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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.

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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	Time by hand sieving	Time by mechanical sieving
mm	min	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.

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

b) Check the iron ore 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.

7.4.3 Hand sieving and assisted hand sieving in the −22,4 mm +1 mm range

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

a) Assemble the nest of sieves with the largest aperture at the top.

b) Place the charge on the sieve with the largest aperture.

c) Take the sieve or nest of sieves in both hands and move to and fro horizontally about 60 times a minute at an amplitude of about 70 mm. If the ore is difficult to sieve, especially in the size fractions − 4 mm + 1 mm the to and fro movement should be interrupted three times per minute by a circular motion. A periodic vertical shake may be given.

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) 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 and assisted hand sieving in the − 1 mm range

This procedure is applicable using a single sieve or nest of sieves. In this size range, a sieve or nest of sieves together with a lid and receiver pan shall be used.

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

b) Place the charge on the sieve with the largest aperture and fit the lid.

c) Take the sieve or nest of sieves in one hand and tap approximately 120 times a 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, turned 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 fixed sieving time. See 7.6.

e) Weigh the separated particle size fractions individually.

7.4.5 Mechanical batch sieving

This procedure is applicable to any size of iron ore 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 7.6.

e) Weigh the separated particle size fractions individually.

7.4.6 Procedures for wet sieving of coarse and fine ores

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 overflow 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 iron ore 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. In using this method, it is necessary to apply an adequate end point ruling and as in the preferred method care shall be taken to ensure that water does not overflow 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 which 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 ores 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 the standard. It is recommended that the manufacturer's instructions be strictly adhered to.

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, sieving and division.

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 ore 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 content to be extracted by filtering (or by another efficient method), dried and 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 iron ore in the washings can be obtained by weight difference as in procedure a).

7.6 Procedures for determining sieving end point

7.6.1 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.

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c) Remove the iron ore which passes into the pan and determine its mass. In the case of wet sieving, dewater and dry the product before weighing.

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

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

f) Repeat this sequence of sieving for one minute and determine its 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 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 ore being tested. If an end point is not reached within 30 min, then adopt an arbitrary sieving time.

7.6.2 Procedure for using a sequence of individual 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 ore 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, thus simulating sieving with a nest of sieves.

c) Remove the ore which passes into the pan and determine its mass. In the case of wet sieving the product should first be dewatered and dried.

d) Continue this "sieve to sieve" sequence of operation until the quantity of ore passing the specification sieve, in 1 min is less than 0,1 % of the 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 ore being tested. If an end point is not reached within 30 min, then adopt an arbitrary sieving time.

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 must 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 6.2 and 7 of ISO 3085:1996. 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. Another 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. 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.

8.4 Verification of sieving machines

The machine sieving operation shall be verified initially as is 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 at agreed intervals 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.

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 composite size sample or a test sample derived from the size sample, calculate the percentage of each size fraction to the nearest first decimal place as follows:

$$\% \text{ (size fraction)} = 100 \times \frac{\text{Mass of size fraction}}{\text{Mass of test sample}}$$

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

9.3 Repeatability and acceptance of results

9.3.1 Where division forms part of the size analysis procedure, the following assessment shall be adopted in accordance with annex C.

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 samples be carried out by the preferred method of division.

9.3.3 Of the four test samples, 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 samples 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 $1,2r$, a third test sample shall be sieved. If the range of these three size analyses agrees within the limit $1,2r$, the mean of the size analysis of the three samples 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 samples 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 $1,2r$, the fourth test sample shall be sieved, or if the first two size analyses do not agree within the limit $1,2r$, the third and the fourth test samples shall be sieved.

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

9.3.8 The value of r shall be 2 % absolute, with reference to the specification size or other designated aperture sizes.4

10 Test report and working log

The test report shall include a detailed working log of all operations and calculations to facilitate checking.

Items to be included are

a)   name and address of the testing laboratory;

b)   identity of test operative;

c)   date of testing;

d)   identity, condition and form of sample;

e)   details of preparation;

f)   details of procedure;

g)   test results with important observations.

The format shown in figure 5 is an example.

11 Precision

11.1 Overall precision β_{SPM}

This International Standard has been prepared with the aim of satisfying the overall precision requirements defined in ISO 3082.

11.2 Precision of division and measurement β_{PM}

It is not practically possible to separate and evaluate the precision of division and measurement. The magnitude of the combined precision of division and measurement, β_{PM}, obtained depends upon the type of ore and mass of sample used for sieving. See clause 6.

Inspect size sample and note its physical features

Is the iron to be dried?
Is the iron ore to be dry or wet sieved?
Is the iron ore to be demagnetized?
Does the ore degrade on handing?

Estimate mass of iron ore (M Total)

Determine β_{PM} required (ISO 3082)

Determine minimum mass for sieving (clause 6.2.2)

M Total » Minimum mass — No / Yes

Divide? — No / Yes

Repeatability and acceptance procedure required (clause 9.3)

Choose equipment, sieving times and sieving procedures to be used (clause 4)

Carry out size determination procedure

Figure 1 — Typical decision tree for selecting size determination procedure

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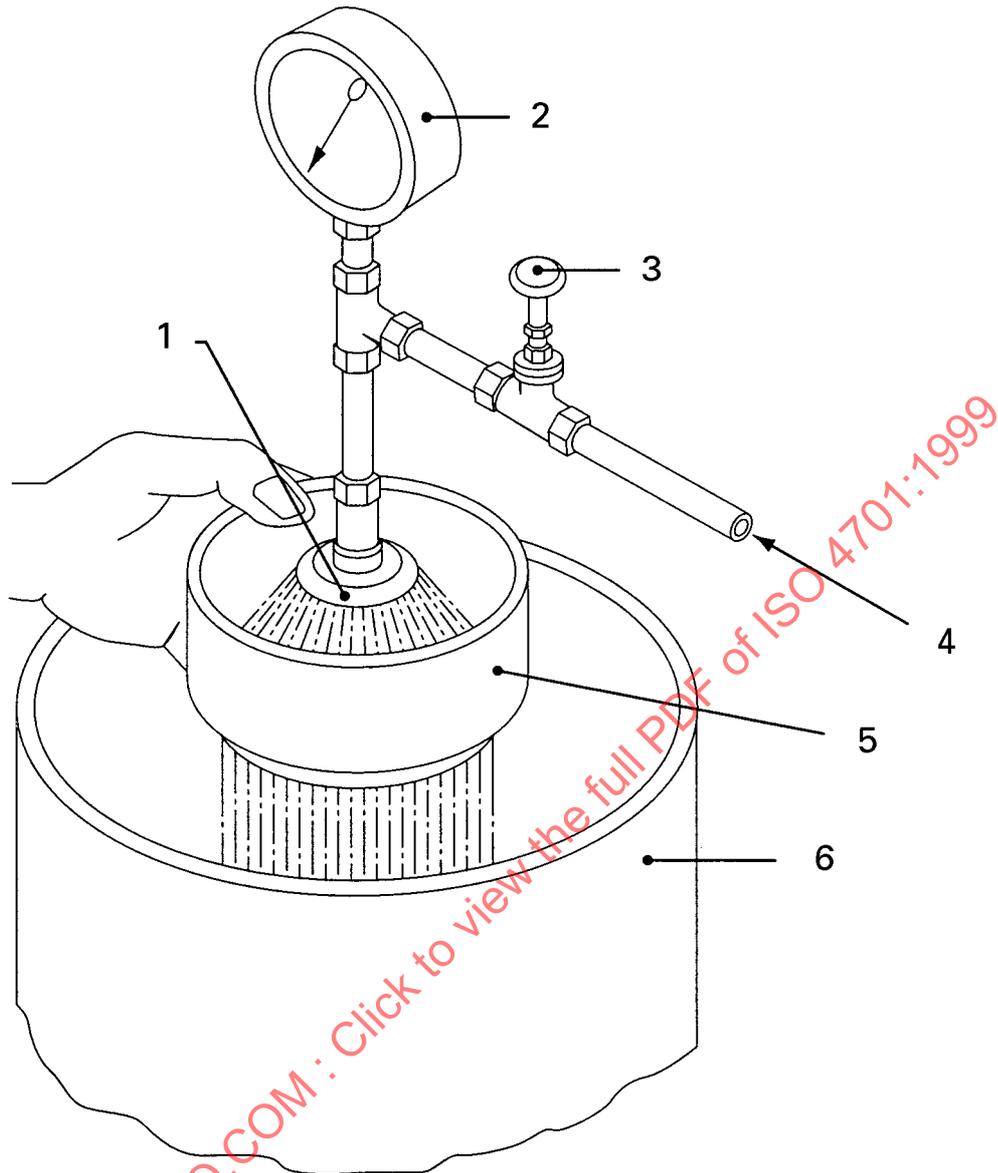
Key

1 Spray nozzle   4 Water supply from reservoir tank
2   Pressure gauge   5 Sieve
3 Regulating valve   6 Collecting tank

Figure 2 — A simple arrangement of wet sieving apparatus
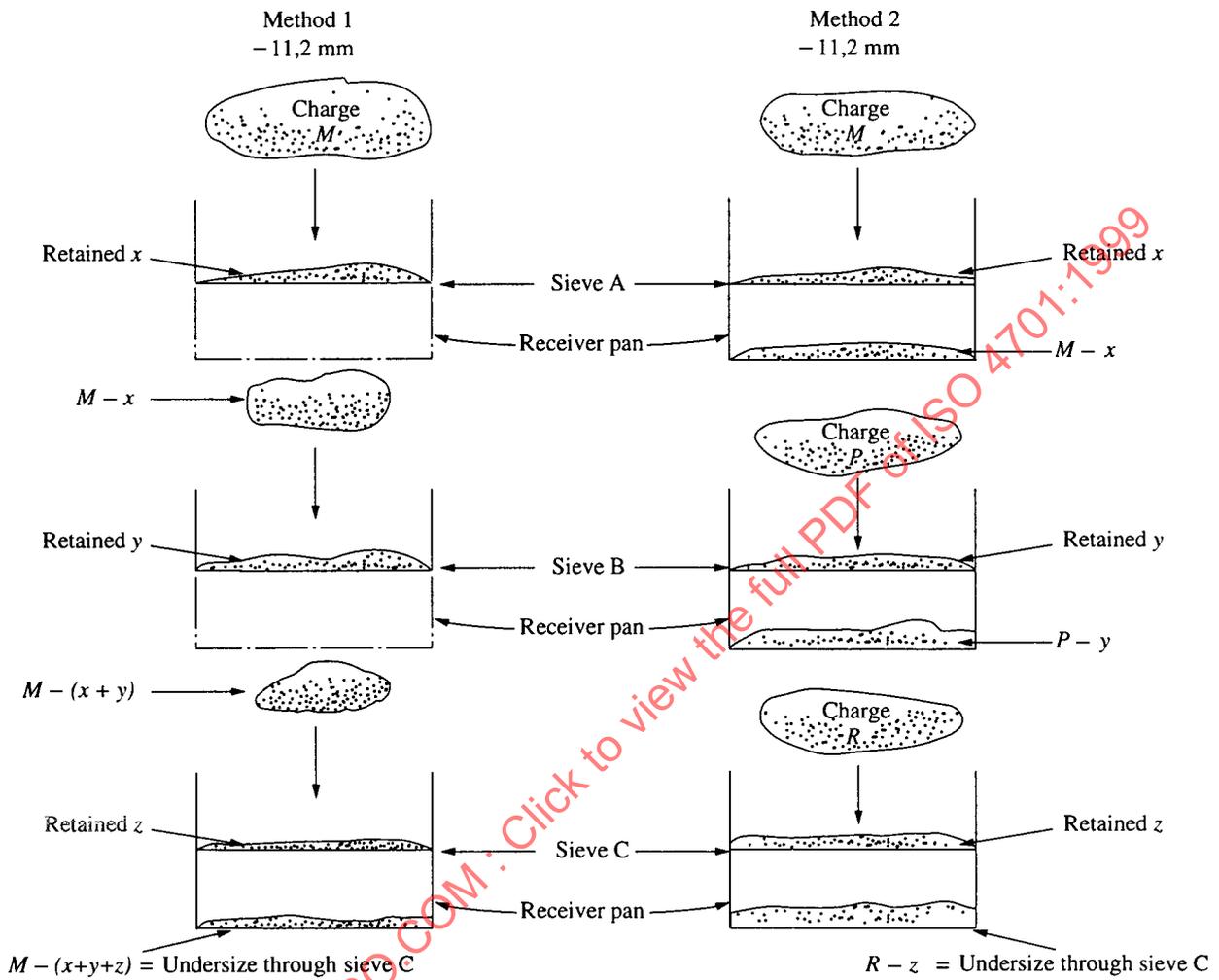
NOTE

1   Sieve A has the largest aperture size.

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 iron ore of $-11,2$ mm $+1$ mm

Figure 4 — Suggested wet sieving procedure for fine ores (− 11,2 mm)
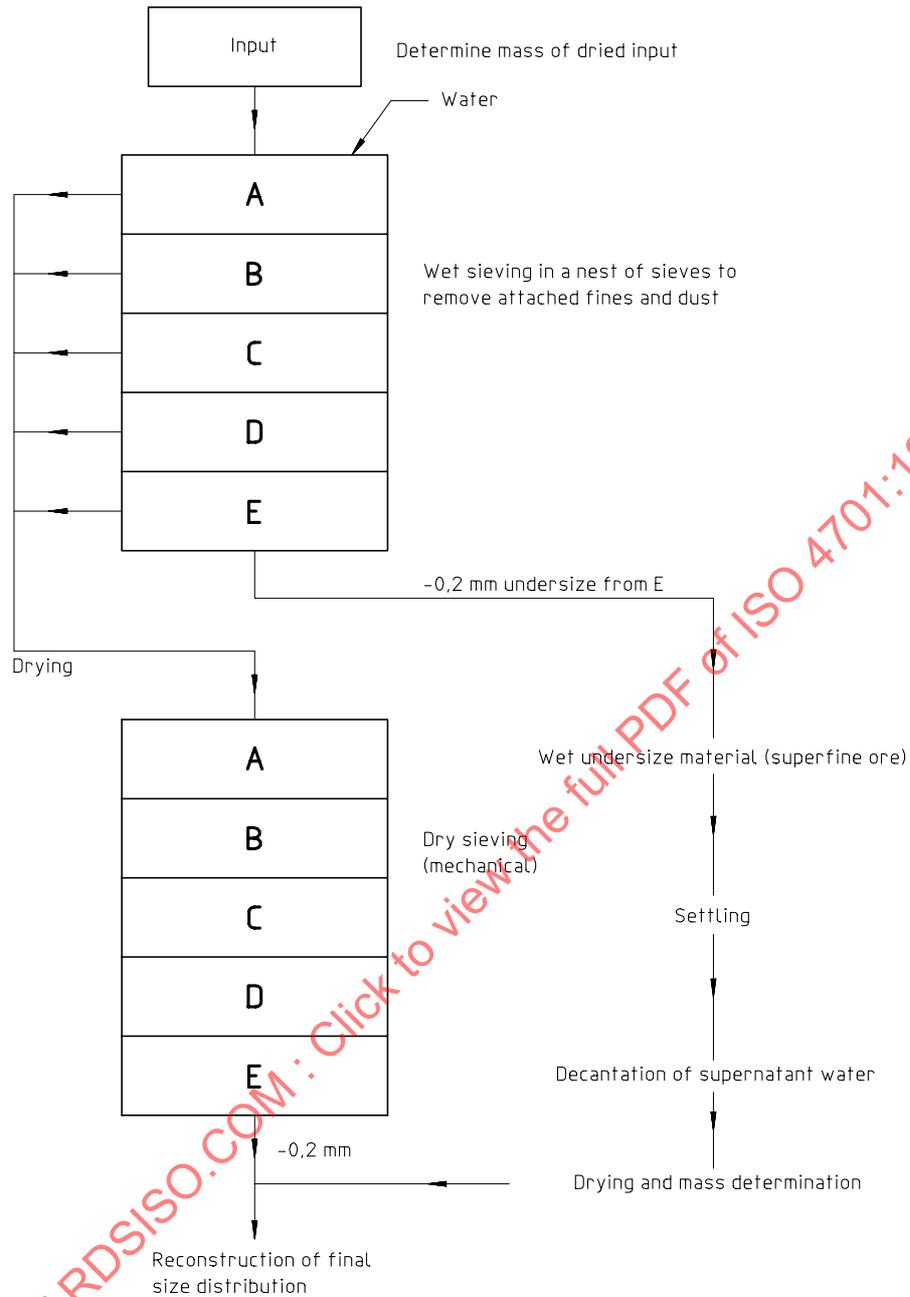
NOTE   If a subsequent size distribution of the total undersize product (superfine ore) is needed, the undersize product should be wet sieved until the water emerging from the underside of the bottom sieve attains absolute clarity on visual inspection.

Data: Référence:

Laboratory		Iron ore		Lot
Name	BSC Teesside	Name abc		Supplier xyz
Operator	J Smith	Type Haematite		Mass of lot (tonnes) 100 151
Signature		As received condition (e.g. moisture) 3 %		Mass of size sample (kg) 2016
Date	27 July 1979	Mean density of iron ore particles 4 500 kg/m^3		Designation of lot MV Crusader
				Date of commencement of discharge 23 July 1979

Details of preparation, Bulk gross sample made up of incremental additions, sample division carried out with a precision of 2 %.

Details of method and results

Size range of fraction	Mass of fraction		Mass	Cumulative oversize	Amount of division from previous size fraction	Sieving time (where appropriate) per batch	Sieving details (tick appropriate columns)									Details of any drying	Notes
	Actually sieved	Total in size sample (calculated)					Continuous	Mechanical batch	Hand batch	Hand placing	Perforated plate	Woven wire	Dry sieving	Wet sieving	Sieve frame size		
mm/μm	kg	kg	%	%		min											
+50 mm	104,3	104,3	5,2	5,2	1	—	./				./		./			None	2 kg piece of wood removed
−50+20	110,6	110,6	5,5	10,7	1	—.	./				./		./		.	None	
−20+10	6,41	106,8	5,3	16,0	0,060	3		./			./		./		600 mm square	Air dry	Mass corrected for 0,2 % loss of moisture
−10+5	13,04	217,3	10,8	26,8	1	3		./			./		./		600 mm square	Air dry	Mass corrected for 0,3 % loss of moisture
−5+1	0,959	515,6	25,6	52,4	0,031	5		./				./	./		450 mm diameter	Air dry	Mass corrected for 0,2 % loss of moisture
−1 mm +200 μm	0,536	574,1	28,5	80,9	0,502	20		./				./	./		300 mm diameter	Oven dry	Mass corrected for a total 3 % loss of moisture
−200 μm	0,357	382,3	19,0 (19,1)[a]	99,9 (100,0)													
Total		2 011,0	99,9 (100,0)														
		loss of 3 kg															

[a] 19,1 obtained by difference.

Figure 5 — Example of suggested format for report of the determination of the size distribution of iron ore

Annex A
(normative)

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

For a typical ore of bulk density 2 300 kg/m^3. For other densities the retained mass shall be changed pro rata.

Sieve aperture size	Maximum mass of iron ore to be retained on sieve at completion of sieving			
	200 mm dia. sieves	300 mm dia sieves	450 mm dia sieves	600 mm × 600 mm square sieves
mm	kg	kg	kg	kg
100				38
90,0				34
80,0				31
63,0			11	25
50,0			9,1	20,7
45,0			8,4	19,0
40,0			7,7	17,4
31,5		2,9	6,4	14,6
25,0		2,4	5,5	12,4
22,4		2,3	5,1	11,6
20,0		2,3	5	11,5
16,0		1,8	4	9
12,5		1,4	3,2	7
	g	g		
11,2	600	1300	2,9	6,5
10,0	500	1100	2,6	6
8,00	400	900	2	4,5
6,30	350	700	1,6	3,5
5,60	300	650	1,4	3,2
4,00	200	450	1	2,3
2,80	180	400		
2,00	180	400		
1,40	140	300		
1,00	140	300		
μm				
710	140	300		
500	110	250		
355	90	200		
250	80	180		
180	70	160		
125	60	130		
90	45	100		
63	40	90		
45	35	80		
36	30	70		

Annex B
(normative)

Procedure for determining the minimum mass of sample used for sieving

B.1 Formulae

When the size sample is (or its constituent increments or sub-samples are) to be divided, the minimum mass of iron ore which is finally sieved may be determined from equation (B.1).

$$m = \frac{k}{\beta_{PM}^2} \times \frac{\rho}{5\,000}$$

. . . (B.1)

where

m is the mass to be sieved, in kilograms;

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

ρ is the mean density of the iron ore particles, in kilograms per cubic metre.

The constant k is the characteristic of the type of ore, the specification size and percentage in the specification size and may be determined from equation (B.2).

$$k = 2,5 \times 10^{-5} P(100 - P)d^3(l/d)^{0,5}$$

. . . (B.2)

where

P is the percentage of the specification size (see table B.1, below);

d is the nominal top size of the size sample, in millimetres (see 5.4 of ISO 11323:1996);

l is the specification sieve size, in millimetres (see a) and b), below).

It is suggested that for practical use of equation (B.2), the following values of P given in table B.1 are adopted.

Table B.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
10,0	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 % "less than" or "greater than" value, this value shall be the value used for l in equation (B.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 in equation (B.2);

b) if the specification size lies in the fine fraction, the larger of the two sieve sizes shall be used for l in equation (B.2).

In the case of fine ores ($-$ 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.

B.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 % of specification size in sample	8 %
Mean density of the iron ore particles	4 800 kg/m^3
Desired β_{PM}	2 %

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

1) Determination of l: the specification size is given as 6,3 mm. By definition (see above), the value of l 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 B.1 the value to be assumed shall be 10 %, hence $P(100-P) = 900$.

3) Determination of k, from equation (B.2):

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

1) Determination of minimum mass, from equation (B.1):

$$m = \frac{17,86}{(2)^2} \times \frac{4800}{5000} = 4,3 \, \text{kg}$$

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 %
Mean density of the iron ore particles	4 500 kg/m^3
Desired β_{PM}	2,5 %

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

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

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

3) Determination of k, from equation (B.2):

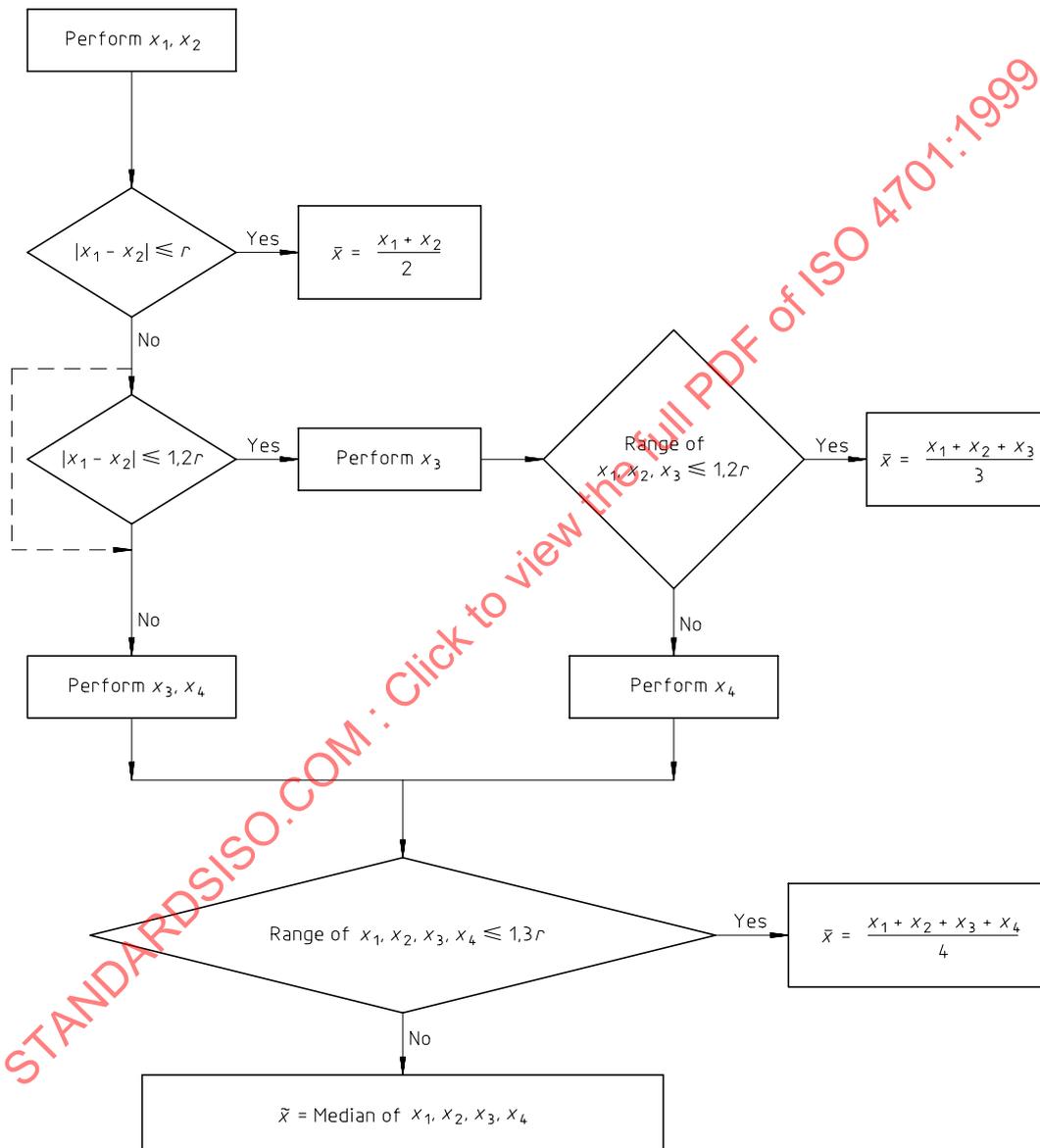$$k = 2,5 \times 10^{-5} \times 1\ 275 \times (31,5)^3 \times (10 / 31,5)^{0,5} = 561,34\ \text{kg}$$

4) Determination of minimum mass, from equation (B.1):

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

Annex C
(normative)

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

r: as defined in 9.3.8

Annex D
(informative)

Sieve apertures in the R 20 series (taken from ISO 565)

mm	mm	μm	μm
125	9,00	900	56
112	8,00	800	50
100	7,10	710	45
90,0	6,30	630	40
80,0	5,80	560	36
71,0	5,00	500	
63,0	4,50	450	
56,0	4,00	400	
50,0	3,55	355	
45,0	3,15	315	
40,0	2,80	280	
35,5	2,50	250	
31,5	2,24	224	
28,0	2,00	200	
25,0	1,80	180	
22,4	1,60	160	
20,0	1,40	150[3]	
18,0	1,25	125	
16,0	1,12	112	
14,0	1,00	100	
12,5		90	
11,2		80	
10,0		71	
		63	

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[3] 150 μm from R 40/3 series.