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Iron ores — Experimental methods for checking the bias of sampling

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

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It has been approved by the Member Bodies of the following countries :

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Austria	Italy	Sweden
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Germany

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Iron ores — Experimental methods for checking the bias of sampling

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the experimental methods for checking the bias of the sampling of iron ores being carried out in accordance with the methods prescribed in ISO 3081 and ISO 3082.

NOTE — These methods may also be applied for checking the bias of sample preparation being carried out in accordance with the methods prescribed in ISO 3083.

2 REFERENCES

This document should be read in conjunction with the following International Standards :

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

ISO 3082, *Iron ores — Increment sampling — Mechanical method.*[1]

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

ISO 3084, *Iron ores — Experimental methods for evaluation of quality variation.*[2]

ISO 3085, *Iron ores — Experimental methods for checking the precision of sampling.*[2]

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

ISO ..., *Iron ores — Determination of size distribution by sieving.*[1]

3 GENERAL CONDITIONS

3.1 In the experimental methods, the results obtained from the method to be checked (referred to as Method B) are compared with the results of a reference method (referred to as Method A) which is considered to produce practically unbiased results, from technical and empirical viewpoints.

3.2 In the event that there is no significant difference in a statistical sense between the results obtained from Method B and Method A, then Method B may be adopted as a routine method, provided that agreement is arrived at between the parties concerned.

NOTES

1 The unbiased result means the value which does not depart from the true value with a statistically significant difference. In the statistical test for significance of difference used in this International Standard, a 5 % level of significance is taken.

2 If, even though the difference is statistically significant, it is regarded as being negligibly small from a practical standpoint, Method B may be adopted as a routine method, provided that the parties concerned agree.

3 When the difference is statistically not significant but is regarded as being so large as not to be negligible from a practical standpoint upon the investigation of the parties concerned, it is required that further experiments be carried out.

3.3 The number of consignments, or lots, on which the differences are based shall be more than 20; however, if this is impracticable, at least 10 consignments or lots shall be covered.

3.4 Quality characteristics may be iron content, moisture content, or particle size distribution (%), as the case may be.

3.5 The method for analysis of experimental data may be applied for checking a difference in the results obtained from samples of one consignment collected at different places, for example a loading point and a discharging point.

4 EXPERIMENTAL METHODS

4.1 The reference method (Method A) for checking the bias of sampling is the stopped-belt method. Any other method shall be checked against this reference method on the same material.

1) In preparation.

2) At present at the stage of draft.

Some of the methods of taking increments for the experiments are given below.

Example 1 — Sampling on conveyors (see 6.2.2 of ISO 3081).

Method A : Take each increment from the stopped conveyor at a specified place for the full width and thickness of the ore stream with the required length. See 6.2.2 (2) of ISO 3081.

NOTE — In order to apply this method it is essential to have the facility of a length of operable conveyor belt.

Method B : Take each increment from a point selected at random each time within the ore stream. See note 2 under 6.2.2 of ISO 3081.

Example 2 — Mechanical sampling (see ISO 3082).

Method A : Take each increment according to Method A of Example 1.

Method B : Take each increment from the moving conveyor by a mechanical sampler.

Example 3 — Sampling from wagons (see 6.3.4 of ISO 3081).

Method A : Take each increment according to Method A of Example 1.

Method B :

1) Take each increment with a sampling probe or boring sampler from the top surface of the ore loaded on a wagon. See 6.3.4 (3) of ISO 3081.

2) Take each increment at random from the new surface of the ore exposed during loading onto or discharging from a wagon. See 6.3.4 (1) of ISO 3081.

Example 4 — Sampling from ships (see B.1 in annex B of ISO 3081).

Method A : Take each increment according to Method A of Example 1.

Method B : Take each increment according to the procedure given in B.1 in annex B of ISO 3081.

4.2 Methods for constituting a pair of gross samples, preparation of samples and testing shall be as given below.

1) Increments obtained from one consignment in accordance with Method A and Method B are grouped respectively, so as to constitute a pair of gross samples A and B.

2) The gross samples A and B are subjected to sample preparation and testing separately, and a pair of measurements obtained.

3) The above procedure is performed on 20 or more consignments or lots (see 3.3).

NOTE — When increments for Method A and Method B can be taken from adjacent portions of the ore, it is recommended that sample preparation and testing be carried out on each increment individually. Thus the comparison can profitably be made on 20 or more individual pairs of measurements to check the bias of the sampling. The above comparison of the measurements is not necessarily restricted to the same consignment. However, it is not permitted to combine a number of paired results, originating from both increments and gross samples. It shall be either a number of pairs from increments or from gross samples.

5 ANALYSIS OF EXPERIMENTAL DATA

The method of analysis of experimental data shall be as given below.

1) Denote individual measurements obtained in accordance with Method A and Method B by x_{Ai}, x_{Bi}, respectively.

2) Calculate the difference between x_{Ai} and x_{Bi} by the following equation :

$$d_i = x_{Bi} - x_{Ai} \quad i = 1,2, ..., k \qquad \ldots (1)$$

where k is the number of individual measurements.

3) Calculate the mean of the differences to one decimal place further than that used in the measurements themselves :

$$\bar{d} = \frac{1}{k}\Sigma d_i \qquad \ldots (2)$$

4) Calculate the sum of the squares and the standard deviation of the difference :

$$S_d = \Sigma d_i^2 - \frac{1}{k}(\Sigma d_i)^2 \qquad \ldots (3)$$

$$s_d = \sqrt{S_d/(k-1)} \qquad \ldots (4)$$

5) Calculate the value of t_o to the third decimal place by rounding off the fourth decimal place :

$$t_o = \frac{\bar{d}}{s_d/\sqrt{k}} \qquad \ldots (5)$$

6) When the absolute value of t_o is smaller than the value of t corresponding to k as given in table 1, conclude that the difference is not significant in a statistical sense.

TABLE 1 — **Value of *t* at 5 % level of significance**

k	10	11	12	13	14	15
t	2,262	2,228	2,201	2,179	2,160	2,145
k	16	17	18	19	20	30
t	2,131	2,120	2,110	2,101	2,093	2,045

where k = (degrees of freedom) + 1.

Source : R.A. Fisher and Frank Yates, *Statistical Tables for Biological, Agricultural and Medical Research,* 4th Ed. (1953).

NOTE — This procedure is the statistical test for significance of difference by the method of *t*-test on paired data.

6 EXAMPLES OF EXPERIMENT

6.1 The numerical example shown in table 2 is the results of experiment on a mechanical sampler carried out in accordance with Example 2 given in 4.1.

TABLE 2 — **Numerical example 1**

Consignment No.	Name of iron ore	% Fe			
		x_{Bi}	x_{Ai}	$d_i = x_{Bi} - x_{Ai}$	d_i^2
1	F	59,20	59,00	0,20	0,040 0
2	E	59,75	59,67	0,08	0,006 4
3	C	62,00	61,74	0,26	0,067 6
4	B	62,62	63,16	− 0,54	0,291 6
5	B	62,96	63,26	− 0,30	0,090 0
6	E	60,02	59,92	0,10	0,010 0
7	B	63,17	63,11	0,06	0,003 6
8	A	63,91	63,87	0,04	0,001 6
9	E	59,98	60,42	− 0,44	0,193 6
10	D	61,21	61,13	0,08	0,006 4
11	D	61,26	61,30	− 0,04	0,001 6
12	E	58,98	59,22	− 0,24	0,057 6
13	F	58,95	59,09	− 0,14	0,019 6
14	C	61,97	61,89	0,08	0,006 4
15	F	59,36	58,88	0,48	0,230 4
16	A	63,74	64,24	− 0,50	0,250 0
17	B	62,74	63,14	− 0,40	0,160 0
18	E	60,47	60,33	0,14	0,019 6
19	B	62,55	63,03	− 0,48	0,230 4
20	A	63,80	63,94	− 0,14	0,019 6
			Sum	− 1,70	1,706 0

(t-test)

$$\bar{d} = \frac{1}{k}\Sigma d_i = -1,70/20 = -0,085$$

$$S_d = \Sigma d_i^2 - \frac{1}{k}(\Sigma d_i)^2 = 1,7060 - \frac{(-1,70)^2}{20} = 1,5615$$

$$s_d = \sqrt{S_d/(k-1)} = \sqrt{1,5615/19} = 0,2867$$

$$t_o = \frac{\bar{d}}{s_d/\sqrt{k}} = \frac{-0,085}{0,287/\sqrt{20}} = -1,3242$$

$t = 2,093$ for $k = 20$ from table 1.

$$|t_o| < t$$

Therefore, the difference, $\bar{d} = -0,085$, is not significant at 5 % level and is very small. Method B could then be adopted as a routine method.

6.2 The other numerical example shown in table 3 is the results of experiment for effects of particle size and mass of test samples upon moisture content. In this experiment, minus 10 mm – 1 kg samples (Method B) were compared with minus 20 mm – 5 kg samples (Method A).

TABLE 3 — **Numerical example 2**

Consignment No.	Name of iron ore	% Moisture			
		x_{Bi}	x_{Ai}	$d_i = x_{Bi} - x_{Ai}$	d_i^2
1	A	2,64	2,99	− 0,35	0,122 5
2	B	1,47	1,60	− 0,13	0,016 9
3	C	2,35	2,27	0,08	0,006 4
4	D	2,70	2,75	− 0,05	0,002 5
5	E	0,64	0,59	0,05	0,002 5
6	F	1,78	1,63	0,15	0,022 5
7	C	0,55	0,91	−0,36	0,129 6
8	G	3,92	4,29	− 0,37	0,136 9
9	H	4,75	4,85	− 0,10	0,010 0
10	A	4,09	4,36	− 0,27	0,072 9
11	A	3,73	3,38	0,35	0,122 5
12	I	4,93	4,83	0,10	0,010 0
13	I	5,37	5,68	− 0,31	0,096 1
14	J	7,09	7,27	− 0,18	0,032 4
15	K	6,94	7,02	− 0,08	0,006 4
16	L	8,24	7,54	0,70	0,490 0
17	M	8,11	7,62	0,49	0,240 1
18	N	0,36	0,46	− 0,10	0,010 0
19	O	1,80	2,07	− 0,27	0,072 9
20	P	7,14	7,06	0,08	0,006 4
			Sum	− 0,57	1,609 5

(t-test)

$$\bar{d} = \frac{1}{k}\Sigma d_i = -0,57/20 = -0,028$$

$$S_d = \Sigma d_i^2 - \frac{1}{k}(\Sigma d_i)^2 = 1,6095 - \frac{(-0,57)^2}{20} = 1,5933$$

$$s_d = \sqrt{S_d/(k-1)} = \sqrt{1,5933/19} = 0,290$$

$$t_o = \frac{\bar{d}}{s_d/\sqrt{k}} = \frac{-0,028}{0,290/\sqrt{20}} = -0,4318$$

$t = 2,093$ for $k = 20$ from table 1.

$$|t_o| < t$$

Therefore, the difference, $\bar{d} = -0,028$ is not significant at 5 % level and is negligibly small. Method B could then be adopted as a routine method.