INTERNATIONAL STANDARD

ISO 4701

Third edition
2008-10-01

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 4701:2008(E)

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 4701 was prepared by Technical Committee ISO/TC 102, *Iron ore and direct reduced iron*, Subcommittee SC 1, *Sampling*.

This third edition cancels and replaces the second edition (ISO 4701:1999), which has been technically revised.

Iron ores and direct reduced iron — 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 and direct reduced iron (exclude 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 International Standard 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 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 referenced documents are indispensable for the application 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 3087, *Iron ores — Determination of moisture content of a lot*

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, *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 International Standard, the terms and definitions given in ISO 11323 apply.

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:

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 International Standard 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.

NOTE 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.

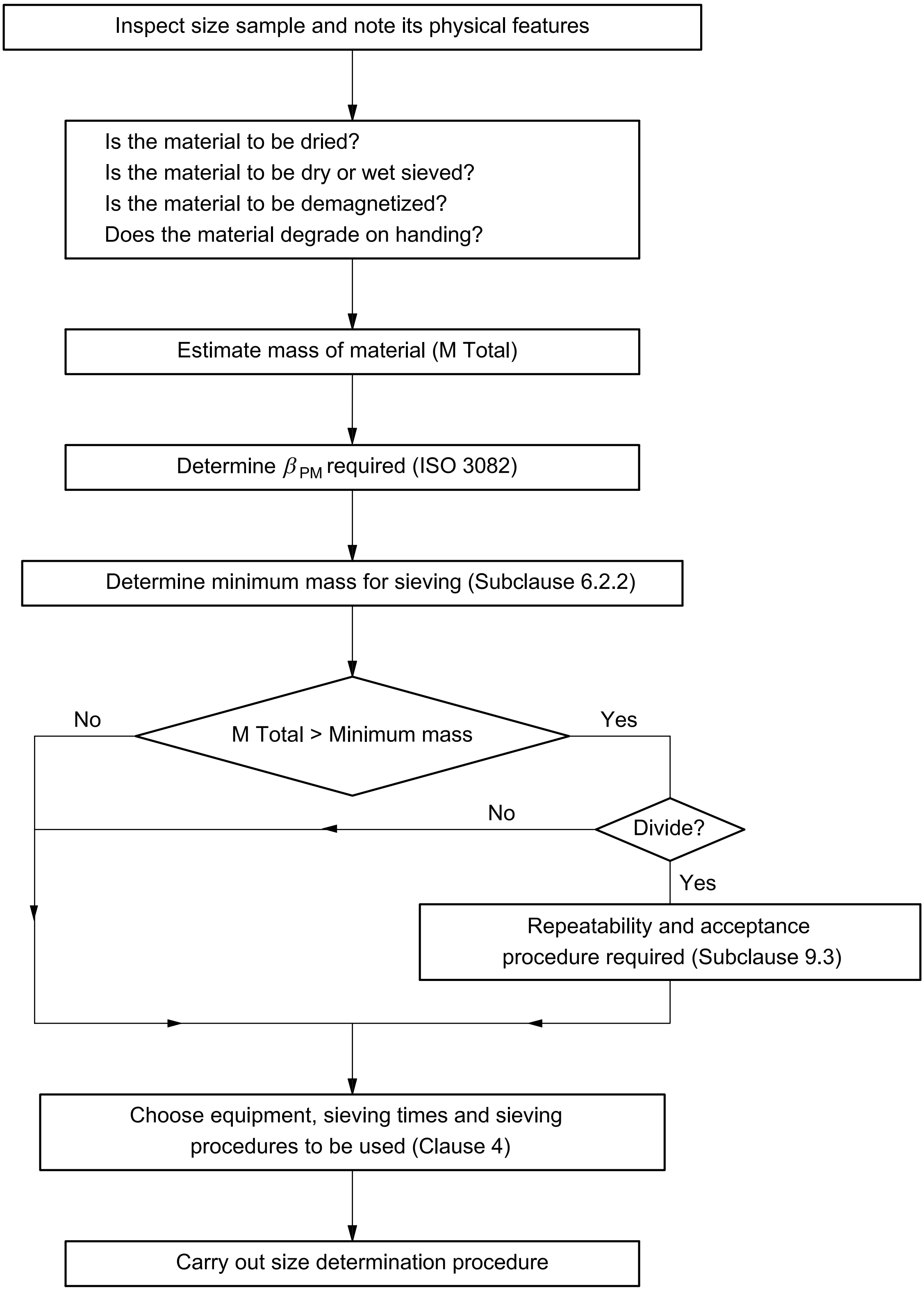


Figure 1 — Typical decision tree for selecting size determination procedure

4.3.2 Degradation of material

Certain iron ores, particularly lump ore, and DRI may 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 may 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 (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 may not be the same. No specific preference is given in this International Standard 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;

   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 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 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) below or the visual rule c).

a) Apertures ⩾ 22,4 mm

$$m = (0{,}005 + 0{,}000\,4W)\rho_\text{b} A \quad (1)$$

b) For apertures < 22,4 mm and ⩾ 4 mm

$$m = 0{,}000\,7W\rho_\text{b} A \quad (2)$$

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:

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 may be impractical. In such cases, 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 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 $\leqslant$ 4 mm, woven wire shall be used.

b) For aperture sizes $>$ 4 mm and $\leqslant$ 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.

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 methods described in 7.4.3 or 7.4.4. Sieving machines shall be tested for bias in accordance with the procedures given in ISO 3086 and will be acceptable if no significant bias against the reference procedure performed in accordance with 7.4.3 or 7.4.4 is proven.

The sieve media shall be kept unblocked (see Annex F).

5.3 Accessories for wet sieving

When wet sieving is carried out, in addition to the apparatus mentioned in 5.1 and 5.2, 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 < 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.

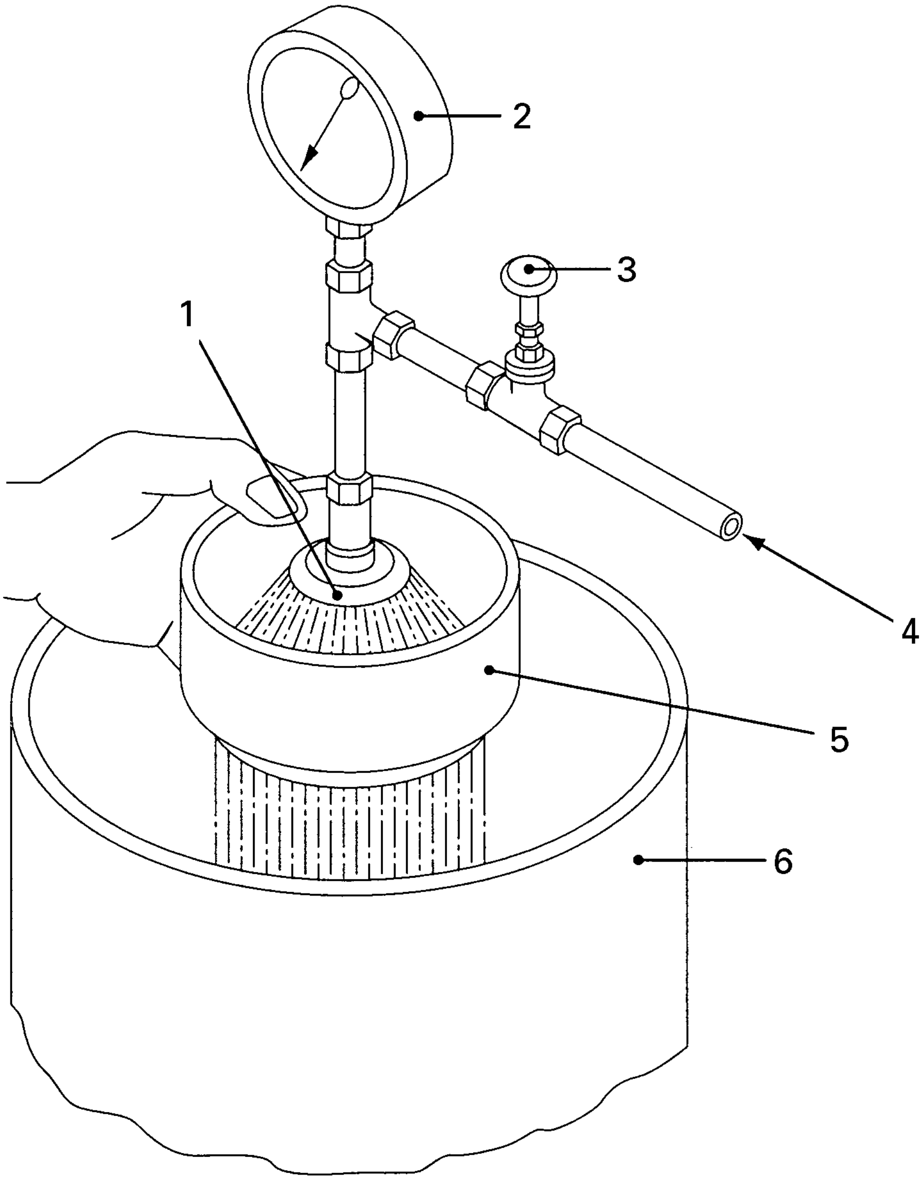
5.4 Drying equipment

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 $\pm$ 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 and DRI 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 $\pm$ 0,1 % or better of the test sample mass.



Key

1 spray nozzle
2 pressure gauge
3 regulating valve
4 water supply from reservoir tank
5 sieve
6 collecting tank

Figure 2 — A simple arrangement of wet sieving apparatus

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 gross sample, partial samples or increments.

6.1.2 The sample shall be composed of ore that has not been previously used for other tests or purposes that 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 gross 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 gross sample, or from each increment or partial sample, by division (see 6.2).

6.1.6 When testing increments or partial samples, only the combined size analysis of all the increments or partial samples shall be representative of the lot.

6.2 Mass of test sample(s) for sieving

6.2.1 General

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 specified precision of preparation and measurement (see Clause 11) the required minimum mass is the same whether the test sample used for sieving is obtained by dividing the gross 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 preparation and measurement, β_{PM}, which is twice the standard deviation of preparation and measurement, and shall be calculated by means of the formula shown in Annex G. The level of precision, β_{PM}, to be used shall be determined so that the overall precision specified in Table 3 shall be met.

Table 3 — Comparison of overall sizing precision, β_{SPM}, with the precisions of sampling, β_S, and sample preparation and measurement, β_{PM}

Mass of lot (1 000 t)	− 200 mm and − 50 mm ore − 10 mm fraction			− 31,5 + 6,3 mm ore + 6,3 mm fraction Sinter feed − 6,3 mm fraction		
	β_{SPM}	β_S	β_{PM}	β_{SPM}	β_S	β_{PM}
> 270	3,4	1,55	3,0	1,7	0,77	1,5
210 - 270	3,5	1,61	3,1	1,75	0,80	1,6
150 - 210	3,6	1,69	3,2	1,8	0,84	1,6
100 - 150	3,7	1,77	3,3	1,85	0,88	1,6
70 - 100	3,9	1,86	3,4	1,95	0,92	1,7
45 - 70	4,0	1,98	3,5	2,0	0,98	1,7
30 - 45	4,2	2,11	3,6	2,1	1,05	1,8
15 - 30	4,4	2,28	3,8	2,2	1,13	1,9
< 15	5,0	2,5	4,3	2,5	1,24	2,2
	Pellet feed − 45 µm fraction			Pellets − 6,3 mm fraction		
	β_{SPM}	β_S	β_{PM}	β_{SPM}	β_S	β_{PM}
> 270	1,7	0,47	1,6	0,68	0,47	0,50
210 - 270	1,75	0,48	1,7	0,70	0,48	0,51
150 - 210	1,8	0,51	1,7	0,72	0,51	0,51
100 - 150	1,85	0,53	1,8	0,74	0,53	0,52
70 - 100	1,95	0,56	1,9	0,78	0,56	0,54
45 - 70	2,0	0,59	1,9	0,80	0,59	0,54
30 - 45	2,1	0,63	2,0	0,84	0,63	0,55
15 - 30	2,2	0,68	2,1	0,88	0,68	0,55
< 15	2,5	0,75	2,4	1,00	0,75	0,66

7 Procedures

7.1 Drying

If drying is specified, the iron ore and direct reduced iron 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. The sample shall be dried to constant mass.

7.2 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 and DRI shall be determined by reference to ISO 3082 and ISO 10835:

a) mechanical increment division;

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

c) manual division.

7.3 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 $\geqslant$ 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 $<$ 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 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 40 mm);

b) hand sieving and assisted hand sieving;

c) mechanical batch sieving;

d) wet sieving;

e) continuous machine sieving.

Of the above, the hand sieving method performed in accordance with 7.4.3 or 7.4.4 is the reference method that shall be used for bias assessments and in settling of between-laboratory disputes.

7.4.2 Hand placing on individual sieves

The minimum aperture size at which this method is considered to be applicable is 40 mm.

a) Gently shake the sieve by hand until separation seems complete.

b) Check the particles remaining on the sieve one by one in all orientations without applying force. Particles which pass through the sieve openings are included in the passing fraction.

c) Weigh the separated size fractions individually.

NOTE The percentage of passing fractions obtained by the hand placing method tend to be greater than those obtained by hand or mechanical sieving. Hand placing measures minimum diameters, while hand or mechanical sieving measures intermediate diameters.

7.4.3 Hand sieving in the − 40 mm to +1 mm range

This procedure is applicable using a single sieve or a sequence of individual sieves.

a) Use an individual sieve with a receiver pan. When using a sequence of individual sieves, start with the largest aperture. Place it on a smooth platform (to minimize attrition).

b) Place the charge on the sieve.

c) Take the sieve in both hands and slide it back and forth on the platform about 120 times per minute at an amplitude of about 120 mm. If the particles are difficult to sieve, especially in the size fractions − 4 mm to + 1 mm, the back and forth movement should be interrupted three times per minute by a circular motion in case of a round sieve, or by a sequence of movements lifting each side of the sieve in case of a square sieve. A periodic vertical shake may be given when using a round sieve.

d) Sieving is terminated either on satisfying the end point rule or at completion of a fixed sieving time. See 4.8 and 7.6.

e) The materials passing the sieve constitute the charge for the test sieve with the next smallest aperture.

f) Weigh the separated particle size fractions individually.

Examples of alternative methods for use of individual sieves are given in Figure 3.

7.4.4 Hand sieving in the − 1 mm range

This procedure is applicable to round sieves with 200 mm and 300 mm diameters, using a single sieve or a sequence of individual sieves. In this size range, a sieve together with a lid and receiver pan shall be used.

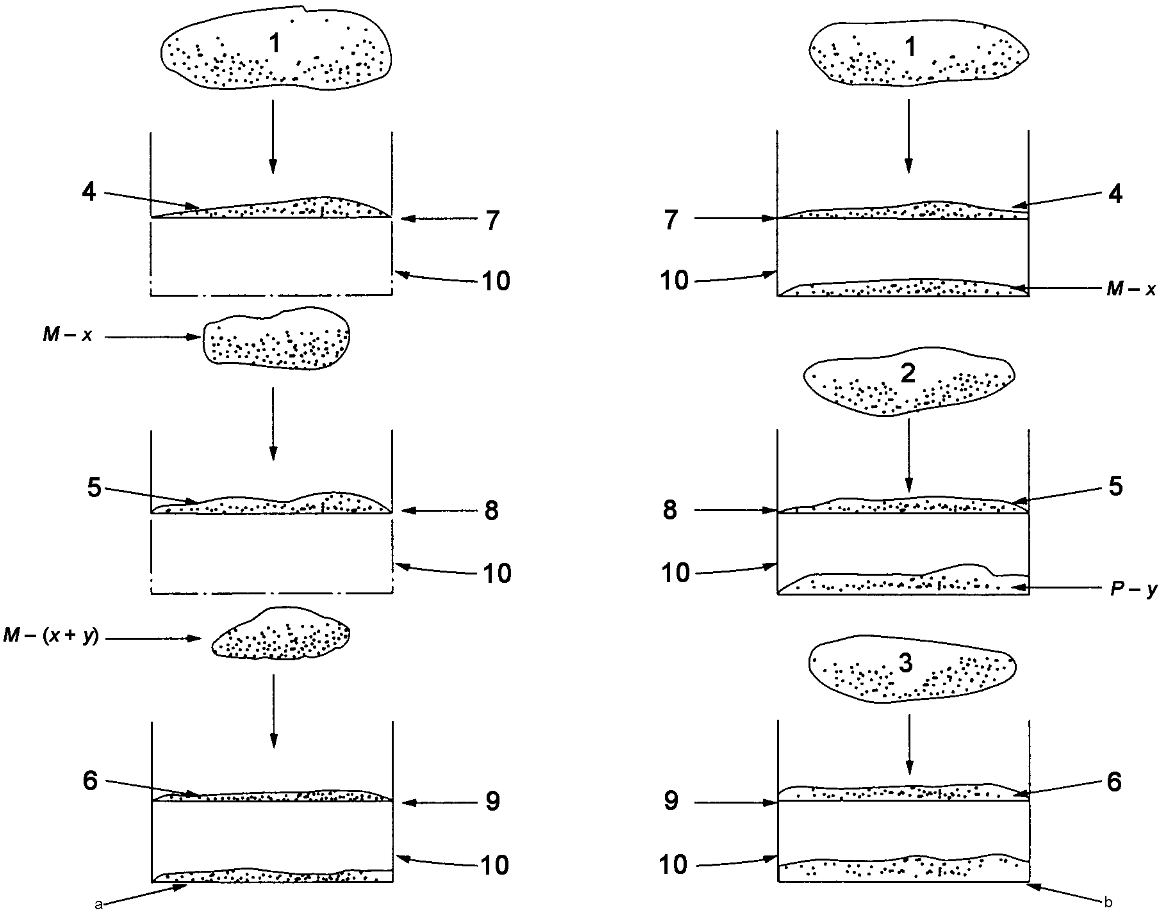
a) Use an individual sieve with a receiver pan. When using a sequence of individual sieves, start with the largest aperture.

b) Place the charge on the sieve and fit the lid.

c) Take the sieve in one hand and tap approximately 120 times per minute against the other hand at an inclination of 10° to 20°, with the grasped point tilted downwards. After 30 taps, put the sieve into the horizontal position, turn 90° and give a hard tap by hand against the sieve frame. A periodic vertical shake may be given. If the particles are difficult to sieve or when using fine sieves, the underside of the sieve medium shall be cleaned gently with a soft brush in order to loosen trapped particles. The resulting dust or particles released below the sieve are added to the undersize material.

d) Terminate sieving either on satisfying the end point rule or at completion of a fixed sieving time. See 4.8 and 7.6.

e) Weigh the separated particle size fractions individually.



Method 1 (– 11,2 mm) Method 2 (– 11,2 mm)

Key

1 charge M
2 charge P
3 charge R
4 retained x
5 retained y
6 retained z
7 sieve A
8 sieve B
9 sieve C
10 receiver pan

a $M - (x + y + z)$ = undersize through sieve C.
b $R - z$ = undersize through sieve C.

NOTE 1 Sieve A has the largest aperture size.

NOTE 2 Replicate charges M, P and R in method 2 are produced by careful sample division.

Figure 3 — Alternative methods for use of individual sieves for samples − 11,2 mm to + 1 mm

7.4.5 Mechanical batch sieving

This procedure is applicable to any size of iron ore and DRI using a single sieve or nest of sieves. The machine shall satisfy the criteria given in 5.2.

a) Assemble the nest of sieves with the largest aperture at the top and the receiver pan at the base.

b) Place the charge on the top sieve and fit the lid.

c) Attach the nest of sieves to the mechanical shaker.

d) Terminate sieving either on satisfying the end point rule or at completion of fixed sieving time. See 4.8 and 7.6.

e) Weigh the separated particle size fractions individually.

7.4.6 Wet sieving of coarse and fine samples

The general procedural rules applicable to dry sieving (see 7.4.2 to 7.4.5) also apply to wet sieving.

Arrange the sieving system so that an entire charge is subjected to a copious flow of clean water. Apply the water at low velocity and also low pressure. Take care that water does not flow over the side of the sieve. Take care to avoid damage to the sieve medium or cause degradation by the application of excessive water pressure. If the sample has been dried prior to wet sieving, wet the sample by mixing with a small quantity of water before agitating the sieves in order to reduce dust losses.

For manual wet sieving using individual sieves, an alternative method is to submerge the charge in water during the agitation of the sieve. On using this method, care shall be taken to ensure that water does not flow over the side of the sieve.

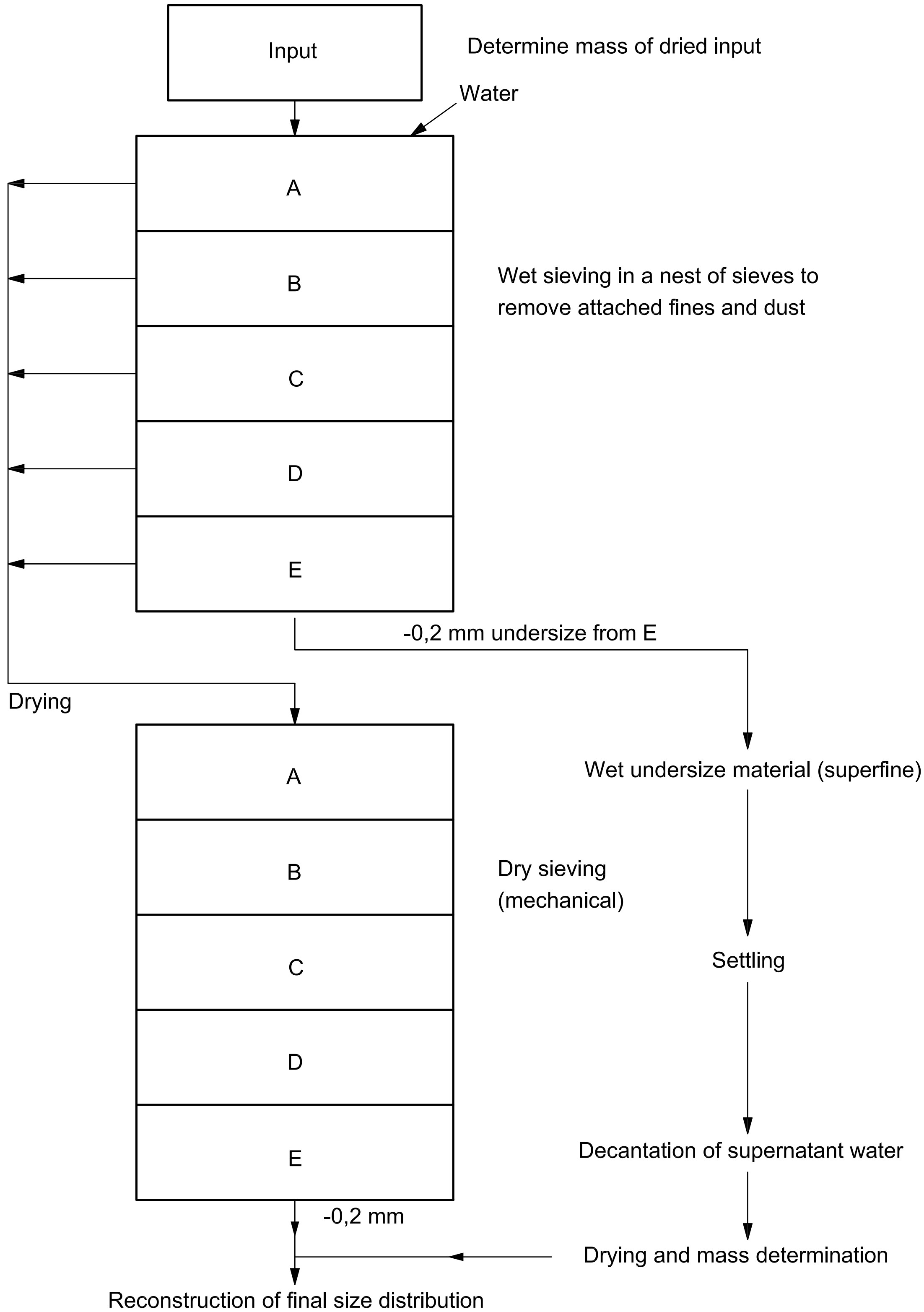
Method 1 described in Figure 3 shall be used if only a limited quantity of material is available. The sample may be washed successively through a nest of sieves with the finest aperture size at the bottom of the nest. The suspension that washes through the coarser sieve shall be placed directly on the next sieve. If the sample is large, a number of individual charges may be used in accordance with method 2 indicated in Figure 3. At completion, dry the sieves together with the retained oversize material under the same conditions as those specified in 7.1.

A schematic diagram of a reliable procedure for wet sieving of fine samples is shown in Figure 4.

7.4.7 Continuous machine sieving

Due to the diversity of type and configuration of continuous sieving machines, no specific procedural guide is provided in this International Standard. It is recommended that the manufacturer's instructions be strictly adhered to.

Continuous sieving machines shall be tested for bias in accordance with 5.2.



NOTE If a subsequent size distribution of the total undersize product (superfine sample) is needed, the undersize product should be wet sieved until the water emerging from the underside of the bottom sieve attains absolute clarity on visual inspection.

Figure 4 — Suggested wet sieving procedure for fine samples (– 11,2 mm)

7.5 Determination of mass

7.5.1 General

At all stages of operation, the mass of the charge and products shall be determined using equipment in accordance with 5.5 and then recorded. These operations cover drying, division and sieving.

7.5.2 Wet sieving — Determination of mass of solids-content in washings

The following procedures are permissible.

a) The charge is dried before and after wet sieving so that the loss of sample in the washings (which need not be collected) can be obtained by difference.

b) The charge is sieved in the “as-received” state, but the washings are collected to enable the solids to be extracted by filtering (or by another efficient method), dried and their mass measured.

c) The charge is sieved in the “as-received” state and the washings are not collected. Instead, the moisture content of the charge needs to be known, and this is obtained in accordance with ISO 3087. Hence, the loss of sample in the washings can be obtained by weight difference as in procedure a).

7.6 Determination of sieving end point

7.6.1 Dry sieving

7.6.1.1 Procedure when using a nest of sieves

a) Position the specification sieve immediately above the pan; add larger aperture size sieves as required then fit the lid. If there is no specification sieve, the end point ruling shall be applied to the sieve having the smallest aperture size.

b) Place the charge on the top sieve of the nest of test sieves and sieve for 1 min.

c) Remove the sample, which passes into the pan, and determine its mass.

d) Replace the empty receiver pan and continue the sieving operation for a second one-minute period.

e) Determine the mass of the sample that passes into the pan during the second one-minute interval.

f) Repeat this sequence of sieving for one minute and determine the mass of undersize until the quantity of material passing the specification sieve in any one minute is less than 0,1 % of the mass of the initial charge or until the collective sieving time reaches 30 min.

g) Adopt the duration of sieving to reach the end point for the specification sieve as the sieving time for all of the sieve size fractions of the sample being tested. If an end point is not reached within 30 min, then adopt an arbitrary sieving time.

7.6.1.2 Procedure for using a sequence of individual sieves

This procedure simulates sieving with a nest of sieves.

a) Use an individual sieve with a receiver pan and lid.

b) Place the charge on the sieve with the largest aperture size, and sieve for 1 min. The sample passing the sieve constitutes the charge for the test sieve with the next smallest aperture size. Sieving for 1 min is performed at successively smaller sieve aperture sizes down to the specification sieve.

c) Remove the sample, which passes from the specification sieve into the pan, and determine its mass.

d) Continue this “sieve to sieve” sequence of operation until the quantity of sample passing the specification sieve in 1 min is less than 0,1 % of the initial charge or until the collective sieving time reaches 30 min.

e) Adopt the duration of sieving to reach the end point for the specification sieve as the sieving time for all sieve size fractions of the sample being tested. If an end point is not reached within 30 min, then adopt an arbitrary sieving time.

7.6.2 Wet sieving

A wet sieving operation on an individual sieve is considered to be complete when the liquid used is practically clear when it flows through.

8 Verification

8.1 General

Regular checking of apparatus and procedures is essential to verify the test results. Checks shall be carried out prior to the commencement of a routine size analysis and at regular intervals thereafter. The frequency of checking is a matter for each laboratory to determine. A detailed record of all verification activities shall be maintained and reference to same be made in each test report.

8.2 Checking of division

The precision of any division procedures adopted during sieve size analysis shall be determined and evaluated in accordance with ISO 3085. More frequent checks shall be carried out on the critical parameters associated with the adopted division method.

8.3 Verification of sieve media

The accuracy of the sieve medium shall be verified initially, verification shall be repeated regularly and a record card shall be kept for each sieve. Verification may be made by the procedures given in ISO 3310-1 or ISO 3310-2. When a sieve medium no longer complies with the tolerances specified in ISO 3310-1 or ISO 3310-2, the marking on the label shall be cancelled and the sieve discarded. An alternative method is to compare the performance of a sieve with that of a reference sieve, using a sample material similar to the one for which the sieve is to be used.

8.4 Verification of sieving machines

The machine sieving operation shall be verified initially as described in 5.2 and shall be checked again at agreed intervals. More frequent checks shall be carried out of machines' operating parameters such as vibrating frequency, amplitude and direction.

8.5 Verification of weighing devices

All weighing devices shall be checked regularly using procedures appropriate to the device.

9 Results

9.1 Evaluation of results

The sum of the fractional masses of each operation shall not differ by more than 1 % for dry sieving and 3 % for wet sieving, from the mass of the input to the operation. All gains or losses shall be recorded in the test report.

NOTE When applying 7.5.2, the above instruction is not applicable.

9.2 Calculation and expression of results

9.2.1 The percentage size fraction content of each of the size ranges of the lot shall be calculated in accordance with 9.2.2 and 9.2.3.

9.2.2 When the size analysis is based on sieving a gross sample or a test sample derived from the gross sample, calculate the percentage of each size fraction to the nearest first decimal place as follows:

$$\%\ (\text{size fraction}) = 100 \times \frac{\text{Mass of a size fraction}}{\text{Total mass of all size fractions}}$$

9.2.3 When the size analysis is based on sieving several partial samples or increments, then sum the masses of each respective fraction from each sample and calculate the result as in 9.2.2.

Tables 4 and 5 illustrate the application of 9.2.2 and 9.2.3 respectively.

NOTE In case the average particle size (APS) is required, calculate APS in accordance with Annex J.

Table 4 — Example of calculation and evaluation of results when sieving a gross sample or test sample derived from the gross sample (see 9.2.2)

Mass of test portion = 14 528 g		
Sieve aperture size mm	**Size fraction**	
	g	%
40	83	0,6
31,5	507	3,5
25	1 228	8,5
20	2 188	15,2
12,5	4 615	32,0
9,5	2 693	18,7
8	1 440	10,0
6,3	990	6,9
Undersize	682	4,7
Total	14 426	100,0
Original mass:	14 528	
Total mass of all size fractions:	14 426	
Difference (see 9.1):	102	102/14 528 = 0,7%

Table 5 — Example of calculation and evaluation of results when sieving several partial samples or increments (see 9.2.3)

Increment (or partial sample) No.	**1**	**2**	**3**	**4**	**Total**	
Mass of test portion, g	14 528	14 400	14 220	15 201	58 349	
Sieve aperture size mm	**Size Fraction**					
	g	g	g	g	g	**%**
40	83	70	65	70	288	**0,5**
31,5	507	465	444	452	1868	**3,2**
25	1 228	1 201	1 185	1 986	5 600	**9,6**
20	2 188	2 189	2 150	2 199	8 726	**15,0**
12,5	4 615	4 598	4 430	4 603	18 246	**31,4**
9,5	2 693	2 700	2 852	2 698	10 943	**18,8**
8	1 440	1 439	1 429	1 426	5 734	**9,9**
6,3	990	998	982	1 002	3 972	**6,8**
Undersize	682	678	700	650	2 710	**4,7**
Total	14 426	14 338	14 237	15 086	58 087	**100,0**
Original mass:	14 528	14 400	14 220	15 201	58 349	
Total mass of all size fractions:	14 426	14 338	14 237	15 086	58 087	
Difference (see 9.1), g:	102	62	17	115	262	
Difference (see 9.1), %:	0,7	0,4	0,1	0,8	0,4	

9.3 Repeatability and acceptance of results

9.3.1 Where the test portions are to be extracted from the gross sample, partial samples or increments, the division forms part of the size analysis procedure and the following assessment shall be adopted in accordance with Annex H.

9.3.2 Four test portions for sieving shall be prepared in accordance with the division procedures adopted. In the case where one sample of selected mass is extracted, e.g. in mechanical division, it is recommended that the required further division to four test portions be carried out by the adopted method of division (see 7.2).

9.3.3 Of the four test portions, two shall be submitted initially for size analysis. If the resulting size analyses agree within the limit r prescribed in 9.3.8 (with reference to the specification size or other key aperture size), the mean of the size analysis of the two test portions is taken to be representative of the lot.

9.3.4 If the two size analyses do not agree within the limit r prescribed below and agree within the limit 1,2 r, a third test portion shall be sieved. If the range of these three size analyses agrees within the limit 1,2 r, the mean of the size analysis of the three test portions is taken to be representative of the lot.

NOTE If the two size analyses do not agree within the limit r prescribed below, the third and the fourth test portions may be sieved in accordance with 9.3.5.

9.3.5 If the range of these three size analyses do not agree within the limit 1,2 r, the fourth test portion shall be sieved, or if the first two size analyses do not agree within the limit 1,2 r, the third and the fourth test portions shall be sieved.

9.3.6 If the range of these four size analyses agrees within the limit 1,3 r, the mean of the size analyses of all four test portions is taken to be representative of the lot.

9.3.7 If the range of these four size analyses do not agree within the limit 1,3 r, the median of these four size analyses is taken to be representative of the lot. The median of four test results is defined as the mean of the two non-extreme test results.

9.3.8 The value of r shall be $\sqrt{2}\ \beta_{PM}$ with reference to the specification size or other designated aperture sizes, where β_{PM}, the precision of sample preparation and measurement, should not exceed the value listed in Table 3 for each type of ore.

10 Test report and working log

The test results shall be traceable and cover the following items:

a) name and address of the testing laboratory;

b) identity of test operator;

c) date of testing;

d) identity, condition and form of sample;

e) details of preparation;

f) details of procedure (including sieving methods and sieving apparatus used);

g) test results with important observations.

11 Precision

11.1 Overall precision, β_{SPM}

This International Standard has been prepared with the aim of satisfying the approximate overall precision requirements defined in ISO 3082 and ISO 10835. These precisions for sizings are set out in Table 6 below.

The overall precision obtained in practice should be determined regularly according to one of the protocols set out in ISO 3085.

11.2 Precision of preparation and measurement, β_{PM}

It is not practically possible to separate and evaluate the precisions of preparation and measurement. The magnitude of the combined precision of preparation and measurement, β_{PM}, should be determined regularly.

Table 3 provides a comparison of overall sizing precision (β_{SPM}) with the precisions of sampling (β_S) and sample preparation and measurement (β_{PM}).

Table 6 — Overall precision of sizing, β_{SPM} (values as absolute percentages)

Size characteristics		Approximate overall precision (β_{SPM})								
		Mass of lot (t)								
		Over 270 000	210 000 to 270 000	150 000 to 210 000	100 000 to 150 000	70 000 to 100 000	45 000 to 70 000	30 000 to 45 000	15 000 to 30 000	Less than 15 000
−200 mm ore	−10 mm fraction mean 20 %	3,4	3,5	3,6	3,7	3,9	4,0	4,2	4,4	5,0
−50 mm ore										
−31,5 +6,3 mm ore	−6,3 mm fraction mean 10 %	1,7	1,75	1,8	1,85	1,95	2,0	2,1	2,2	2,5
Sinter feed	+6,3 mm fraction mean 10 %									
Pellet feed	−45 µm fraction mean 20 %									
Pellets	−6,3 mm fraction mean 20 %	0,68	0,70	0,72	0,74	0,78	0,80	0,84	0,88	1,00
−31,5 +6,3 mm DRI lump	−6,3 mm fraction mean 10 %						2,0	2,2	2,2	2,5
DRI pellets	−6,3 mm fraction mean 5 %						0,8	0,9	0,9	1,0
NOTE Data from ISO 3082 and ISO 10835:2007, Table 1.										

Annex A
(informative)

Steps for establishing the operating conditions for the determination of size distribution using a single sieve or a nest of sieves

Step	Sieving Scheme	Reference
1	Identify the material to be sieved.	
1.1	Ascertain the bulk density.	4.7.2
1.2	Ascertain the apparent density (ρ_a).	Annex G [Equation (G.1)]
1.3	Ascertain the required β_{PM}.	Annex G [Equation (G.1)]
1.4	Ascertain the nominal top size.	Annex G [Equation (G.2)]
1.5	Ascertain the specification sieve and its percentage.	Annex G [Equation (G.2)]
	Note If there is no specification sieve, use the smallest aperture size.	
2	Calculate the minimum mass of sample to be sieved.	Annex G [Equation (G.1)]
3	Define the single sieve or nest of sieves to be used, to avoid damage to sieves.	4.6
4	Determine the number of batches to be carried out.	–
4.1	Ascertain the approximate size distribution of the material to be sieved, corresponding to the single sieve or nest of sieves defined in step 3.	–
4.2	Calculate the mass to be retained on the single sieve or nest of sieves selected, using the minimum mass calculated in step 2 and the size distribution in step 4.1.	–
4.3	Compare the masses obtained in step 4.2 with the ones established in 4.7.2 and establish the number of batches to be carried out.	4.7.2
5	Determine the sieving time.	4.8
6	Check the sieve machines using ISO 3086, taking hand sieving as the reference method.	5.2.

Annex B
(normative)

Scheme of sample preparation and sieving procedure

Test sample conditions	Test portion preparation	Sieving	Size fraction drying	Results
Natural or as received	Natural	Dry	No	Natural basis [a]
			Yes	Dry basis
		Wet	Yes	Dry basis [7.5.2. b) and c)]
	Dried	Wet	Yes	Dry basis [7.5.2 a)]
		Dry	No	Dry basis
Dried	Dried	Wet	Yes	Dry basis [7.5.2 a)]
		Dry	No	Dry basis

NOTE 1 If it is not possible to cover the range of a single distribution using a single method, overlap the methods of size determination so that one or more size classes are assessed by both methods (refer to ISO 2591-1).

NOTE 2 The changeover from one method to another shall be clearly indicated in the report.

[a] Not recommended for size fractions under 4 mm.

Annex C
(normative)

Maximum mass to be retained on a sieve at completion of batch sieving (*m*) in order to obtain good sieving efficiency

The following applies for a typical sample of bulk density 2 300 kg/m^3. For other densities, the retained mass shall be changed pro rata.

Sieve aperture size mm	**Maximum mass to be retained on sieve at completion of sieving**		**Sieve aperture size** µm	**Maximum mass to be retained on sieve at completion of sieving**	
	200 mm dia. sieves kg	300 mm dia. sieves kg		200 mm dia. sieves g	300 mm dia. sieves g
100			900	140	300
90,0			850	140	300
80,0			800	140	300
63,0			710	140	300
50,0			630	125	270
45,0			600	120	260
40,0			560	110	250
31,5		2,9	500	110	250
25,0		2,4	450	100	230
22,4		2,3	425	95	220
20,0		2,3	400	90	200
16,0		1,8	355	90	200
12,5		1,4	315	80	180
			300	80	180
			280	80	180
			250	80	180
	g	g	224	70	160
11,2	600	1 300	212	70	160
10,0	500	1 100	200	70	160
8,00	400	900	180	70	160

Sieve aperture size mm	Maximum mass to be retained on sieve at completion of sieving		Sieve aperture size µm	Maximum mass to be retained on sieve at completion of sieving	
	200 mm dia. sieves g	300 mm dia. sieves g		200 mm dia. sieves g	300 mm dia. sieves g
6,30	350	700	160	60	145
5,60	300	650	150	60	135
4,00	200	450	140	60	130
3,55	180	400	125	60	130
3,35	180	400	112	60	120
3,15	180	400	106	50	115
2,8	180	400	100	50	110
2,5	180	400	90	45	100
2,36	180	400	80	40	90
2,24	180	400	75	40	90
2	180	400	71	40	90
1,8	160	360	63	40	90
1,7	150	340	56	35	80
1,6	145	320	53	35	80
1,4	140	300	50	35	80
1,25	140	300	45	35	80
1,18	140	300	40	30	70
1,12	140	300	38	30	70
1	140	300	36	30	70

Annex D
(informative)

Size apertures in R20 and R40/3 series (taken from ISO 565)

Millimetre sizes		Micrometre sizes	
125[a]	8[a]	900	56
112	7,1	850[b]	53[b]
106[b]	6,7[b]	800	50
100	6,3	710[a]	45[a]
90[a]	5,6[a]	630	40
80	5	600[b]	38[b]
75[b]	4,75[b]	560	36
71	4,5	500[a]	
63[a]	4[a]	450	
56	3,55	425[b]	
53[b]	3,35[b]	400	
50	3,15	355[a]	
45[a]	2,8[a]	315	
40	2,5	300[b]	
37,5[b]	2,36[b]	280	
35,5	2,24	250[a]	
31,5[a]	2[a]	224	
28	1,8	212[b]	
26,5[b]	1,7[b]	200	
25	1,6	180[a]	
22,4[a]	1,4[a]	160	
20	1,25	150[b]	
19[b]	1,18[b]	140	
18	1,12	125[a]	
16[a]	1[a]	112	
14		106[b]	
13,2[b]		100	
12,5		90[a]	
11,2[a]		80	
10		75[b]	
9,5[b]		71	
9		63[a]	

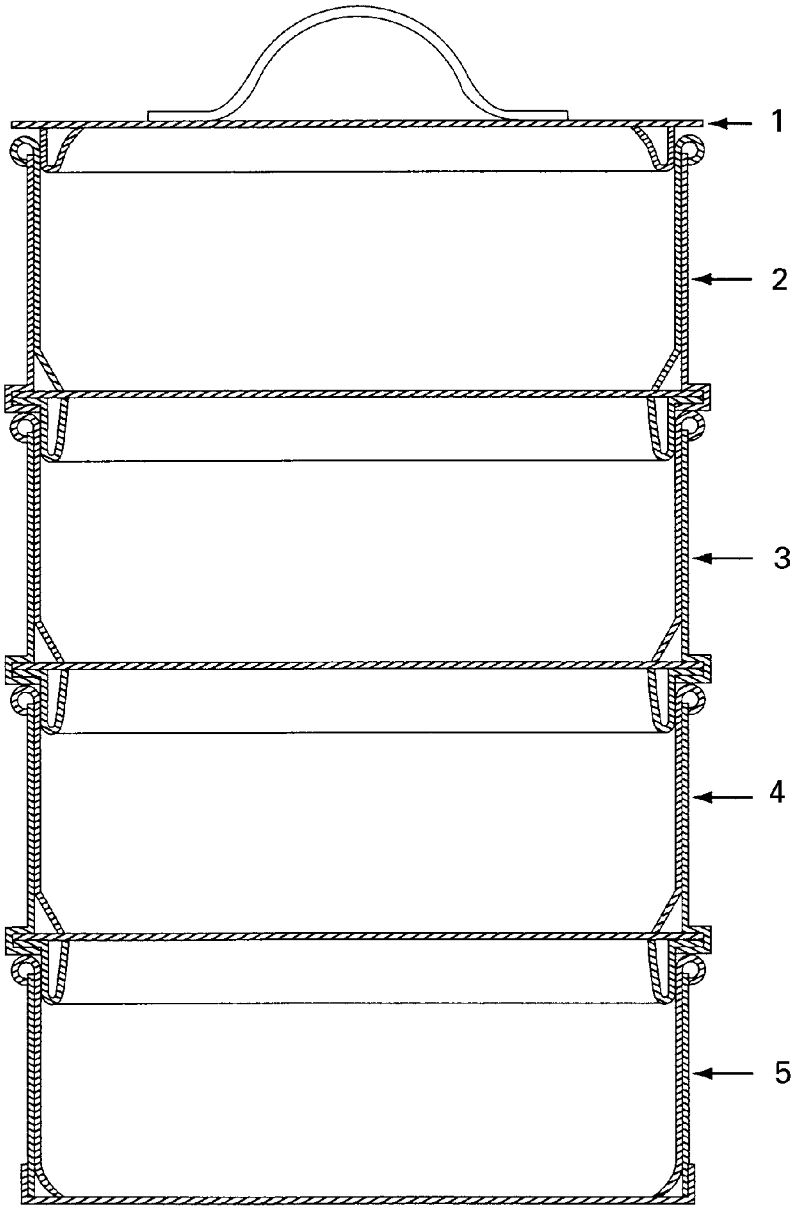
[a] R20 and R40/3 series screens.

[b] R40/3 series screens.

Annex E
(informative)

Typical batch sieving apparatus

Batch sieving is usually carried out on a sieve or on a nest of sieves. Typical apparatus for carrying out batch sieving is shown in Figure E.1.



Key

1 lid

2 largest aperture sieve

3 intermediate aperture sieve or sieves

4 smallest aperture sieve

5 receiving pan

Figure E.1 — Typical batch sieving apparatus

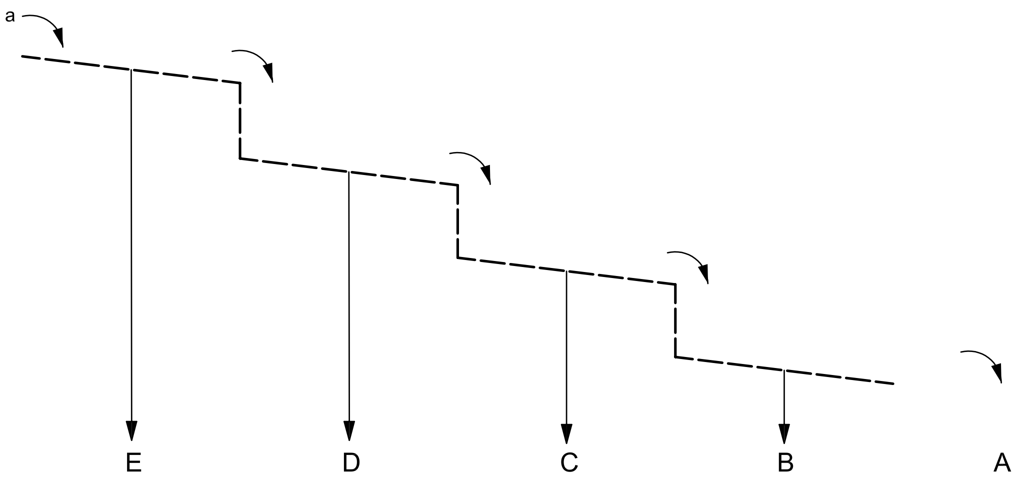
Annex F
(informative)

Desirable features of mechanical sieving machines

F.1 Continuous sieving machines

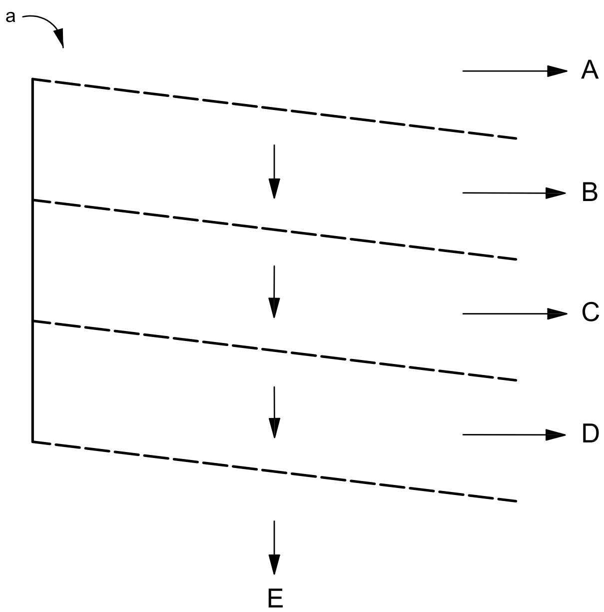
Examples of sieve deck arrangements are given in Figures F.1 to F.4.

(Coarsest A → B → C → D→ E finest)



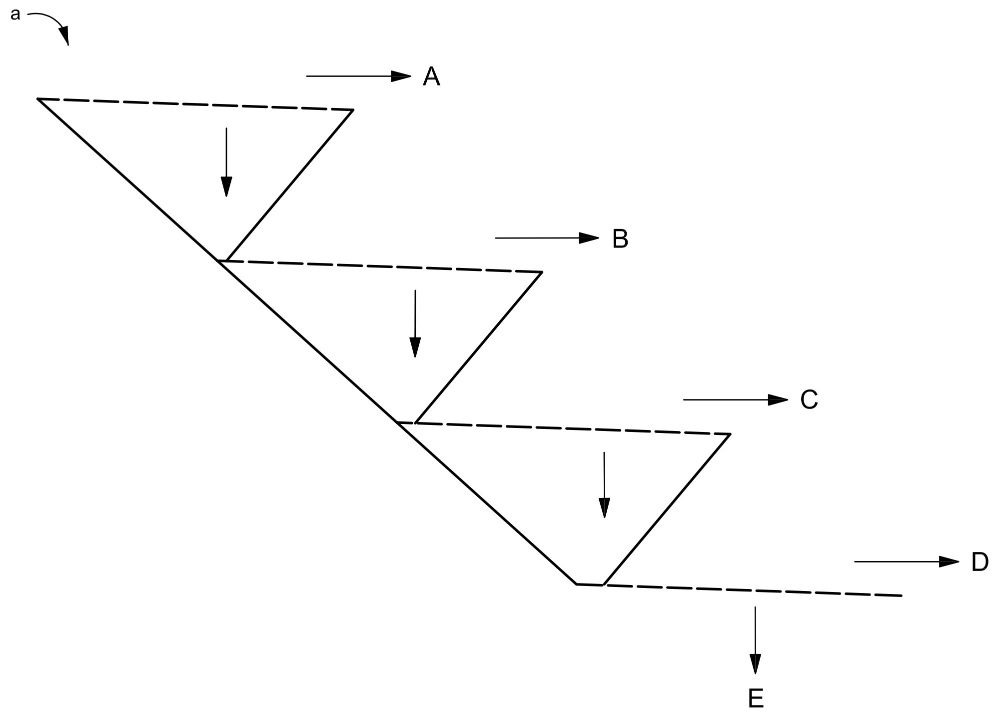
a Feed.

Figure F.1 — One deck, one drive



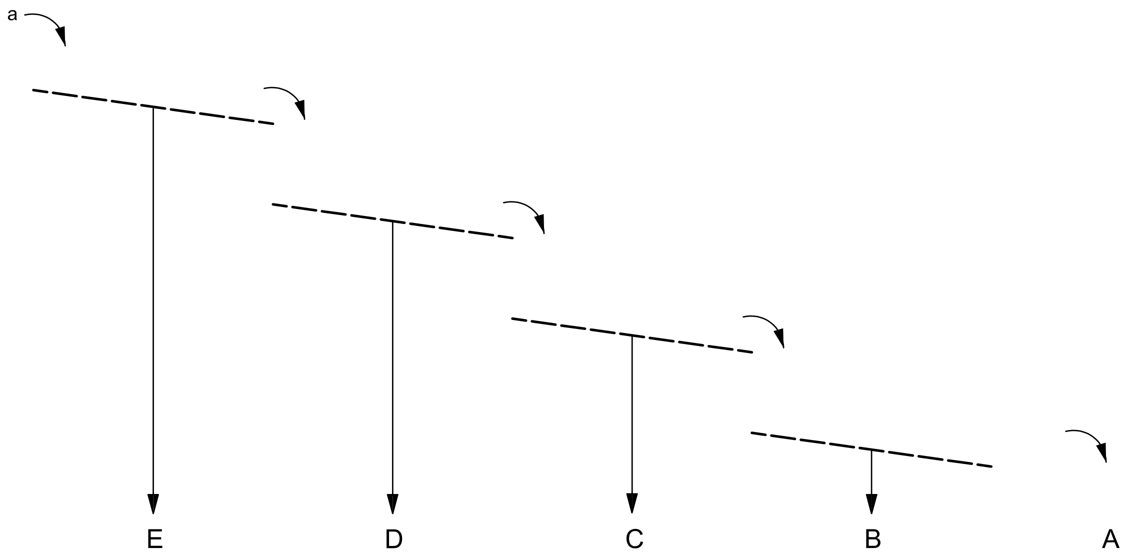
a Feed.

Figure F.2 — Multi-deck, one drive



a Feed.

Figure F.3 — Multi-deck, multi-drive, coarse particles removed first



a Feed.

Figure F.4 — Multi-deck, multi-drive, fine particles removed first

The motion imparted to the sieving medium should:

a) stratify the sample causing large particles to rise to the top of the bed and fines to move to the bottom;

b) ease the particles through the apertures of the sieving surface;

c) turn the particles over so that they present different aspects to the apertures;

d) move the sample steadily along the sieving surface;

e) prevent particles blocking the sieve apertures (i.e. “blinding”).

More common continuous sieving machines are of the vibratory type. The motion in the vertical plane is either circular or linear (occasionally elliptical).

There is no evidence to show that one type of motion is better than another. Linear motion (provided it has a forward throw) has the advantage that the sieving medium need not be inclined and thus saves headroom. It may give greater retention time.

Based on practical experience the amplitude of vibration rather than frequency should be increased if the sieve apertures are tending to blind-up, or if the “size-of-cut” is large (say + 22,4 mm apertures).

With circular motion and for test sieving as opposed to commercial sieving, a backward throw coupled with a forward sieve inclination of 10° to 15° should ensure a reasonable flow-rate of sample ore, provided that the sample is free-flowing. Samples that are not free-flowing will require a steeper deck and a forward throw.

F.2 Nest sieving machines

Most of the details regarding continuous sieving machines also apply to nest sieving machines. A major difference is that generally, particles should be made to progress over the whole sieving surface, moving either from side to side or in circular paths. A vibratory motion that causes particles to pile up against one side of the sieving frame is undesirable. Two possible methods of meeting the desired objectives are:

a) mounting the nest of sieves on a rotating wedge-shaped turntable, thereby tilting the sieves cyclically and causing the particles to move from side to side;

b) imparting a swirling motion to the nest of sieves, similar to that imparted by hand sieving operations.

The above motions may be additional to any primary up-and-down sieving action.

For sieving in the − 4 mm range, it is acceptable to have a simple up-and-down motion only. The slight irregularities in the motion are sufficient to cause the fine particles to progress randomly over the surface of the sieves.

In view of the fact that sieves are emptied and cleaned at frequent intervals, the sieve motion can be chosen, more to give efficient size separation than to overcome blinding. Thus, low amplitude (say, − 3 mm), high frequency motions tend to be used. Besides giving efficient size separation, they also inhibit degradation of friable particles.

F.3 Variable motion drives

Greater flexibility of operation is obtained, particularly with continuous sieving machines, if the frequency and amplitude of the drive can be made variable. Frequency variation is readily obtained if the motion is derived from a rotary device. Amplitude variation is normal practice with electromagnetic vibrators (where amplitude is small anyway) and can be obtained fairly easily with out-of-balance type vibrators. In the latter case, the variation normally has to be made by means of a mechanical adjustment after the sieving machines have been stopped. A variable motion drive is of less importance with nest sieving machines since with these the efficiency of size separation can normally be increased simply by increasing the sieving time.

Electromagnetic vibratory shakers should not be used when strict comparability with other tests or laboratories is required, since it is difficult to be sure of the identical intensity of vibration in different tests.

Annex G
(normative)

Procedure for determining the minimum mass of sample used for sieving

G.1 Formula

When the gross sample (or its constituent increments or sub-samples are) is to be divided, the minimum mass of sample which is finally sieved may be determined from Equation (G.1).

$$m_3 = \frac{k}{\beta_{PM}^2} \times \frac{\rho_a}{5\,000} \qquad \text{(G.1)}$$

where

m_3 is the mass to be sieved, in kilograms;

k is a constant;

β_{PM} is the required precision of sample preparation and measurement as a percentage;

ρ_a is the apparent density of the particles, in grams per cubic centimetre.

$$k = 2{,}5 \times 10^{-5}\ P(100 - P)d^3 \left(\frac{l_2}{d}\right)^{0{,}5} \qquad \text{(G.2)}$$

The constant, k, is characteristic of the type of sample, the specification size and percentage in the specification size and may be determined from Equation (G.2).

where

P is the percentage of the specification size (see Table G.1);

d is the nominal top size of the size sample, in millimetres (see ISO 11323);

l_2 is the specification sieve size, in millimetres [see a) and b), below].

It is suggested that for practical use of Equation (G.2), the values of P given in Table G.1 be adopted.

Table G.1 — Values of P

% of specification size	P	$P(100 - P)$
0 to 4,9	5	475
5,0 to 9,9	10	900
10,0 to 14,9	15	1 275
15,0 to 19,9	20	1 600
20,0 to 24,9	25	1 875
25,0 to 29,9	30	2 100
30,0 to 34,9	35	2 275
35,0 to 40,0	40	2 400

Where the specification size is a cumulative percentage “less than” or “greater than” value, this value shall be the value used for l_2 in Equation (G.2).

Where the specification size is defined by two sieve aperture sizes, then:

a) if the specification size lies in the coarse fraction, the smaller of the two sieve sizes shall be used for l_2 in Equation (G.2);

b) if the specification size lies in the fine fraction, the larger of the two sieve sizes shall be used for l_2 in Equation (G.2).

In the case of fine samples (– 6,3 mm), practical experience has indicated that the minimum mass of sample used for sieving shall be not less than 50 g and this value shall be used whenever the mass indicated by the equation is smaller.

When each increment or each partial sample is divided, the minimum mass, m_5, in kilograms, of divided increment or partial sample for size determination is given by Equation (G.3):

$$m_5 = \frac{m_3}{n_1} \qquad \text{(G.3)}$$

where

m_3 is the minimum mass, in kilograms, of divided gross sample determined from Equation (G.1);

n_1 is the number of primary increments or partial samples to be divided.

G.2 Examples of calculation of the minimum mass of sample used for sieving

EXAMPLE 1

Material type	Sinter feed – 10 mm
Specification size	+ 6,3 mm
Approximate percentage of specification size in sample	8 %
Apparent density of particles	4 800 kg/m^3
Desired β_{PM}	2 %

Task: to determine the minimum mass to be used for sieving.

1) Determination of l_2: the specification size is given as 6,3 mm. By definition (see above), the value of l_2 shall be 6,3 mm.

2) Determination of P and $P(100 - P)$: the approximate value of P is given as 8 %. According to Table G.1, the value to be assumed shall be 10 %, hence $P(100 - P)$ = 900.

3) Determination of k, from Equation (G.2):

$$k = 2,5 \times 10^{-5} \times 900 \times (10)^3 \times (6,3/10)^{0,5} = 17,86 \text{ m}^3$$

4) Determination of minimum mass, from Equation (G.1):

$$m_3 = \frac{17,86}{2^2} \times \frac{4\,800}{5\,000} = 4,3 \text{ kg}$$

EXAMPLE 2

Material type	Sized ore − 31,5 mm + 6,3 mm
Specification size	− 10 mm + 6,3 mm
Approximate % of specification size in sample	12 %
Apparent density of particles	4 500 kg/m^3
Desired β_{PM}	2,5 %

Task: to determine the minimum mass to be used for sieving.

1) Determination of l_2: the specification size is given as − 10 mm + 6,3 mm. By definition (see above), the value of l_2 shall be 10 mm.

2) Determination of P and $P(100 - P)$: the approximate value of P is given as 12 %. According to Table G.1, the value to be assumed shall be 15 %, hence $P(100 - P)$ = 1 275.

3) Determination of k, from Equation (G.2):

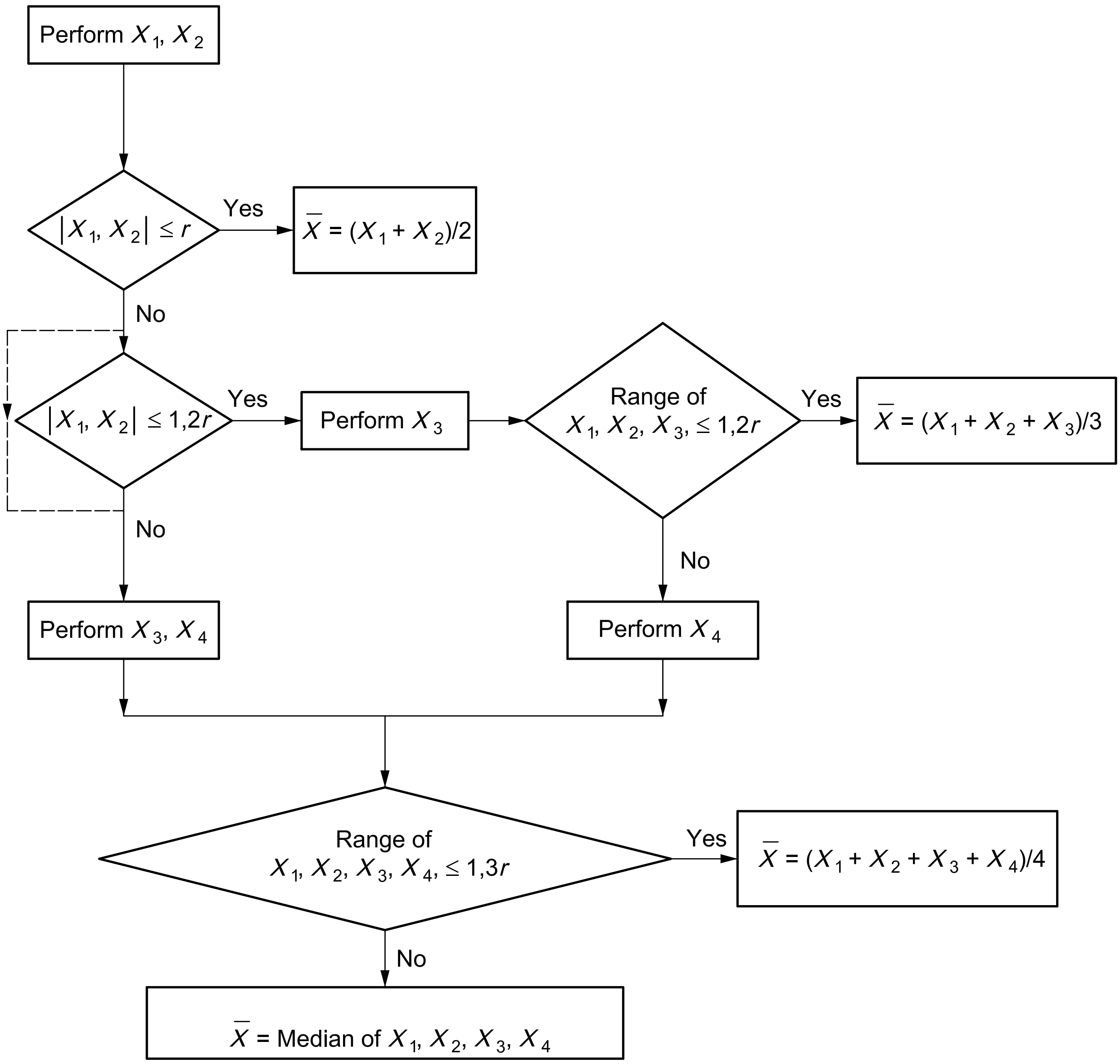
$$k = 2{,}5 \times 10^{-5} \times 1\,275 \times (31{,}5)^3 \times (10/31{,}5)^{0{,}5} = 561{,}34\text{m}^3$$

4) Determination of minimum mass, from Equation (G.1):

$$m_3 = \frac{561{,}34}{(2{,}5)^2} \times \frac{4\,500}{5\,000} = 80{,}8\text{ kg}$$

Annex H
(normative)

Flowsheet of the procedure for the acceptance of analytical values for test portions



r: as defined in 9.3.8.

Annex I
(informative)

Additional information

I.1 Scope

This annex contains additional information in the form of explanations to certain subclauses contained in the main body of this International Standard.

I.2 Choice of sieving method (4.5)

The effectiveness of dry sieving depends on:

a) the duration of sieving;

b) the force applied to tap the sieve;

c) the number of taps per minute applied to the sieve (frequency);

d) the direction in which the tapping is applied;

e) the amplitude of shaking;

f) the inclination of the sieve medium;

g) the state of dryness of the sample to be sieved.

NOTE Moisture can affect the separation of individual particles, the mass of a particle and the size of particles, as well as the flow of the charge on or through the sieves.

I.3 End point ruling (4.8.2)

Application of the end point ruling may be unsuitable for samples that are susceptible to degradation. In such cases, hand placing should be used as far as practicable, followed by fixed time sieving based upon agreed time limits. Even for non-grading samples, strict application of the end point ruling may be impracticable and fixed time sieving based on experience may be more convenient to use. Strict application of the end point ruling is often inconvenient for wet sieving. Fixed time sieving can be used, or sieving may be considered as complete when the liquid emerging from the underside of the sieve attains a reasonable clarity on visual inspection. Dry sieving of fine particles may cause difficulty due to the tendency of the sieve apertures to blind. Care should be taken to ensure that, throughout the sieving operation, changes in moisture contents are measured and taken into account. For accurate dry size analysis of ores of less than 1 mm in size, it is essential that the sample be free flowing. In the case of most samples, surface moisture adversely affects this characteristic. The sample should be appropriately dried, if necessary, to zero moisture.

I.4 Construction of sieve media (5.1.3)

In view of the high densities of iron ores and direct reduced iron, perforated metal plate is preferred as the sieving medium for aperture sizes > 4 mm. For aperture sizes $\leqslant 4$ mm, woven wire shall be utilized. It is recommended that indiscriminate mixing of perforated plate and woven wire sieves should be avoided within any determination in order to ensure continuity of results.

In cases where woven wire sieves are used, particularly in the + 4 mm range, it should be recognized that:

a) with round frame sieves, incomplete apertures are unavoidable; this increases the risk of accidental retention of undersized particles which may become wedged in the incomplete apertures;

b) tolerances on aperture size are wider than for perforated plate and this may influence results;

c) this type of sieve medium is prone to distortion.

In cases where perforated plate is utilized as the medium, all incomplete apertures of the sieve should be blanked off. Omission of this blanking off is permissible, provided that the particles retained in these incomplete apertures are removed without breakage and correctly sized before the size fractions are weighed.

Annex J
(normative)

Determination of the average particle size (APS)

Consider a size distribution of a sample given as "percent retained". The average particle size is calculated using the following expression:

$$\text{APS} = \frac{\sum f_i d_i}{100} \qquad \text{(J.1)}$$

where

APS is the average particle size, in millimetres;

f_i is the percentage retained in size fraction i;

d_i is the midpoint of the sieve apertures defining the fraction i, in millimetres.

The midpoint d_i is calculated as follows:

a) for the coarsest size fraction, obtain the arithmetic mean of the corresponding sieve aperture and the immediately larger one, taken from R20 or R40/3 series (20 mm sieve from series R20 in the example below);

b) for the intermediate size fractions, obtain the arithmetic mean between the two sieve apertures that define the fraction;

c) for the finest size fraction, divide the corresponding sieve aperture by 2.

EXAMPLE

Sieve aperture, mm	**Midpoint** (d_i), mm	**% Retained** (f_i)	**Product of** d_i **and** f_i
20,0			
18,0	19,0	0,7	13,30
16,0	17,0	4,5	76,50
14,0	15,0	11,8	177,00
12,5	13,25	27,2	360,40
11,2	11,85	49,3	584,21
9,0	10,10	3,8	38,38
8,0	8,50	1,7	14,45
6,3	7,15	0,4	2,86
5,0	5,65	0,3	1,70
− 5,0	2,50	0,3	0,75
TOTAL		**100**	**1 269,54**

APS = 1 269,54/100 = 12,7 mm

ICS 73.060.10

Price based on 39 pages