INTERNATIONAL STANDARD

ISO 4701

Second edition
1999-03-01

Iron ores — Determination of size distribution by sieving

Minerais de fer — Détermination de la granulométrie par tamisage

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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.

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 4701 was prepared by Technical Committee ISO/TC 102, *Iron ores*, Subcommittee SC 1, *Sampling*.

This second edition cancels and replaces the first edition (ISO 4701:1985), which has been technically revised.

Annexes A, B and C form an integral part of this International Standard, annexes D, E, F and G are for information only.

Iron ores — Determination of size distribution by sieving

1 Scope

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

When this International Standard is used for comparative purposes, agreement should be reached between the concerned parties on selection of the detailed method to be employed in order to eliminate sources of subsequent controversy.

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 565:1990, *Test sieves — Metal wire cloth, perforated metal plate and electroformed sheet — Nominal sizes of openings.*

ISO 2591-1:1988, *Test sieving — Part 1: Methods using test sieves of woven wire cloth and perforated metal plate.*

ISO 3082:1998, *Iron ores — Sampling and sample preparation procedures.*

ISO 3085:1996, *Iron ores — Experimental methods for checking the precision of sampling.*

ISO 3086:1998, *Iron ores — Experimental methods for checking the bias of sampling.*

ISO 3087:1998, *Iron ores — Determination of moisture content of a lot.*

ISO 3310-1:—[1)], *Test sieves — Requirements and tests — Part 1: Metal wire cloth sieves.*

ISO 3310-2:—[2)], *Test sieves —Requirements and tests — Part 2: Perforated metal plate sieves.*

ISO 11323:1996, *Iron ores — Vocabulary.*

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1) To be published. (Revision of ISO 3310-1:1990)

2) To be published. (Revision of ISO 3310-2:1990)

3 Definitions

For the purpose of this International Standard, the definitions given in ISO 11323 apply.

4 Principles and planning

4.1 General

Before a particle size determination is carried out, it is necessary to plan the entire sequence of procedures to be followed. In some cases agreement between parties will be necessary.

This sequence of procedures will depend on:

a) the purpose of the size analysis;

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

c) the form in which the iron ore 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.

Sieving of iron ores shall be carried out in accordance with 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 percentage mass of an ore 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 and the need to satisfy sieve loading constraints.

4.3 Properties of ore to be evaluated

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.

It may be desirable to dry or partially dry the size sample before carrying out sample division or sieving. Drying of iron ores in accordance with 7.1, or wet sieving in accordance with 7.4.5 may result in changes of internal moisture which may affect the masses of size fractions. Under such circumstances reliable masses can only be obtained by drying the fractions at 105 °C and cooling under anhydrous conditions. Some iron ores readily absorb moisture and should not safely be allowed to come into equilibrium with laboratory atmospheres. These ores shall be handled in such a way as to reduce to a minimum the duration of their contact with the atmosphere.

4.3.2 Friable ores

For iron ores subject to significant degradation during the size analysis sequence it is essential that any mechanical sizing procedure be checked for bias against hand placing and sieving in accordance with the procedure given in ISO 3086 (see 5.2).

4.3.3 Magnetic ores

For iron ores with pronounced magnetic properties it may be desirable that the size sample be demagnetized.

4.4 Nature of sample

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

The procedures for sampling of iron ores (ISO 3082) 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) the size 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 wet or dry sieving

4.5.1 The results of dry and wet sieving may not be the same. No specific preference is given in this International Standard for either method.

4.5.2 The choice of dry or wet sieving (see 4.5.4) 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 procedure shall be recorded in the working log.

4.5.3 If a combination of dry and wet sieving 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).

4.5.4 The following factors should be taken into account when making the choice between dry and wet sieving:

a) For dry sieving, 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 lumps, or if the ore has a tendency to cake on drying;

   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 below.

4.7.2 Batch sieving with a single sieve or nest of sieves

The mass of ore that may be loaded on to any sieve is limited by the conditions covering the mass to be retained and by the need to avoid undue degradation. It may 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 A or as determined in 4.7.2.1 or 4.7.2.2.

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

4.7.2.1 For apertures larger than or equal to 500 µm

The loading of the sieve shall be such that the maximum mass of iron ore retained on any sieve at the completion of sieving shall be in accordance with formulae a) and b) below or the visual rule c).

a) Apertures larger than 22,4 mm

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

b) For apertures less than 22,4 mm and larger than or equal to 500 µm

$$m = 0{,}000\,7W\rho A$$

where

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

W is the sieve aperture size, in millimetres;

ρ is the bulk density of iron ore, in kilograms per cubic metre;

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 area) exceeds 40 %. For open areas of less than 40 %, the values of m shall be reduced pro rata.

c) Alternatively the following visual rule may be applied.

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.

4.7.2.2 Apertures smaller than 500 µm

For sieves in the −500 µm range, the maximum mass to be loaded on a sieve shall not exceed twice the maximum permitted mass of residue given in annex A.

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:

a) the characteristics of the ore;

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, strict application of the end point ruling may be impractical. In such cases hand placing or fixed time sieving based on experience may be agreed.

Examples in table 2 are given as a general indication of times for dry batch sieving of stable iron ores.

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

Sieve aperture size mm	Time by hand sieving min	Time by mechanical sieving min
4 and larger	3	3
− 4 to 1	variable	5
− 1	variable	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.

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 ore being sieved.

The procedure parameters must be optimized 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 R 20 and R 40/3 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) – d) below.

a) For aperture sizes of 4 mm or smaller, woven wire shall be used.

b) For aperture sizes greater than 4 mm and up to and including 16 mm, either woven wire or perforated plate shall be used (see also d) below).

c) For all sizes above 16 mm perforated plate is preferred; woven wire may be used but it should be recognized that the tolerances on aperture size is 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 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. Typical nest sieving apparatus is shown in annex E.

Sieves other than test sieves shall have frames that nest snugly with each other and with the lid and receiver. The frame should be smooth and the seals of the sieves so constructed as to avoid lodging of particles and loss of fines.

5.2 Sieving machines

Any type of apparatus is acceptable provided that the results obtained with reference to the specification size selected, or other designated aperture size, are unbiased in relation to those obtained by hand placing or hand sieving. Sieving machines shall be tested for bias in accordance with the procedures given in ISO 3086 and will be acceptable if no significant bias is proven.

It may be necessary for an operator to keep the sieve media unblocked (see annex F).

5.3 Accessories for wet sieving

When wet sieving is carried out, in addition to the apparatus mentioned above it is necessary to have available a controllable supply of water, a spray nozzle and, where appropriate, a collecting tank. A simple arrangement is shown in figure 2. When wet sieving on sieves having apertures of less than 125 μm it is preferable that:

a) the sieve be constructed of stainless steel;

b) the medium have a backing to prevent possible sagging and distortion caused by water pressure; this backing may typically consist of a sieve medium having 2 mm square apertures;

c) the backing be made so that the particles cannot get trapped between two sieve media;

d) the water pressure be adjusted as gently as possible in order to avoid damage to the sieve media.

5.4 Drying equipment

Any form of ventilated equipment is acceptable for drying, provided that it be fitted with a temperature control apparatus capable of regulating the temperature in the equipment to within ± 5 °C of the desired temperature and shall be so designed as to maintain this temperature. Loss of dust from the equipment shall be avoided.

It is recommended that the parties concerned with the iron ore use the same drying procedure in order that the effect on the size determination be similar.

5.5 Equipment for the determination of mass

Each device for the determination of mass shall have a sensitivity of at least 0,1 % of its rated capacity and a level of accuracy such that the mass of the test sample and of each size fraction may be determined to a precision of ± 0,1 % or better of the test sample mass.

6 Samples

6.1 Derivation of size sample

6.1.1 The size sample shall have been taken in accordance with the specifications of ISO 3082 and be in the form of a composite size sample, partial samples or increments.

6.1.2 The sample shall be composed of ore which has not been used previously for other tests or purposes which in any way modify the mass and the particle size distribution.

6.1.3 For replicate size determinations the corresponding number of size samples shall be provided.

6.1.4 Increments or partial samples may be combined into a single size sample or into new partial samples.

6.1.5 Where it is not required to sieve the total mass, one or more test samples for sieving shall be extracted from the size sample, or from each increment or partial sample by division. (See 6.2.)

6.1.6 Only the combined size analysis of all the increments or partial samples shall be representative of the lot.

6.2 Division and derivation of test sample(s) for sieving

6.2.1 Mass of the test samples

The mass of the test samples used for sieving shall be equal to or greater than the minimum mass defined in 6.2.2.

6.2.2 Minimum mass

For a specified precision of division and measurement (see clause 11) the required minimum mass is the same whether the test sample used for sieving is obtained by dividing the size sample or by dividing increments or partial samples and combining those divided increments or partial samples.

The minimum mass to be used for sieving depends on the required precision of division and measurement β_{PM} and shall be calculated by means of the formula shown in annex B. The level of precision β_{PM} to be used shall be determined so that the overall precision specified in table 1 of ISO 3082:1998 shall be met.

7 Procedures

7.1 Procedure for drying iron ore

Iron ores shall be dried in air or by the use of drying equipment in accordance with 5.4. The maximum temperature setting shall be 105 °C so that the actual temperature shall not exceed 110 °C.

7.2 Procedure for division

One or more of the following methods of sample division shall be conducted individually or jointly; the applicability of each method for division of the particular ore shall be determined by reference to ISO 3082:

a) mechanical increment division;

b) other mechanical division methods (e.g. mechanically charged riffle divider);

c) manual division.

7.3 Procedure for the preparation and maintenance of sieves for test or nest sieving

The preparation of sieves shall be carried out in accordance with the specifications of ISO 2591-1. Before use, each sieve medium and frame shall be degreased and cleaned. The cleaning of a sieve shall be carried out with great care so that the sieve medium is not damaged. For sieves with apertures equal to or greater than 500 μm, cleaning shall be undertaken by the application of a soft brass wire brush to the underside of the sieve. For sieves with apertures of less than 500 μm, ultrasonic cleaning is the preferred method. Cleaning shall not entail brushing of the sieve media. The frame should be tapped gently to assist in freeing trapped particles. At times it may be necessary to wash fine sieves in a warm soft soap and water solution. After washing or after ultrasonic cleaning the sieves shall be dried thoroughly.

7.4 Procedures for sieving

7.4.1 General

The procedure shall employ one or more of the following methods:

a) hand placing on individual sieves (minimum aperture size is 22,4 mm);

b) hand sieving and assisted hand sieving;

c) mechanical batch sieving;

d) wet sieving;

e) continuous machine sieving.

7.4.2 Hand placing on individual sieves

The minimum aperture size at which this method is considered to be applicable is 22,4 mm.