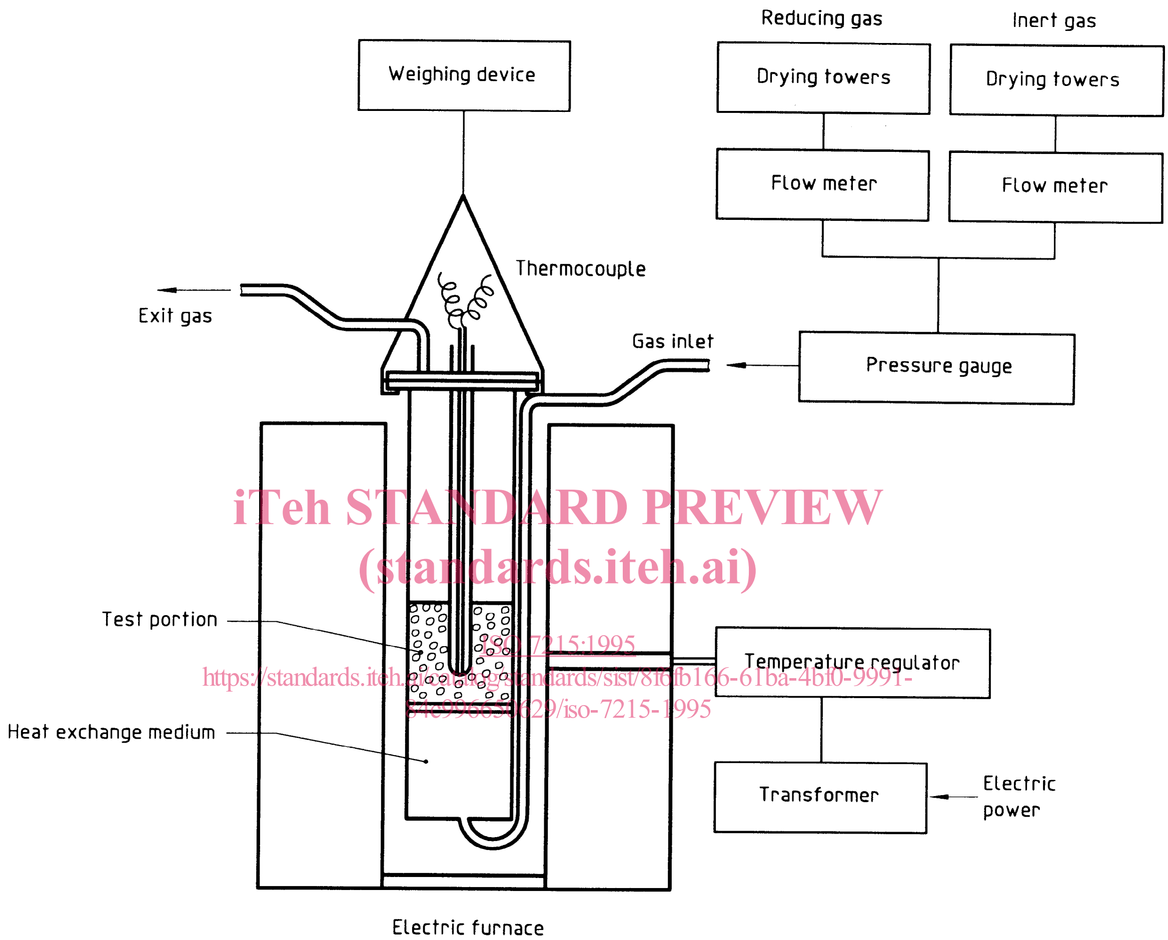

Figure 1 — Schematic diagram of reduction test apparatus