International Standard ISO 4701

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Iron ores — Determination of size distribution by sieving

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Foreword

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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 4701 was prepared by Technical Committee ISO/TC 102, *Iron ores.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Contents

		Page
1	Scope	1
2	Field of application	1
3	References	1
4	Definitions	1
5	Apparatus	2
6	Derivation of size sample	5
7	Mass of sample used for sieving	5
8	Division of size sample	6
9	Effect of moisture content	6
10	Choice of dry or wet sieving	6
11	Procedure for drying iron ore	7
12	Determination of mass	7
13	Sieve loading for test sieving	7
14	Maximum particle size permitted on a sieve	9
15	Sieving time	9
16	General principles of sieving	9
17	Sieving procedures for coarse ores (sieve apertures 11,2 mm and above)	10
18	Sieving procedure for fine ores (sieve apertures less than 11,2 mm)	10
19	Additional rules for wet sieving of coarse and fine ores	12
20	Report sheet and working log	12
21	Precision	15

Annexes

A	Maximum mass of iron ore to be retained on a sieve at completion of batch sieving (*m*) in order to obtain good sieving efficiency	16
B	Typical batch sieving apparatus	17
C	Desirable features of mechanical sieving machines	19
D	Sieve aperture sizes in the R20 series	22
E	Determination of the sieving end-point	23
F	Procedure for determining the minimum mass of sample used for sieving	24
G	Examples of minimum mass of divided size gross sample in the division methods other than increment division method and division precision (β_{DM})	26

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, whether natural or processed (e.g. concentrates and agglomerates, such as pellets, sinters or briquettes), utilizing sieves having the aperture size of 45 µm and over.

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

The sample of iron 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 mass and percentage mass, passed or retained on selected sieves.

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

2 Field of application

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, 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 subsequent controversy.

3 References

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

ISO 2591, *Test sieving.*

ISO 3081, *Iron ores — Increment sampling — Manual method.* [1]

ISO 3082, *Iron ores — Increment sampling — Mechanical method.* [2]

ISO 3083, *Iron ores — Preparation of samples — Manual method.* [3]

ISO 3084, *Iron ores — Experimental methods for the evaluation of quality variation.*

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

ISO 3086, *Iron ores — Experimental methods for checking the bias of sampling.* [4]

ISO 3310, *Test sieves — Technical requirements and testing —*

Part 1: Test sieves of metal wire cloth.

Part 2: Test sieves of metal perforated plate.

4 Definitions

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

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

4.3 increment: A quantity of an ore obtained by a sampling device at one time from a consignment or lot; also a quantity taken in the increment division method.

4.4 subsample: A quantity of an ore consisting of several increments or divided increments taken from a part of the consignment or lot.

4.5 gross sample: The quantity of an ore consisting of all of the increments or divided increments or subsamples or divided subsamples taken from a consignment.

4.6 final sample: Any sample for determination of size distribution, moisture content, chemical composition or other

1) At present at the stage of draft. (Revision of ISO 3081-1973.)

2) At present at the stage of draft.

3) At present at the stage of draft. (Revision of ISO 3083-1973.)

4) At present at the stage of draft. (Revision of ISO 3086-1974.)

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.

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

4.8 mass of sample used for sieving: The quantity of iron ore which is actually sieved (i.e. the sum total of all charges used in obtaining a particular size distribution).

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

4.10 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.

4.11 maximum particle size: The maximum particle size of a sample designates the largest size of sieve aperture on which approximately 5 % (m/m) of iron ore is retained.

4.12 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.

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

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

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

4.16 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).

4.17 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.

4.18 bulk density: The mass in air of a unit volume of iron ore, including the voids within and between particles, expressed as mass units per unit volume e.g. kg/m^3.

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

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

4.21 specification sieve: The sieve having an aperture size corresponding to the specification size (see 4.17).

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

4.23 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.

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

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

4.26 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.

4.27 batch sieving: A sieving operation in which a specific quantity of iron ore is presented to one or more sieves which are agitated either by hand or by mechanical means.

Characteristically, the resulting products are retained within the frame of the sieve or sieves until the end of the operation is reached and the number of presentations of particles to the apertures is dependent on the length of sieving time.

Batch sieving is usually carried out on a sieve or a nest of sieves as indicated in figure 6 (annex B).

4.28 continuous sieving: A sieving operation in which the ore is fed continuously into one or several consecutive sieving surfaces, over which it travels (e.g. by virtue of the sieving surface being agitated, rotated and/or inclined). The products are continuously discharged. (See annex C.) The operation is a form of mechanical sieving.

Characteristically, the number of presentations of particles to the aperture is dependent on the path length over the sieve media.

4.29 wet sieving: Sieving with the application of water.

4.30 dry sieving: Sieving without the application of water.

4.31 charge: A quantity of ore to be treated at one time on an individual sieve or nest of test 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 utilized shall be selected from the R20 series given in ISO 565 (see annex D).

5.1.3 Construction of sieve media

The sieve media shall be in accordance with ISO 565, ISO 3310/1 and ISO 3310/2. In view of the high densities of iron ores, metal perforated plate is preferred as the sieving medium. For aperture sizes of 4 mm or smaller, 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, partial apertures are unavoidable. This increases 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 utilized 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

The preparation of sieves shall be carried out in accordance with the recommendations of ISO 2591, amplified as follows:

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 ultrasonic 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 iron ore sieved will influence the frequency of verification. It is recommended that a record card be kept for each sieve.

Verification may be made by the procedure included in ISO 3310/1 and ISO 3310/2.

Another method 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 % 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 3086 and will be acceptable if no significant bias is proven. It may be necessary to have an operator available to keep the sieve media unblocked. (See annex C — desirable features of sieving machines.)

5.5 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 preferred 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.

NOTES

1 The backing should be made so that the particles cannot get stuck between two sieve media.

2 The water pressure should be adjusted as gently as possible in order to avoid damage to the sieve media.

5.6 Drying equipment

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

NOTE — 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 is similar.

5.7 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 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 to ensure that the final reporting can be to the first decimal place.

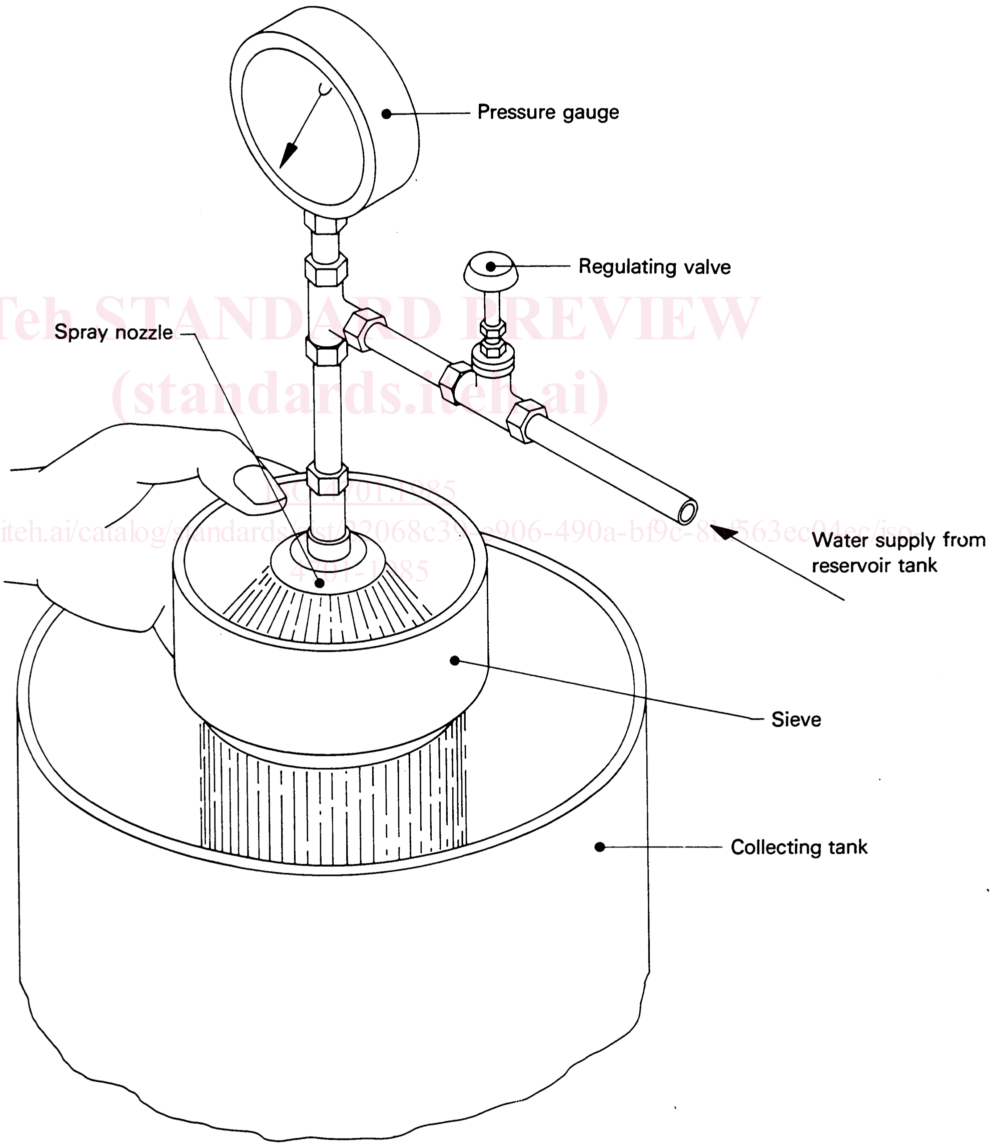

Figure 1 — A simple arrangement of wet sieving apparatus

6 Derivation of size sample

6.1 The size sample shall be taken in accordance with the recommendations of ISO 3081 and ISO 3082 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. A dried sample, dried for moisture determination or otherwise, may be used as a size sample.

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

6.3 When increments or subsamples are not combined into one gross sample, either one final 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 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, i.e. sieving separately each final sample;

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

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

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 requirements of ISO 3082 (8.3.2.1 and annex B) and ISO 3083 (8.2.4).

7.1 Sieving the size sample as a whole

The advantages of this method are:

— simplicity of procedure;

— avoidance of errors of sample division.

The disadvantages of this method are:

— it may be onerous in the case of large quantities;

— no possibility exists of checking procedural errors.

7.2 Sieving separately each increment or subsample or divided increment or divided subsample

The advantages of this method are:

— convenience of sieving separately each increment or subsample or divided increment or divided subsample;

— aligns with mechanical sampling procedures.

The disadvantage of this method is

— it may be onerous in the case of large quantities.

7.3 Derivation from the size sample of replicate final samples used for sieving

The advantages of this method are:

— reduction of sieving effort;

— provision of checks for procedural errors.

The disadvantages of this method are:

— lower precision due to division errors;

— increased effort for sample derivation;

— possibility of introducing bias due to extra handling.

7.4 Derivation from the size sample of one final sample used for sieving

The advantage of this method is:

— minimum of sieving effort.

The disadvantages of this method are:

— no provision for checking procedural errors;

— error of sample division;

— increased effort for sample derivation.

7.5 Procedure for determining the mass used for sieving

7.5.1 The mass to be used for sieving shall be agreed between the parties concerned and shall be in accordance with ISO 3082 or ISO 3083. For frequent practical cases, the minimum mass of the divided gross sample for size determination to be obtained by the division method other than the increment division method is shown in annex G.

7.5.2 The minimum mass to be used for sieving may be calculated by means of the formula shown in annex F. The level of precision to be used in the formula shall be agreed between the parties concerned.

For the formula and worked examples see annex F.

7.5.3 Typical examples of the minimum mass of the divided gross sample with associated precisions are given in the table in annex G.

8 Division of size sample

8.1 General

Recommended procedures for sampling of ores (ISO 3081 and ISO 3082) will generally provide quantities of material in excess of the requirements for sieving. If it is undesirable to sieve the entire mass of sample, division of the following is permissible:

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

b) subsamples;

c) increments;

d) fractions obtained during sieving.

The total sample used for sieving shall be not less than the minimum mass according to 7.5. 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.

8.2 Method of division

One or more of the following methods of sample division shall be conducted individually or jointly:

a) increment division method (see ISO 3083);

b) division by riffle divider (see ISO 3083);

c) coning and quartering method (see ISO 3083);

d) division by mechanical dividing apparatus (see ISO 3082);

e) any other method of division agreed between contracting parties. However, such methods should be checked experimentally for precision and bias in accordance with ISO 3085 and ISO 3086.

8.3 Checking of division procedure

The following method is designed to determine the reproducibility of results and is to be applied:

a) when division of the size sample is part of the procedure;

b) when division is applied at any stage during the sieving operation.

Four samples for sieving shall be prepared in accordance with the division procedures set forth in 8.2. In the case where one sample of selected mass is extracted, e.g. in mechanical division, it is recommended that the required further reduction to four samples be carried out by the preferred method of increment division.

Of the four final samples, two shall be submitted initially for size analysis. If these size analyses agree within the limit prescribed below (with reference to the specification size of either aperture size agreed upon within the limit), the combined size analysis of the two samples is taken to be representative of the consignment. If they do not agree within the limit prescribed below, a third final sample shall be sieved. If its size analysis agrees with one of the first two samples within the limit prescribed below, the combined size analysis of these two samples is taken to be representative of the consignment.

If no two of the three final 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.

In the case of ores with which it is possible to attain the end point ruling it is recommended that the prescribed limit should be within 2 % with reference to the specification size or other aperture sizes agreed upon.

9 Effect of moisture content

The effect of the moisture content of the size sample on sample division and sieving should be assessed by a method agreed 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 iron ores in accordance with clause 11 or wet sieving in accordance with clause 19 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 iron 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.

10 Choice of dry or wet sieving

10.1 General

The choice of dry or wet sieving (see 10.2) 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 for either method.

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 20.1).

10.2 Factors influencing the choice between dry and wet sieving

Account should be taken of the following factors when making the choice between dry and wet sieving.

a) When dry sieving is used the moisture content of the charge shall be sufficiently low to ensure that it will not bias, beyond the accepted limits, the following:

1) the separation of individual particles of iron ore, for example by

— causing fine particles to adhere to the larger ones

— altering adversely the flow of iron ore over the sieves,

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

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

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

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

11 Procedure for drying iron ore

In cases where it is necessary to dry an iron ore, this may be done either by drying in air or by the use of drying equipment in accordance with 5.6. The maximum setting shall be 105 °C so that the actual temperature shall not exceed 110 °C.

12 Determination of mass

At all stages of operations, the mass of the charge and products shall be determined using equipment in accordance with 5.7 and recorded. These operations cover drying, sieving and division.

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.

13 Sieve loading for test sieving

13.1 General

The charge to be placed on a sieve depends on

a) the size of sieve aperture;

b) the area of the sieve;

c) the bulk density of the iron ore.

The mass of ore that may be loaded on to a sieve is limited merely by the conditions covering the mass to be retained and by the need to avoid undue degradation.

The mass placed on a given sieve should be such that the mass retained after completion of sieving is not greater than indicated in annex A. It may be necessary therefore to sieve a sample in several portions. The results shall be combined.

When using sieves of shapes and sizes differing from those specified in annex A, the maximum masses retained should be modified on the basis of sieve area.

The masses recommended in annex A are also applicable to nests of sieves and to mechanical sieving. These masses should be used with the sieve of the largest aperture uppermost in the nest, provided that the particle size distribution of the sample does not cause excessive mass on any of the finer aperture sieves in the nest.

13.2 Specific loading of sieves

13.2.1 Apertures larger than or equal to 22,4 mm

In order to obtain good sieving efficiency, the loading of the sieve shall be such that the maximum mass of iron ore retained at the completion of sieving on any sieve having apertures larger than or equal to 22,4 mm shall be in accordance with the following formula:

$$m = (0{,}005 + 0{,}000\,4\,W)\,\varrho\,A \quad \text{(kg)}$$

where

W is the sieve aperture size, in millimetres;

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

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

m is tabulated in annex A against sieve aperture size.

NOTE — The above formula applies only if the percentage open area of the sieve (partial apertures are regarded as blanked-off area) exceeds 40 %. For percentage open areas of less than 40 %, the values of m should be reduced *pro rata*.

The formula is based on the rule that at the completion of sieving, the particles should cover not more than three quarters of the floor area of the sieve when the particles are spread out as a single layer. In practice it may be more convenient to use this visual rule than to calculate m.

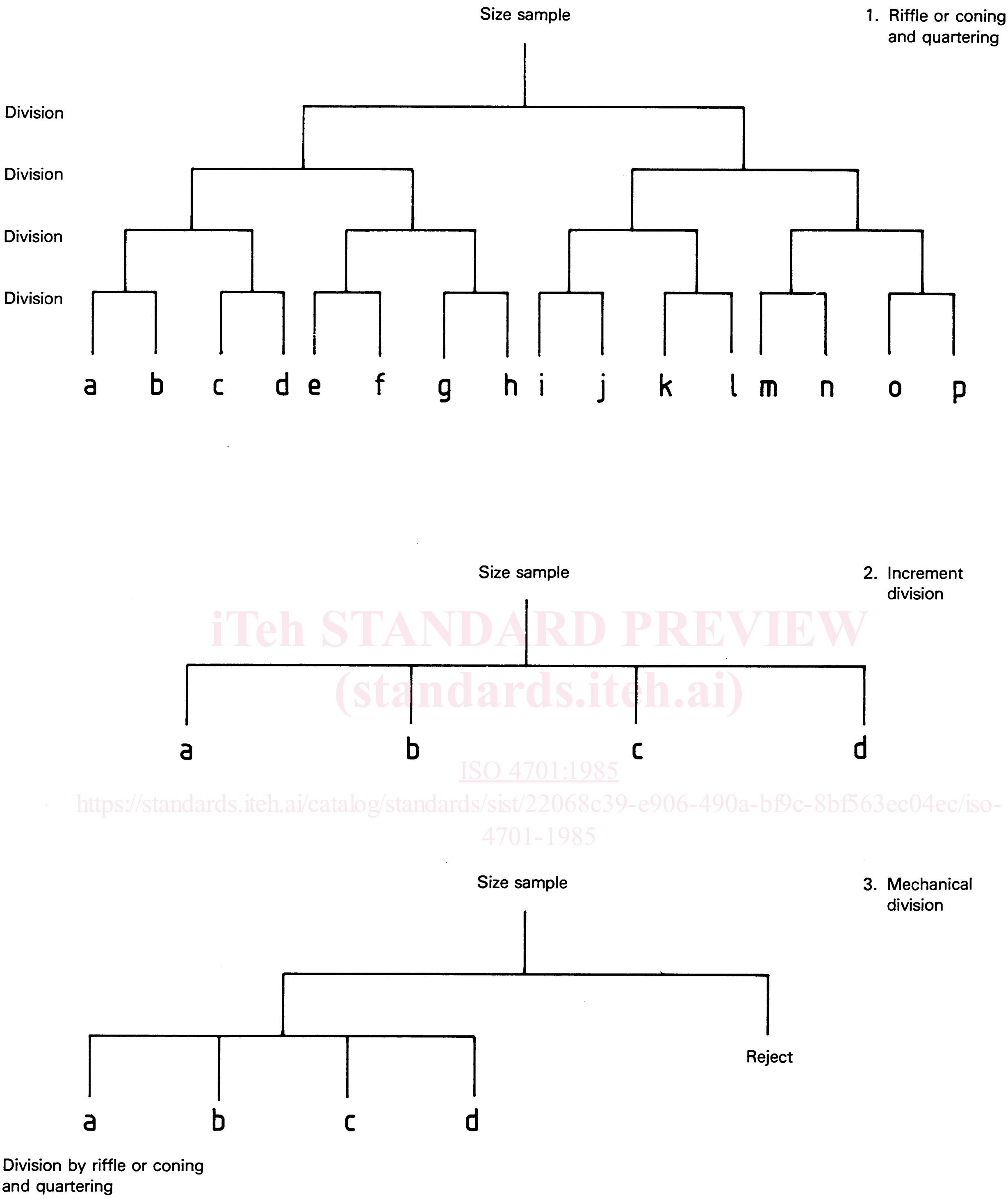

Figure 2 — Derivation of the samples used for sieving