

INTERNATIONAL STANDARD

ISO
3082

First edition
1987-06-01



INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Iron ores — Increment sampling and sample preparation — Mechanical method

Minerais de fer — Échantillonnage par prélèvements et préparation des échantillons — Méthode mécanique

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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.

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 3082 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.

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Iron ores — Increment sampling and sample preparation — Mechanical method

1 Scope

This International Standard gives

- a) the underlying theory;
- b) the basic principles for sampling and preparation of samples;
- c) the basic requirements for the design, installation and operation of the sampling system

for mechanical sampling and mechanical preparation of samples, or combination of mechanical and manual sampling and preparation of samples, to be taken from a consignment of an iron ore while being transferred for the purpose of determining the quality characteristics of the consignment.

The theory and basic principles given herein are similar to those given in ISO 3081 and ISO 3083.

This International Standard should be read in conjunction with the International Standards listed in clause 3.

2 Field of application

The methods specified are applicable to all iron ores, whether natural or processed (for example concentrates and agglomerates, such as pellets, sinters or briquettes).

The methods are applicable to both the loading and discharging of a consignment by means of belt conveyors and other ore handling equipment to which a mechanical sampler may be installed.

Samples are prepared for the determination of the following quality characteristics: size distribution, moisture content, chemical composition and physical properties.¹⁾

3 References

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

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

ISO 3084, *Iron ores — Experimental methods for 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.*

ISO 3087, *Iron ores — Determination of moisture content of a consignment.*

ISO 4701, *Iron ores — Determination of size distribution by sieving.*

4 Definitions

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

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:

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

(2) A quantity taken in the increment division method (also referred to as **cut**).

4.4 subsample:

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

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

4.5 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 individually has been optionally crushed and/or optionally divided as necessary.

1) The sampling and sample preparation of iron ores for physical testing will form the subject of a future International Standard.

4.6 divided sample: A sample obtained by a method of division.

4.7 test sample: A sample ready for 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.

A representative part of a test sample which is actually subjected to the test is designated the **test portion**. If the entire quantity of a test sample is subjected to the test, the test sample may also be called "test portion".

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

4.9 sample for moisture determination; moisture sample: The sample taken for the determination of moisture content of the consignment or part of the consignment.

4.10 sample for chemical analysis: The sample taken for the determination of chemical composition of the consignment or part of the consignment.

4.11 sample for physical testing: The sample taken for the determination of physical properties of the consignment or part of the consignment.

4.12 maximum particle size: The size of opening of the sieve on which approximately 5 % (m/m) of iron ore is retained.

NOTE — It is essential to ascertain the maximum particle size of the consignment either from past experience or by experiment. However, if no information is available, visual estimation is acceptable.

4.13 whole-through sieve size: The size of the smallest sieve aperture through which all of a sample passes.

4.14 stratified sampling: For a consignment which can be divided into strata, sampling carried out in such a way that specified proportions of the sample are drawn from different strata.

NOTE — The stratum is a part of a consignment which is derived by division of the consignment according to specific criteria.

4.15 periodic systematic sampling: Sampling in which increments are taken from a consignment at regular intervals.

When a mass interval is adopted, it is called **periodic systematic sampling on a mass basis**, and when a time interval is adopted, it is called **periodic systematic sampling on a time basis**.

4.16 constant-mass division and fixed-rate division: When plural increments or subsamples are prepared individually and constituted into subsamples or a gross sample, the division of increments or subsamples shall be conducted either by constant-mass division or by fixed-rate division at an appropriate stage of sample preparation, according to the type of sampling adopted.

The **constant-mass division** is a method to obtain divided samples having almost uniform mass (coefficient of variation less than 20 %) regardless of the variation in masses of samples to be divided, and the **fixed-rate division** is a method to obtain divided samples having such masses as to be proportional to the varied masses of samples to be divided.

5 General procedure for sampling and sample preparation

Sampling shall be carried out by periodic systematic sampling, either on a mass basis or on a time basis. According to the type of sampling, not only the method of sampling but also the method of sample preparation is different.

The following is the general procedure for the sampling and sample preparation:

- a) identify the consignment or part of the consignment to be sampled;
- b) ascertain the maximum particle size;
- c) determine the actual mass of increment in relation to the maximum particle size, the ore handling equipment and the mechanical device for taking increments;
- d) ascertain the quality variation, σ_w , of the consignment;
- e) determine the minimum number of increments, n_1 , required;
- f) determine the sampling interval, in tonnes, for mass-basis sampling, or in minutes, for time-basis sampling;
- g) take increments having almost uniform mass in mass-basis sampling or having a mass proportional to the flow rate of the ore stream at the time of sampling in time-basis sampling. Increments are to be taken, during the whole period of handling the entire consignment, at the intervals determined in f);
- h) determine the method of combining the increments and constitute a gross sample or subsample, if necessary;
- j) crush the sample, if necessary, except for the size sample;
- k) dry the sample, if necessary, except for the moisture sample;
- m) divide the sample according to the minimum permissible mass of sample after division, employing constant-mass or fixed-rate division for mass-basis sampling, or fixed-rate division for time-basis sampling when dividing increments or subsamples;
- n) prepare the test sample.

6 Fundamentals of sampling

6.1 Overall precision

The overall precision (denoted by β_{SDM}), at a probability level of 95 %, for determining the mean values of the iron content, moisture content and percentage undersize fraction of the consignment, measured using the relevant International Standards, shall be as shown in table 1 or as agreed between the interested parties.

The overall precision of an intermediate mass of consignment other than those shown in table 1 may be obtained by linear interpolation.

Variations from the other tables in this International Standard may be made, provided it can be demonstrated that the overall precision limits given in table 1 can be met. The precision should be determined in accordance with ISO 3085.

Generally for chemical elements other than iron, the values of overall precision will be smaller than that for the iron content specified in table 1.

The overall precision, β_{SDM} , is a measure of the overall precision including sampling, sample division and measurement, and is twice the standard deviation of the overall process, σ_{SDM} , expressed as an absolute percentage, i.e.

$$\beta_{SDM} = 2\sigma_{SDM} \quad \dots (A1)$$

$$\sigma_{SDM} = \sqrt{\sigma_S^2 + \sigma_D^2 + \sigma_M^2} \quad \dots (A3)$$

$$\sigma_S = \frac{\sigma_w}{\sqrt{n_1}} \quad \dots (A5)$$

where

σ_S is the precision of sampling;

σ_D is the precision of sample division;

σ_M is the precision of measurement;

σ_w is the quality variation;

n_1 is the number of increments.

Equations (A1), (A3) and (A5) are based on the theory of stratified sampling (refer to annex A for details). The number of increments to be taken for a consignment of ore is dependent on the sampling precision desired and on the quality variation of the ore to be sampled.

Therefore, before the number of increments can be determined, it is necessary to define:

- the sampling precision to be attained;
- the quality variation of the ore to be sampled.

Table 1 — Overall precision, β_{SDM} (%)

Quality characteristics			Approximate overall precision, β_{SDM}			
			Mass of consignment (t)			
			270 000 to 210 000	70 000 to 45 000	15 000 to 5 000	< 500
Iron content			± 0,35	± 0,4	± 0,5	± 1,0
Moisture content			± 0,35	± 0,4	± 0,5	± 1,0
Size	— 200 mm ore	— 10 mm fraction, mean 20 %	± 3,5	± 4,0	± 5,0	± 10,0
	— 50 mm ore					
	— 31,5 + 6,3 mm sized ore	— 6,3 mm fraction, mean 10 %	± 1,75	± 2,0	± 2,5	± 5,0
	Sinter feed	+ 6,3 mm fraction, mean 10 %				
	Pellet feed	— 45 µm fraction, mean 70 %				
	Pellets	— 5 mm fraction, mean 5 %	± 0,7	± 0,8	± 1,0	± 2,0

6.2 Mass of increment

6.2.1 The average mass of increment shall be decided according to the maximum particle size of the consignment, and the value given in the fourth column of table 2 is the minimum average mass of increment.

The actual mass of an individual increment shall be greater than the minimum mass specified in the third column of table 2.

Table 2 — Mass of increment

Maximum particle size (mm)		Minimum mass of individual increment (kg)	Minimum average mass of increment (kg)
Over	Up to and including		
150	250	190	320
100	150	40	70
50	100	12	20
20	50	4	6,5
10	20	0,8	1,3
	10	0,3	0,5

NOTE — The minimum mass of individual increment is the basic requirement and the minimum average mass of increment is shown for reference.

6.2.2 The average mass of increment, $\bar{m}$, in kilograms, being taken by a cutter-type primary sampler from the ore stream on or at the discharge end of a conveyor belt is given by the equation

$$\bar{m} = \frac{q_m l_1}{3,6 v}$$

where

q_m is the average flow rate, in tonnes per hour, of the conveyor belt;

l_1 is the cutting aperture, in metres, of the primary sampler;

v is the cutter speed, in metres per second, of the primary sampler.

NOTES

1 The calculated average mass of increment, $\bar{m}$, will in the majority of cases be in excess of the minimum stated in table 2.

2 It is essential that $\bar{m}$ meet the minimum mass stated in table 2 for the minimum intended flow rate, q_m , l_1 or v or both may be adjusted to achieve this.

3 The cutter speed, v , is dependent on the type of cutter selected. Mechanical limitations provide safeguards against cutting speeds reaching the upper limit which may introduce bias.

6.2.3 When the average mass of increment has been determined, increments shall be taken in a manner which ensures that they have an almost uniform mass in mass-basis sampling (see 7.1.1) or a mass proportionate to the flow rate of ore stream at the time of sampling in time-basis sampling.

6.3 Quality variation

6.3.1 The quality variation, σ_w , is a measure of the heterogeneity of a consignment and is the standard deviation of the quality characteristics of the increments within the strata of the consignment for periodic systematic sampling being made by mass-basis sampling.

The estimated value of σ_w should be derived by experimentation for each type of iron ore and at each handling plant, under normal operating conditions in accordance with ISO 3084.

In the case of time-basis sampling, if the flow rate of the ore is uniform on the belt, then time-basis sampling is the same as mass-basis sampling and ISO 3084 can be applied.

6.3.2 The characteristics to be selected for determining quality variation are iron content, moisture content, percentage undersize fraction and in certain cases other characteristics.

6.3.3 Depending on the types of iron ore and the handling plant, the magnitudes of quality variation in terms of σ_w shall be classified into three categories as indicated in table 3.

6.3.4 All ore whose quality variation is unknown shall be considered to have 'large' quality variation.

6.3.5 If separate samples are to be taken for the determination of chemical composition, moisture content, size distribution, etc., the quality variation shall be classified for individual characteristics.

6.3.6 If the sample is to be used for the determination of more than one quality characteristic, the quality variation shall be classified for the characteristic which has the largest classification of quality variation.

6.4 Number of increments and precision of sampling

6.4.1 Mass-basis sampling

When the value of σ_w is known, then the number of increments, n_1 , can be calculated from equation (A7) at the desired sampling precision of β_s

$$n_1 = \left(\frac{2\sigma_w}{\beta_s} \right)^2 \dots (A7)$$

When the value of σ_w is classified in terms of large, medium or small quality variation in accordance with table 3, then table 4 shall be used to determine the minimum number of increments required for a particular consignment (see annex A for the theoretical background).

When n_1 increments are taken according to table 4, the precision of sampling, β_s , will be as shown in the same table. (See figures 1 and 2.)

Table 3 — Classification of quality variation, σ_w

Values as absolute percentages

Quality characteristics			Classification of quality variation		
			Large	Medium	Small
Iron content			$\sigma_w > 2,0$	$2,0 > \sigma_w > 1,5$	$\sigma_w < 1,5$
Moisture content			$\sigma_w > 2,0$	$2,0 > \sigma_w > 1,5$	$\sigma_w < 1,5$
Size	– 200 mm ore	– 10 mm fraction, mean 20 %	$\sigma_w > 10$	$10 > \sigma_w > 7,5$	$\sigma_w < 7,5$
	– 50 mm ore				
	– 31,5 + 6,3 mm sized ore	– 6,3 mm fraction, mean 10 %	$\sigma_w > 5$	$5 > \sigma_w > 3,75$	$\sigma_w < 3,75$
	Sinter feed	+ 6,3 mm fraction, mean 10 %			
	Pellet feed	– 45 μ m fraction, mean 70 %	$\sigma_w > 3$	$3 > \sigma_w > 2,25$	$\sigma_w < 2,25$
	Pellets	– 5 mm fraction, mean 5 %			

6.4.2 Time-basis sampling

The sampling interval shall be determined by the maximum flow rate and table 4, therefore the number of increments taken will be greater than that for mass-basis sampling.

7 Method of sampling

7.1 Mass-basis sampling

7.1.1 Mass of increment

7.1.1.1 The mass of increment shall be determined according to 6.2.

7.1.1.2 The mass of individual increments shall be almost uniform. "Almost uniform mass" means that the variation in mass shall be less than 20 % in terms of the coefficient of variation. The coefficient of variation (CV), expressed as a percentage, is defined as the ratio of standard deviation, s , to the mean value, $\bar{m}$, of the mass of the increments times 100

$$\frac{s}{\bar{m}} \times 100 < 20 \%$$

For example when the average mass of increment is to be 100 kg, the increments should be taken in such a manner that 95 % of the increments vary between 60 and 140 kg, with an average of 100 kg.

7.1.1.3 If the coefficient of variation in the mass of individual increments is 20 % or greater, each increment shall be subjected to division (according to the rules of division) and the quality characteristics determined. Alternatively divided increments of "almost uniform mass" may be combined at an appropriate stage of division into a subsample or a gross sample.

7.1.1.4 The increments shall be taken in such a manner as to ensure that they are of "almost uniform mass". Because of possible variations in the handling rate, the masses of successive increments might vary. Therefore provision must be made, either in the manner in which the increments are taken, or by subsequent weighing of each increment, to ensure that they have almost uniform mass.

7.1.1.5 In order to avoid taking an increment whose mass is below the minimum mass specified in the third column of table 2, one or more of the following measures shall be taken:

- control of the flow of ore on the conveyor belt ahead of the primary sampler;
- installation of a sensor which monitors the flow rate of the ore on the conveyor belt, to move the primary sampler only when a sufficient flow of ore is on the belt;
- installation of an apparatus which rejects the short-mass increment and re-starts the primary sampler;
- adoption of a variable speed cutter.

7.1.2 Quality variation

The quality variation should be derived by experimentation in accordance with ISO 3084.

7.1.3 Number of increments

The number of increments shall be determined as described in 6.4.1.

7.1.4 Sampling interval

7.1.4.1 The mass interval, Δm , in tonnes, between taking increments shall be calculated from the condition

$$\Delta m < \frac{m_1}{n_1}$$

where

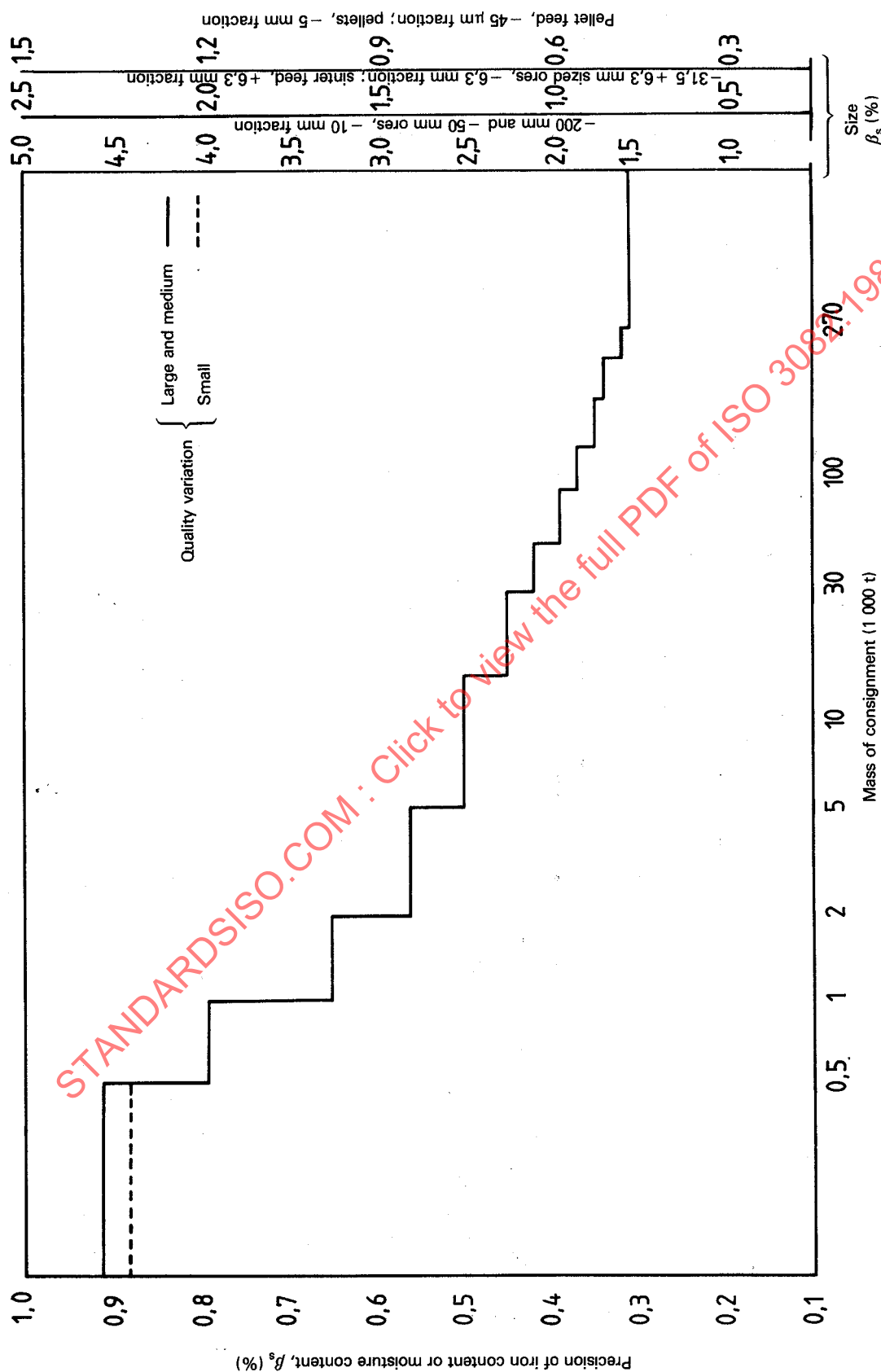
m_1 is the mass, in tonnes, of the consignment;

n_1 is the number of increments determined in 6.4.1.

Table 4 — Minimum number of increments required, n_1 , and sampling precision, β_s

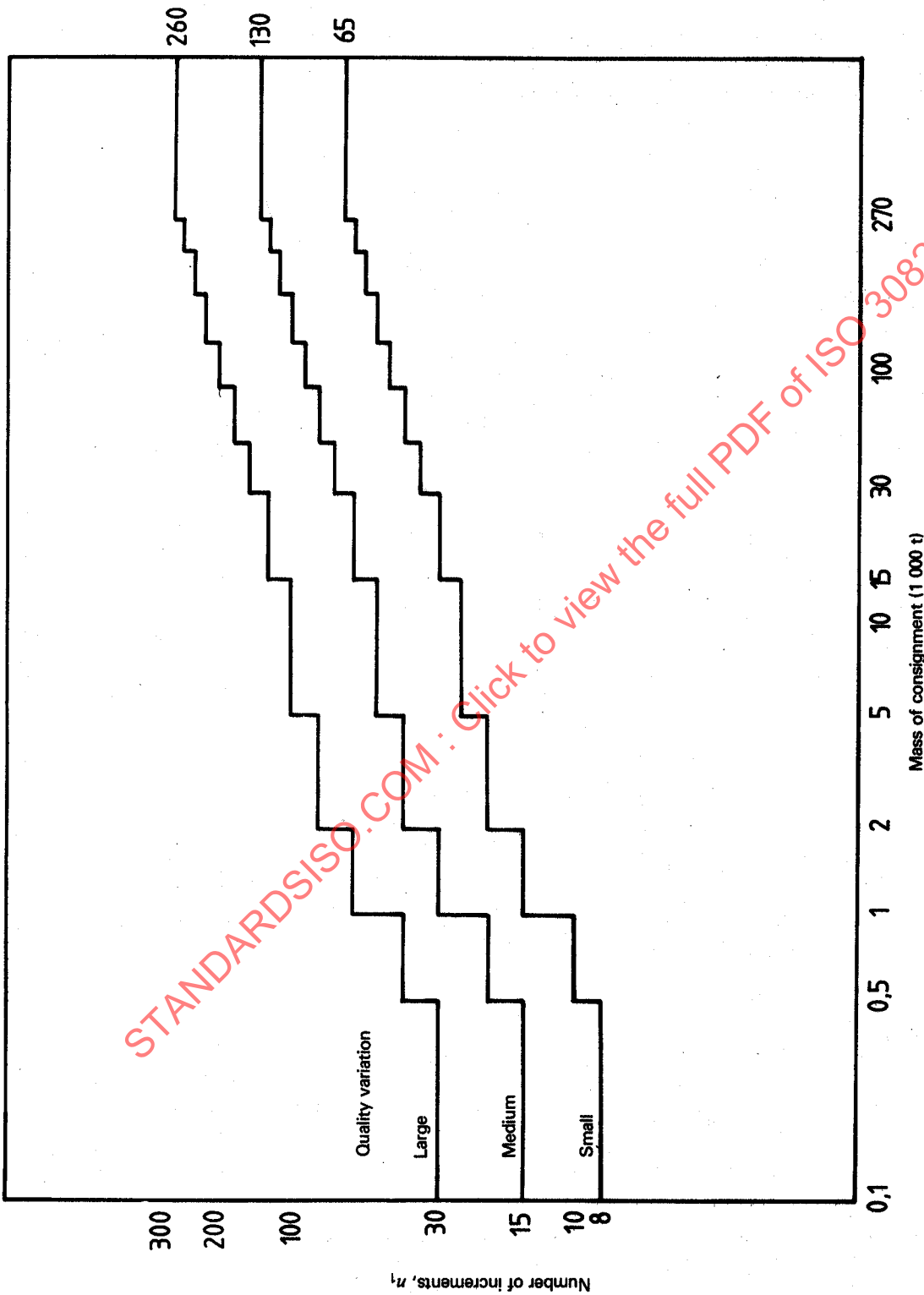
Mass of consignment (t)		Quality variation, σ_w											
		Large				Medium				Small			
		β_s %				β_s %				β_s %			
		Size				Size				Size			
Over	Up to and including	n_1				n_1				n_1			
		Iron content	Moisture content	- 200 mm and - 50 mm ores, - 31,5 + 6,3 mm sized ores, - 6,3 mm fraction	Sinter feed, + 6,3 mm fraction	Pellet feed, - 45 μ m fraction	Pellets, - 5 mm fraction	Iron content	Moisture content	- 200 mm and - 50 mm ores, - 31,5 + 6,3 mm sized ores, - 6,3 mm fraction	Sinter feed, + 6,3 mm fraction	Pellet feed, - 45 μ m fraction	Pellets, - 5 mm fraction
270 000		260	0,31	1,55	0,77	0,47	130	0,31	1,55	0,77	0,47	65	0,31
270 000	270 000	240	0,32	1,61	0,80	0,48	120	0,32	1,61	0,80	0,48	60	0,32
150 000	210 000	220	0,34	1,69	0,84	0,51	110	0,34	1,69	0,84	0,51	55	0,34
100 000	150 000	200	0,35	1,77	0,88	0,53	100	0,35	1,77	0,88	0,53	50	0,35
70 000	100 000	180	0,37	1,86	0,92	0,56	90	0,37	1,86	0,92	0,56	45	0,37
45 000	70 000	160	0,39	1,98	0,98	0,59	80	0,39	1,98	0,98	0,59	40	0,39
30 000	45 000	140	0,42	2,11	1,05	0,63	70	0,42	2,11	1,05	0,63	35	0,42
15 000	30 000	120	0,45	2,28	1,13	0,68	60	0,45	2,28	1,13	0,68	30	0,45
5 000	15 000	100	0,50	2,50	1,24	0,75	50	0,50	2,50	1,24	0,75	25	0,50
2 000	5 000	80	0,56	2,80	1,39	0,84	40	0,56	2,80	1,39	0,84	20	0,56
1 000	2 000	60	0,65	3,23	1,60	0,97	30	0,65	3,23	1,60	0,97	15	0,65
500	1 000	40	0,79	3,96	1,96	1,19	20	0,79	3,96	1,96	1,19	10	0,79
	500	30	0,91	4,56	2,27	1,37	15	0,91	4,56	2,27	1,37	8	0,88

NOTE — By agreement between the interested parties and where feasible, the values of n_1 may be increased or decreased. For example if the minimum number of increments is $2n_1$, then β_s will be improved by $1/\sqrt{2} = 0,71$; and if it is $n_1/2$, then β_s will be worsened by $\sqrt{2} = 1,4$.



NOTE — Figure 1 is a graphic illustration of β_s in table 4.

Figure 1 — The precision of sampling for each mass of consignment



NOTE — Figure 2 is a graphic illustration of the minimum number of increments in table 4.

Figure 2 — Minimum number of increments required

7.1.4.2 The mass interval between taking increments that is selected shall be smaller than that calculated in 7.1.4.1 to ensure that the minimum number of increments is greater than that calculated in 6.4.1.

7.1.4.3 If the flow of ore is regular, the mass interval may be converted into an equivalent time interval.

7.1.5 Methods of taking increments

7.1.5.1 Each increment shall be taken at one time by a single motion or by a complete cycle of the sampling device so that a full cross-section of the ore stream shall be taken.

NOTE — This does not prevent the sampler taking a forward and return cut through the ore stream.

7.1.5.2 The first increment shall be taken after a randomly selected tonnage has been handled within the first mass interval after commencing the handling operation.

7.1.5.3 The increments shall be taken subsequently at a fixed mass interval until the handling operation of the consignment has been completed.

7.1.5.4 When the calculated quantity of the sample is less than that required for testing (size determination, physical testing, etc.), the number and/or mass of the increments shall be increased.

7.1.5.5 Either of the following two kinds of cutters may be employed for the primary sampler:

- a) a fixed-speed cutter whose cutting speed is constant during the course of handling the entire consignment;
- b) a variable-speed cutter whose cutting speed is constant while cutting the stream but can be regulated, increment by increment, corresponding to the flow rate of the ore on the conveyor belt.

7.2 Time-basis sampling

7.2.1 Mass of increment

7.2.1.1 The mass of increment corresponding to the average flow rate of ore stream shall be determined according to 6.2.

7.2.1.2 The mass of increment shall be proportional to the flow rate of the ore stream at the time of sampling.

7.2.1.3 When a test sample is prepared from each increment or subsample, the mass of each increment shall be determined in order to obtain the weighted mean of the value of the quality characteristics for the consignment.

7.2.2 Quality variation

When the variation of the flow of ore is not so large, ISO 3084 may be applied to give an approximation of the quality variation.

7.2.3 Sampling interval

The time interval, Δt , in minutes, between taking increments shall be calculated from the condition

$$\Delta t \leq \frac{60 m_1}{q_{m \max} n_1}$$

where

m_1 is the mass, in tonnes, of the consignment;

$q_{m \max}$ is the maximum flow rate, expressed in tonnes per hour, of the conveyor belt;

n_1 is the number of increments given in table 4.

The time interval between taking increments that is selected shall be smaller than that calculated to ensure that the minimum number of increments is greater than that given in table 4.

7.2.4 Number of increments

The number of increments will be greater than that for mass-basis sampling.

7.2.5 Methods of taking increments

7.2.5.1 Each increment shall be taken at one time by a single motion or by a complete cycle of the sampling device so that a full cross-section of the ore stream shall be taken.

NOTE — This does not prevent the sampler taking a forward and return cut through the ore stream.

7.2.5.2 The first increment shall be taken at random within the first time interval from the start of the handling operation.

7.2.5.3 The increments shall be taken at a fixed time interval until the handling operation of the consignment is completed.

7.2.5.4 When the calculated quantity of the sample is less than that required for testing (size determination, physical testing, etc.), the sampling interval shall be shortened.

7.2.5.5 A fixed-speed cutter whose cutting speed is constant during the course of handling the entire consignment shall be employed for the primary sampler.

7.2.6 Special procedure of time-basis sampling

When the flow rate of the ore stream is uniform, the same number of increments may apply as in mass-basis sampling.

8 Method of sample preparation

8.1 Fundamentals

8.1.1 Outline of the method

Increments taken by the procedure specified in clause 7 shall be prepared to the test sample on each increment, on each subsample after having been constituted from increments, or on a gross sample after having been constituted from subsamples or increments.

The gross sample shall be constituted from all of the increments or subsamples either as taken or after having been prepared individually to an appropriate stage of division.

A subsample shall be constituted from two or more increments either as taken or after having been prepared individually to an appropriate stage of division.

An example of the method of constituting subsamples from increments and a gross sample from subsamples is given in figure 3.

8.1.2 Sample division

The sample division shall be carried out on the sample, crushed if necessary to an appropriate particle size.

8.1.2.1 Method of division

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

- a) manual division methods (see ISO 3083);
- b) mechanical increment division method (see 8.3.1);
- c) other mechanical division methods (for example mechanically charged riffle divider).

8.1.2.2 Types of division

When plural increments or subsamples are prepared individually and constituted into subsamples or a gross sample, the division of increments or subsamples shall be conducted either by constant-mass division or by fixed-rate division subject to the conditions set out in 8.2.1 and 8.2.2.

8.1.2.3 Types of divider

Types of divider are classified as follows: cutter-chute; rotary cone; rotary container; mechanically charged riffle; chain bucket; slotted belt; etc. (see 11.2.3).

8.1.3 Precision of sample preparation

The precision of sample preparation, β_D , for the iron or moisture sample shall be within $\pm 0,3$ % in iron or moisture content with 95 % probability. However, if sample preparation is carried out first on individual increments or subsamples to an appropriate stage (-10 mm or less), and then those divided

increments or subsamples are combined into a gross sample, the precision of sample preparation, β_D , will be further improved (see 8.2.4.2 and 8.2.4.3).

The combined precision of sample preparation and measurement, β_{DM} , for the size sample shall be within the values as specified in table 6 on the characteristic size fraction of each type of iron ore.

8.2 Method of constitution of subsamples or a gross sample

According to the requirement of measurement, it should be decided whether a gross sample be constituted for a consignment or subsamples be constituted for individual parts of the consignment. Further, in some cases, according to the requirement of sample preparation, it is necessary to constitute subsamples first and then constitute a gross sample.

8.2.1 Method of constitution for mass-basis sampling

8.2.1.1 Constitution of subsamples or a gross sample from increments

8.2.1.1.1 When the variation of the masses of increments is under 20 % (coefficient of variation less than 20 %), the increments either as taken or after having been prepared individually by the constant-mass or fixed-rate division to an appropriate stage, may be combined into subsamples or a gross sample.

8.2.1.1.2 When the variation of the masses of increments is 20 % or over, the increments as taken shall not be combined into subsamples or a gross sample.

The prepared increments after having been divided individually by the constant-mass division at a practical stage may be combined into subsamples or a gross sample at an appropriate stage.

Otherwise, each increment should be prepared to a test sample to be subjected to quality determination.

8.2.1.2 Constitution of a gross sample from subsamples

8.2.1.2.1 The subsamples constituted by 8.2.1.1 may be combined into a gross sample.

8.2.1.2.2 When division is carried out on each subsample to constitute a gross sample, the division shall be carried out as follows:

- a) if the subsamples consist of an equal number of increments, constant-mass or fixed-rate division may be applied;
- b) if the subsamples consist of different numbers of increments, only fixed-rate division shall be applied.

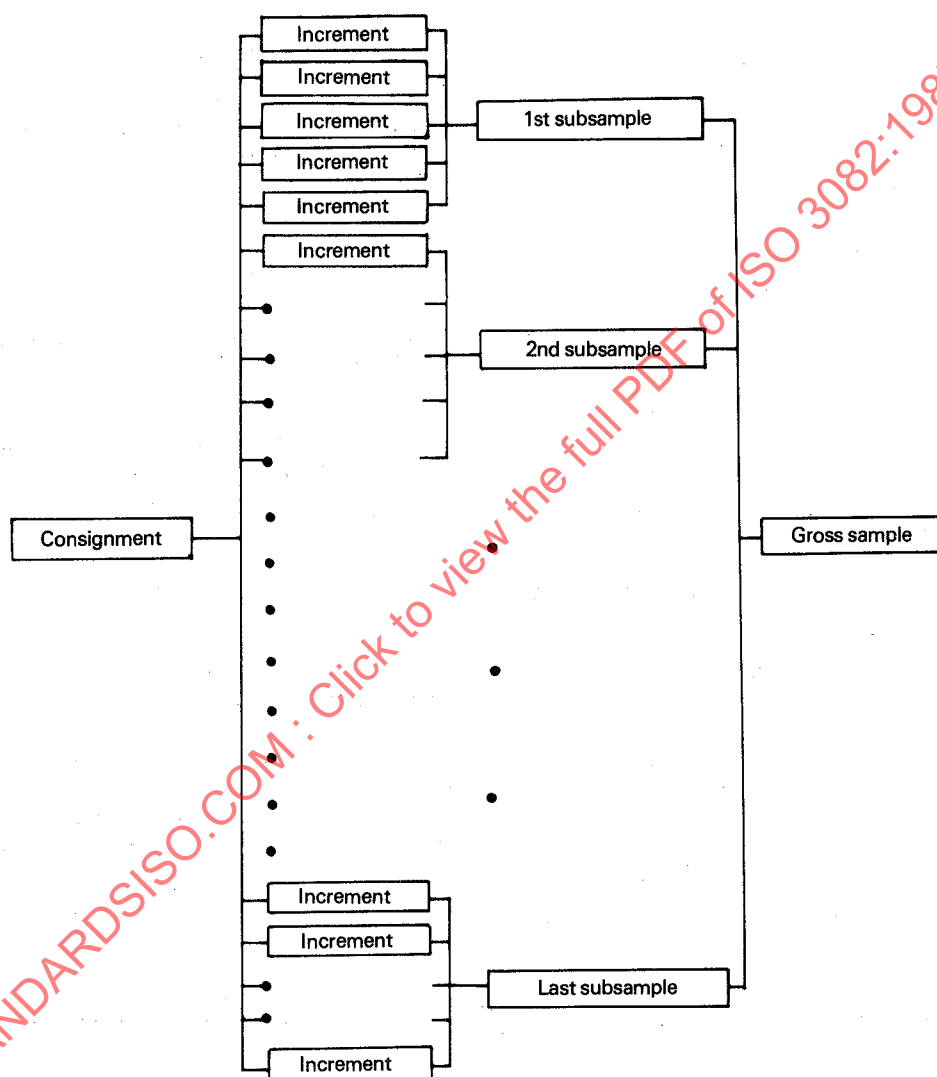


Figure 3 — An example for constitution of subsample and a gross sample

8.2.2 Method of constitution for time-basis sampling

8.2.2.1 Constitution of subsamples or a gross sample from increments

8.2.2.1.1 The increments as taken may be combined into subsamples or a gross sample irrespective of the variation of masses of increments.

8.2.2.1.2 When division is carried out on each increment and the divided increments are combined to constitute subsamples or a gross sample, the division shall be carried out on each increment by the fixed-rate division at any stage.

8.2.2.2 Constitution of a gross sample from subsamples

8.2.2.2.1 The subsamples constituted by 8.2.2.1 may be combined into a gross sample irrespective of the variation of masses of subsamples.

8.2.2.2.2 When division is carried out on each subsample and the divided subsamples are combined to constitute a gross sample, the division shall be carried out on each subsample by the fixed-rate division at any stage.

8.2.3 Special procedure for moisture content

8.2.3.1 If a moisture determination is required on a very large consignment, it is recommended that the consignment be divided into the number of parts indicated in table 5 and a separate moisture sample be prepared from each part, in order to complete sampling of each moisture sample in a short period of time and avoid moisture evaporation from the sample. This will give a better overall precision (including sampling, sample preparation and moisture determination) and minimize bias.

Table 5 — Minimum number of parts per consignment for moisture determination

Mass of consignment (t)		Minimum number of parts per consignment
Over	Up to and including	
270 000		15
70 000	270 000	10
30 000	70 000	5
15 000	30 000	3
5 000	15 000	2
	5 000	1

8.2.3.2 When it takes a long time for loading or unloading of a consignment, the consignment shall be divided for each 8 h period, and a moisture subsample shall be constituted and a moisture determination carried out for each part thus obtained. Such division should be subject to the condition of weather, for example heavy rain or high temperature, and/or to the conditions or circumstances at the time of loading or unloading, and

should be decided by agreement between the parties concerned. The moisture subsample may be constituted for each appropriate period of time. Alternatively if the moisture sample containers and the storage conditions are such as to prevent a change of moisture in the moisture samples, a moisture gross sample may be prepared for the whole consignment.

8.2.3.3 The above sub-samples or gross sample for moisture determination shall be constituted by the procedure prescribed in 8.2.1 or 8.2.2.

8.2.4 Method of constitution and overall precision

8.2.4.1 When a gross sample is constituted for a consignment and n_7 determinations are carried out on the gross sample, the overall precision will be

$$\sigma_{SDM}^2 = \sigma_S^2 + \sigma_D^2 + \frac{\sigma_M^2}{n_7}$$

where σ_D is the precision of sample preparation from the gross sample to the test sample.

8.2.4.2 When n_8 subsamples, whereby each subsample consists of an equal number of increments, are constituted and n_7 determinations are carried out on each subsample, the overall precision will be

$$\sigma_{SDM}^2 = \sigma_S^2 + \frac{\sigma_D^2 + (\sigma_M^2/n_7)}{n_8}$$

where σ_D is the precision of sample preparation from the subsample to the test sample.

Further, when the above n_8 subsamples are combined into a gross sample at an appropriate (— 10 mm or less) stage after individual sample preparation, and n_7 determinations are carried out on the gross sample, the overall precision will be

$$\sigma_{SDM}^2 = \sigma_S^2 + \frac{\sigma_D^2}{n_8} + \frac{\sigma_M^2}{n_7}$$

where σ_D is the precision of sample preparation from the subsample to the divided subsample at the appropriate stage.

8.2.4.3 When n_7 determinations are carried out on each increment, the overall precision will be

$$\sigma_{SDM}^2 = \sigma_S^2 + \frac{\sigma_D^2 + (\sigma_M^2/n_7)}{n_1}$$

where

σ_D is the precision of sample preparation from the increment to the test sample;

n_1 is the number of increments.

Further, when all the increments are combined into a gross sample at an appropriate (— 10 mm or less) stage after

individual sample preparation, and n_7 determinations are carried out on the gross sample, the overall precision will be

$$\sigma_{\text{SDM}}^2 = \sigma_{\text{S}}^2 + \frac{\sigma_{\text{D}}^2}{n_1} + \frac{\sigma_{\text{M}}^2}{n_7}$$

where σ_{D} is the precision of sample preparation from the increment to the divided increment at the appropriate stage.

8.3 Method of division

8.3.1 Mechanical increment division method

The size sample, moisture sample and sample for chemical analysis may be divided by the mechanical increment division method satisfying the following conditions, using a cutter-type divider.

8.3.1.1 Mass of increment (cut)

8.3.1.1.1 The mass of cut shall be uniform. In order to realize this, the flow of sample to be divided shall be uniform and the cutting aperture and speed of the cutter shall be constant.

NOTE — As another system of taking a uniform cut, a combination of variable feed rate of sample and variable speed cutter may be considered.

8.3.1.1.2 The cutting aperture shall be at least three times the maximum particle size of the sample to be divided.

8.3.1.1.3 The actual mass of an individual cut shall be greater than the minimum mass specified in the third column of table 2.

8.3.1.2 Number of increments (cuts)

A lesser number may be taken provided it has been demonstrated that no bias and/or no lack of precision is introduced (see ISO 3085 and ISO 3086).

8.3.1.2.1 Division of a gross sample

A minimum of 20.

8.3.1.2.2 Division of individual subsample

A minimum of 10 in the case of constant-mass division. In the case of fixed-rate division, a minimum of 10 on the average mass of subsample.

8.3.1.2.3 Division of individual increment

A minimum of four in the case of constant-mass division.

In the case of fixed-rate division, a minimum of five on the average mass of increment.

8.3.1.3 Interval between cuts

8.3.1.3.1 When constant-mass division is applied in 8.3.1.2.2 and 8.3.1.2.3, the interval between taking cuts shall be made variable according to the mass of the sample to be divided.

8.3.1.3.2 When fixed-rate division is applied in 8.3.1.2.2 and 8.3.1.2.3, the interval between taking cuts shall be constant irrespective of the variation of masses of samples to be divided.

8.3.1.4 Taking the first cut

In order to avoid bias, it is necessary to take the first cut for each sample to be divided at a random position within the first interval.

8.3.2 Other mechanical division methods (for example mechanically charged riffle divider)

The size sample, moisture sample and sample for chemical analysis may be divided by the method classified under this category using mechanical dividers other than the cutter-type divider in accordance with the following division limits.

8.3.2.1 Division of size sample

The division of the size sample shall be carried out in accordance with the stipulations of 8.3.2.1.1 or 8.3.2.1.2. According to variations from tables 6 and 7 on the percentage of the size fraction, the minimum mass specified in the tables shall be modified by the equation specified in 8.3.2.1.1.

In the case of variations from tables 6 and 7 on the type of iron ore and specification size fraction, annex B shall be applied instead of 8.3.2.1.1 and 8.3.2.1.2 in the division of the size sample.

8.3.2.1.1 Division of gross sample

When the gross sample is divided, the mass of the divided gross sample shall not be less than the minimum specified in table 6.

NOTE — Bias is easily introduced in the division of a size sample and sufficient care must be taken when dividing a size sample. It is recommended that when minus 200 mm ore is to be divided, the manual increment division method should not be used as large lumps of ore could be segregated.

When the actual percentage of the size fraction is considerably higher than that stipulated in table 6, the minimum mass, m_3 , specified in table 6 shall be revised by the following equation derived from the binomial rule:

$$m_4 = m_3 \times \frac{P(100 - P)}{P_0(100 - P_0)}$$

where

m_4 is the revised minimum mass of the divided gross sample;

m_3 is the minimum mass of the divided gross sample specified in table 6;

P is the actual percentage of the size fraction, which is considerably higher than that stipulated in table 6;

P_0 is the percentage of the size fraction stipulated in table 6.

For example for a consignment of 40 000 t of minus 200 mm ore, if the percentage of minus 10 mm fraction is about 50 %, the minimum mass of the divided gross sample to be applied shall be revised as follows:

$$m_4 = 750 \times \frac{50(100 - 50)}{20(100 - 20)} \approx 1\,175 \text{ kg}$$

8.3.2.1.2 Division of increment or subsample

When each increment or each subsample is divided, the division shall be carried out, satisfying the following two conditions:

- the mass of the divided sample shall not be less than the minimum specified in table 7;
- the mass of the gross sample to be constituted for the consignment, by combining those divided increments or subsamples, shall not be less than the minimum specified in table 6.

Table 6 — Examples of minimum mass of divided size gross sample in other mechanical division methods (for example mechanically charged riffle divider) and division precision, β_{DM}

Type of iron ore	−200 mm ore	−50 mm ore	−31,5 + 6,3 mm sized ore	Sinter feed	Pellet feed	Pellets							
Typical specification size fraction	− 10 mm	− 10 mm	− 6,3 mm	+ 6,3 mm	+ 45 μm	− 5 mm							
Average percentage of the size fraction (%)	20	20	10	10	30	5							
Mass of consignment (t)	Minimum mass of divided gross sample, m_3 (kg)												
Over	Up to and including		β_{DM} (%)		β_{DM} (%)		β_{DM} (%)		β_{DM} (%)		β_{DM} (%)		β_{DM} (%)
270 000	—	1 080	3,0	250	3,0	120	1,5	8,0	1,5	0,5	1,6	250	0,50
210 000	270 000	1 010	3,1	230	3,1	110	1,6	7,0	1,6	0,5	1,7	240	0,51
150 000	210 000	950	3,2	220	3,2	110	1,6	7,0	1,6	0,5	1,7	240	0,51
100 000	150 000	890	3,3	210	3,3	110	1,6	7,0	1,6	0,5	1,8	230	0,52
70 000	100 000	840	3,4	190	3,4	95	1,7	6,0	1,7	0,5	1,9	215	0,54
45 000	70 000	790	3,5	180	3,5	95	1,7	6,0	1,7	0,5	1,9	215	0,54
30 000	45 000	750	3,6	170	3,6	85	1,8	5,0	1,8	0,5	2,0	210	0,55
15 000	30 000	670	3,8	150	3,8	75	1,9	5,0	1,9	0,5	2,1	210	0,55
5 000	15 000	530	4,3	120	4,3	60	2,2	4,0	2,2	0,5	2,4	145	0,66
2 000	5 000	350	5,3	80	5,3	40	2,6	2,5	2,6	0,5	2,9	85	0,86
1 000	2 000	250	6,2	60	6,2	30	3,2	2,0	3,2	0,5	3,4	60	1,04
500	1 000	190	7,1	50	7,1	25	3,5	1,5	3,5	0,5	3,9	50	1,10
	500	120	8,9	30	8,9	15	4,4	1,0	4,4	0,5	4,8	50	1,47

Table 7 — Examples of minimum mass of divided increment or subsample for size determination in other mechanical division methods (for example mechanically charged riffle divider)

Type of iron ore	−200 mm ore	−50 mm ore	−31,5 + 6,3 mm ore	Sinter feed	Pellet feed	Pellets
Typical specification size fraction	−10 mm	−10 mm	−6,3 mm	+6,3 mm	+45 μ m	−5 mm
Average percentage of the size fraction (%)	20	20	10	10	30	5
Minimum mass of divided increment (kg)	160	16	16	1,2	1,2	3,2
Minimum mass of divided subsample (kg)	400	40	40	3	3	8

8.3.2.2 Division of moisture sample and sample for chemical analysis

8.3.2.2.1 Division of gross sample

When a gross sample is divided, the division shall be carried out in accordance with table 8. The gross sample shall not be divided further than the mass corresponding to the whole-through sieve size which is specified in table 8.

Table 8 — Minimum mass of divided gross sample for moisture determination and/or chemical analysis for other mechanical division methods (for example mechanically charged riffle divider)

Whole-through sieve size up to and including	Minimum mass of divided sample (kg)
31,5 mm	750
22,4 mm	250
10 mm	50
5 mm	25
2,8 mm	15
1,4 mm	10
500 µm	5
250 µm	0,5

8.3.2.2.2 Division of individual increment or subsample

When an individual increment or subsample is divided, the division shall be carried out in accordance with table 9. The sample shall not be divided further than the mass corresponding to the whole-through sieve size which is specified in table 9.

Table 9 — Minimum mass of divided individual increment of subsample for moisture determination and/or chemical analysis for other mechanical division methods (for example mechanically charged riffle divider)

Whole-through sieve size up to and including	Minimum mass of divided sample (kg)
31,5 mm	150
22,4 mm	50
10 mm	10
5 mm	5
2,8 mm	3
1,4 mm	2
500 µm	1
250 µm	0,1

8.4 Preparation of sample for size determination

Each increment, each subsample or the gross sample taken for size determination, or the divided sample obtained by division of the size sample without crushing, shall be used and the size determination shall be carried out in accordance with the method specified in ISO 4701.

8.5 Preparation of sample for moisture determination

8.5.1 In mass-basis sampling, the test sample for moisture determination may be taken from each increment, each subsample or the gross sample.

In time-basis sampling, the test sample should be taken from each subsample or the gross sample to ensure that the specified mass is obtained.

8.5.2 The moisture sample shall be kept in an airtight, non-absorbent container in order to avoid any change of moisture.

8.5.3 If necessary, the moisture sample shall be crushed to either minus 31,5 mm or minus 22,4 mm or minus 10 mm. The first stage of division shall be carried out according to the rules of division specified in 8.3.1 or 8.3.2. Then in order to obtain the test sample of 10 kg minimum for minus 31,5 mm or 5 kg minimum for minus 22,4 mm or of 1 kg minimum for minus 10 mm, the method of division specified in 8.1.2.1 shall be applied. The minimum mass of divided sample as given in tables 8 and 9 no longer applies. Such preparation of test sample for moisture determination shall be carried out carefully but quickly, in order to avoid moisture evaporation. The remainder of the sample may be used for preparation of a sample for chemical analysis.

NOTES

1 Instead of preparing one test sample of 10 kg minimum at minus 31,5 mm, two test portions of 5 kg minimum, each, may be prepared by dividing the test sample of 10 kg minimum.

2 A check is recommended as to whether the minus 10 mm test sample shows a biased result against the minus 22,4 mm or minus 31,5 mm test sample.

3 It is recommended that moisture samples be prepared by the manual increment division method in accordance with ISO 3083, in order to avoid moisture evaporation.

In this case, a scoop for the increment division method with a scoop number of two-ranks smaller than that specified may be used for the ores of whole-through sieve size 12,5 mm or under; however, the test sample thus obtained must not be used for preparation of a sample for chemical analysis.

8.5.4 The mass of the test sample (test portion) shall be determined immediately. When the immediate determination of the mass is not possible, the sample shall be packed tightly in a moisture-proof container and kept in an environment which has approximately constant temperature and humidity.

8.5.5 The relationship between each increment or subsample and each part (by mass) of the consignment shall be shown.

8.5.6 The number of test portions for moisture determination should be as specified in table 10.

Table 10 — Number of test portions for moisture determination

Preparation of test sample	Number of test portions to be tested	Number of subsamples per consignment
Per gross sample	4	—
Per subsample	4	2
	2 min.	3 to 7
	1 min.	>8
Per increment	1 min.	—

8.6 Preparation of sample for chemical analysis

8.6.1 Mass and particle size

The particle size of the test sample for chemical analysis shall be either minus 100 μm or minus 160 μm by agreement between the interested parties. The preferred method is to prepare the test sample for chemical analysis of 50 g minimum and minus 100 μm in particle size from the divided gross sample of minus 250 μm in particle size.

However, for ores containing significant amounts of combined water and/or oxidizable compounds, when excessive grinding would affect the result, the test sample for chemical analysis should be minus 160 μm in particle size and 100 g minimum in mass.

The preparation of sample for chemical analysis is classified into three cases as shown in figure 4.

NOTE — In the preparation of ores which contain significant amounts of combined water and/or oxidizable compounds, special precautions should be taken to ensure that the grinding process does not generate excessive heat which could significantly change the chemical composition of the ore. Precautions may include

- reducing the grinding time by grinding smaller charges;
- use of a single pass straight through type of grinder;
- grinding for the minimum time to satisfy the attainment of whole-through sieve size.

Grinding by agate pestle and mortar, hand rolling, or suitable manual techniques should be used for reference purposes.

8.6.2 Preparation to minus 250 μm

Each increment, each subsample or the gross sample shall be ground to minus 250 μm in particle size, as a primary procedure of sample preparation, by repeating crushing and division according to 8.3 and ISO 3083. When the division is conducted on an individual increment or subsample before constitution of a gross sample, the gross sample shall be obtained, at a certain stage of the division, by combining quantities proportional to the mass of the individual increment or subsample. After drying if necessary, the sample of minus 250 μm in particle size shall be ground to minus 160 μm or minus 100 μm in particle size.

8.6.3 Final preparation

8.6.3.1 Case 1

A 500 g sample of minus 250 μm in particle size shall be ground to minus 100 μm in particle size. From this sample, a set of not less than four test samples, each of 50 g minimum shall be prepared by an appropriate division method specified.

8.6.3.2 Case 2

A 500 g sample of minus 250 μm in particle size shall be ground to minus 160 μm in particle size. From this sample, a set of not less than four test samples, each of 100 g minimum, shall be prepared by an appropriate division method specified.

The test sample for chemical analysis sent to the laboratory shall be ground to minus 100 μm in particle size.

8.6.3.3 Case 3

A 500 g sample of minus 250 μm in particle size shall be ground to minus 160 μm in particle size. From this sample, a set of not less than four test samples, each of 100 g minimum shall be prepared by an appropriate division method specified.

The test samples for chemical analysis sent to the laboratory shall not be ground to any finer particle size.

8.6.4 Grinding to minus 100 μm or 160 μm

When a sample is ground to minus 100 μm or 160 μm from minus 250 μm in particle size, the following procedure shall be used.

8.6.4.1 Type of grinder

Several types of grinders may be used to grind the sample for chemical analysis from minus 250 μm to minus 160 μm or minus 100 μm , for example top grinder, disc grinder, pot mill, hammer mill, vibrating mill, and other suitable types of mill.

8.6.4.2 Selection of material of construction of grinder

The selection of material for the grinder is one of the most important considerations to be given so that the chemical composition of the sample does not change during the grinding operation.

NOTE — It is recommended that an experiment be carried out, in accordance with ISO 3086, to check whether bias in chemical composition has been introduced by the grinding operation.

8.6.4.3 Dry grinding

The whole mass of the sample for chemical analysis of 500 g minimum with a particle size of minus 250 μm should be ground at one time to minus 100 μm or 160 μm , using an appropriate grinder. When the grinding of the sample cannot be carried out at one time, the grinding may be carried out on each

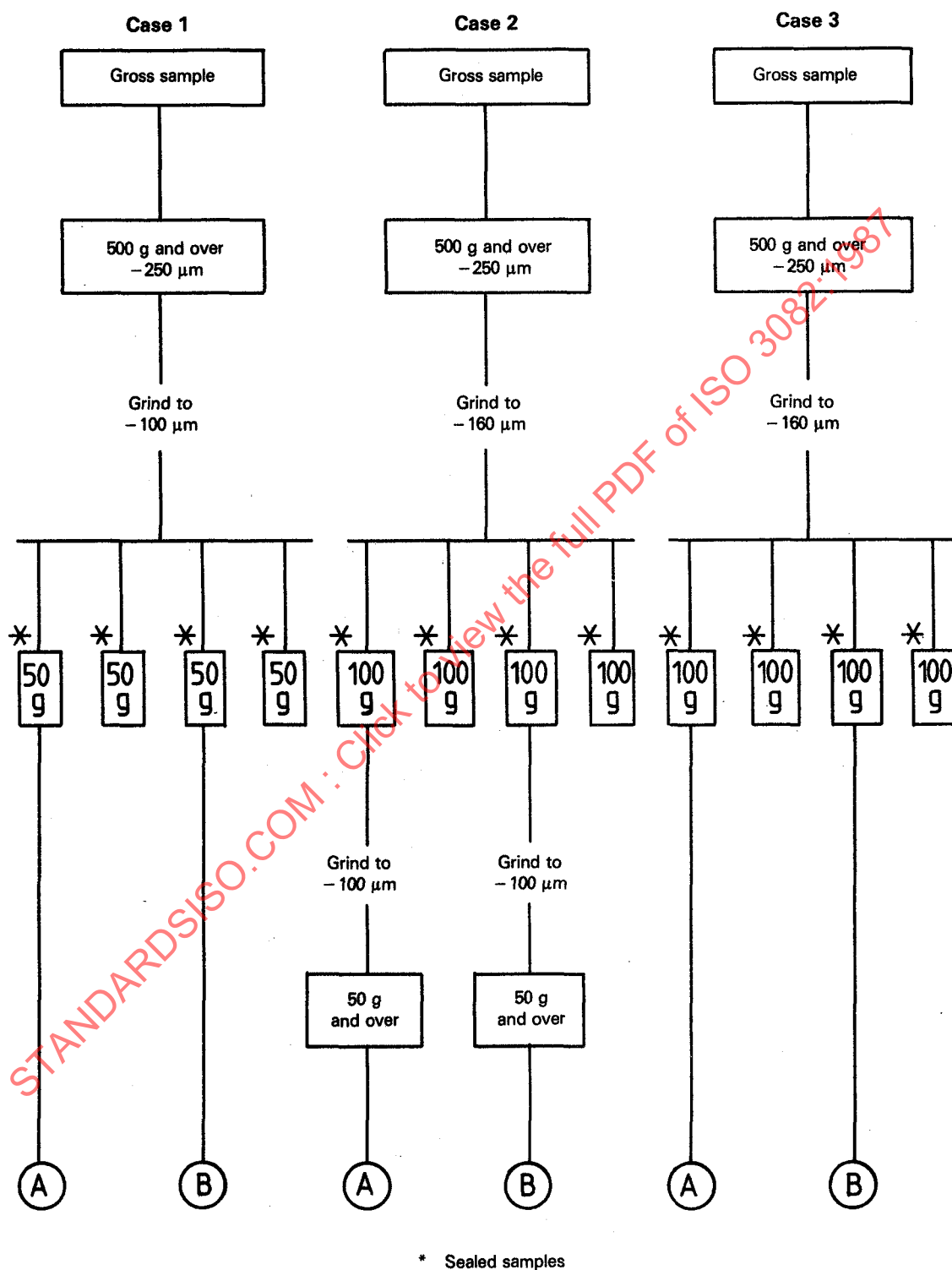


Figure 4 — Sample preparation for chemical analysis

part obtained, after dividing the sample into parts, and then after all the divided parts have been ground to minus 100 μm or 160 μm , they shall be mixed thoroughly in an appropriate mixer.

NOTES

1 The sample for finer grinding should not be screened into oversize and undersize fractions, for example plus and minus 100 μm fractions, in order to carry out the grinding on the oversize fraction only.

2 The impact-type mill should be avoided for ore containing materials which have an extraordinarily different grindability to the constituent iron minerals, such as grains of quartz and fragments of shale, because of its tendency of selective grinding.

8.6.4.4 Wet grinding

When the sample for chemical analysis is cohesive in the vibrating mill during finer grinding, and when shorter grinding time is preferable to avoid oxidation of the samples, wet grinding with a chemical medium of *n*-hexane is permissible for the sample for chemical analysis as far as a vibrating mill is used.

8.6.5 Distribution of samples for chemical analysis

A set of not less than four test samples for chemical analysis shall be prepared in accordance with 8.6.3.

The test samples to be distributed shall be placed in suitable containers, sealed, and clearly marked in accordance with clause 9.

One sample shall be provided for the seller, one for the purchaser, and one for the arbitrator and if required one is to be held in reserve, or as agreed between the interested parties.

The reserve sample shall be retained for 6 months.

8.7 Example of sample preparation process

An example of the sample preparation process for moisture samples and samples for chemical analysis is shown in figure 5.

NOTE — The flow chart shown in figure 5 provides an example of sample preparation of lump ore, when a subsample comprises three increments and several subsamples compose a gross sample.

9 Packing and marking of sample

The samples for distribution shall be tightly sealed in airtight containers. The following information should be shown on the label and on a card placed in the container, if necessary:

- type and grade of the ore and name of the consignment (name of ship or train, etc.);
- mass of the consignment;
- sample number;

- place and date of sampling;
- moisture content of the consignment;
- place and date of sample preparation;
- particle size of the sample;
- any other item (if necessary).

10 Requirements for mechanical systems

10.1 Basic requirements

10.1.1 The diversity of types of installation for sampling and sample preparation and of the conditions under which the mechanical sampling is performed makes it impracticable to lay down rigid rules that may be applicable to the industry world-wide.

10.1.2 The basic requirements together with typical examples of application are described for the guidance of installation and operation of the systems for mechanical sampling and mechanical preparation of samples.

10.1.3 The basic requirements should be taken into account from the early stages of designing and engineering of the systems as well as during the operation and maintenance of the systems.

10.1.4 It is not essential to construct or operate the mechanical sampling system as a whole. Any principal unit or combination of principal units may be operated mechanically and combined at any stage with manual operation specified in ISO 3081 and/or ISO 3083, to form a complete sampling and sample preparation system.

10.2 Safety of operators

10.2.1 From the initial stage of designing and constructing the systems, due consideration shall be given to the safety of the operators. Local or national safety codes shall be respected.

10.2.2 It is recommended that mechanical sampling be used if the speed of the conveyor belt is high or the mass of the ore handled by the conveyor belt is large. The use of manual sampling in such cases could be dangerous for the sampling staff.

10.3 Robustness of installation

The systems for mechanical sampling and mechanical preparation of samples should be designed and constructed robustly in order to fulfil without failure the required function under given conditions at all times.

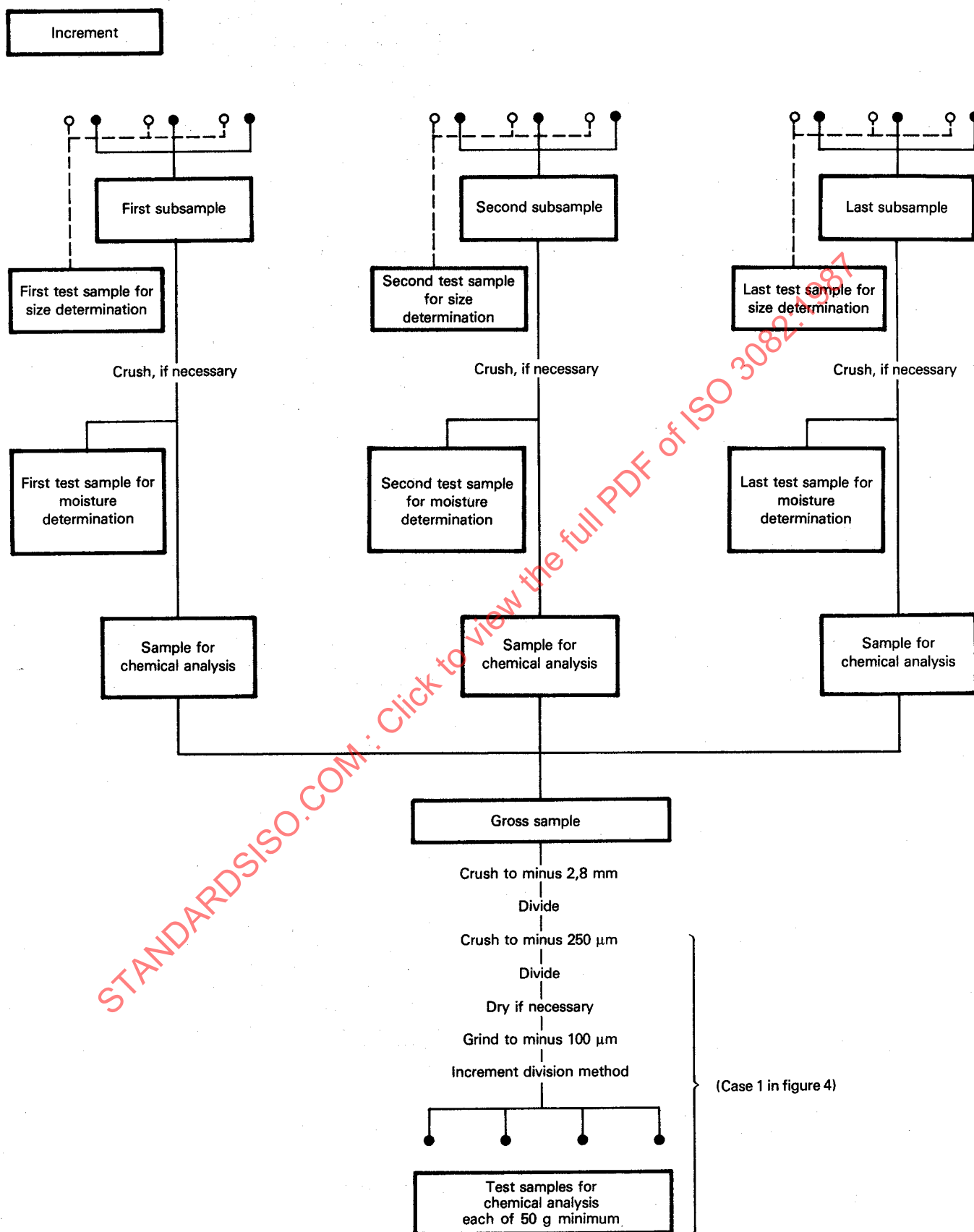


Figure 5 — An example of sample preparation

10.4 Versatility of application

10.4.1 The design of the systems for sampling and sample preparation should be

- a) guided by the types of ore likely to be handled, the quality characteristics to be determined and the desired precisions;
- b) such that bias is not introduced.

10.4.2 In all cases the minimum mass and number of increments of a sample shall comply with the values given in tables 2 and 4, respectively, in order to attain the specified precision and the appropriate amount of sample for a specific requirement.

10.4.3 The size sample shall be taken before any crushing takes place.

10.4.4 Multiple use of increments of a sample is permissible, provided that the general procedures given in clause 5 are fulfilled. If a size determination is carried out on a sample which will subsequently be used for other purposes, care shall be taken to ensure that the size fractions are fully remixed before division or preparation is undertaken.

10.4.5 In order to meet the sampling requirements of ISO 3085, one of the design requirements for a primary sampler is that the sampler should be capable of taking at least $2n_1 + n_8$ increments from a particular consignment, where n_1 is the number of increments specified in table 4, and n_8 is the number of increments required for other test or tests.

NOTE — If the note to 3.2 of ISO 3085 is to be applied, $n_1 + n_8$ may be used instead of $2n_1 + n_8$.

10.5 System for evaluating the quality variation (see ISO 3084)

As one of the design criteria for operating the mechanical installation for periodic systematic sampling, it is recommended that a system be provided which is capable of processing the increments in order to constitute pairs of subsamples, each member of the pair being designated A and B, by combining the alternate increments.

The installation should be designed so that check experiments can be carried out in conjunction with the routine sampling operation.

NOTE — This system is also indispensable to the experiment for checking the precision of sampling (see ISO 3085).

10.6 System for checking the precision and bias (see ISO 3085 and ISO 3086)

When a mechanical installation is newly constructed, when principal parts of the installation are modified or when a new ore is being sampled, check experiments for precision and bias

should be carried out for the installation as a whole as well as for each stage of the installation. Thus, the bias should be verified in accordance with ISO 3086 by the results produced by the installation which should be capable of attaining a precision better than that specified in table 4.

The bias of a mechanical sampling installation should be checked by comparison with 'stopped-belt' sampling, preferably using size determination as the criterion.

NOTES

1 For stopped-belt sampling, the reference increment must be taken on a complete cross-section of the ore on the main conveyor belt at a fixed position for a length which is at least three times the maximum particle size of the consignment. The sampling frame should be placed on the stationary belt so that it is in contact with the belt across its full width, and all ore particles lying inside the sampling frame should be swept off into a container. Any ore particles obstructing the insertion of the sample frame must be

- a) included in the increment if they are predominantly on the left side of the sampling frame;
- b) excluded from the increment if they are predominantly on the right side of the sampling frame.

2 If it is not practicable to use the stopped-belt method, annex D or one of the schemes described in annex C may be used.

10.7 Check experiments (see ISO 3085 and ISO 3086)

During the period of continuous operation of the mechanical installation, check experiments for precision and bias should be conducted as necessary so that significant errors in the results caused by the installation may be detected. Maintenance and verification of the installation should be carried out at regular intervals, and at any time when modification is made or a change is detected.

10.8 Operation of system

10.8.1 A mechanical installation shall be operated according to the requirements of clauses 7 and 8.

10.8.2 To maintain good control, during the full period of sampling and sample preparation of a consignment, the sampling installation should be supervised at all times. In the case of a breakdown of the installation or failure of the system, provision should be made for the mechanical operation to be replaced immediately by a manual sampling procedure, within the framework of relevant methods included in ISO 3081 and ISO 3083.

NOTE — The samples taken by the manual method should be processed separately from the samples taken mechanically.

10.9 Emergency measures

10.9.1 In the case of breakdown of the installation or if it is inadvisable to use the installation on a particular ore (for example an excessively sticky ore), an alternative sampling procedure should be available.

For example increments taken by the primary sampler may be bypassed through a preinstalled facility (for example short conveyor, concrete pad or base with smooth working surface, receiving truck) so that sample preparation by manual method can proceed as described in ISO 3083. Samples, other than for moisture determination, may be prepared by the mechanical installation after drying.

10.9.2 It is recommended that the mechanical installation be arranged in such a way that the principal units can be operated individually. This would facilitate the rapid repair of the apparatus either in the case of a breakdown or of a unit malfunctioning within the mechanical installation.

10.10 Prevention of contamination of sample and avoiding bias

10.10.1 Each part of the apparatus with which the sample will be in contact shall be designed to avoid bias and in such a manner that the construction materials will not change the quality of the sample to be determined either chemically or physically.

10.10.2 In order to avoid bias in taking increments, the primary sampler should be checked during its operation to ascertain whether the following design criteria are realized:

- a) there shall not be any overflow or spillage of the sample material and loss of ultra-fine material;
- b) there shall not be any clogging in the primary sampler;
- c) there shall not be any impedance of the flow of the sample material through the primary sampler;
- d) the primary sampler shall be of the self-cleaning type and there shall be no retention of residual material in the sampler;
- e) there shall be no contamination or introduction of materials other than the sample into the primary sampler;
- f) there shall be no change of the quality of the sample while taking increments by the primary sampler, for example degradation of the constituent particles if the sample is taken for size determination or no moisture change if the sample is taken for moisture determination.

10.10.3 Care shall be taken not to affect the general quality of a consignment after sampling at loading and prior to sampling at discharge. If this cannot be followed, for example in the case of the introduction of water sprayed on a cargo for dust suppression, or where water is removed from a consignment, a correction procedure, to be decided by agreement between the interested parties, shall be applied.

10.11 Cleaning and maintenance

10.11.1 The system should be readily accessible at all levels to facilitate inspection, thorough cleaning, repairs or check experiments.

10.11.2 Upon the completion of operation of the installation for a consignment, the major units of the installation should be cleaned, either by applying fresh water or by the use of a dry and oil-free compressed air and vacuum system. In cases where fresh water has been used, the equipment should be thoroughly dried before further use.

When a change is made in the type of ore being sampled, a quantity of material taken from the consignment to be sampled should be passed through the entire installation in order to remove any possible contaminants.

11 Installation for mechanical systems

11.1 Primary samplers

11.1.1 Location of installation

The primary sampler, with which increments are to be taken, shall be installed at a point so that the entire consignment may be sampled.

The primary sampler should be installed at the nearest point to the loading or discharging facilities, preferably immediately before or immediately after the weighing device.

11.1.2 Types of primary sampler

There are several types of primary sampler varying in mode of movement and shape. The most widely accepted type is a primary sampler installed at a discharge end of the conveyor belt and constructed to cut a complete cross-section of the trajectory of the ore stream for an increment, by travelling through the ore stream at a uniform speed.

Examples of cutter-type primary samplers are shown diagrammatically in figure 6.

11.1.3 Movement of primary sampler

The increment should preferably be taken from a falling stream of ore. The leading and trailing edges of the primary sampler should clear the ore stream in one path and the primary sampler should cut a complete cross-section of the falling stream of ore either

- a) in a plane perpendicular to the stream;
- b) along an arc normal to the mean trajectory path of the stream.

11.1.4 Cutting aperture of primary sampler

The cutting aperture (dimension l_1 in figure 6) of the primary sampler shall be at least three times the maximum particle size.

However with certain ores (for example sticky ores), bridging and consequent bias may occur at the cutting aperture of three times the maximum particle size and greater. In these instances, the cutting aperture should be established without being bound by the above stipulation but considering the cutting speed, belt speed and condition of the ore so that bias may not be introduced when samples are taken.

Legend

l_1 Cutting aperture of primary sampler

→ Main ore flow

→ ○ Increment

→ ○ Travelling pass of primary sampler

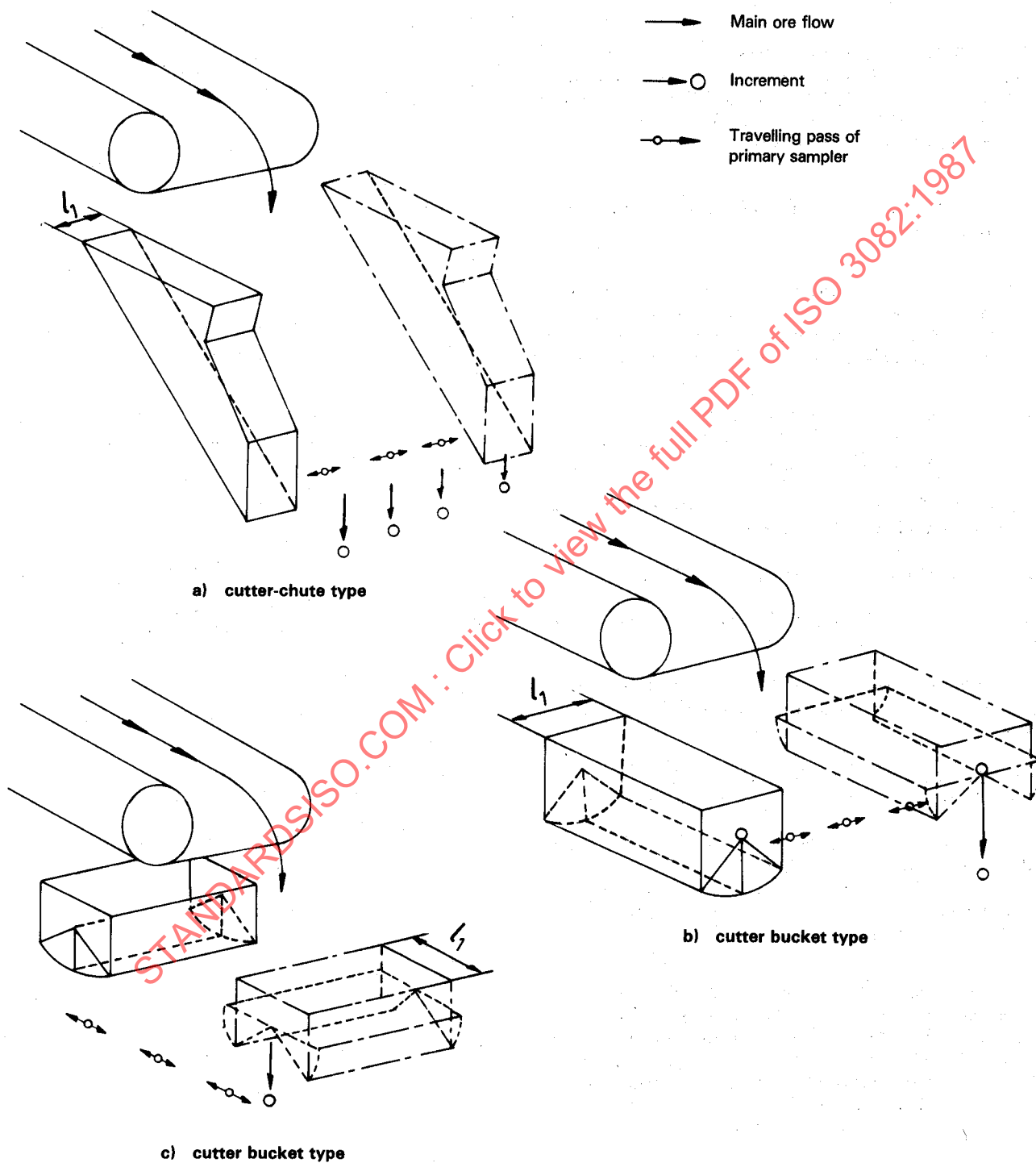


Figure 6 — Examples of diagrammatic illustration for cutter-type primary samplers

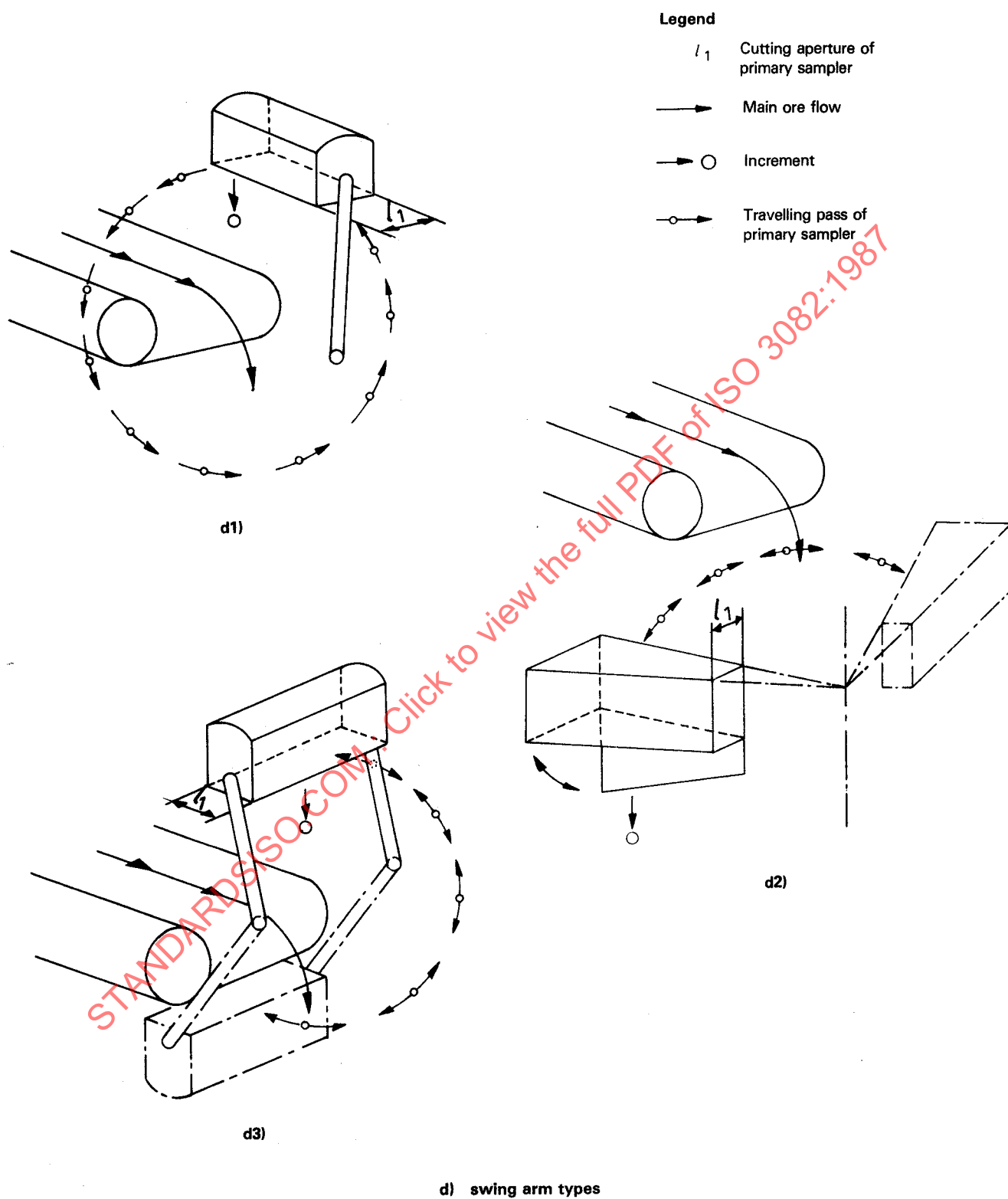


Figure 6 (continued) — Examples of diagrammatic illustration for cutter-type primary samplers

The geometric opening design of the primary sampler shall have parallel, radial or other pattern such that the cutting time of each point in the stream is equal, not deviating by more than $\pm 5\%$.

11.1.5 Dimensions of primary sampler

The dimensions of primary sampler should give a sufficient capacity in the bucket type and be non-restrictive in the cutter-chute type in order to accept the entire quantity of an increment without loss or overflow at the cutter speeds and ore flow rates used.

The primary sampler shall take, in one cycle, at least the mass of ore specified in table 2.

11.1.6 Cutting speed of primary sampler

For either of the two kinds of primary samplers mentioned in 7.1.5.5, the cutting device of a primary sampler should be designed to travel at a uniform speed, not deviating by more than $\pm 5\%$, during the course of taking each increment.

The cutting speed in relation to the speed of conveyor belt and flow rate of ore should be established so as not to introduce bias in the sample.

11.2 Equipment for sample preparation

11.2.1 Arrangement for sample preparation

11.2.1.1 The mechanical plant for sample preparation should be so designed as to carry out preparation of individual increments, individual subsamples or gross sample in accordance with the requirements given in clause 8.

11.2.1.2 The system for handling the primary increment, from the primary sampling station to that stage of the sample preparation system where size testing is undertaken, or where size and other physical test samples are taken, shall be carefully designed to avoid severe handling that could cause size degradation of the ore sample. The number of transfer points, and the height of fall at each transfer point, shall be kept to a minimum.

11.2.1.3 The installations for sampling and sample preparation may be either integrated or separated. In the case of an integrated layout, the installation for sample preparation should be capable of processing each increment within the given time which is practically shorter than the time between taking two consecutive increments for the same purpose.

11.2.1.4 The installation for sample preparation should be capable of crushing, grinding and pulverizing the sample to the desired particle size and then dividing the sample to the desired mass without bias.

11.2.1.5 The crushing and dividing equipment should be appropriately sealed to protect the samples from excessive air flow. The circulation of air through the equipment should also be reduced to a minimum in order to prevent loss of fine materials and moisture.

11.2.1.6 If it is difficult to include the equipment for grinding to minus 160 μm or minus 100 μm into the system of sample preparation, the grinding operation may be carried out separately.

11.2.1.7 A drier for the sample for chemical analysis may be installed, if necessary, at a point before the sample grinder after the moisture sample has been taken out.

11.2.2 Crushers

In order to obtain the desired whole-through sieve size of the sample at each stage of crushing, grinding or pulverizing, the equipment for these processes should be adjusted so that there will not be any oversize material remaining.

11.2.3 Dividers

The following are examples of dividers:

- a) cutter-chute type divider [the structure is the same as the primary sampler given in figure 6a)];
- b) slotted belt type divider [see figure 7a)];
- c) chain bucket type divider [see figure 7b)];
- d) rotary cutter chute type divider [see figure 7c)];
- e) rotary container type divider [see figure 7d)];
- f) rotary cone type divider [see figure 7e)];
- g) rotary plate type divider [see figure 7f)];
- h) mechanically charged riffle type divider [see figure 7g)];

A divider shall be used that is free from bias.

A cutter-type divider shall satisfy the conditions of 11.2.3.1 to 11.2.3.5.

11.2.3.1 In order to avoid bias, it is necessary to have a random start. The operation of the cutter should be interlocked with the operation of the feeder by way of a random timing process. The time range of operation of the random selector in the timing process should be adjusted to equal the computed cutting interval, so that there is equal probability of the first cut being taken at any point of time within the duration of the first interval. Special design precautions are required for the random timing process used for constant mass division. Since the cutting interval may be different for each increment or subsample to be divided, the time range of operation of the random selector in the timing process should be manually or automatically adjusted for each successive sample division, to match the computed cutting interval.

11.2.3.2 If the installation is such that the requirements of 11.2.3.1 cannot be met, then a considerably larger number of cuts than the specified minimum will be required to ensure that there is no bias.

11.2.3.3 It is recommended that a uniform feed be provided to the divider at each stage of division.

11.2.3.4 The cutting aperture of the divider shall be specified in 11.1.4.

11.2.3.5 The cutting speed shall be constant (refer to 11.1.2 to 11.1.6).

11.2.4 Driers

The installation may be equipped with a drier, for the purpose of carrying out subsequent preparation of the sample for chemical analysis without trouble.

If the moisture determination is intended to be made by dual use of a sample, the drier shall be installed at a point after the moisture sample has been taken.

The drying shall be conducted below the temperature where there is likely to be a change in quality.

When drying is applied to normal iron ores, it shall be conducted at 105 °C or less.

Care should be taken not to introduce bias in chemical composition, for example by loss of fines.

11.3 Example of flowsheet for installation

Variation of mechanical installations for sampling and sample preparation makes it impracticable to describe a standardized flowsheet for layout. The objective of this subclause is, therefore, to provide guidelines for constructing a new mechanical installation.

An example of flowsheet given in figure 8 illustrates the case for:

- mass-basis sampling;
- fixed-speed primary sampler;
- coefficient of variation of mass of increments $\geq 20\%$;
- constant-mass division of increment;
- separate preparation of size sample, moisture sample and sample for chemical analysis.

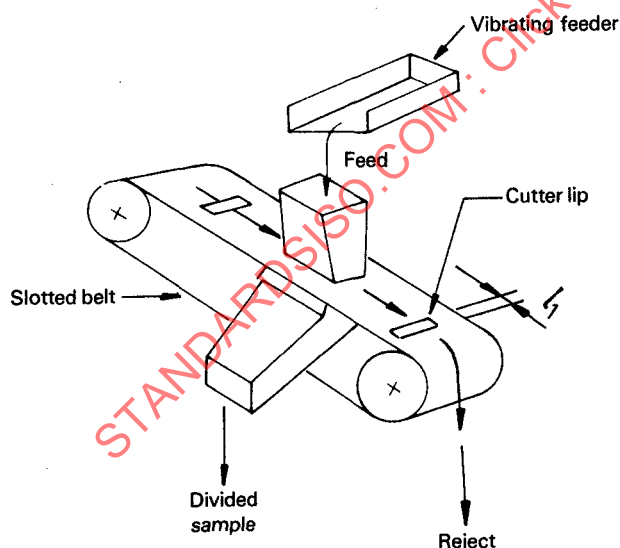


Figure 7a) — Example of slotted belt type divider

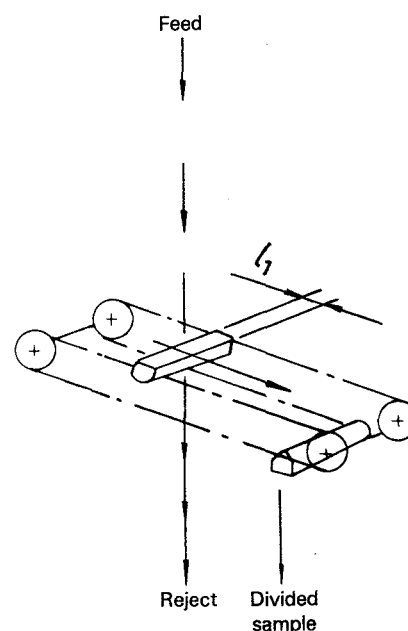


Figure 7b) — Example of chain bucket type divider

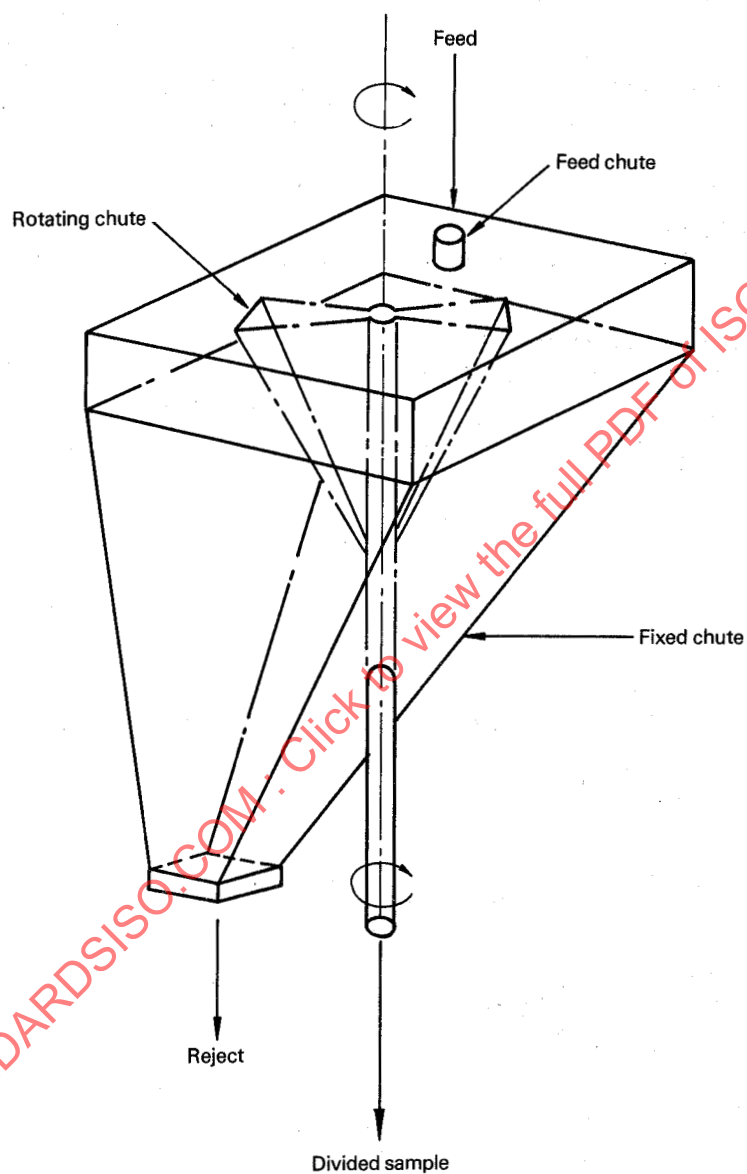


Figure 7c) — Example of rotary cutter-chute type divider

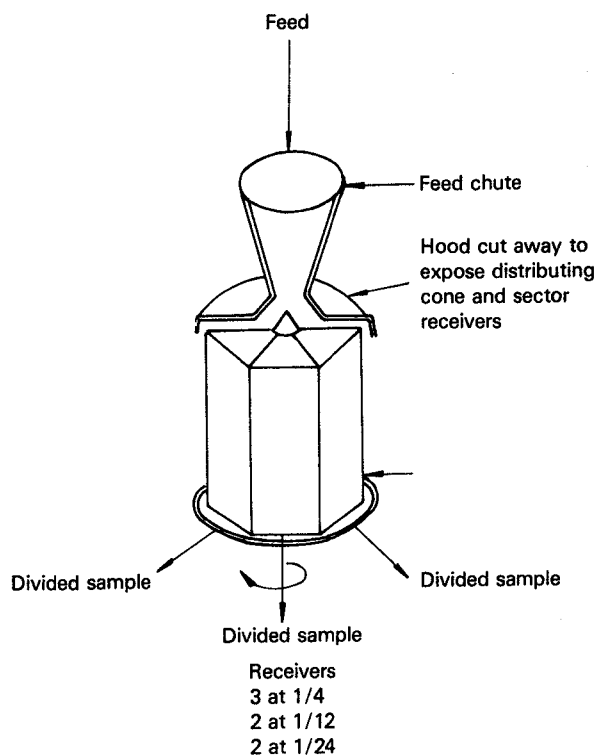


Figure 7d) — Example of rotary container type divider

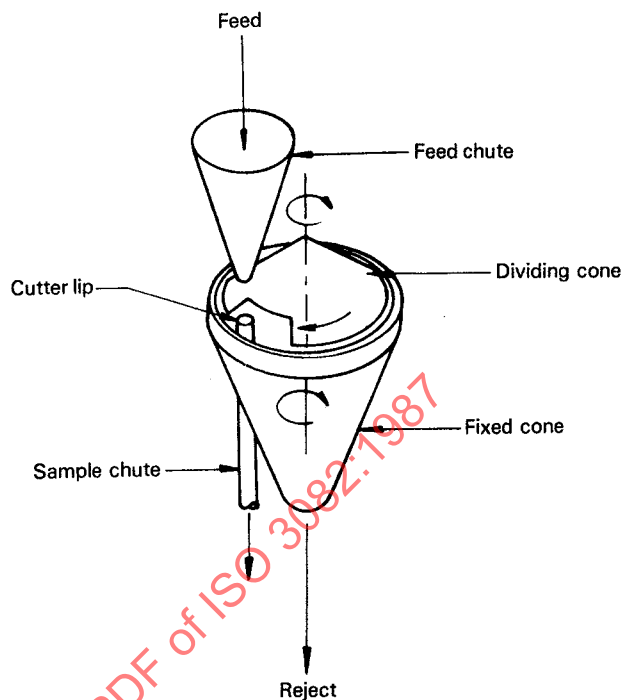


Figure 7e) — Example of rotary cone type divider

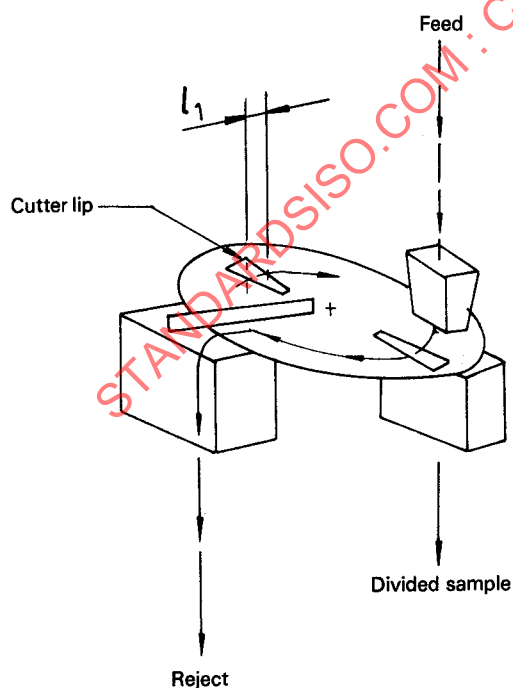


Figure 7f) — Example of rotary plate type divider

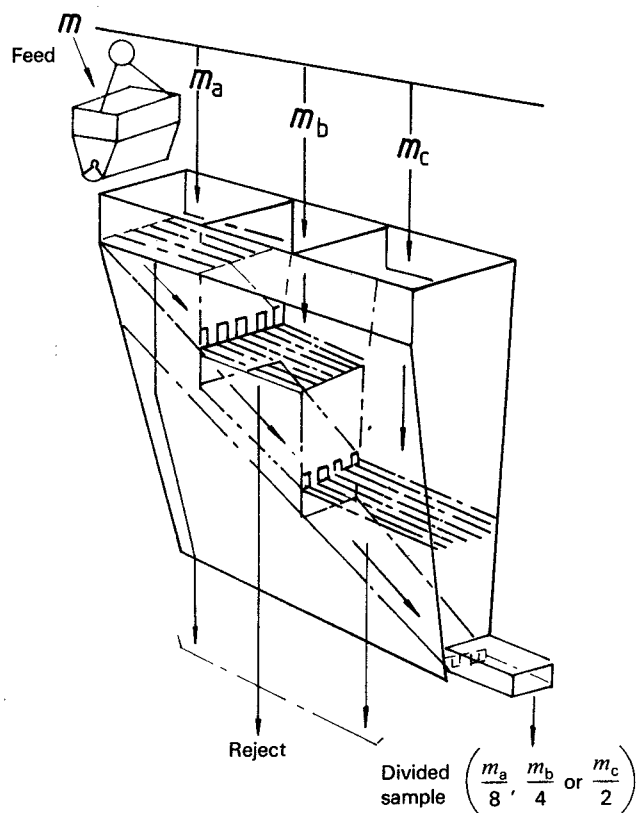


Figure 7g) — Example of mechanically charged riffle type divider

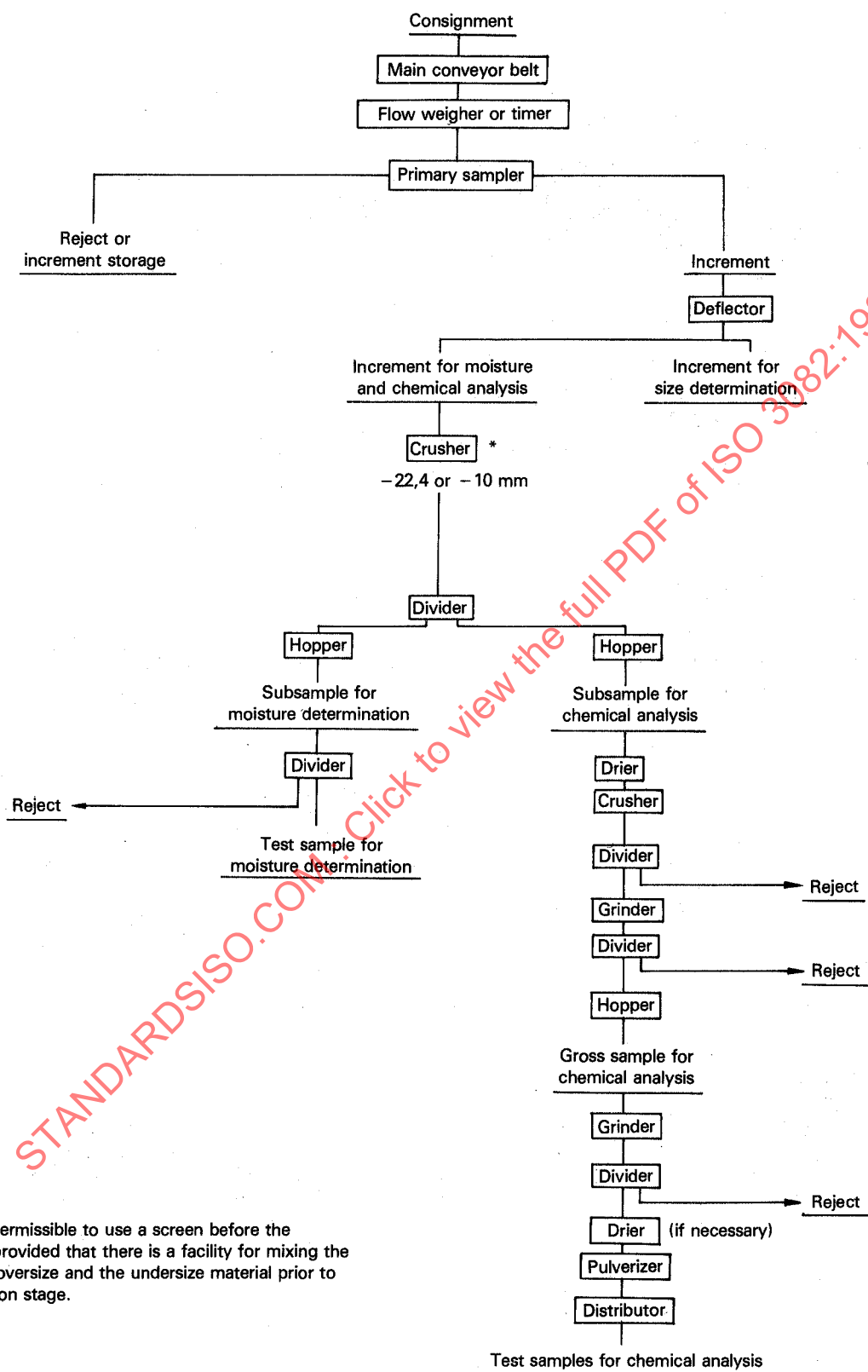


Figure 8 — Example of flowsheet for installation

Annex A

Equation for number of increments

(This annex forms an integral part of the standard.)

A.1 Symbols

n_1 is the minimum number of increments of a sample required to be taken from a consignment for the attainment of the desired 95 % probability precision of sampling

β is the precision at 95 % probability level (or two-sigma probability level) and is twice the standard deviation

β_D is the 95 % probability precision of sample division

β_M is the 95 % probability precision of measurement

β_S is the 95 % probability precision of sampling

β_{SDM} is the overall precision, i.e. aggregate 95 % probability precisions of sampling, sample division and measurement

σ is the precision in terms of standard deviation

σ_D is the precision of sample division

σ_M is the precision of measurement

σ_S is the precision of sampling

σ_w is the standard deviation within strata (or parts) applicable to the method of periodic systematic sampling.

A.2 Derivation

The number of increments, n_1 , to be taken from a single consignment specified in table 4 is derived from equation (A7), the theoretical basis of which is stratified sampling.

From the definition of overall precision at a 95 % probability level, the relationship may be expressed mathematically as follows:

$$\beta_{SDM} = 2\sigma_{SDM} \quad \dots (A1)$$

or

$$\sigma_{SDM} = \frac{\beta_{SDM}}{2} \quad \dots (A2)$$

where

$$\sigma_{SDM} = \sqrt{\sigma_S^2 + \sigma_D^2 + \sigma_M^2} \quad \dots (A3)$$

or

$$\sigma_S = \sqrt{\sigma_{SDM}^2 - \sigma_D^2 - \sigma_M^2} \quad \dots (A4)$$

NOTE — If the consignment has been divided into n_8 parts, each of an equal tonnage, a test sample has been prepared for each part thus created and n_7 determinations have been carried out on each test sample thus prepared to obtain the mean value of the quality characteristic for each part, the following equation should be used for determining the mean value of a quality characteristic of a consignment instead of equation (A3):

$$\sigma_{SDM} = \sqrt{\sigma_S^2 + (\sigma_D^2/n_8) + (\sigma_M^2/n_8n_7)}$$

Since the mass of the increment is much smaller than that of the stratum, the finite multiplier in the theoretical equation will become nearly one and the standard deviation of sampling for stratified sampling based on a sample of n_1 increments is as follows:

$$\sigma_S = \frac{\sigma_w}{\sqrt{n_1}} \quad \dots (A5)$$

therefore

$$\beta_S = 2\sigma_S = 2 \frac{\sigma_w}{\sqrt{n_1}} \quad \dots (A6)$$

or

$$n_1 = \left(\frac{2\sigma_w}{\beta_S} \right)^2 \quad \dots (A7)$$

The relation between β_{SDM} and β_S is as follows, from equations (A2), (A4) and (A6).

$$\beta_S = 2 \sqrt{\left(\frac{\beta_{SDM}}{2} \right)^2 - \sigma_D^2 - \sigma_M^2} \quad \dots (A8)$$

If it is not possible to estimate σ_D separately from σ_M , β_S is expressed as follows:

$$\beta_S = 2 \sqrt{\left(\frac{\beta_{SDM}}{2} \right)^2 - \sigma_{DM}^2} \quad \dots (A9)$$

NOTE — The values of σ_w shown in table 11 were used for the calculation of n_1 in table 4.

Table 11 — Value of σ_w

Values as absolute percentages

Quality characteristics			Classification of quality variation		
			Large	Medium	Small
Iron content			2,5	1,75	1,25
Moisture content			2,5	1,75	1,25
Size	— 200 mm ore	— 10 mm fraction mean 20%	12,5	8,75	6,25
	— 50 mm ore				
	— 31,5 + 6,3 mm ore	— 6,3 mm fraction mean 10 %	6,25	4,375	3,125
	Sinter feed	+ 6,3 mm fraction mean 10 %			
	Pellet feed	— 45 μ m fraction mean 70 %	3,75	2,625	1,875
	Pellets	— 5 mm fraction mean 5 %			

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Annex B

Procedure for determining the minimum mass of divided gross sample for size determination using other mechanical division methods (for example mechanical riffle divider)

(This annex forms an integral part of the standard.)

B.1 Scope and field of application

This annex specifies the procedure for determining the minimum mass of the divided size gross sample in other mechanical division methods (for example mechanical riffle divider) instead of the specification of 8.3.2.1 in the case of variations from tables 6 and 7 on the type of iron ore and specification size fraction.

B.2 Procedure

When the size gross sample is to be divided, the minimum mass, m_3 , in kilograms, of divided size gross sample may be determined from equation (B1)

$$m_3 = \frac{k}{\beta_{DM}^2} \times \frac{\rho}{5} \quad \dots (B1)$$

where

β_{DM} is the division precision, expressed as a percentage, shown in table 6;

ρ is the apparent density, expressed in tonnes per cubic metre, of a particle including closed pores within the particle;

k is a constant which is characteristic of the type of iron ore, the specification size fraction and percentage of the size fraction, and may be determined from equation (B2)

$$k = 2,5 \times 10^{-5} P(100 - P)d^3(l_2/d)^{0,5} \quad \dots (B2)$$

in which

P is the percentage of the size fraction;

d is the maximum particle size, in millimetres, in the gross sample to be divided;

l_2 is the specification sieve size in millimetres.

When each increment or each subsample is divided, the minimum mass, m_5 , in kilograms, of divided increment or subsample for size determination is given by equation (B3)

$$m_5 = \frac{m_3}{n_1} \quad \dots (B3)$$

where

m_3 is the minimum mass, in kilograms, of divided gross sample determined from equation (B1);

n_1 is the number of increments or subsamples to be divided.

The actual mass of divided increment or subsample should be determined in accordance with table 7 to avoid introduction of bias.

B.3 Examples of calculation of the minimum mass of divided size gross sample

B.3.1 Example 1

Type of iron ore	– 70 mm ore
Specification size fraction	– 10 mm
Percentage of the size fraction	20 %
Apparent density	4,5 t/m ³
Required β_{DM}	4,0 %

Problem: determine minimum mass of divided size gross sample, m_3

From equation (B2)

$$k = 2,5 \times 10^{-5} \times 20(100 - 20) \times (70)^3 \times \sqrt{10/70} = 5\,185,7$$

From equation (B1)

$$m_3 = \frac{5\,185,7}{(4,0)^2} \times \frac{4,5}{5} = 292 \text{ kg}$$

B.3.2 Example 2

Type of iron ore	sinter feed – 12,5 mm
Specification size fraction	+ 10 mm
Percentage of the size fraction	≤ 10 %
Apparent density	4,5 t/m ³
Required β_{DM}	1,6 %

Problem: determine minimum mass of divided size gross sample, m_3

From equation (B2)

$$k = 2,5 \times 10^{-5} \times 10(100 - 10) \times (12,5)^3 \times \sqrt{10,0/12,5} = 39,3$$

From equation (B1)

$$m_3 = \frac{39,3}{(1,6)^2} \times \frac{4,5}{5} = 13,8 \text{ kg}$$