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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

Reference number
ISO 3082 : 1987 (E)

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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Annexes

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.

$$\beta_{SDM} = 2\sigma_{SDM} \qquad \text{. . . (A1)}$$

$$\sigma_{SDM} = \sqrt{\sigma_S^2 + \sigma_D^2 + \sigma_M^2} \qquad \text{. . . (A3)}$$

$$\sigma_S = \frac{\sigma_w}{\sqrt{n_1}} \qquad \text{. . . (A5)}$$

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:

a) the sampling precision to be attained;

b) 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	$\leqslant$ 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, $\overline{m}$, 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

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

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, $\overline{m}$, will in the majority of cases be in excess of the minimum stated in table 2.

2 It is essential that $\overline{m}$ 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

$$n_1 = \left(\frac{2\sigma_W}{\beta_s}\right)^2 \qquad \text{. . . (A7)}$$

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			$\sigma_w \geqslant 2,0$	$2,0 > \sigma_w \geqslant 1,5$	$\sigma_w < 1,5$
Moisture content			$\sigma_w \geqslant 2,0$	$2,0 > \sigma_w \geqslant 1,5$	$\sigma_w < 1,5$
Size	−200 mm ore	−10 mm fraction, mean 20 %	$\sigma_w \geqslant 10$	$10 > \sigma_w \geqslant 7,5$	$\sigma_w < 7,5$
	−50 mm ore				
	−31,5+6,3 mm sized ore	−6,3 mm fraction, mean 10 %	$\sigma_w \geqslant 5$	$5 > \sigma_w \geqslant 3,75$	$\sigma_w < 3,75$
	Sinter feed	+6,3 mm fraction, mean 10 %			
	Pellet feed	−45 µm fraction, mean 70 %	$\sigma_w \geqslant 3$	$3 > \sigma_w \geqslant 2,25$	$\sigma_w < 2,25$
	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, $\overline{m}$, of the mass of the increments times 100

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

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:

a) control of the flow of ore on the conveyor belt ahead of the primary sampler;

b) 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;

c) installation of an apparatus which rejects the short-mass increment and re-starts the primary sampler;

d) 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

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

where

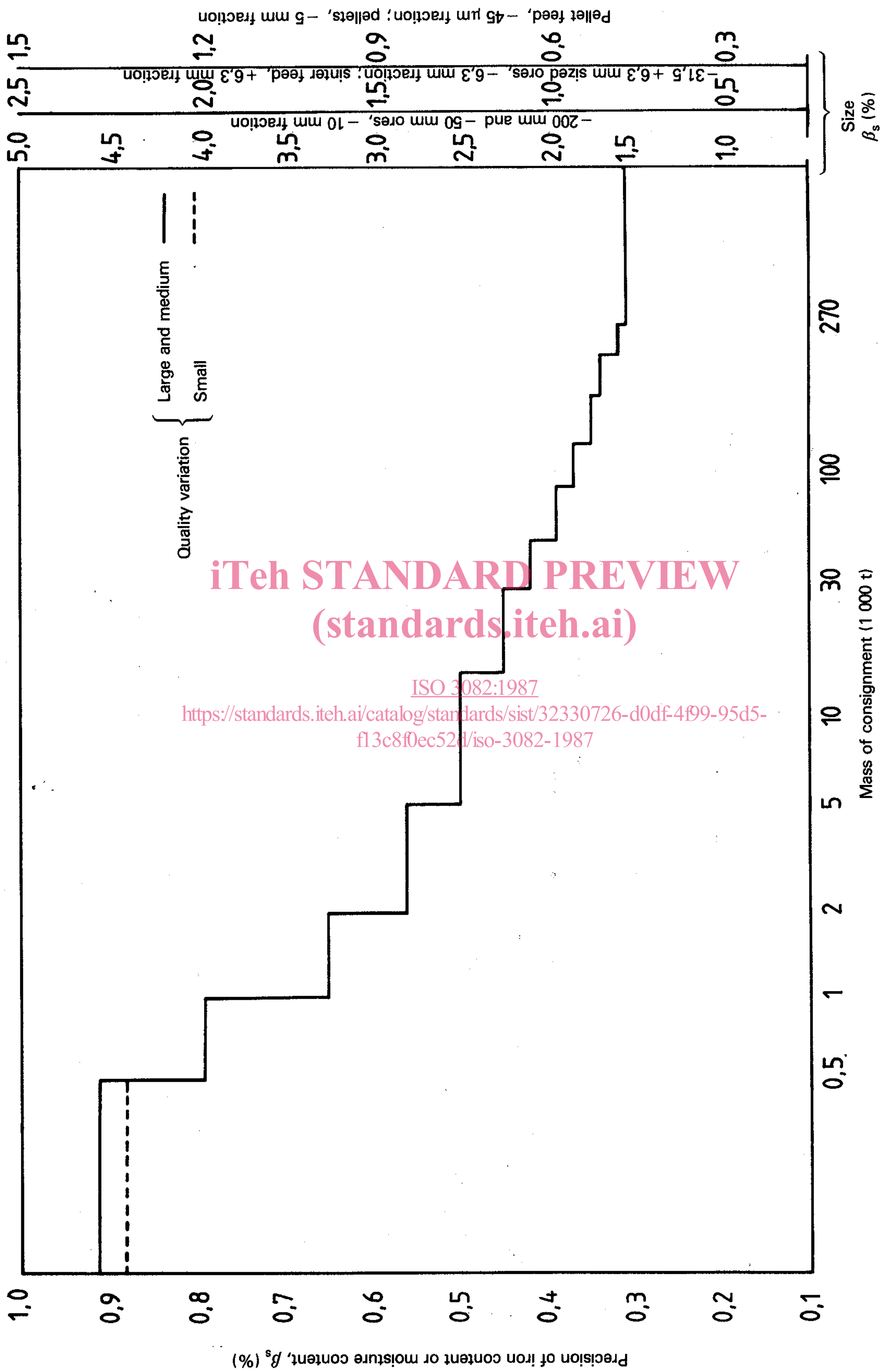
m_1 is the mass, in tonnes, of the consignment;

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

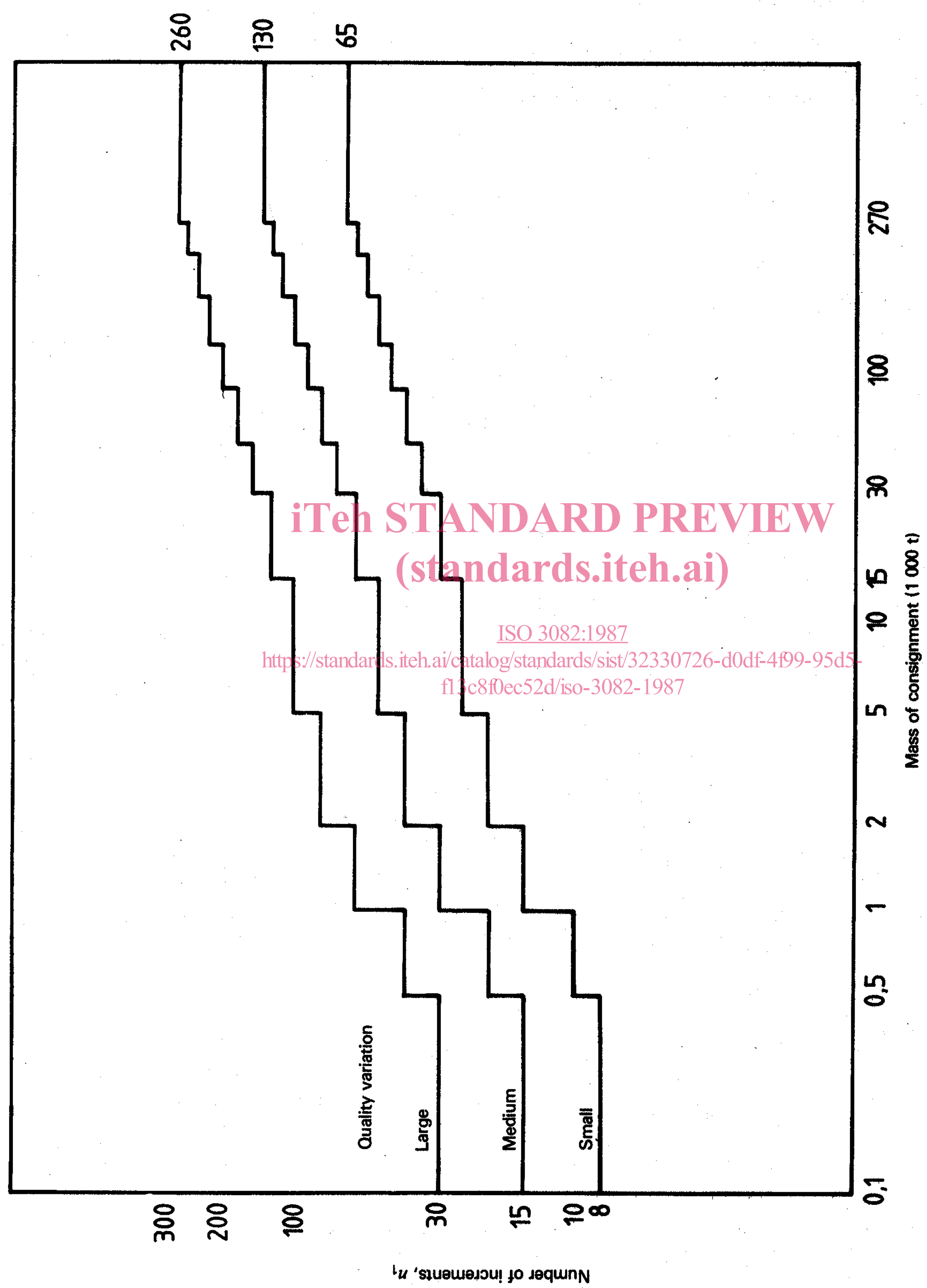
Mass of consignment (t)		Quality variation, σ_w												
		Large					Medium					Small				
			β_s %					β_s %					β_s %		
				Size					Size					Size	
Over	Up to and including	n_1	Iron content / Moisture content	−200 mm and −50 mm ores, −10 mm fraction	−31,5 +6,3 mm sized ores, −6,3 mm fraction Sinter feed, + 6,3 mm fraction	Pellet feed, −45 µm fraction Pellets, −5 mm fraction	n_1	Iron content / Moisture content	−200 mm and −50 mm ores, −10 mm fraction	−31,5 +6,3 mm sized ores, −6,3 mm fraction Sinter feed, + 6,3 mm fraction	Pellet feed, −45 µm fraction Pellets, −5 mm fraction	n_1	Iron content / Moisture content	−200 mm and −50 mm ores, −10 mm fraction	−31,5 +6,3 mm sized ores, −6,3 mm fraction Sinter feed, + 6,3 mm fraction	Pellet feed, −45 µm 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	1,55	0,77	0,47
210 000	270 000	240	0,32	1,61	0,80	0,48	120	0,32	1,61	0,80	0,48	60	0,32	1,61	0,80	0,48
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	1,69	0,84	0,51
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	1,77	0,88	0,53
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	1,86	0,92	0,56
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	1,98	0,98	0,59
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	2,11	1,05	0,63
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	2,28	1,13	0,68
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	2,50	1,24	0,75
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	2,80	1,39	0,84
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	3,23	1,60	0,97
500	1 000	40	0,79	3,96	1,96	1,19	20	0,79	3,96	1,96	1,19	10	0,79	3,96	1,96	1,19
	500	30	0,91	4,56	2,27	1,37	15	0,91	4,56	2,27	1,37	8	0,88	4,42	2,21	1,33

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

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

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.