
**Iron ores for shaft direct-reduction
feedstocks — Determination of
the low-temperature reduction-
disintegration index and degree of
metallization**

*Minerais de fer pour charges utilisées dans les procédés par réduction
directe — Détermination de l'indice de désintégration par réduction à
basse température et du degré de métallisation*

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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).

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#)

The committee responsible for this document is ISO/TC 102, *Iron ore and direct reduced iron*, Subcommittee SC 3, *Physical testing*.

This third edition cancels and replaces the second edition (ISO 11257:2007), of which it constitutes a minor revision to contemplate the care needed during hand sieving, to introduce the mechanical sieving and to exclude the reference to ISO 4701.

Introduction

This International Standard concerns one of a number of physical test methods that have been developed to measure various physical parameters and to evaluate the behaviour of iron ores, including reducibility, disintegration, crushing strength, apparent density, etc. This method was developed to provide a uniform procedure, validated by collaborative testing, to facilitate comparisons of tests made in different laboratories.

The results of this test have to be considered in conjunction with other tests used to evaluate the quality of iron ores as feedstocks for direct reduction processes.

This International Standard can be used to provide test results as part of a production quality control system, as a basis of a contract, or as part of a research project.

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Iron ores for shaft direct-reduction feedstocks — Determination of the low-temperature reduction-disintegration index and degree of metallization

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

1 Scope

This International Standard specifies a method to provide a relative measure for evaluating the degree of size degradation and degree of metallization of iron ores, when reduced under conditions resembling those prevailing in shaft direct-reduction processes.

This International Standard is applicable to lump ores and hot-bonded pellets.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2597-1, *Iron ores — Determination of total iron content — Part 1: Titrimetric method after tin(II) chloride reduction* <https://standards.iteh.ai/catalog/standards/sist/8cc12043-04df-4619-91a8-87531a1ec163/iso-11257-2015>

ISO 2597-2, *Iron ores — Determination of total iron content — Part 2: Titrimetric methods after titanium(III) chloride reduction*

ISO 3082, *Iron ores — Sampling and sample preparation procedures*

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

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

ISO 5416, *Direct reduced iron — Determination of metallic iron — Bromine-methanol titrimetric method*

ISO 11323, *Iron ore and direct reduced iron — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11323 apply.

4 Principle

The test portion is isothermally reduced in a rotating tube bed, at 760 °C, using a reducing gas consisting of H₂, CO, CO₂, and CH₄, for 300 min. The reduced product is sieved with a sieve having square openings of 3,15 mm. Then, it is analysed for total iron and metallic iron. The reduction-disintegration index is calculated as the mass percentage of material less than 3,15 mm. The degree of metallization is calculated from the chemical analysis results.

5 Sampling, sample preparation, and preparation of test portions

5.1 Sampling and sample preparation

Sampling of a lot and preparation of a test sample shall be in accordance with ISO 3082.

The size ranges for pellets shall be 50 % - 16,0 mm + 12,5 mm and 50 % - 12,5 mm + 10,0 mm.

The size ranges for lump ores shall be 50 % - 20,0 mm + 16,0 mm and 50 % - 16,0 mm + 10,0 mm.

A test sample of at least 2,0 kg, on a dry basis, of the sized material shall be obtained.

Oven-dry the test sample to constant mass at $105\text{ °C} \pm 5\text{ °C}$ and cool it to room temperature before preparation of the test portions.

NOTE Constant mass is achieved when the difference in mass between two subsequent measurements becomes less than 0,05 % of the initial mass of the test sample.

5.2 Preparation of test portion

Collect each test portion by taking ore particles at random.

NOTE Manual methods of division recommended in ISO 3082, such as riffing, can be applied to obtain the test portions.

At least four test portions, each of approximately 500 g (\pm the mass of 1 particle), shall be prepared from the test sample.

Weigh the test portions to the nearest 1 g and register the mass of each test portion on its recipient label.

6 Apparatus

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6.1 General

The test apparatus shall comprise the following:

- a) ordinary laboratory equipment, such as an oven, hand tools, time-control device, and safety equipment;
- b) reduction tube assembly;
- c) furnace, with a system to rotate the reduction tube;
- d) system to supply the gases and regulate the flow rates;
- e) test sieves;
- f) weighing device.

[Figure 1](#) shows an example of the test apparatus.

6.2 Reduction tube, without lifters, made of non-scaling, heat-resistant metal to withstand temperatures higher than 760 °C and resistant to deformation.

The internal diameter shall be $130\text{ mm} \pm 1\text{ mm}$ and its internal length shall be 200 mm. A dust collector shall be connected to the tube to trap any fine particles carried in the gas stream out of the tube during the test.

6.3 Furnace, having a heating capacity and temperature control able to reach the test temperature within 90 min and to maintain the entire test portion, as well as the gas entering the bed, at $760\text{ °C} \pm 5\text{ °C}$.

- 6.4 Rotation equipment**, capable of rotation the reduction tube at a constant rate of 10 r/min \pm 1 r/min.
- 6.5 Gas-supply system**, capable of supplying the gases and regulating gas flow rates.
- 6.6 Test sieves**, conforming to ISO 3310-1 or ISO 3310-2 and having mesh apertures of the following nominal sizes: 10,0 mm and 3,15 mm.
- 6.7 Weighing device**, capable of weighing the test sample and test portions to an accuracy of 0,1 g.

7 Test conditions

7.1 General

Volumes and flow rates of gases used are as measured at a reference temperature of 0 °C and at a reference atmospheric pressure of 101,325 kPa (1,013 25 bar).

7.2 Reducing gas

7.2.1 Composition

The reducing gas shall consist of the following:

CO	36,0 % \pm 1,0 % (volume fraction)
CO ₂	5,0 % \pm 1,0 % (volume fraction)
H ₂	55,0 % \pm 1,0 % (volume fraction)
CH ₄	4,0 % \pm 1,0 % (volume fraction)

7.2.2 Purity

Impurities in the reducing gas shall not exceed the following:

O ₂	0,1 % (volume fraction)
H ₂ O	0,2 % (volume fraction)

7.2.3 Flow rate

The flow rate of the reducing gas, during the entire reducing period, shall be maintained at 13 L/min \pm 0,5 L/min.

7.3 Heating and cooling gas

Nitrogen (N₂) shall be used as the heating and cooling gas. Impurities shall not exceed 0,1 % (volume fraction).

The flow rate of N₂ shall be maintained at 10 L/min until the test portion reaches 760 °C and at 13 L/min during temperature-equilibration period. During cooling, it shall be maintained at 10 L/min.

7.4 Temperature of the test portion

The temperature of the entire test portion shall be maintained at 760 °C \pm 5 °C during the entire reducing period and, as such, the reducing gas shall be preheated before entering the test portion.