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Manganese ores — Determination of moisture content

Minerais de manganèse — Détermination de l'humidité

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Manganese ores — Determination of moisture content

1 Scope

This International Standard specifies a method for determining the mean value of the moisture content of a consignment (lot) of manganese ores, whether natural or processed, including concentrates, pellets and agglomerates.

The method is intended to be applied at the places of dispatch and/or acceptance of the ore.

Annex A specifies a method to be used in the case of adhesive or wet manganese ores. Annex B specifies methods of correction for sprinkled water and/or rain-water.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

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

3 Definitions

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

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

3.2 test sample : A sample prepared for moisture determination from each increment, from each sub-sample, or from the gross sample, in accordance with the method specified for the moisture sample.

3.3 test portion : A representative part of a test sample subjected to moisture measurement.

If the entire quantity of a test sample is subjected to moisture measurement, the test sample may also be called "test portion".

4 Principle

Drying of the test portion in an oven at 105 °C and determination of the moisture content, as a percentage by mass, from the initial and dried masses.

5 Apparatus

5.1 Drying pans, made of stainless material (for example, stainless steel or brass), having a smooth surface, free from contamination and capable of accommodating the specified quantity of moisture sample in a layer of thickness less than 30 mm.

5.2 Drying oven, equipped with a temperature-controlling device capable of regulating the temperature at all points in the oven to within ±5 °C of the desired temperature.

5.3 Weighing device, accurate to at least 0,05 % of the initial mass of a sample.

6 Sampling and samples

Test samples which have been taken in accordance with ISO 4296-1 and prepared in accordance with ISO 4296-2 shall be used. The mass of a test portion in relation to its whole-through sieve size is specified in table 1.

Table 1 — Minimum mass of test portion

Whole-through sieve size of test portion (mm)	Minimum mass of test portion (kg)
22,4	5
10	1

7 Procedure

7.1 Number of moisture measurements

7.1.1 If one gross sample is obtained from the consignment, four test portions shall be prepared. Two of these shall be submitted for the determination of moisture content and the other two test portions shall be reserved as duplicates in case a check determination is required.

7.1.2 If sub-samples or increments from a consignment are not combined into one gross sample, one test portion shall be prepared from each sub-sample or increment and each of these shall be submitted for the determination of moisture content.

NOTE — Samples which have been sieved in water for size determination are not to be used for determination of moisture content.

7.2 Measurement

7.2.1 Weigh a drying pan (5.1) and record its mass.

7.2.2 Spread the test portion (6) to a thickness of less than 30 mm in the tared drying pan (5.1) and weigh. Record the total mass and the initial mass of the test portion.

7.2.3 Place the drying pan with the test portion in the drying oven (5.2) set at 105 °C and maintain at this temperature for not less than 4 h.

7.2.4 Remove the drying pan with the test portion from the oven and weigh immediately while still hot.

NOTE — The weighing device (5.3) should be protected from the effects of the hot material by a suitable heat-resisting material.

7.2.5 Replace the drying pan with the test portion in the drying oven, heat for a further 1 h, and repeat the weighing.

7.2.6 Repeat the procedure described in 7.2.5 until the difference in mass between subsequent measurements becomes 0,05 % or less of the initial mass of the test portion. If, after repeated drying, the mass increases, the mass measured before the last weighing shall be used.

7.2.7 The moisture content of adhesive or wet ores shall be determined by the method specified in annex A unless the mass of the sample is small, in which case the entire mass of the sample may be dried to determine the moisture content using the procedure described above.

8 Calculation and expression of results

8.1 Moisture content of each test portion

The moisture content, w_i, expressed as a percentage by mass, shall be calculated from equation (1) and reported to the second decimal place :

$$w_i = \frac{m_1 - m_2}{m_1} \times 100 \qquad \ldots (1)$$

where

m_1 is the initial mass, in grams, of the test portion;

m_2 is the mass, in grams, of the test portion after drying.

8.2 Moisture content of the consignment

The moisture content of the consignment, $\overline{w}$, expressed as a percentage by mass, shall be calculated from one of the equations (2) to (5), as appropriate, and reported to the second decimal place.

8.2.1 When the moisture determination is conducted on a gross sample from the consignment, the moisture content, as a percentage by mass, shall be calculated from the arithmetic mean of the two results obtained from the two test portions as given by the equation

$$\overline{w} = \frac{w_1 + w_2}{2} \qquad \ldots (2)$$

where

w_1 and w_2 are the moisture contents, as a percentage by mass, of test portions 1 and 2 respectively.

8.2.2 When the moisture determination is conducted on each sub-sample, the moisture content, as a percentage by mass, shall be calculated from the weighted mean of the results for all sub-samples considering the number of increments in each sub-sample as given by the equation

$$\overline{w} = \frac{\sum_{i=1}^{k} N_i w_i}{\sum_{i=1}^{k} N_i} \qquad \ldots (3)$$

where

k is the number of sub-samples;

N_i is the number of increments in the ith sub-sample;

w_i is the result of moisture determination, as a percentage by mass, of the ith sub-sample (test portion).

NOTE — If it is impracticable to sample the consignment as a whole or desirable to sample a consignment in separate parts of unequal mass as in the case of time-basis sampling, the moisture content of each part should be determined independently and the weighted mean of moisture content of the consignment calculated from the individual results as given by the equation

$$\overline{w} = \frac{\sum_{i=1}^{k} m_i w_i}{\sum_{i=1}^{k} m_i} \qquad \ldots (4)$$

where

k is the number of parts in the consignment;

m_i is the mass, in grams, of the ith part;

w_i is the result of moisture determination, as a percentage by mass, of the ith part.

8.2.3 When the moisture determination is conducted on each increment, the moisture content, as a percentage by mass, shall be calculated from the arithmetic mean of the results obtained as described in 8.2.1 for all the increments, as given by the equation

$$\bar{w} = \frac{\sum_{i=1}^{n} w_i}{n} \qquad \ldots (5)$$

where

n is the number of increments;

w_i is the result of moisture determination, as a percentage by mass, of the ith increment.

9 Precision

The following precision requirements relate to the precision in determining the values of moisture content in a moisture sample when moisture determinations are made in the same laboratory. The method is designed so as to obtain the values of precision, with 95 % probability, shown in table 2.

Table 2 — Precision and maximum permissible tolerances between results of duplicate determinations

Moisture content % (m/m)		Precision	Maximum permissible tolerance
>	<	(absolute %)	(absolute %)
—	5	±0,4	0,5
5	10	±0,5	0,7
10	15	±0,7	0,9
15	—	±0,8	1,1

If the values of precision and maximum tolerance obtained exceed those given in the table, the moisture determination shall be repeated.

When two duplicate determinations are carried out, the final results shall be obtained as shown in the flow chart (see figure 1).

10 Test report

The test report shall include the following information :

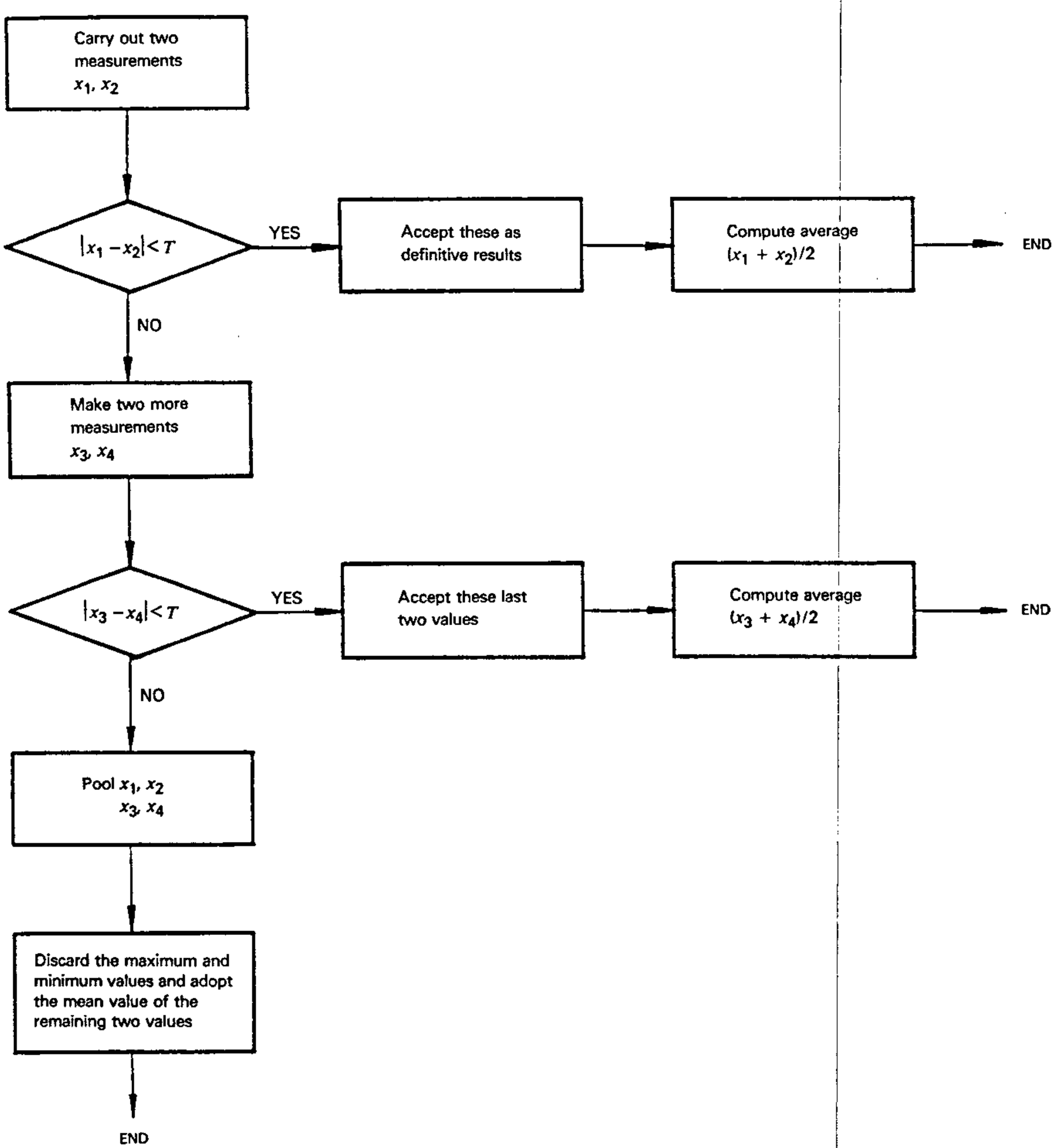
a) reference to this International Standard;

b) details necessary for the identification of the sample;

c) result of the test;

d) any characteristics noticed during the determination and any operations not specified in this International Standard which may have had an influence on the results.

Examples of suitable test reports are given in tables 3, 4 and 5.



NOTE — T is the maximum permissible tolerance given in table 2.

Figure 1 — Flow chart — Procedures for processing the results of moisture determinations

Table 3 — Example of a test report for values of moisture measurement on a test portion

Type and grade of manganese ore :				
Identity and quality of consignment :				
Sample No :	Minimum mass of sample : 5 kg	Particle size of sample : −22,4 mm		Date :
Total mass before drying (g)		(1)		6 021
Mass of drying pan (g)		(2)		896
Initial mass of sample (g)		$3 = (1) - (2)$		5 125
Value of 0,05 % of initial mass of sample (g)		$(4) = \frac{(3)}{2\,000}$		2,56
			mass	**difference***
Total mass after 4 h drying (g)		(5)	5 592	
Total mass after further 1 h drying (g)		(6)	5 583	$(5) - (6) = 9$
Total mass after another 1 h drying (g)		(7)	5 581	$(6) - (7) = 2$
Final loss on drying (g)		$(8) = (1) - (7)$		440
Moisture content, w_i (%)		$(9) = \frac{(8)}{(3)} \times 100$		8,59
Remarks :				
Assayer :				

* The difference (5) − (6) was 9 g and exceeded (4); so another 1 h drying was conducted. The difference (6) − (7) became 2 g and was less than (4). Therefore, the drying of this sample was terminated.

Table 4 — Example of a test report for determination of the moisture content of a gross sample (Duplicate determinations)

Type and grade of manganese ore :						
Identity and quality of consignment :						
Sample No. :	Minimum mass of sample : 1 kg	Particle size of sample : −10 mm				Date :
Total mass before drying (g)		(1)	1 228,4			1 220,9
Mass of drying pan (g)		(2)	204,1			196,0
Initial mass of sample (g)		$(3) = (1) - (2)$	1 024,3			1 024,9
Value of 0,05 % of initial mass of sample (g)		$(4) = \frac{(3)}{2\,000}$	0,51			0,51
			mass	**difference**	**mass**	**difference**
Total mass after 4 h drying (g)		(5)	1 169,6		1 167,0	
Total mass after further 1 h drying (g)		(6)	1 161,9	$(5) - (6) = 7,7$	1 158,6	$(5) - (6) = 8,4$
Total mass after another 1 h drying (g)		(7)	1 161,7	$(6) - (7) = 0,2$	1 158,3	$(6) - (7) = 0,3$
Final loss on drying (g)		$(8) = (1) - (7)$	66,7		62,6	
Moisture content of each sample (%)		$(9) = \frac{(8)}{(3)} \times 100$	6,51		6,11	
Difference between two determinations (%)			0,4			
Maximum permissible tolerance (%)			0,7			
Moisture content (%)			6,31			
Remarks :						
Assayer :						

Table 5 — Example of a test report for determination of the moisture content of a consignment

Sample No. :					Minimum mass of sample : 1 kg			Particle size of sample : – 10 mm	
Date :		Type and grade of manganese ores :			Name of consignment :			Assayer :	
Sub-sample No.	(1) No. of increments	(2) Total mass before drying (g)	(3) Total mass after drying (g)	(4) Mass of drying pan (g)	(5) Initial mass of sample (g)	(6) Mass of dried sample (g)	(7) Loss on drying (g)	(8) Moisture content (w_i) (%)	(9) (1) × (8)
1	6	1 344,8	1 306,1	236,1	1 108,7	1 070,0	38,7	3,49	20,94
2	6	1 369,3	1 340,4	270,0	1 099,3	1 070,4	28,9	2,62	15,72
3	6	1 335,5	1 299,4	253,0	1 082,5	1 046,4	36,1	3,33	19,98
4	5	1 395,8	1 356,5	249,3	1 146,5	1 107,2	39,3	3,43	17,15
5	5	1 387,4	1 359,4	264,6	1 122,8	1 094,8	28,0	2,49	12,45
Total	28	Moisture content $(\bar{w})$ (%) $= \frac{\Sigma\,(9)}{\Sigma\,(1)} = \frac{86{,}24}{28} = 3{,}08$							86,24
Final result : 3,08 %									

Annex A
(normative)

Determination of moisture content of wet manganese ores

If the sample is difficult to sieve, crush and divide owing to it being adhesive or excessively wet, it should be pre-dried until preparation can be conducted satisfactorily. In this case the moisture content shall be obtained by using the pre-drying method described below.

A.1 Determine the initial mass of the test sample.

A.2 Spread the test sample in a uniform thickness and dry it by air-drying or in a drying apparatus at a temperature no higher than 105 °C. The choice of temperature and time for this pre-drying stage shall not exceed a point where an ore is likely to re-absorb moisture during subsequent processing.

A.3 After drying, again determine the mass of the test sample.

A.4 Calculate the pre-dried moisture content, w_p, as a percentage by mass, using the equation

$$w_p = \frac{m'_1 - m'_2}{m'_1} \times 100 \qquad \ldots (6)$$

where

m'_1 is the initial mass, in grams, of the test sample;

m'_2 is the mass, in grams, of the test sample after pre-drying.

A.5 Record the pre-dried moisture content to the second decimal place.

A.6 Prepare the test portions for moisture measurement from the pre-dried sample according to clause 6.

A.7 Determine the loss of mass on drying of the test portion by the method specified in clause 7 and calculate the additional moisture content as a percentage by mass, according to 8.1.

A.8 Calculate the total (as received) moisture content, w_{pd}, as a percentage by mass, using the equation

$$w_{pd} = w_p + \frac{100 - w_p}{100} \times w_d \qquad \ldots (7)$$

where w_d is the additional moisture content obtained according to 8.1 after pre-drying, as a percentage by mass.

NOTE — Take care in handling the sample and weighing the initial mass and pre-dried mass of the sample in order to ensure the measurement precision of the pre-dried moisture content.

A.9 Calculate the moisture content as a percentage by mass of the consignment according to 8.2.

Annex B
(normative)

Correction for sprinkled water and/or rain-water

B.0 Introduction

Nowadays, in many countries, strict environmental regulations must be observed in the handling of ores. When water is sprinkled over an ore during loading and/or unloading operations to prevent dust evolution, the moisture content of a consignment shall be corrected, according to the procedure specified in this annex, for the mass of water sprinkled.

This annex also describes a method for correcting the moisture content of a consignment exposed to rainwater.

B.1 General

B.1.1 Water may be sprinkled for the following reasons :

a) where environmental regulations at loading and/or unloading ports require dust control, or

b) where difficulty of handling ores due to the characteristics of the ore, weather conditions, handling equipment, etc., make the presence of additional water beneficial.

B.1.2 Correction for rain-water is made when it significantly affects the moisture content of the consignment. The level at which such a correction is made may be agreed between the parties concerned.

B.2 Correction for sprinkled water

B.2.1 Sprinkled water

Sprinkled water refers to water added between the time of moisture determination and tonnage determination.

B.2.2 Measurement of mass of sprinkled water

The measurement of the sprinkled water should be made with a meter with an accuracy of ± 5 %. The volume obtained should be converted to a mass, m_3, in tonnes by multiplying the value obtained by the density of the water sprinkled.

NOTE — Fresh water is assumed to have a density of 1 t/m^3.

B.2.3 Mass of consignment

The mass of the consignment, m_4, in tonnes, shall be determined by calculation of the difference between the initial and final draft survey tonnage.

B.2.4 Calculation of moisture content corrected for sprinkled water during unloading operations, prior to taking moisture samples

The moisture content, w_s, expressed as a percentage by mass, corrected for sprinkled water, is given by equation (8) and reported to the first decimal place

$$w_s = \bar{w} - (100 - \bar{w}) \frac{m_3}{m_4} \times f \qquad \ldots (8)$$

where

$\bar{w}$ is the mean value of the moisture content, as a percentage by mass, as determined in 8.2;

m_3 is the mass, in tonnes, of sprinkled water;

m_4 is the mass, in tonnes, of the consignment;

f is the factor to correct for water lost during sprinkling. The value of f is decided by commercial agreement between the parties concerned.

B.2.5 Calculation of moisture content corrected for sprinkled water during loading operations, after taking moisture samples

The moisture content, w_s, expressed as a percentage by mass, corrected for sprinkled water, is given by equation (9) and reported to the first decimal place

$$w_s = \bar{w} + (100 - \bar{w}) \frac{m_3}{m_4} \times f \qquad \ldots (9)$$

where $\bar{w}$, m_3, m_4 and f are as previously defined.

B.3 Corrections for rain-water

B.3.1 Rain-water

The moisture content of the consignment shall be determined from the as-tested moisture content by allowing for the influx of rain-water into the vessel's hold(s) and/or on the handling equipment during both loading and unloading operations.

B.3.2 Effective area exposed to rainfall

The effective area exposed to rainfall shall be calculated by adding up the areas specified in B.3.2.1 to B.3.2.3, rounded to the nearest square metre.

B.3.2.1 Hold(s)

The open area, in square metres, of the hold(s) through which the consignment is exposed to the rain, shall be calculated on the basis of the drawings provided on board the carrying vessel.

B.3.2.2 Surge hopper(s)

The open area, in square metres, of the hopper(s) used for handling the consignment and which are exposed to the rain, shall be calculated on the basis of drawings of the hopper(s).

B.3.2.3 Belt conveyor(s)

The open area, in square metres, of the belt conveyor(s) shall be calculated by multiplying the effective belt width by the length exposed to the rain during transportation of the consignment between the vessel and the point where moisture samples are taken.

B.3.3 Duration of rainfall

The duration of rainfall shall be determined from the time of the initial draft survey to completion of sampling.

B.3.4 Method for determination of rain-water

The rain-water shall be determined by means of an approved rain-water gauge placed close to the loading or unloading point. The rain-water shall be measured in millimetres.

B.3.5 Mass of rain-water

The mass of rain-water, m_R, in tonnes, is given by equation (10), rounded to the nearest tonne :

$$m_R = \frac{ARQ}{1\,000} \qquad \ldots (10)$$

where

A is the area, in square metres, calculated in B.3.2;

R is the rain-water, in millimetres, obtained in B.3.4;

Q is the density, in tonnes per cubic metre, of the rain-water, (usually $Q = 1$ t/m3).

B.3.6 Calculation of moisture content corrected for rain-water during unloading operations, prior to taking moisture samples

When a consignment is partially or totally exposed to the rain prior to taking moisture samples, the moisture content of the consignment, w_R, expressed as a percentage by mass, corrected for rain-water, is given by equation (11) and reported to the first decimal place

$$w_R = \overline{w} - (100 - \overline{w}) \times \frac{m_R}{m_4} \qquad \ldots (11)$$

where

$\overline{w}$ is the mean value of the moisture content of the consignment, as a percentage by mass, determined in clause 8.2;

m_R is the mass, in tonnes, of rain-water;

m_4 is the mass, in tonnes, of the consignment.

B.3.7 Calculation of moisture content corrected for rain-water during loading operations, after taking moisture samples

When a consignment is partially or totally exposed to the rain after taking moisture samples, the moisture content of the consigment, w_R, expressed as a percentage by mass, corrected for rain-water, is given by equation (12) and reported to the first decimal place

$$w_R = \overline{w} + (100 - \overline{w}) \times \frac{m_R}{m_4} \qquad \ldots (12)$$

where $\overline{w}$, m_R and m_4 are as previously defined.

B.4 Corrections for both sprinkled water and rain-water during unloading operations, prior to taking moisture samples

The corrected moisture content, w_o, expressed as a percentage by mass, of a consignment which has been exposed to both sprinkled water and rain-water prior to taking moisture samples is given by equation (13) and reported to the first decimal place

$$w_o = \overline{w} - (100 - \overline{w}) \left(\frac{m_3 f + m_R}{m_4} \right) \qquad \ldots (13)$$

where f, m_3, m_4, m_R and $\overline{w}$ are as previously defined.

B.5 Corrections for both sprinkled water and rain-water during loading operations, after taking moisture samples

The corrected moisture content, w_o, expressed as a percentage by mass, of a consignment exposed to both sprinkled water and rain-water after taking moisture samples is given by equation (14) and reported to the first decimal place

$$w_o = \overline{w} + (100 - \overline{w}) \left(\frac{m_3 f + m_R}{m_4} \right) \qquad \ldots (14)$$

where f, m_3, m_4, m_R and $\overline{w}$ are as previously defined.

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