INTERNATIONAL STANDARD

ISO 4701

Fifth edition
2019-04

Iron ores and direct reduced iron — Determination of size distribution by sieving

Minerais de fer et minerais de fer préréduits — Détermination de la granulométrie par tamisage

Reference number
ISO 4701:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 102, *Iron ore and direct reduced iron*, Subcommittee SC 1, *Sampling*.

This fifth edition cancels and replaces the fourth edition (ISO 4701:2017), of which it constitutes a minor revision. The following change has been made:

— in Annex C, a formula has been included to correct the maximum mass to be retained on the sieve at completion of sieving in accordance with the actual bulk density of iron ore.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Iron ores and direct reduced iron — Determination of size distribution by sieving

1 Scope

This document specifies the methods to be employed for determination of size distributions by sieving of iron ore and direct reduced iron (excluding briquetted iron), utilizing sieves having aperture sizes of 36 µm or larger. The size distribution is expressed in terms of mass and percentage mass, passed or retained on selected sieves. The purpose of this document is to provide a basis for any testing of iron ore and direct reduced iron involving size determination for use by contracting parties in the sale and purchase of these materials.

When this document is used for comparative purposes, the concerned parties will agree on the selection of the detailed method to be employed in order to eliminate sources of subsequent controversy.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 565, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings*

ISO 2591-1, *Test sieving — Part 1: Methods using test sieves of woven wire cloth and perforated metal plate*

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

ISO 3085, *Iron ores — Experimental methods for checking the precision of sampling, sample preparation and measurement*

ISO 3086, *Iron ores — Experimental methods for checking the bias of sampling*

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 3852, *Iron ores for blast furnace and direct reduction feedstocks — Determination of bulk density*

ISO 10835:2007, *Direct reduced iron and hot briquetted iron — Sampling and sample preparation*

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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principles and planning

4.1 General

The determination of size distribution of iron ores and direct reduced iron (DRI) may be carried out on a "dry" or "natural" (or "as-received") basis. Before a particle size determination is carried out, it is necessary to plan the entire sequence of procedures to be followed.

The basis for determination and the sequence of procedures will depend on the following:

a) the purpose of the size analysis;

b) the properties of the iron ore and DRI to be evaluated;

c) the form in which the iron ore and DRI is received, e.g. gross sample, increments or partial samples;

d) the apparatus available.

A typical decision tree to determine the sequence of procedures necessary to perform size analysis is shown in Figure 1. The guidelines for practical application of this document are provided in Annex A.

General principles of sieving are given in ISO 2591-1.

4.2 Purpose of the analysis

The principal purposes of particle size determination are as follows.

a) To measure the mass and calculate the percentage mass of an ore or DRI passing or retained on one or more specification sieves.

   The choice of sieve aperture sizes shall be determined by the specification size(s) required together with the necessity for introducing intermediate aperture sizes to satisfy the maximum particle size and sieve loading constraints. See 4.6 and 4.7.

b) To generate an overall size distribution curve.

   The choice of sieve apertures will depend on the resolution required for the curve and the need to satisfy sieve loading constraints.

4.3 Impact of ore and DRI properties

4.3.1 Effect of moisture content

The effect of the moisture content of the size sample on sample division and sieving should be assessed before the commencement of the size determination procedure.

When it is difficult to conduct sample division due to sample being adhesive or excessively wet, the sample shall be dried to constant mass in accordance with 7.1.

Partial drying of a sample for the purpose of size distribution analysis is not acceptable, as residual moisture might affect the effective separation of the individual size fractions.

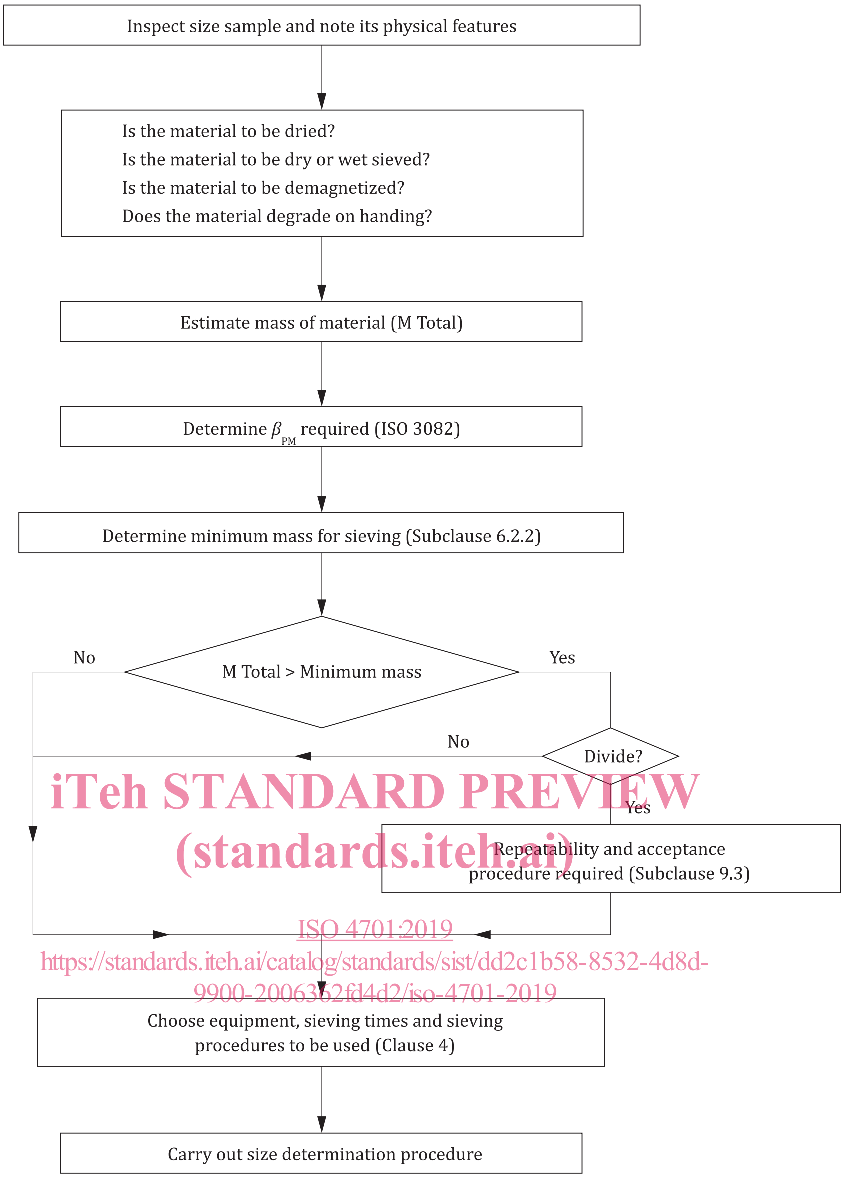

Figure 1 — Typical decision tree for selecting size determination procedure

4.3.2 Degradation of material

Certain iron ores, particularly lump ore, and DRI can be subject to significant degradation during the sampling and size analysis sequences. Furthermore, different sampling and size analysis processes can cause degradation of ores and DRI to different extents. Consequently, this could lead to significant variation in results for the same lot.

It is therefore essential that any degradation should be minimized through the correct design of handling, sampling and size analysis systems.

Sampling systems should be designed in accordance with the guidelines set out in ISO 3082 and ISO 10835.

4.3.3 Magnetic ores

For iron ores with pronounced magnetic properties and DRI that has been handled by magnets, it is desirable to ensure that the size sample be demagnetized or that the sieves are non-magnetic.

4.4 Nature of sample

The sample may be received in the form of a gross sample, several partial samples or increments.

The procedures for sampling of iron ores and direct reduced iron (see ISO 3082 and ISO 10835) will generally provide quantities of material in excess of the requirements for sieving.

If it is undesirable to sieve the entire mass, division of the following is permissible:

a) gross sample;

b) partial samples;

c) increments;

d) fractions obtained during sieving.

Methods governing the division and the mass of sample to be sieved are provided in Clause 6.

4.5 Choice of sieving method

4.5.1 Two different sieving methods are available to perform particle size analysis (see Annex I):

a) dry sieving, i.e. sieving without the application of water;

b) wet sieving, i.e. sieving with a sufficient application of water to ensure the passage of undersize particles through the sieve apertures.

A table summarizing the sample preparation and sieving procedure is given in Annex B.

4.5.2 The results of these methods could be different. No specific preference is given in this document for either method when sieving iron ore samples. For DRI, dry sieving is recommended.

4.5.3 The choice of sieving method (see 4.5.5) for each part of a size determination shall be made on the basis of attaining the defined precision of testing (see 11.1). Details on the procedure shall be recorded in the working log.

4.5.4 If a combination of any of the sieving methods is employed for different parts of the same overall size distribution, the changeover from dry to wet sieving shall be clearly indicated on the report sheet (see Clause 10).

4.5.5 The following factors should be taken into account when making the choice of sieving method.

a) For dry sieving on a natural basis sample, the moisture content of the charge shall be sufficiently low so as not to introduce any bias beyond acceptable limits.

b) Wet sieving should be used

   1) if there is a tendency for a significant proportion of fine particles to adhere to the larger ones, or if the ore has a tendency to cake on drying, or

   2) if the fine particles of iron ore tend to become charged with static electricity during the sieving operation and adhere tenaciously to the sieve.

4.6 Maximum particle size permitted on a sieve

To avoid damage to sieves, the maximum particle size in any charge shall not exceed 10 $W^{0,7}$, where W is the sieve aperture size, in millimetres.

Examples of the relationship between maximum particle size and sieve aperture size are given in Table 1.

Table 1 — Maximum particle size permitted on a sieve

Sieve aperture size W	Approximate size of largest particle
25 mm	95 mm
11,2 mm	55 mm
4 mm	26 mm
1 mm	10 mm
250 µm	3,8 mm
45 µm	1,2 mm
36 µm	1,0 mm

4.7 Specified loading of sieves

4.7.1 General

The loading of a sieve or nest of sieves or continuous sieving machine shall be limited as prescribed in 4.7.2 and 4.7.3, and requires previous information about the size distribution of the sample to be sieved.

4.7.2 Batch sieving with a single sieve or nest of sieves

4.7.2.1 General

The mass of sample that may be loaded onto any sieve is limited by the conditions covering the mass to be retained and by the need to avoid undue degradation. It could be necessary to sieve a sample in several portions. The results shall be combined. The maximum mass retained shall not exceed the values tabulated in Annex C or as determined in 4.7.2.2 or 4.7.2.3.

The maximum loading is defined as that corresponding to the maximum mass retained but shall not exceed twice the maximum mass retained.

4.7.2.2 Apertures > 4 mm

The loading of the sieve shall be such that the maximum mass of sample retained on any sieve at the completion of sieving shall be in accordance with Formulae (1) and (2) or the visual rule c).

a) Apertures ≥ 22,4 mm

$$m = (0{,}005 + 0{,}000\,4W)\rho_b A \tag{1}$$

b) For apertures < 22,4 mm and ≥ 4 mm

$$m = 0{,}000\,7W\rho_b A \tag{2}$$

where

m is the maximum mass to be retained on the sieve, in kilograms;

W is the sieve aperture size, in millimetres;

ρ_b is the bulk density of the sample, in kilograms per cubic metre, determined in accordance with ISO 3852;

A is the area of the sieve, in square metres.

The formulae apply only if the open area of the sieve (incomplete apertures are regarded as blanked-off areas) exceeds 40 %. For open areas of less than 40 %, the values of *m* shall be reduced pro rata.

c) Alternative visual rule

On completion of sieving, the particles spread out as a single layer shall cover not more than three-quarters of the floor area of the sieve.

4.7.2.3 Apertures < 4 mm

For sieves in the < 4 mm range, the maximum mass of sample retained shall be as given in Annex C.

4.7.3 Loading of continuous sieving machines

In the case of continuous sieving machines, the rate of feed shall be constant and so adjusted that during the sieving operation a maximum of 50 % of any sieve area is covered by the material.

4.8 Sieving time

4.8.1 General

The practicable sieving time is mainly influenced by the following:

a) the properties of the sample;

b) the volume of the initial charge;

c) the sieving intensity;

d) the nominal aperture size of the sieve;

e) the acceptable limits of accuracy.

No exact time can be defined at which a sieving process is completed. Where possible, sieving time shall be based on strict application of the end point ruling. However, in some cases, strict application of the end point ruling could be impractical. In such cases, fixed time sieving based on experience may be agreed.

The examples in Table 2 are given as a general indication of times for dry batch sieving of stable iron ores and DRI.

Table 2 — Examples of dry sieving times for stable ores and DRI using batch methods

Sieve aperture size mm	**Sieving time** min
4 and larger	3
−4 to 1	5
−1	20

4.8.2 End point ruling

The method for determining the sieving end point in accordance with ISO 2591-1 is given in 7.6 (see Annex I).

4.8.3 Retention time for continuous sieving machines

Retention time depends on the material feed rate and the rates at which particles pass through the sieves and move forward across the surface of the sieving media. It depends on the type of machine, the inclination of the sieve media and the nature of the sample sieved.

The procedure parameters shall be optimized in order to minimize material degradation and maximize sieving efficiency in order to satisfy the requirements defined in 5.2.

5 Apparatus

5.1 Sieve media

5.1.1 Shape of aperture

The sieve media shall have square apertures in accordance with ISO 565.

5.1.2 Size of aperture

The nominal size of aperture to be utilized shall be selected from the R20 and R40/3 series given in ISO 565 (see Annex D).

5.1.3 Construction of sieve media

The sieve media shall be in accordance with ISO 3310-1 or ISO 3310-2 and the requirements of a) to d) below. (See Annex I.)

a) For aperture sizes ≤ 4 mm, woven wire shall be used.

b) For aperture sizes > 4 mm and ≤ 16 mm, either woven wire or perforated plate shall be used, see also d).

c) For all sizes > 16 mm, perforated plate is preferred; woven wire may be used, but it should be recognized that the tolerances on aperture size are wider than those for perforated plate.

d) Within a size determination, one change-over point from wire to perforated plate is allowed. This shall be established for each size determination procedure and shall be adopted for all subsequent determinations.

5.1.4 Sieve frames for hand or mechanical nest sieving

Test sieves used for hand or mechanical nest sieving shall have frames in accordance with ISO 3310-1 and ISO 3310-2. Frames may be either round or rectangular. A typical nest sieving apparatus is shown in Annex E.