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Manganese ores — Determination of size distribution by sieving

Minerais de manganèse — Détermination de la distribution granulométrique par tamisage

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Contents

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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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6230 was prepared by Technical Committee ISO/TC 65, *Manganese and chromium ores.*

Annex A of this International Standard is for information only.

Manganese ores — Determination of size distribution by sieving

1 Scope

This International Standard specifies the methods to be employed for determination of size distribution by sieving of manganese ore, whether natural or processed (such as pellets, sinters and other agglomerated ores).

In this International Standard the terms "manganese ore" or "ore" refer to all the above-mentioned types of materials.

The methods described in this International Standard are equally applicable to size determination utilizing one or more sieves.

The purpose of this International Standard is to provide a basis for any testing of manganese 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, agreements should be reached between the producer and the consumer in respect of the detailed method to be employed in order to eliminate sources of 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 listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 565 : 1983, *Test sieves — Woven metal wire cloth, perforated plate and electroformed sheet — Nominal sizes of openings.*

ISO 2591 : 1973, *Test sieving.*

ISO 3310-1 : 1982, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth.*

ISO 3310-2 : 1982, *Test sieves — Technical requirements and testing — Part 2: Test sieves of metal perforated plate.*

ISO 4296-1 : 1984, *Manganese ores — Sampling — Part 1: Increment sampling.*

ISO 4296-2 : 1983, *Manganese ores — Sampling — Part 2: Preparation of samples.*

ISO 4299 : 1989, *Manganese ores — Determination of moisture content.*

ISO 8541 : 1986, *Manganese and chromium ores — Experimental methods for checking the bias of sampling and sample preparation.*

ISO 8542 : 1986, *Manganese and chromium ores — Experimental methods for evaluation of quality variation and methods for checking the precision of sampling.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 lot : A definite quantity of an ore, processed or produced under conditions which are presumed uniform.

3.2 consignment : A quantity of an ore delivered at one time. The consignment may consist of one or more lots or parts of lots.

3.3 increment :

1) A quantity of an ore taken by a sampling device at one time from a consignment.

2) A quantity of ore taken by the increment division method.

3.4 subsample :

1) A quantity of an ore consisting of two or more increments taken from a consignment.

2) An aggregation of two or more increments each of which may have been individually crushed and/or divided as necessary.

3.5 gross sample :

1) The quantity of an ore consisting of all the increments taken from a consignment.

2) An aggregation of all the increments or all the subsamples each of which may have been individually crushed and/or divided as necessary.

3.6 test sample : Any sample for the determination of size distribution, moisture content, chemical composition or other physical properties, which is prepared from each increment, each subsample, or from the gross sample in accordance with the specified method for that type of sample.

3.7 size sample : The sample taken for the determination of size distribution of the consignment or part of the consignment.

3.8 particle : A discrete coherent body of the ore regardless of size.

3.9 particle size (in sieve analysis) : The size of the smallest sieve aperture through which the particle has passed and the size of the largest sieve aperture on which the particle has been retained.

3.10 nominal top size : The smallest sieve in the range included in the R 20 Series (in table 1 of ISO 565, square hole) such that not more than 5 % of the ore is retained.

3.11 size distribution : The quantitative grouping of particles in the sample according to size. It is expressed in terms of percentage mass, passed or retained on selected sieves in relation to the total mass of the sample.

3.12 size fraction : The portion of the sample separated by one or two sieves of different apertures.

3.13 oversize fraction : The portion of the sample not passing the coarsest sieve in the test, e.g. $+ x$ mm (or µm).

3.14 undersize fraction : The portion of the sample passing the finest sieve in the test, e.g. $- z$ mm (or µm).

3.15 size fraction yield : The ratio of the mass of a given size fraction to the total mass of the sample as a percentage by mass.

3.16 intermediate size fraction : The portion of the sample specified by the smallest sieve aperture, x mm (or µm), through which the fraction has passed together with the size of the largest sieve aperture, y mm (or µm), on which the fraction has been retained in the test, e.g. $- x + y$ mm (or µm).

3.17 specification size : Any sieve size (or sizes) selected by the interested parties to define the limit (or limits) of the fraction considered by them to be significant.

3.18 sieving : The process of separating a mixture of particles, according to their size, by means of one or more sieves.

3.19 dry sieving : Sieving without the application of water.

3.20 wet sieving : Sieving with the application of water.

3.21 hand sieving : A sieving operation in which the sieve or sieves are supported and agitated manually.

3.22 assisted hand sieving : A sieving operation in which the sieve or sieves are supported mechanically but are agitated manually.

3.23 mechanical sieving : A sieving operation in which the sieves are supported and agitated by mechanical means. This operation may be either batch or continuous sieving.

3.24 continuous sieving : A sieving operation in which the ore is fed continuously into one or several consecutive sieving surfaces, over which it travels. The products are continuously discharged.

3.25 batch sieving : A sieving operation in which the resulting products are retained on the sieving surfaces until the end of the operation.

3.26 hand placing : A sieving operation in which particles are presented individually and by hand to the sieve apertures and orientated until either they can be passed through without force being applied, or they can be clearly classified as oversize.

3.27 sieve : An apparatus for the purpose of sieving consisting of a sieving medium mounted in a frame.

3.28 nest of test sieves : A set of test sieves mounted together with the lid and receiver pan.

3.29 charge : A quantity of ore to be treated at one time on an individual sieve or nest of test sieves.

3.30 sieving medium : A surface containing regularly arranged apertures of uniform shape and size.

3.31 sieve analysis : A method for determination of size distribution of an ore by sieving.

4 Principle

The sample of manganese ore is subjected to sieving procedures for the purpose of determining the size distribution of the constituent particles. The size distribution is to be expressed in terms of percentage mass, passed or retained on selected sieves.

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 used shall be selected in accordance with ISO 565.

5.1.3 Construction of sieve media

The sieve media shall be in accordance with ISO 565, ISO 3310-1 and ISO 3310-2. 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, partial apertures are unavoidable, thus increasing the risk of accidental retention of undersized particles which may become wedged in the partial 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 used as the medium, all incomplete apertures in the floor of the sieve should be blanked off. Omission of this blanking off is permissible, provided that it is recognized that the particles retained in these partial apertures are removed without breakage and correctly sized before the size fractions are weighed.

5.2 Sieve frames

5.2.1 Shape and size

Sieves used for hand or mechanical nest sieving shall have frames in accordance with ISO 2591. Frames may be either round or rectangular.

5.2.2 Construction

The sieve frames shall nest snugly with each other and with the lid and receiver pan of the same type. The frame should be smooth and the seals of the sieves so constructed as to avoid lodging of the material and loss of fines.

5.3 Preparation and maintenance of sieves

5.3.1 Preparation

Preparation of sieves shall be carried out in accordance with the recommendations of ISO 2591 along with the procedure given below.

Before use, the sieve medium and frame shall be degreased and cleaned. The cleaning of a sieve should 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 should be undertaken by the application of a soft brass wire brush to the underside of the sieve; for fine sieves with apertures less than 500 µm, 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 cleaning the sieves should be dried thoroughly.

5.3.2 Maintenance (including verification procedure)

The accuracy of the sieve medium should be verified initially and verification should be repeated regularly during use. Factors such as the frequency of use and type of manganese ore sieved will influence the frequency of verification. It is recommended that a record card be kept for each sieve.

Verification may be carried out using the procedure specified in ISO 3310-1 and ISO 3310-2.

Another method of verification is to compare the performance of the sieve with the performance of a reference sieve using a sample material similar to the one for which the test sieve is to be used.

When a sieve medium no longer complies with the tolerances specified in ISO 3310-1 and ISO 3310-2, the marking on the label should be cancelled and the sieve discarded.

5.4 Sieving machines

Any type of apparatus is acceptable, provided that the results obtained with reference to the specification size selected or other aperture size as agreed upon, are within ± 2 % (absolute) of those of hand placing or hand sieving methods carried out under closely controlled conditions in accordance with ISO 2591.

Each type of sieving machine should be tested for bias in accordance with the procedures given in ISO 8541 and will be acceptable if no significant bias is proven.

5.5 Drying equipment

Any form of ventilated equipment is acceptable for drying provided that it is fitted with a temperature control apparatus capable of maintaining the temperature in the equipment within 105 °C ± 5 °C. Loss of dust from the equipment should be avoided.

5.6 Weighing device

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

Equipment should be chosen in a suitable range of capacities to meet these requirements and to ensure that the final reporting can be made to the first decimal place.

5.7 Accessories for wet sieving

When wet sieving is carried out it is necessary to have available, in addition to the apparatus previously mentioned, a controllable supply of water, a spray nozzle and, where appropriate, a collecting tank. A simple arrangement is shown in figure 1.

When wet sieving on sieves having apertures less than 125 µm it is preferable that

a) the sieve be constructed of stainless steel;

b) the medium has a backing to prevent possible sagging and distortion caused by water pressure. This backing may typically consist of a sieve media having 2 mm square apertures.

5.8 Chronometer, or time relay.

5.9 Sample container and sample delivery means
(trays, buckets, pots, polyethylene bags)

5.10 Shovels, scoops, brushes

6 General principles of sieving

Prior to commencing a size determination, it is necessary to plan the entire sequence of procedures to be followed. The sequence of procedures will depend on

- the manganese ore being evaluated;
- the form in which it is received (i.e. as separate increments, subsamples or a combined size sample);
- the available equipment;
- the purpose of the analysis.

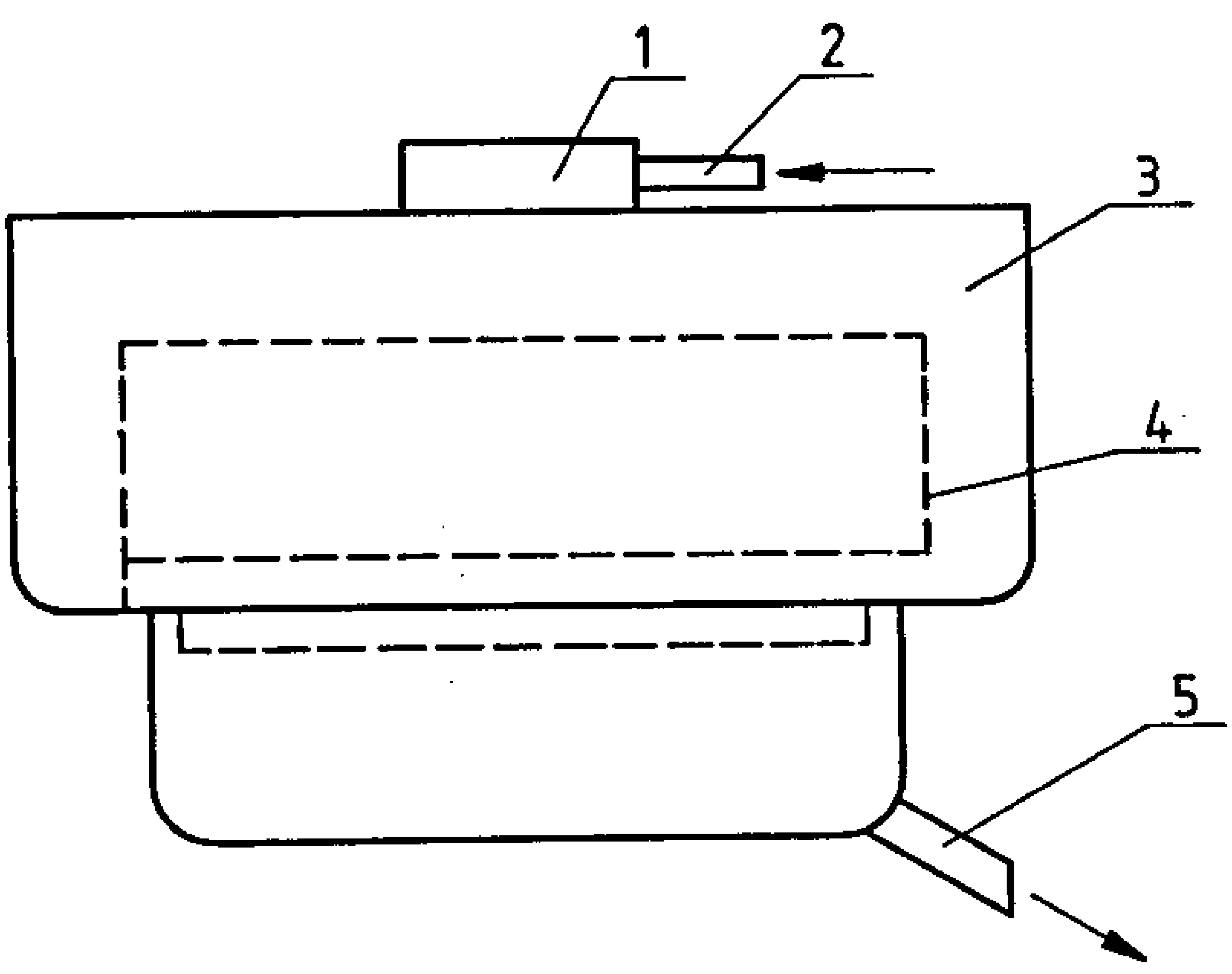
A typical decision tree to enable the sequence of procedures to be formulated is given in figure 2.

Sieving shall be carried out under controlled conditions strictly in accordance with ISO 2591.

For manganese ores subject to considerable degradation, it is essential that the organization responsible for the size determination agree to utilize similar equipment and the same procedure so that the results of their analyses are comparable.

Due to the difference in physical properties of manganese ores, sieving analysis should be carried out by two methods for two size fractions : +5 mm and −5 mm.

Nominal top size is defined either by prior sieving or on the basis of results of the previous analysis.



1 hydrocyclonic sprayer
2 regulating valve for water supply
3 body of the attachment
4 sieve
5 branch pipe for the discharge of the undersize product

Figure 1 — Diagram of the arrangement for wet sieving

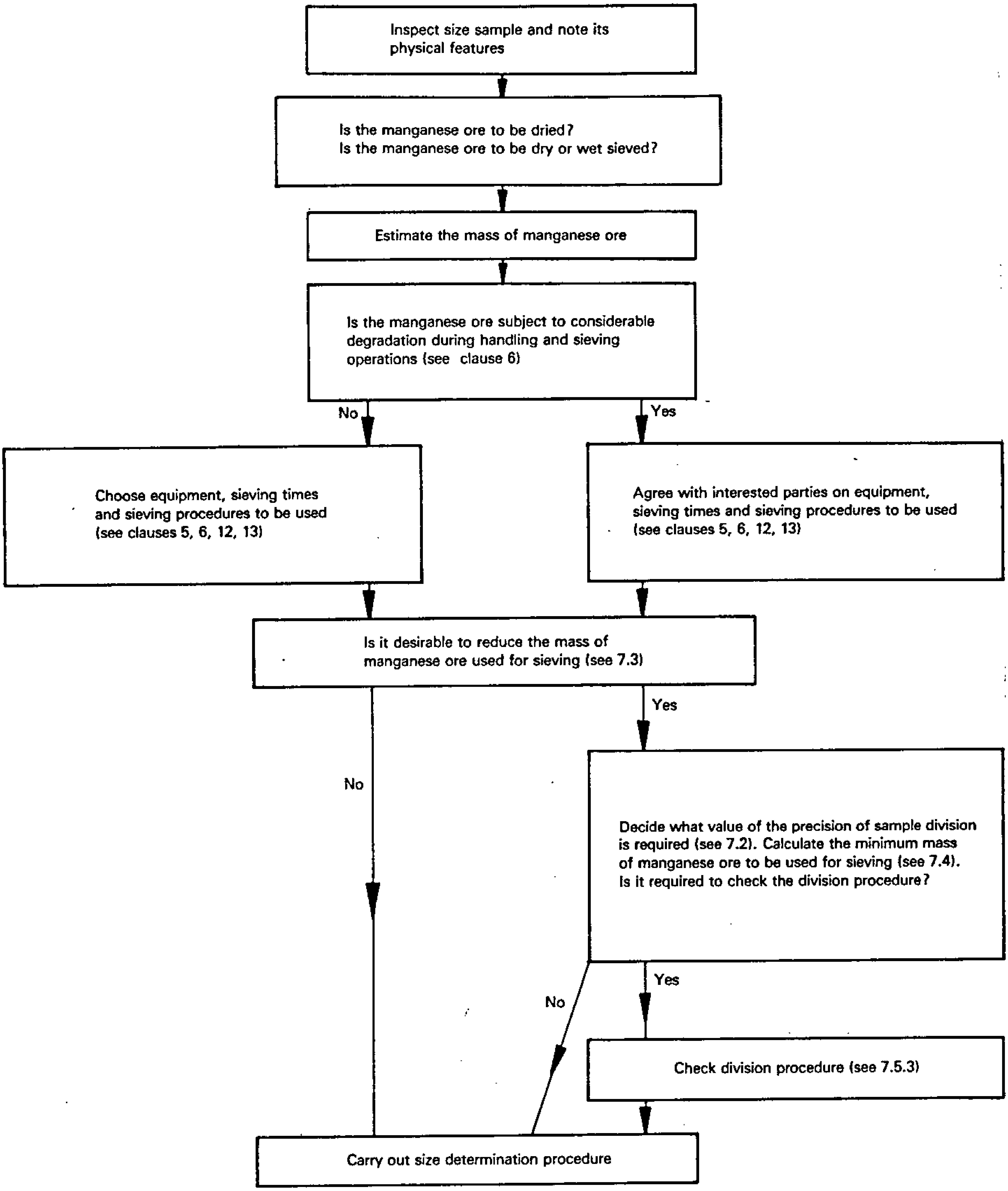


Figure 2 — Typical decision tree for selecting size determination procedure

The sieving is carried out either by use of mechanical sieves or sieving analysers, or manually (one sieve or a nest of sieves is used). The choice of sieves depends on the technical requirements for a given type of the ore and on the purpose of the analysis. The procedure may be performed as one continuous operation (continuous sieving) or in separate stages (batch sieving).

Sieves in the nest of sieves are arranged in descending order of sieve apertures, beginning with the largest one uppermost.

In case of ores + 100 mm hand placing is permissible. Methods of hand sieving and hand placing are applied as reference methods.

The schemes of devices for continuous and batch sieving are shown in figures 3 and 4.

7 Derivation of size sample

7.1 General

The size sample shall be taken in accordance with the recommendations of ISO 4296-1 and ISO 4296-2 and 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.

If replicate size determinations are required, the corresponding number of size samples should be provided and used independently.

When increments or subsamples are not combined into one gross sample, either one test sample for sieving shall be extracted from each increment or subsample or the complete increment or subsample shall be submitted for size analysis. Only the combined size analysis of all the increments or subsamples is taken to be representative of the consignment.

7.2 Precision of sieving

This International Standard has been prepared with the aim of producing a precision of testing within ± 2 % (absolute) (95 % probability).

7.3 Mass of sample used for sieving

The final sieving operation shall be based on one of the following procedures :

a) sieving the size sample as a whole;

b) sieving separately each increment or subsample or divided increment or divided subsample;

c) derivation of replicate test samples used for sieving from the size sample;

d) derivation of one test sample used for sieving from the size sample.

Each user should consider the respective merits of these four procedures in relation to the available equipment and the quantity of sample to be processed. Sample division shall be carried out in accordance with the methods given in 7.5.

7.4 Procedure for determining the minimum mass used for sieving

The minimum mass to be used for sieving (q_{min}), expressed in kilograms, shall be not less than the mass calculated by equation (1)

$$q_{min} = 0{,}02\, d^2 + 0{,}5\, d \qquad \ldots (1)$$

where d is the nominal top size of the test material, in millimetres.

7.5 Division of size sample

7.5.1 General

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

a) the size sample (or gross sample used for size determination);

b) subsample;

c) increments;

d) fractions obtained during sieving.

For a specified precision, the required minimum mass is the same whether the sample used for sieving is obtained by dividing the size sample or by dividing increments or subsamples and combining those divided increments or subsamples.

7.5.2 Methods of division

The procedure shall be carried out in accordance with ISO 4296-2.

7.5.3 Checking of division procedure

When division of the size sample is part of the procedure, determination of the reproducibility of results shall be carried out as follows.

Four samples for sieving shall be prepared. Of the four test samples, two shall be submitted initially for size analysis. If these size analyses agree within the prescribed limits, the combined size analysis of the two samples is taken to be representative of the consignment. If they do not agree within the prescribed limits, a third sample shall be sieved. If its size analysis agrees with one of the first two samples within the prescribed limit, the combined size analysis of these two samples is taken to be representative of the consignment. If no two of the three test samples agree within the prescribed limits, the fourth sample shall be sieved and the combined size analysis of all four samples is taken to be representative of the consignment.

The method for selection of four test samples depends on the sample division method.

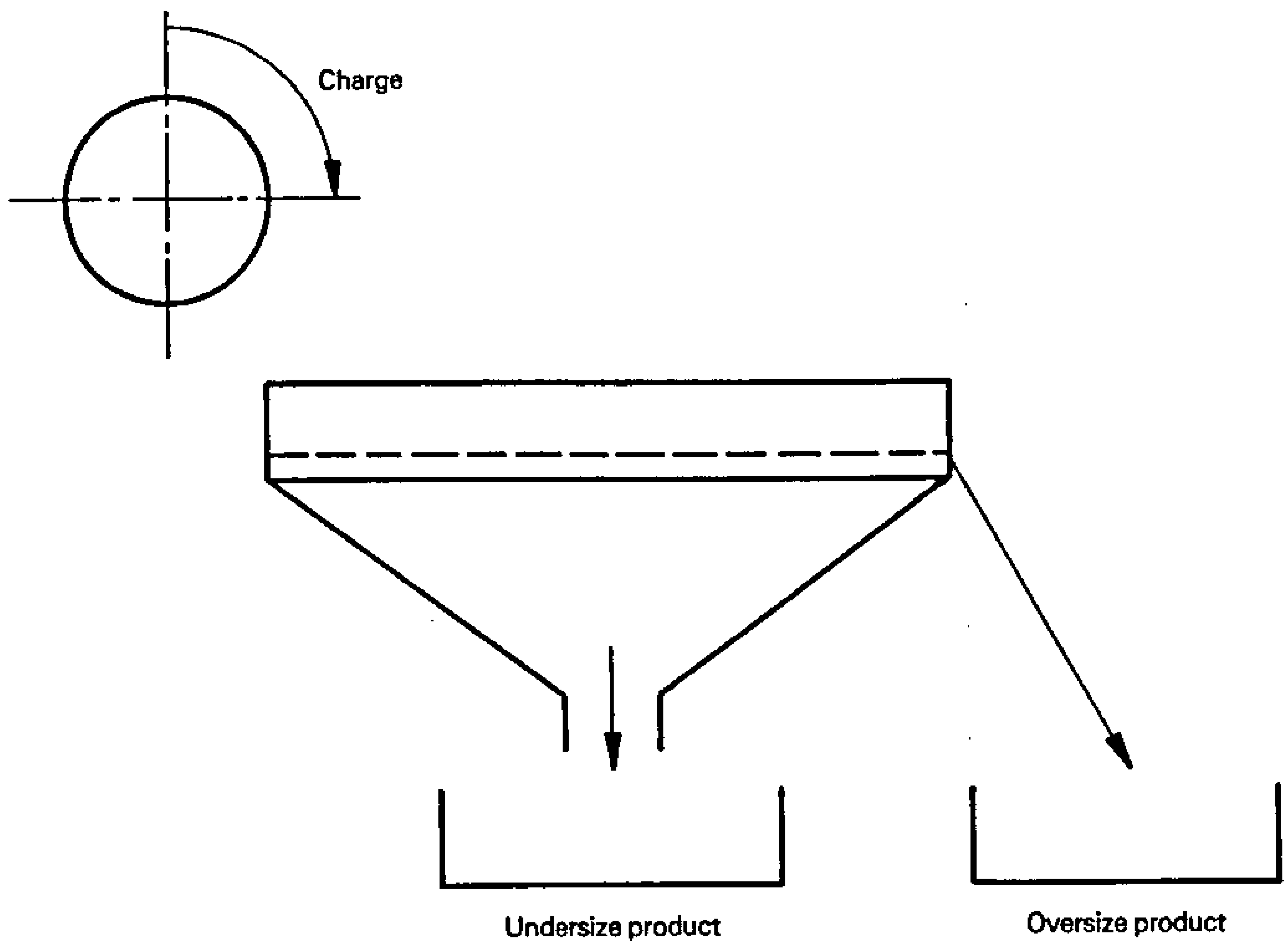


Figure 3 — The scheme of continuous sieving equipment

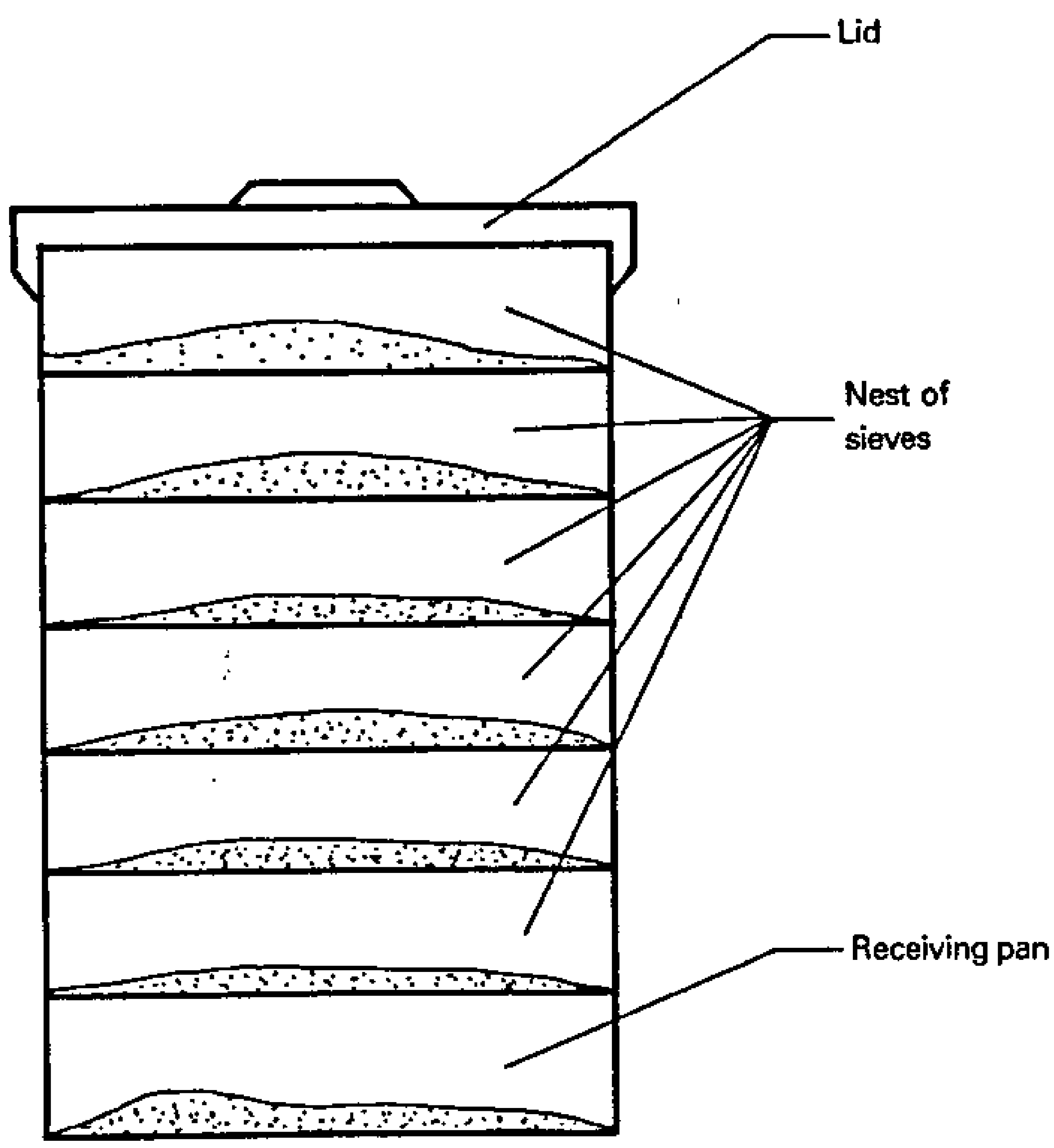


Figure 4 — The scheme of batch sieving apparatus

8 Effect of moisture content

The effect of the moisture content of the size sample on sieving should be assessed by a method agreed upon before the commencement of the size determination procedure.

When the ore is wet or sticky, it is likely that most of the suggested methods of division will be impaired. It may be desirable to dry or partially dry the size sample before carrying out the sample division.

Surface moisture may adversely affect the flow of ore on a sieve. Drying of the manganese ores or wet sieving will eliminate this problem.

If there is a change of internal moisture during sieving (i.e. by absorption of atmospheric moisture under humid conditions), cognizance should be taken of the fact that the masses of the fractions will be affected. Under such circumstances reliable masses can only be obtained by drying the fractions at 105 ± 5 °C and cooling under anhydrous conditions.

Some manganese ores readily absorb moisture and cannot safely be allowed to come into equilibrium with the laboratory atmosphere. In such cases these materials must be handled in such a way as to reduce their time of contact with the atmosphere to a minimum.

9 Procedure for drying and determination of moisture content

In cases where the process of sieving is onerous, it is necessary to dry a manganese ore. This may be done either by drying in air or by the use of drying equipment in accordance with 5.5. Drying shall be undertaken at any temperature, provided that this does not exceed 110 °C.

In cases where ore +5 mm is analyzed, the whole size sample shall be dried to moisture content 8 % or lower, and it shall be dried to constant mass in cases of ore −5 mm.

Determination of moisture content in the ore shall be carried out in accordance with ISO 4299.

10 Determination of mass of charge and products

At all stages of operations, the mass of the charge and products shall be determined using equipment in accordance with 5.6 and recorded. These operations cover drying, sieving and division.

The ore of different size fractions, obtained by sieving, shall be placed into separate containers, weighed and recorded.

The sum of the fractional masses of each operation should not differ by more than 1 % from the mass of the input to the operation. In any case, gains or losses shall be reported.

11 Choice of dry or wet sieving

11.1 General

The choice of dry or wet sieving shall be agreed between the parties concerned and the same method shall be used by both. It should be appreciated that the results of dry and wet sieving may not be the same. No specific preference is given in this International Standard.

If a combination of dry and wet sieving is employed for different parts of the same overall size distribution this shall be agreed between the parties concerned, in which case the changeover from dry to wet sieving shall be clearly indicated on the report sheet (see annex A).

11.2 Factors influencing the choice between dry and wet sieving

11.2.1 When dry sieving is used the moisture content of the charge shall be not more than 8 % (*m*/*m*) to ensure that it will not bias, beyond the accepted limits,

a) the separation of individual particles of manganese ore, for example by

- causing fine particles to adhere to the larger ones;
- altering adversely the flow of manganese ore over the sieves;

b) the mass of ore particles (even if correctly sized) separated by the individual sieves.

11.2.2 Wet sieving should be used if the ore has a tendency to cake on drying.

11.2.3 Wet sieving should be used if there is a tendency for a significant proportion of fine particles to adhere to the larger lumps.

11.2.4 Wet sieving should be used if the fine particles of manganese ore tend to become charged with static electricity during the sieving operation and adhere tenaciously to the sieve.

12 Sieving time

Sieving cannot produce a perfect separation under normal sieving conditions. A few particles which are smaller than the nominal size of the sieve aperture tend to remain in the manganese ore retained on the sieve or adhere to larger particles.

The 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.

Sieving time depends on size fractions and is considered to be sufficient when additional sieving for 3 min does not change the results by more than 0,5 %.

13 Sieving procedures

13.1 General

Ore material should be fed continuously or in portions (charges) avoiding overcharging.

In the case of batch sieving the ore mass loaded on a sieve or an upper sieve in the nest shall form a layer the thickness of which should not exceed four times the nominal top size.

In the case of continuous sieving the ore loaded on the upper sieve shall form not more than one layer the thickness of which shall be equal to the nominal top size.

If dry hand sieving is carried out, the sieve or the nest of sieves is taken with both hands and moved to and fro horizontally about 120 times a minute at an amplitude of about 70 mm to 100 mm.

In the case of a nest of sieves together with a lid and receiver pan, the sieve or nest of sieves should be taken into one hand and tapped approximately 120 times a minute against the other hand at an inclination of 10°to 20° the grasped point having the lower position. After 30 taps, the sieve is put into the horizontal position, turned through 90° and given a hard tap by hand against the sieve frame.

Fine concentrates with a tendency to stick should be wet sieved. Along with wet sieving, a combined (wet-dry) sieving may be applied.

Wet mechanical sieving shall be carried out on a sieve analyzer fitted with a special attachment. The scheme of the attachment is shown in figure 1.

The ore shall be charged on the sieve placed in the chamber for sieving. The chamber shall be hermetically sealed with a lid having a hydrocyclonic sprayer and mounted in the frame of the sieve analyzer. Then the electric motor of the analyzer shall be switched on and simultaneously water shall be supplied into the sprayer. Water flow rate shall be about 3 l/min. Sieving time shall be about 3 min.

The undersize product together with water shall be let through a branch pipe into a collecting tank, the oversize product shall be transferred with great care on a receiver pan.

In the case of hand wet sieving the sieve with ore shall be submerged in water and shaken by gentle movement until the whole through pass of particles. After overturning the sieve, the oversize product shall be washed into a collecting container. After settlement of the particles, the water shall be poured out and the oversize product dried to constant mass at 105 °C ± 5 °C and weighed.

The fines content shall be determined as the difference between the mass of the test portion and the mass of the fraction obtained.

13.2 Sieving procedure for fraction +5 mm

Sieving time for batch sieving +5 mm fraction

- hand sieving : 2 min;
- mechanical sieving : 10 min.

13.3 Sieving procedure for fraction −5 mm

The mass of the ore loaded on a sieve shall be 500 g to 1 000 g.

In the case of fine concentrates of −0,25 mm fraction the mass of the ore shall be 100 g. Sieving time for batch sieving

- hand sieving : 10 min;
- mechanical sieving : 30 min.

14 Expression of results

14.1 Size fraction yield for the test sample

The size fraction yield (γ_n) expressed as a percentage by mass, shall be calculated from equation (2)

$$\gamma_n = \frac{m_n \times 100}{m} \qquad \ldots (2)$$

where

m_n is the mass, in kilograms, of the given fraction;

m is the mass, in kilograms, of the test sample.

14.2 The size fraction yield for the consignment

The final value of size fraction yield for the consignment as a percentage by mass shall be calculated as follows and reported to the first decimal place.

a) When sieving is carried out on an individual increment, calculate the size fraction yield for the consignment (γ) expressed as a percentage by mass from the arithmetic mean of the results for all increments as given by equation (3)

$$\gamma = \frac{\Sigma \gamma_{Ii}}{n} \qquad \ldots (3)$$

where

γ_{Ii} is the size fraction yield of i-th increment, calculated from equation (2);

n is the number of increments.

b) When sieving is carried out on each subsample, calculate the size fraction yield for the consigment (γ), expressed as a percentage by mass from the weighted mean of the results for all subsamples, considering the number of increments in each subsample, as given by equation (4)

$$\gamma = \frac{\Sigma \gamma_{si} \times V_i}{\Sigma V_i} \qquad \ldots (4)$$

where

γ_{si} is the size fraction yield of i-th subsample, calculated from equation (2);

V_i is the number of increments in the i-th subsample.

c) When sieving is carried out on the gross sample, calculate the size fraction yield for the consignment (γ), expressed as a percentage by mass from equation (5)

$$\gamma = \frac{M_{GF}}{M_G} \times 100 \qquad \ldots (5)$$

where

M_{GF} is the mass of the specific size fraction;

M_G is the mass of the gross sample.

Annex A
(informative)

Example of suggested format for report of the determination of the size distribution of manganese ore

Date:

References:

Laboratory: Name: Operator: Signature: Date:	Manganese concentrate: Name: oxidized Type: As-received condition: (e.g. moisture) 9 % Mean density of manganese ore particles:	Consignment: Supplier: Mass of consignment (tonnes): 500 Mass of size sample (kg): 172 Designation of consignment: Date of commencement of discharge:

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 mm	Mass of fraction		Mass %	Cumulative oversize %	Amount of division from previous size fraction	Sieving time min	Sieving details (tick appropriate columns)									Details of any drying	Notes
	Actually sieved kg	Total in size sample (calculated) kg					Continuous	Hand batch	Mechanical batch	Hand placing	Perforated plate	Woven wire	Dry sieving	Wet sieving	Sieve frame size		
+ 10	46,1	46,1	26,8	26,8	1	3		+					+			drying in desiccator	
− 10 + 5	17,7	38,5	22,4	49,2	0,459	3		+					+				
− 5 + 3	5,07	33,7	19,6	68,8	1	5		+						+			
− 3 + 1	1,10	29,9	17,4	86,2	0,056	20		+						+			
− 1	0,870	23,8	13,8	100,0	1											,, ,,	
Total		172,0	100,0														

UDC 553.32 : 622.74

Descriptors : minerals and ores, manganese ores, tests, sieve analysis, grain size analysis.

Price based on **11** pages