BRITISH STANDARD

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Hard coal and coke — Guidance to the inspection of mechanical sampling systems

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British Standards

National foreword

This British Standard is the UK implementation of ISO 21398:2007.

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Hard coal and coke — Guidance to the inspection of mechanical sampling systems

Houille et coke — Lignes directrices pour l'inspection des systèmes d'échantillonnage 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21398 was prepared by Technical Committee ISO/TC 27, *Solid mineral fuels*, Subcommittee SC 4, *Sampling*.

Introduction

The objective of this International Standard is to provide users of new and existing mechanical sampling systems for minerals with guidance on their operation and inspection.

An ‘informative’ annex is for information and guidance only.

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Hard coal and coke — Guidance to the inspection of mechanical sampling systems

1 Scope

This International Standard sets out recommended practices for the inspection of mechanical sampling systems. It serves as a reference for conformance with applicable ISO/TC 27 International Standards.

This International Standard covers general considerations including precision, mineral variability and bias, establishment of inspection systems and inspection procedure.

2 Normatives references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13909-1, *Hard coal and coke — Mechanical sampling — Part 1: General introduction*

ISO 13909-2:2001, *Hard coal and coke — Mechanical sampling — Part 2: Coal — Sampling from moving streams*

ISO 13909-3, *Hard coal and coke — Mechanical sampling — Part 3: Coal — Sampling from stationary lots*

ISO 13909-4, *Hard coal and coke — Mechanical sampling — Part 4: Coal — Preparation of test samples*

ISO 13909-5:2001, *Hard coal and coke — Mechanical sampling — Part 5: Coke — Sampling from moving streams*

ISO 13909-6, *Hard coal and coke — Mechanical sampling — Part 6: Coke — Preparation of test samples*

ISO 13909-7, *Hard coal and coke — Mechanical sampling — Part 7: Methods for determining the precision of sampling, sample preparation and testing*

ISO 13909-8:2001, *Hard coal and coke — Mechanical sampling — Part 8: Methods of testing for bias*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13909-1 and the following apply.

3.1
audit
⟨external⟩ critical review of a mechanical sampling system, which measures its compliance with stipulated operating specifications, undertaken by a suitably qualified independent person who is not directly involved in the management of that particular system

3.2
audit
⟨internal⟩ critical review of a mechanical sampling system, which measures its compliance with stipulated operating specifications, undertaken by a suitably qualified person who is not a day-to-day operator of that particular system

3.3
operational inspection
observations and inspections of operation conditions undertaken by the operator during sampling of a consignment

NOTE The operator is the person responsible for monitoring the sampling system on a shift-to-shift basis.

4 Safety

This International Standard does not purport to address safety issues that can be associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices in line with site safety regulations and relevant Occupational Health and Safety Acts. It is highly recommended that the auditor or inspector start by conducting a careful review of all safety rules and procedures regarding the sampling system to be inspected.

5 General considerations

5.1 Precision

Precision checks are recommended for each coal or coke type used in the system. If there is a significant change in a coal or coke type or a new coal or coke type introduced, then a precision check should be carried out. The test should outline the precision of sampling, preparation and analysis of each type of material (or coal and coke) sampled with the system. These tests shall be in accordance with ISO 13909-7.

5.2 Bias

It is recommended that, after commissioning and auditing of a new system or any major engineering modifications of an existing system, a bias test be carried out to confirm the system. If it is intended that the system be verified in accordance with ISO 13909 (all parts) procedures, reference is made to ISO 13909-2:2001, Clause 10, and ISO 13909-5:2001, Clause 10, where bias tests are mandatory. When choosing a coal or coke type for bias testing, refer to ISO 13909-8:2001, 9.1 and 9.2. It is recommended that further bias sample pairs be taken on a regular basis to confirm that the initial bias result is still relevant. If a significant change is made to the sampling system, or a new mineral having more difficult sampling characteristics is introduced, a new bias test should be considered.

5.3 Operation of sampling system

The mechanical plant system should be started some time in advance of the start of conveying the mineral so that any foreign substances (including water) are purged. Where hydraulic drives are used, sufficient time should be allowed for the hydraulic oil and the associated system to attain temperature equilibrium. It is recommended, particularly in multi-coal or coke sampling systems, that one primary cut be allowed to pass through the mechanical system as a conditioner before actual sampling commences.

It is recommended that the operator review any sampling records for the plant maintained by the previous operator. These records should include quantities of coal or coke handled and sampled, and notations as to system malfunctions, stoppages, blockages or other deficiencies. The operator should use a suitable checklist, such as the example given in Annex A. It is recommended that the operator complete all items on a suitable checklist designed for the particular system. For large, multi-user systems, an operators' inspection report, such as the example in given Annex B, should be developed.

Sufficient suitably designed inspection points should be available to observe that the falling-stream and cross-belt cutters cut the full stream of coal or coke and that cutter apertures can be inspected for blockages and blinding.

6 Establishment of inspection system

6.1 General

6.1.1 To ensure reliable operation, it is recommended that a sampling checklist (see Annex B) and operators' sampling record (see Annex C) be developed with input from the following sources:

a) original design criteria;

b) sampling equipment operating and maintenance manuals;

c) management responsible for the system;

d) personnel operating or maintaining the system;

e) for a new system, the designers and commissioning personnel;

f) relevant International Standards where applicable;

6.1.2 The general method for establishing these procedures is as follows.

a) Reference should be made to ISO 13909-2 and ISO 13909-5 to ascertain the correct sampling scheme.

b) Reference should be made to the equipment supplier's operating and maintenance manual to ascertain correct procedures for operation and intervals for routine maintenance. The manuals can provide useful information on the basis of the system design. Such information as conveyor rates, conveyor speeds, material parameters (particularly sizing and variability) are significant data and should always be kept in mind when changes are contemplated.

c) Existing sampling and maintenance records for an extended period should be examined. This information provides guidance for operators to ensure that the required level of inspection and maintenance is carried out to ensure reliable operation and possibly to alert operators to any inappropriate maintenance or modifications that can have been made to the equipment.

d) Personal experience of maintenance, operational and sampling personnel should be sought with respect to the sampling system. This information, together with that obtained from items b) and c), enable appropriate operators' manual, operators' sampling record and system checklist to be prepared.

6.2 Audit — External

A scheme for regular audits of the sampling system should be established. Reference should be made to the original operating parameters and equipment supplier's design data in order to establish conformance with the currently applicable International Standards.

NOTE Annex B provides a typical reference list.

It is recommended that correct operation of all new systems be confirmed by an audit following the commissioning stage before being accepted as operational. Also, the design and operation of the system should be confirmed by an audit prior to any bias test.

6.3 Audit — Internal

A scheme for routine inspections of the sampling system by operators should be established. The frequency and detail of inspections is determined by such factors as, but not limited to, reliability of the system, handling characteristics of the sampled material and frequency of use of the system and purpose of sampling (e.g. process control compared to large multi-user port facilities).

6.4 Operational inspections

Operational procedures and inspections should be established and carried out immediately before, during and immediately after operation of the sampling system for a given lot or sub-lot. These procedures and inspections are less extensive than those undertaken as audits or mechanical inspections as given in 6.2 and 6.3. They should be designed to be simple inspections of the integrity of the sampling process. For large, multi-user facilities, it is recommended that a system of operational reports, as per the example in Annex B, be developed.

7 Procedures

7.1 Audit — External

When assessing the conformance of a mechanical sampling system, an auditor should refer to Annexes A and B, the relevant parts of ISO 13909-2 and ISO 13909-5, and the design flow chart of the particular system being evaluated. It is recommended that a person who is not directly involved in the operation and management of that particular sampling system carry out an audit at least once per year.

It is essential that reference be made to the original operational parameters upon which the sampling system is designed. Operational conditions such as conveyor capacity, belt speed or material top size can have been altered without due regard to the impact on the operation and conformity of the sampling system.

The following are common examples of such alterations and their potential consequences.

— An increase in the capacity of a conveyor can result in excessive primary increment mass that can no longer be entirely contained by the primary sample cutter.

— A change in conveyor speed can affect the trajectory of material at a transfer point, which can result in a part of the material stream being missed by the sample cutter.

— A change in nominal top size of the coal or coke can result in the original cutter aperture no longer being large enough (i.e. three times nominal top size of the mineral) to conform to the relevant parts of ISO 13909.

Items that should be covered as a minimum are as follows:

a) safety requirements of site;

b) original and current operating parameters;

c) selection of appropriate sampling procedure;

d) general condition of the equipment, including build-up of material or blockages in chutes, cutters and sample loss or sample contamination. Attention should be paid to wear items or corrosion that can lead to moisture loss from air flow through the sampling system;

e) confirmation and comparison of design and actual increment masses for all cutters at several flow rates on the product belt, up to the maximum;

f) condition of cutters, cutter apertures and cutter lips. Check for foreign material such as wood, rags, stones and material that can be blinding the cutter apertures;

g) conformity to ISO 13909. In particular, the following information should be referenced:

   1) minimizing bias;

   2) correct design and operation of sample cutters;

   3) number of primary increments per lot or sub-lot required;

   4) methods of taking primary, secondary or tertiary increments and the division of increments and/or gross samples;

h) crusher inspection (inspect hammers or rolls and screens for wear and blinding);

i) determination of the top size of feed and crusher product;

j) staff training and procedures manual assessment;

k) check of previous mechanical inspections and operational inspections.

7.2 Audit — Internal

It is recommended that an experienced inspector should start at the primary cutter and follow through the system to the final on-line sample collection point. The mechanical inspection should be made both with and without coal or coke running through the system. Mechanical inspections should be carried out at more frequent intervals than audits. For systems in daily use, it is recommended that the management of the sampling system and not the direct operators of the system carry out mechanical inspections at least once per month.

The following items should be inspected:

a) falling-stream and/or cross-belt cutter apertures, to determine that they comply with ISO 13909 requirements and with the design flow chart of the system;

b) speed in both directions of all cutters. For time-based sampling check that the speed is constant; for mass-based sampling check that the speed is proportional to the flow rate to ensure that the mass of increment is constant;

c) movement of all cutters to verify uniform speed while in the material stream;

d) that all cutters take a complete cross-section of material flow;

e) for all cutters, that the proper number of increments is taken to satisfy the requirements of ISO 13909-2 and ISO 13909-5. It should also be verified that the time or mass interval between primary cuts is correct to assure that the minimum number of increments is collected for the lot of material being sampled during the inspection, based on maximum attainable feed rates;

f) that all cutters are parked out of the material stream in the at-rest position and that no coal or coke is entering the cutter opening. There should be no holes in the baffle plates, dust doors or seals that can cause leaking of material into the primary sample hopper. In the case of slotted-belt cutters, checks should be undertaken to confirm the aperture size, cutter lips and belt speed;

g) masses of the sample increments for falling-stream and/or cross-belt cutters to confirm that they conform to ISO 13909-2 and ISO 13909-5;

h) that the cycle time for all cutters, including dividers, is not evenly divisible into the cycle time of the previous division stage;

i) that belt feeders (sample conveyors) and vibrating feeders are in good condition. This is especially important for sample integrity. The correct tracking of belts, condition of belts, skirt rubbers and belt scrapers can have a significant impact on sample integrity. Check that the belt scrapers and skirts are adjusted properly to avoid spillages. Check the flow rate settings of vibrating belt feeders;

j) the general condition of the crusher and the size of the crushed product. Variations in product size over time can indicate that maintenance is required to screens, hammers in hammer-mill crushers and rolls and gaps in roll crushers. Ensure the crusher body and chutes are not spilling material from the system;

k) final sample collector to determine general condition. Checks should be made to ensure that sample integrity is not being compromised through contamination, sample loss or total moisture loss;

l) records of previous operations and inspections.

7.3 Operational inspections

Operational inspections should be carried out immediately prior to, during and immediately after each sampling operation. This falls due at changes of shift or material type, or for each lot. The emphasis of operational inspections should be on ensuring that the sampling system is operated at correct settings and that reliable operation is achieved during the sampling period. It is recommended that the direct operators of the system carry out operational inspections. The following points should be checked and reported:

a) that operational settings are correct, taking into account lot size, sub-lot size, time- or mass-based sampling, number of primary, secondary and tertiary increments, division ratios and sample collection interval;

b) that all equipment and sample chutes are clear of coal and coke build-up or blockages. Evidence of chute damage due to damage to external walls or scraping should be recorded;

c) that all equipment and sample chutes are clear of foreign material such as wood, paper, rags, stones or metal;

d) that all drives have been checked for correct operation, with attention paid to smooth operation of sample cutter drives. Any unusual noises or vibrations should be reported;

e) that all drives, including hydraulic systems, have been started well before sampling is required. Hydraulic systems require a period of time to attain temperature equilibrium;

f) that the sampling system has been “conditioned” by passing one or more primary increments through the sampling system before commencing or recommencing sampling. Any sample collected during conditioning should be discarded;

g) that control charts have been maintained in accordance with Clause 8. This provides evidence of restricted flow through the system, if this occurs. An example of this can be found in Annex C;

8 Quality control

8.1 General

In addition to the operators’ sampling record, it is recommended that control charts also are maintained. Two types of control charts are recommended, viz. for sampling ratio and extraction ratio.

8.2 Sampling ratio

The sampling ratio control chart is a plot of sampling ratio as a function of units sampled, where the sampling ratio, F_{SR}, is defined by Equation (1):

$$F_{SR} = \frac{m_1}{m_2} \times 1\,000 \qquad (1)$$

where

m_1 is the mass of the sample, expressed in kilograms;

m_2 is the mass of the material that the sample represents, expressed in tonnes.

Sampling ratio comparisons should be made only for like system settings (same cutter apertures, timer settings, sub-lot size and mass flow rate through the system). Thus, a separate control chart is required for each set of system settings used.

Samples having a sampling ratio out of the control range are suspect and should be investigated for validity. When there is a significant variation in the sampling ratio, the reasons for this should be investigated.

A detailed description of how to use control charts to monitor sampling ratios is provided in Annex A. An example of sampling ratio charting is provided in Figure 1 and Table 1.

An example of an inspection summary and the associated sampling ratio control chart is shown in Table 1 and Figure 1, respectively.

8.3 Coefficient of variation

After the sampling ratio is shown to be under control, it is good practice to monitor the percent coefficient of variance (% CV) of the sampling ratio as an additional measure of whether the sampling process is under control. See Annex A, Clause A.5, for instructions on how to calculate the % CV. A value for the % CV of more than 15 % can indicate that system improvement is necessary.

8.4 Extraction ratio

The extraction ratio is the actual mass of the sample divided by the design mass of the sample expected from the material flow rate, frequency of cuts, cutter aperture, cutter speed, etc.

The example shown in Figure 2 is calculated for a single lot. However, in practice, extraction ratio control charts are constructed for multiple lots to indicate long-term trends. Thus, each point on an extraction ratio control chart represents one sampled lot or the average of a number of sampled sub-lots. The data are plotted over many lots and long-term trends for a particular system can be monitored. Control limits for the extraction ratio are based on the average moving range. The aim in practice should be set at unity (1), not to the average of the data. When the extraction ratio differs significantly from 1, the system should be audited and investigated.

This ratio is useful in determining whether there are long-term problems with a particular system. For example, if a cutter speed is reduced over several weeks due to a faulty drive, the mass of sample through the system increases and the long-term extraction ratio data would indicate a problem with the system.

When system settings are changed, the extraction ratio is less likely to change than the sampling ratio, so it is more useful in comparing the effectiveness of different sampling systems.

8.5 Sampling records

Records of sampling should contain the following:

a) description of sample, such as coal or coke type, shipment name, or other descriptive reference;

b) date and time each sample was taken;

c) description of any sampling problems. This should include

   1) time at which problem occurred,

   2) reasons for problem, such as blockage, plant failure,

3) amount of coal not sampled,

4) time at which plant was brought back into service;

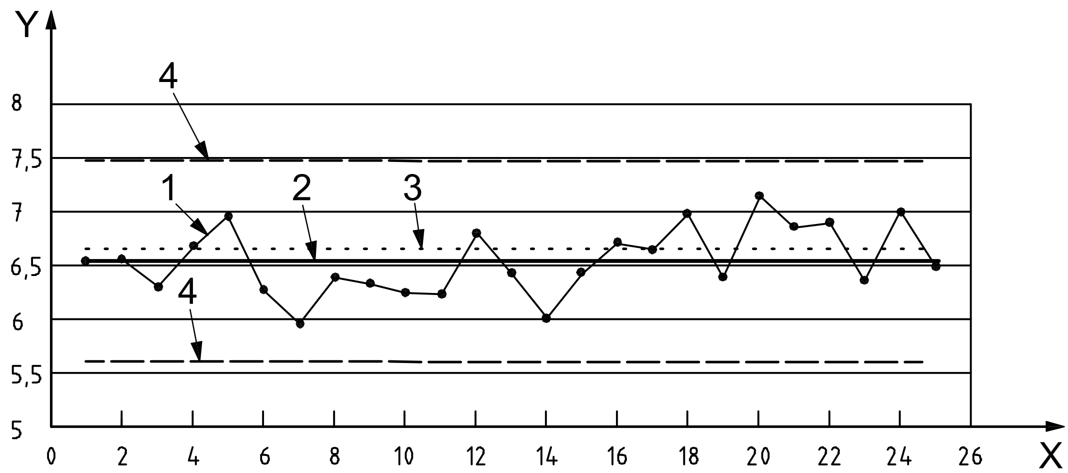
d) sampling unit mass;

e) condition of sampling plant;

f) name of the inspector and operator. Include information that can reflect on the integrity of the sample or assist any relieving operators to ensure reliable operation of the plant.

8.6 Operators' inspection report

In large and multi-user sampling systems involving large throughput of different grades of coal or coke, it is recommended that a consistent record of the sampling plant's performance be developed and maintained. Annexes B and C show typical examples of an operator's inspection report and a worked example of an operation's inspection summary, respectively. The operator's inspection report is prepared during the sampling of each lot in conjunction with the summary. The control chart in the operations inspection summary in Annex C highlights the low sample mass and sampling ratio of the nineteenth sub-lot sample.



Key

X sub-lot number
Y sampling ratio

1 sample ratio
2 sampling ratio centre line
3 AIM / design sampling ratio
4 upper and lower control limits

NOTE 1 When the sampling plant is in control, points are distributed evenly around the sampling ratio centre line (SRCL).

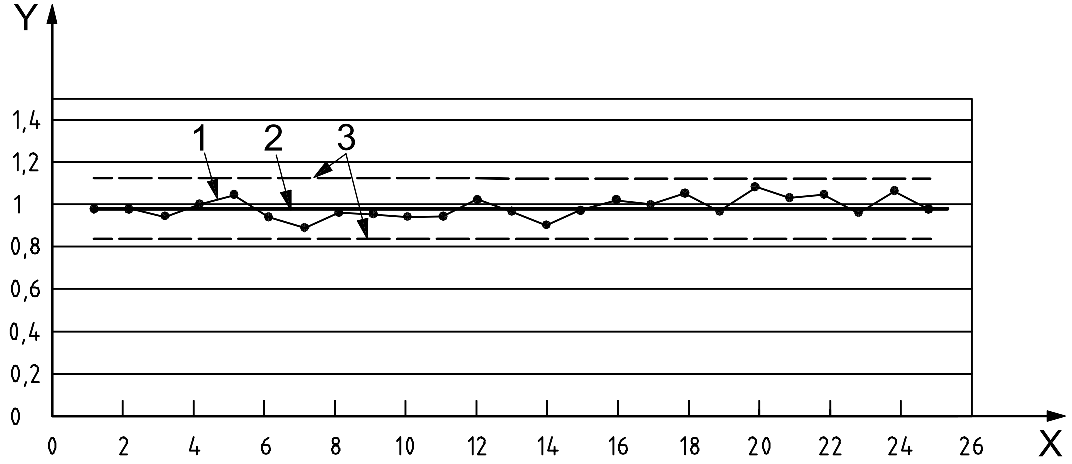
NOTE 2 Any point below the lower control limit (L_{LowC}) or any point above the upper control limit (L_{UppC}) indicates a possible serious problem and an inspection of the sampling plant is required.

Figure 1 — Example of a sampling ratio control chart from the sampling ratio vessel "Shoal Bay"

Table 1 — Inspection summary outlining the mass of each sub-lot sample collected and sampling/extraction ratios determined at a mechanical sampling plant during the loading of a lot

Vessel	'Shoal Bay'
Lot	74 624 t
Loading rate	3 000 t/h
Number of sub-lots	25
Sub-lot design mass	20 kg

Sub-lot number	Sub-lot mass kg	Sub-lot design mass kg	Tonnes loaded t	Sampling ratio	Extraction ratio
1	20,0	20,4	3 060	6,54	0,98
2	20,0	20,3	3 050	6,56	0,98
3	18,5	19,6	2 938	6,30	0,94
4	20,2	20,1	3 020	6,69	1,00
5	21,0	20,1	3 018	6,96	1,04
6	18,2	19,3	2 898	6,28	0,94
7	18,4	20,6	3 090	5,95	0,89
8	19,9	19,8	2 974	6,39	0,96
9	18,4	19,4	2 904	6,34	0,95
10	19,0	20,3	3 043	6,24	0,94
11	18,2	19,4	2 917	6,24	0,94
12	20,4	20,0	3 005	6,79	1,02
13	20,0	20,7	3 109	6,43	0,96
14	18,6	20,7	3 098	6,00	0,90
15	18,0	18,7	2 800	6,43	0,96
16	20,2	20,1	3 010	6,71	1,01
17	20,0	20,1	3 010	6,64	1,00
18	20,8	19,9	2 980	6,98	1,05
19	19,4	20,3	3 040	6,38	0,96
20	20,6	19,3	2 890	7,13	1,07
21	20,6	20,1	3 010	6,84	1,03
22	20,0	19,3	2 900	6,90	1,03
23	19,2	20,1	3 020	6,36	0,95
24	20,6	19,6	2 940	7,01	1,05
25	18,8	19,3	2 900	6,48	0,97
Average of sampling/extraction ratios				6,54	0,98
Upper control limit (UCL)	Determined using formula in Annex A			7,47	1,12
Aim / design ratio				6,66	1,0
Lower control limit (LCL)	Determined using formula in Annex A			5,62	0,84
Coefficient of variation	Determined using formula in Annex A			4,79	—



Key

X sub-lot number
Y extraction ratio

1 extraction ratio
2 sampling ratio centre line
3 upper and lower control limits

NOTE 1 When the sampling plant is in control, points are distributed evenly around the extraction ratio centre line (ERCL).

NOTE 2 Any point below the lower control limit (L_{LowC}) or any point above the upper control limit (L_{UppC}) indicates a possible serious problem and an inspection of the sampling plant is required.

Figure 2 — Example of an extraction ratio control chart from the extraction ratio vessel "Shoal Bay"

Annex A
(informative)

Monitoring coal sampling ratios using control charts

A.1 Scope

This procedure may be used to monitor the consistency of coal sampling ratios obtained with common mechanical sampling system control settings of cutter operating intervals, cutter openings, cutter speeds (for falling-stream samplers) and belt speeds (for cross-belt samplers). Conditions outside control limits (see Clause A.4) or excessive variation (see Clause A.5) serve to alert the operator to potential problems that should be investigated.

A.2 Rationale — Commentary

The procedure offered in Clauses A.3 to A.6 is one means of carrying out continual monitoring of the consistency of the sampling ratio using methodology following the general principles of the Shewhart control charts as given in ISO 8258. An explanation of the value and use of control charts is given by Deming[4].

A.3 Data collection and charting procedure

A.3.1 For each sub-lot sampled using a common sampling scheme, obtain and record the net mass of the sample collected at the final stage of mechanical sampling before any off-line sample preparation. Masses should be accurate to within 0,5 % of the mass recorded.

A.3.2 Obtain and record the sub-lot mass (in tonnes) using belt scales or another similarly accurate device normally used for determining the quantity of material from which the sample is drawn.

A.3.3 Divide the sample mass by the sub-lot mass and express the result in kilograms per thousand tonnes.

A.3.4 Calculate the average sampling ratio, $\bar{r}$, using Equation (A.1):

NOTE The average, $\bar{r}$, is equal to the sampling ratio central line on Figure 1.

$$\bar{r} = \frac{1}{n}\sum_{i=1}^{n} r_i \qquad \text{(A.1)}$$

where

n is the number of sampling ratios in the chart;

r_i is the ith sampling ratio in the series of ratios numbered 1 to n.

A.3.5 Calculate the average moving range, $\bar{R}$, from the absolute value of the difference between two consecutive values using Equation (A.2):

$$\bar{R} = \frac{1}{n-1}\sum_{i=2}^{n} \left|\left(r_i - r_{i-1}\right)\right| \qquad \text{(A.2)}$$

A.3.6 Calculate the lower control limit line, L_{LowC}, from Equation (A.3) and upper control limit line, L_{UppC}, from Equation (A.4):

$$L_{\text{LowC}} = \overline{r} - 2{,}66\overline{R} \tag{A.3}$$

$$L_{\text{UppC}} = \overline{r} + 2{,}66\overline{R} \tag{A.4}$$

NOTE 1 The values of these limits are such that if there is a common system of random variation (no special bias is present) there is only about 1 chance in 100 that a sampling ratio value will be either below the L_{LowC} value or above the L_{UppC} value.

NOTE 2 The constant 2,66 is not a function of the number, n, of sampling ratios being charted.

A.3.7 Plot the sampling ratios on a line chart, with the vertical axis denoting sampling ratio values and the horizontal axis denoting dates (and times, if appropriate). Sampling ratio values should always be plotted in chronological order. Add the sampling ratio centre line, SRCL, the lower control limit line, L_{LowC}, and the upper control limit line, L_{UppC}, to the chart. See for example Figure 1.

A.4 Detection of special causes — Out-of-control conditions

A.4.1 A biased cause of variation is indicated if one or more values are either above the upper control line or below the lower control line.

A.4.2 A biased cause of variation is indicated when there is a run defined by one of the following:

- at least seven consecutive values are on one side of the centre line;
- at least ten out of eleven consecutive values are on one side of the centre line;
- at least twelve out of fourteen consecutive points on one side of the centre line.

A.4.3 A biased cause of variation is indicated if there is a trend consisting of at least seven consecutive points increasing continually or at least seven consecutive points decreasing continually.

A.4.4 If no out-of-control conditions are indicated, the sampling system is considered to be stable and in-control.

A.5 Monitoring the coefficient of variation

A.5.1 When there are 20 or more sampling ratios charted ($n \geqslant 20$) and the system is stable, calculate the percent coefficient of variation, F_{cv}, using Equation (A.5):

$$F_{\text{cv}} = \frac{s_r(100)}{\overline{r}} \tag{A.5}$$

where

s_r is the sample standard deviation of the sampling ratios obtained from Equation (A.6):

$$s_r = \left[\frac{1}{n-1} \sum_{i=1}^{n} \left(r_i - \overline{r} \right)^2 \right]^{1/2} \tag{A.6}$$

A.5.2 A value for F_{cv} greater than 15 can indicate that the system should be improved. Items that should be checked include the following:

— consistency of velocity of sampling-system cutters;

— cleanliness of oil and filters;

— hydraulic-oil temperature variations;

— proper operation of all valves, cylinders and pumps;

— consistency of operation of timers;

— accuracy of the sample masses and partial sample sizes used in the calculations.

A.6 Monitoring the average observed sampling ratio

A.6.1 The division ratio, d, of either a falling-stream or a cross-belt sampler is calculated from Equation (A.7):

$$d = \frac{W}{tv} \tag{A.7}$$

where

W is the tip-to-tip cutter aperture width, expressed in millimetres (inches);

t is the activation interval, expressed in seconds;

v is the velocity of the cutter (for falling-stream samplers) or the velocity of the conveyor belt (for cross-belt samplers), expressed in millimetres per second (inches per second).

A.6.2 The division ratio, d_{sys}, for a sampling system consisting of N sampling stages is calculated from Equation (A.8):

$$d_{sys} = d_1 d_2 \dots d_N \tag{A.8}$$

where

d_1 is the division ratio for the primary stage;

d_2 is the division ratio for the secondary stage;

d_N is the division ratio for the Nth stage.

A.6.3 The expected value of the observed sampling ratio is the design sampling ratio (alternatively known as the theoretical sampling ratio), r_D. The value of r_D, expressed in kilograms per thousand tonnes, is calculated from Equation (A.9):

$$r_D = d_{sys} K \tag{A.9}$$

where K is equal to 1 000 000.

NOTE 1 The term design sampling ratio means the sampling ratio expected (by design), given the specific set of operating parameter values (W, t, v) for each sampling stage. If one or more of the operating parameters is changed at any stage of sampling, the design sampling ratio changes.

NOTE 2 The constant value K in Equation (A.9) converts the division ratio from a fraction to units of kilograms per thousand tonnes.

Table A.1 illustrates an example of the calculations described in Clause A.6.

A.6.4 When there are twenty or more observed sampling ratios charted with no out-of-control condition indicated and the percent coefficient of variation, F_{cv}, calculated using Equation (A.5) is less than 15 %, compare the average observed ratio to the calculated design ratio. If the difference between the design ratio and the average observed ratio is greater than 10 % of the design ratio, it is necessary to investigate the cause. One of the following is possible.

a) There is a significant error in measurement of one of the measured parameters, W, t, or v, for one or more stages of sampling.

b) There is a mechanical problem with the sampling system.

Table A.1 — Calculations of systems design sampling ratio

Stage	Parameter				
	W mm	t s	v m/s	d	r_D kg/kt
Primary	150	190	2,54	0,000 310 8	—
Secondary	50	21	0,35	0,006 802 7	—
System	—	—	—	2,114 E–06	2,11

Annex B
(informative)

Examples of sampling checklists

Sample cutters	Design criteria/range	Frequency of checks[a]		
		Operational inspection	Mechanical inspection	Audit
Identification				
Type				
Stage				
Feed rate, t/h		d	m	y
Nominal top size, mm		d	m	y
Drive mechanism				
Type				
Condition		d	m	y
Operating pressure		d	m	y
(if applicable)				
Cutter velocity			m	y
Uniform speed		d	m	y
Cutter				
Condition		d	m	y
Cutter aperture, mm			m	y
Cutter lips - Yes/No		d	m	y
Cutter length, mm				y
Cutter volume				y
Increment mass, kg			m	y
Number of increments		d	m	y
Cuts: Primary			m	y
Secondary			m	y
Tertiary			m	y
Parked clear of stream?		d	m	y
Complete stream cut		d	m	y
Build-up of fines		d	m	y
Loss of sample		d	m	y
Sample contamination		d	m	y
Speed		d	m	y
Blockages		d	m	y
Sample reflux		d	m	y

[a] "d" signifies daily; "w" signifies weekly; "m" signifies monthly; "y" signifies yearly.

Sample chutes	Comment/ Measurement	Frequency of checks[a]		
		Operational check	Inspection	Audit
Identification				
Type				
Chutes				
Speed		d	m	y
Blockages		d	m	y
Build-up of fines		d	m	y

[a] “d” signifies daily; “w” signifies weekly; “m” signifies monthly; “y” signifies yearly.

Sample feeders	Design criteria/range	Frequency of checks[a]		
		Operational check	Inspection	Audit
Identification				
Type				
Feeder				
General condition		d	m	y
Drive unit		d	m	y
Skirts			m	y
Covers		d	m	y
Scraper			m	y
Belt width, m			m	y
Between skirt width			m	y
Adjustable speed				y
Belt speed, m/s			m	y
Adjustable gate				y
Gate height, mm			m	y
Feed rate, t/h			m	y
Build-up of fines		d	m	y
Loss of sample		d	m	y
Sample contamination		d	m	y
Belt tracking		d	m	y
Blockages		d	m	y

[a] “d” signifies daily; “w” signifies weekly; “m” signifies monthly; “y” signifies yearly.

Sample crushers	Comment/ Measurement	Frequency of checks[a]		
		Operational check	Inspection	Audit
Identification				
Type				
Crusher				
General condition			m	y
Nominal feed size			m	y
Nominal product size check		d	m	y
Feed rate, t/h			m	y
Rated capacity, t/h			m	y
Hammers			m	y
Screens			m	y
Scrapers			m	y
Drive unit(s)		w	m	y
Build-up of fines		d	m	y
Loss of sample		d	m	y
Sample contamination		d	m	y
Blockages		d	m	y

[a] "d" signifies daily; "w" signifies weekly; "m" signifies monthly; "y" signifies yearly.

Sample storage	Design criteria/range	Frequency of checks[a]		
		Operational check	Inspect	Audit
Identification				
Type				
Collector				
General condition		d	m	y
Number of containers		d	m	y
Container capacity			m	y
Sample mass / sub-lot		d	m	y
Indexing interval		d	m	y
Collection interval		d	m	y
Build-up of fines		d	m	y
Loss of sample		d	m	y
Sample contamination		d	m	y

[a] "d" signifies daily; "w" signifies weekly; "m" signifies monthly; "y" signifies yearly.

Annex C
(informative)

Example of sampling plant operators inspection report

Vessel	Pinheiro Explorer	**Berth**	North Port
Coal type	Withers Duff	**Sampling plant**	No 3 Pier Greenock
Lot mass (t)	40 000	**Sub-lot interval (t)**	2 000
Sampling standard	ISO 13909 (all parts)	**Sampling plant start**	1928 h 30.02.04
Commenced sampling	0948 h 30.02.98	**Completed sampling**	2120 h 30.02.04

Tick if ok ☑ — Cross if problem found ☒

Shift	D/S	A/S	N/S	**Comments**
Operator initials	JD	RH	...	
Primary cutter				
*Smooth operation cutter	☑	☑	☐	
*Condition of cutter lips	☑	☑	☐	
*Check for blockages/blinding	☑	☒	☐	Blocked chute 2044 h sample 19 Piece of wood blocking cutter
Main product conveyor				
*Belt tracking	☑	☑	☐	
*Belt damage	☑	☑	☐	
*Belt scrapers	☑	☑	☐	
*Spillages/build-ups	☑	☑	☐	

Comments

Shift	D/S	A/S	N/S	
Operator initials	JD	RH	...	
	Tick if ok ☑		**Cross if problem found** ☒	**Comments**
Primary cutter product conveyor				
*Belt tracking	☑	☑	☐	....
*Belt damage	☑	☑	☐	....
*Belt scrapers	☑	☑	☐	....
*Spillages/build-ups	☑	☑	☐	....
Comments	....			
Primary cutter product conveyor magnet				
*Scrap on magnet. Identify and remove if present. Retain scrap for supervisor	☑	☑	☐	....
Physical sampler and carousel				
*Cutter clear of material stream	☑	☑	☐	....
*Condition of canisters	☑	☑	☐	....
*Spillage inside carousel	☑	☑	☐	....
*Spillage outside carousel	☑	☑	☐	....
*Physical sample mass (kg) at completion of consignment	☑	☑	☐	....
*Comments: Sample returned to laboratory for size analysis.				
Secondary cutter feed conveyor belt				
*Belt tracking	☑	☑	☐	....
*Belt damage	☑	☑	☐	....
*Belt scrapers/skirts	☑	☑	☐	....
*Spillage/build-ups	☑	☑	☐	....
Comments	....			

	D/S	A/S	N/S	Comments
Shift	D/S	A/S	N/S	
Operator initials	JD	RH	...	
	Tick if ok ☑		**Cross if problem found** ☒	**Comments**
Secondary cutter product conveyor belt				
*Belt tracking	☑	☑	☐	
*Belt damage	☑	☑	☐	
*Condition of lips	☑	☑	☐	
*Slots intersect full stream	☑	☑	☐	
*Belt scrapers/skirts	☑	☑	☐	
*Spillage/build-ups	☑	☑	☐	
Comments				
Conveyor belt feeder to crusher				
*Belt tracking	☑	☑	☐	
*Belt damage	☑	☑	☐	
*Belt scrapers/skirts	☑	☑	☐	
*Spillage/build-ups	☑	☑	☐	
Comments				
Crusher performance				
*Leakage of material	☑	☑	☐	
*Excessive vibration	☑	☑	☐	
*Condition of hammers/rolls	☑	☑	☐	

Shift	D/S	A/S	N/S	
Operator initials	JD	RH	...	
	Tick if ok ☑		**Cross if problem found** ☒	**Comments**
*Percentage of + 11,2 mm (day shift only)		3,2 %		
*Percentage of – 80 mm (day shift only)		94,0 %		
Tertiary sample feed conveyor				
*Belt tracking	☑	☑	☐	
*Belt damage	☑	☑	☐	
*Spillage/build-up	☑	☑	☐	
*Belt scrapers	☑	☑	☐	
*Comments				
Tertiary sampler slotted belt				
*Belt tracking	☑	☑	☐	
*Belt damage	☑	☑	☐	
*Condition of lips	☑	☑	☐	
*Slots intersect full stream	☑	☑	☐	
*Belt scrapers/skirts	☑	☑	☐	
*Spillage/build-ups	☑	☑	☐	
*Comments				
Slotted belt sample carousel				
*Condition of canisters	☑	☑	☐	
*Spillage inside carousel	☑	☑	☐	
*Spillage outside carousel	☑	☑	☐	
Sample masses approx. correct	☑	☒	☐	Sample 19 low mass
Reject conveyor				

Shift	D/S	A/S	N/S	
Operator initials	JD	RH	...	
	Tick if ok ☑		**Cross if problem found** ☒	**Comments**
*Belt tracking	☑	☑	☐	....
*Belt damage	☑	☑	☐	....
*Spillage/build-up	☑	☑	☐	....

*Comments ....

Safety/housekeeping				
*Are all inspection hatches closed	☑	☑	☐	....
*Are all conveyor covers in place	☑	☑	☐	....
*Is safety equipment operational	☑	☑	☐	....
*Danger/out-of-service tags supplied	☑	☑	☐	....
*Safety signs clean and clearly displayed	☑	☑	☐	....
*All sampling equipment neatly stored	☑	☑	☐	....
*All walkways clear, areas adjacent to conveyors/crushers/stairs clear and tidy	☑	☑	☐	....
*Plant tidy/clean, e.g. hoses wound back, material washed away, etc.	☑	☑	☐	....
*Fire extinguishers operational, service records up to date.	☑	☑	☐	....
*Power point/cords/equipment checked and tagged by certified electrician	☑	☑	☐	....
	☑	☑	☐	....

Comments: Problem with sample 19, primary cutter blockage. Piece of wood found jammed in cutter:

No. of automatic samples: 20 **No of manual samples: 0**

Annex D
(informative)

Example of sampling plant operations inspection summary

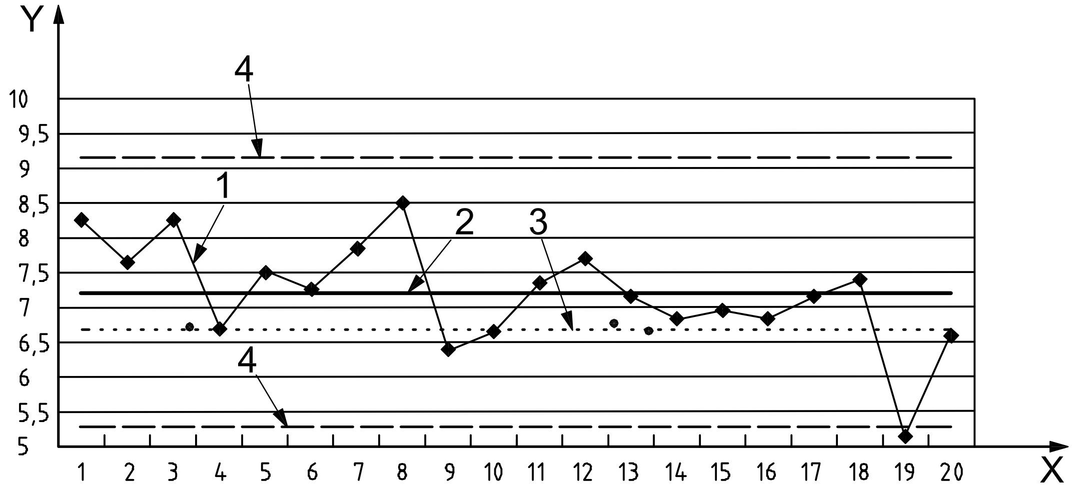
Table D.1 presents an example of a plant-operations inspection summary. The data are plotted in Figure D.1.

Table D.1 — Sampling summary

Vessel	Pinheiro Explorer	**Berth**	Greenock Pier
Coal / Coke type	Withers Duff Coal	**Sampling plant**	No 3 Pier
Lot mass (t)	39 985	**Sub-lot interval (t)**	2 000
Sampling standard	ISO 13909-2	**Sampling plant start**	0928 h 30.02.98
Commenced sampling	0948 h 30.02.98	**Completed sampling**	2120 h 30.02.98

Sub-lot sample no.	Mass loaded t	Sub-lot sample mass kg	Time start h	Time end h	Sampling ratio	Auto/ manual (A/M)	Sampling problems	Sampler operator initials
1	2 000	16,5	0 948	1 019	8,25	A	No problems	JD
2	2 000	15,3	1 020	1 050	7,65	A	No problems	JD
3	2 000	16,5	1 051	1 125	8,25	A	No problems	JD
4	2 000	13,4	1 126	1 150	6,70	A	No problems	JD
5	2 000	15,1	1 151	1 226	7,55	A	No problems	JD
6	2 000	14,5	1 227	1 305	7,25	A	No problems	JD
7	2 000	15,7	1 306	1 340	7,85	A	No problems	JD
8	2 000	17,0	1 341	1 414	8,50	A	No problems	JD
9	2 000	12,8	1 415	1 445	6,40	A	No problems	JD
10	2 000	13,3	1 446	1 517	6,65	A	No problems	JD
11	2 000	14,7	1 518	1 553	7,35	A	No problems	JD
12	2 000	15,4	1 554	1 630	7,70	A	No problems	RH
13	2 000	14,3	1 631	1 705	7,15	A	No problems	RH
14	2 000	13,7	1 706	1 740	6,85	A	No problems	RH
15	2 000	13,9	1 741	1 823	6,95	A	No problems	RH
16	2 000	13,7	1 824	1 908	6,85	A	No problems	RH
17	2 000	14,3	1 909	1 939	7,15	A	No problems	RH
18	2 000	14,8	1 940	2 013	7,40	A	No problems	RH
19	1 985	10,2	2 014	2 044	5,14	M	Blocked chute	RH
20	2 000	13,2	2 047	2 120	6,60	A	No problems	RH

Average of sampling ratios		7,21
Upper control limit (UCL)	Determined using formula in Annex A	9,15
Aim / design ratio		6,66
Lower control limit (LCL)	Determined using formula in Annex A	5,27
Coefficient of variation	Determined using formula in Annex A	10,59



Key

X sub-lot number

Y sampling ratio

1 sample ratio

2 sampling ratio centre line

3 AIM / design sampling ratio

4 upper and lower control limits

NOTE 1 Out-of-control condition indicated at sub-lot 19 caused by blocked chute.

NOTE 2 When the sampling plant is in control, points are distributed evenly around the sampling ratio centre line (SRCL).

Figure D.1 — Sampling ratio control chart showing out-of-control condition from the sampling ratio vessel "Pinhiero Explorer"

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