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Coal — Guidance for sampling in coal preparation plants

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 27, *Coal and coke*, Subcommittee SC 1, *Coal preparation: Terminology and performance*.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Coal — Guidance for sampling in coal preparation plants

1 Scope

This document specifies recommended practices for sampling in coal preparation plants (CPPs).

The document is applicable to sampling of all coal product(s), reject material(s) and magnetite. The coal and mineral matter size covered by this document ranges from a nominal top size of 63 mm to 0,1 mm.

This document also covers larger sizes in the case of mechanical sampling. Manual sampling is not recommended for particle size larger than 63 mm.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 1213-1, *Coal and coke — Vocabulary — Part 1: Terms relating to coal preparation*

ISO 1213-2, *Solid mineral fuels — Vocabulary — Part 2: Terms relating to sampling, testing and analysis*

ISO 7936, *Coal — Determination and presentation of float and sink characteristics — General directions for apparatus and procedures*

ISO 8833, *Magnetite for use in coal preparation — Test methods*

ISO 13909 (all parts), *Hard coal and coke — Mechanical sampling*

ISO 18283, *Coal and coke — Manual sampling*

ISO 20904, *Hard coal — Sampling of slurries*

AS 1038.21.1.1, *Coal and coke — Analysis and testing, Part 21.1.1: Higher rank coal and coke — Relative density — Analysis sample/density bottle method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1213-1, ISO 1213-2, ISO 13909 (all parts), ISO 18283, ISO 20904 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
boil-box
box or compartment installed in a piped flow stream, designed for very short residence time and vigorous turbulence of the flow-through stream, with a fully accessible weir overflow arrangement that the full stream shall pass over

3.2
by-line
side-stream or branch line that only accommodates a portion of the total stream flow

3.3
diverter type sampler
device that temporarily diverts the full stream to a position accessible to full-stream sampling

3.4
full-stream sampler
sampling device that traverses the full extent of a flowing stream at constant speed

3.5
hindered bed separator
beneficiation device based on the principles of hindered bed settling

3.6
hydraulic separator
coal beneficiation device that uses water as the separation medium

EXAMPLE Spirals, *hindered bed separators* (3.5) and water washing cyclones.

3.7
partition curve
curve indicating each density (or size) fraction, expressed as a percentage, contained in one of the products of the separation

3.8
point sampler
device that collects a sample from only one point within the flowing stream

3.9
pressure pipe sampler
variation of a *point sampler* (3.8)

3.10
RD_{50}
cut-point being the exact relative density at which a separation into two fractions is desired or achieved

3.11
supervisory control and data acquisition
SCADA
user software interface for accessing process control setpoints, current and historical on-line parameter data

Note 1 to entry: Data come from belt scales, pressure and level transducers, on-line ash analysers, motor amperages, etc.

3.12
sampling implement
device used to collect or extract a sample increment

3.13
two-in-one slurry sampler
device that includes both primary and secondary slurry sampling apparatus

4 General principles and considerations

4.1 General

The objective of sampling is to collect a manageable quantity of material and use it to represent the total amount of material from which it was collected. This manageable quantity of material is called a sample. As the sample will be used to estimate the characteristics of the whole material from which it was collected, some important rules should be followed to ensure the sample is statistically representative of the population. This includes consideration of the location and time of sampling; type of sampling implements and volume of sample.

Results are required to be precise (of minimum scatter) and accurate (as close as possible to the true value) to generate information for decision making.

Table A.1 in Annex A shows all major equipment found in coal preparation plants, the manual sampling technique that should be used for each, and where to find details on the technique in this document.

WARNING — This document does not purport to address safety issues that can be associated with its use. It is the responsibility of the user to establish appropriate safety and health practices in line with site safety regulations and work health and safety legislation in the country where it is being used. It is highly recommended that clear safety instructions be provided to all staff involved, and a risk assessment be undertaken prior to conducting any sampling exercise.

4.2 Principles of sampling

Correct sampling in a coal preparation plant (CPP) should ensure that every particle and associated entity (e.g. water and medium) in the stream have an equal chance of reporting to the collected sample during the sampling process.

The full stream should be accessible to the sampling implement. It should be noted that incorrect sampling methodology will adversely affect the accuracy of the measured result. Depending on the stream nature, sampling methods can be categorized as follows:

a) sampling of dry or moist solids stream, e.g. screen discharge;

b) sampling of slurry stream, e.g. correct medium.

In addition, the sampling methods can be categorized depending on the purpose of sampling as:

— sampling for feed quality characterization;

— sampling for quality monitoring and control;

— sampling for equipment/process performance evaluation, i.e. “special case” sampling.

It is recommended that each CPP maintain a sample point register, listing each sample point, the sampling implement required (photographs are helpful), the volume of sample collected per implement cut, and the usual number of cuts (increments) per sample. If special sampling implements are required, the fabrication drawings should be referenced in the register and filed for re-ordering purposes.

4.3 Objectives of sampling in coal preparation plants

4.3.1 General

Reasons for sampling include:

a) identification of process problems to assist formulation of solutions;

b) process auditing;

c) measuring process efficiency;

d) generating data for process modelling;

e) assessing coal quality;

f) providing reliable results for decision-making;

g) process control;

h) inventory accounting and reconciliation;

i) process evaluation.

The sampling method (location and time, sample mass, procedure etc.) will depend on the reason for sampling. Hence, the sampling objective(s) should first be clearly established. A decision tree will assist with choosing and implementing the best sampling method.

A sample is subject to certain preparation procedures that render it suitable for either physical testing or laboratory analysis. The type of tests or analyses that are performed are dependent on the characteristics required to categorize the material.

4.3.2 Determination of scope of sampling using a sampling decision tree

Before planning and carrying out sampling, it is necessary to determine the scope of the sampling exercise. The methods used, duration of sampling and sample volume will each depend on the sampling goal, i.e. what the user is looking to achieve. The decision tree in Figure 1 will assist with planning.

If sampling is for quality control, smaller sample masses may be used since individual samples may be analysed separately, for example, as a shift production sample, thereby generating many individual results over time. However, in the case of a process audit where only a single sample of each stream is collected, and the result of its analysis considered as final, then the sample taken should be larger, and will correspond to a composite of increments. Therefore, the sample requirement depends on whether the results of analysis are accumulated or singular.

When sampling for process performance investigations, requiring the calculation of size and/or density partition data, larger samples are required so that enough material is present for size analysis and/or float-sink testing.

For partition curve determinations, density tracers offer an alternative to methods based on coal sampling. Density tracers are synthetic particles of precise sizes, shapes, and densities. For separators with feed top size greater than 63 mm, they usually provide the only economically and practically viable technique. Known numbers of tracer particles of known sizes, shapes and densities are added to the feed of a density separator. After partitioning, they are collected from, or detected in, the product and reject streams, and the partition number for each density class is calculated for reporting in a partition curve.

Coal sampling offers the following advantages:

a) sampling facilitates measurement of process impacts for each size class of particles;

b) sampling facilitates fractionation and analyses of the resulting samples for any relevant coal quality parameter.

Density tracer tests typically only comprise a single size of tracer for any given test, but offer the following advantages:

— tracers facilitate a rapid result (no analysis requirements);

— tracers facilitate a rapid assessment of validity and possible error-range of result (based on tracer losses).

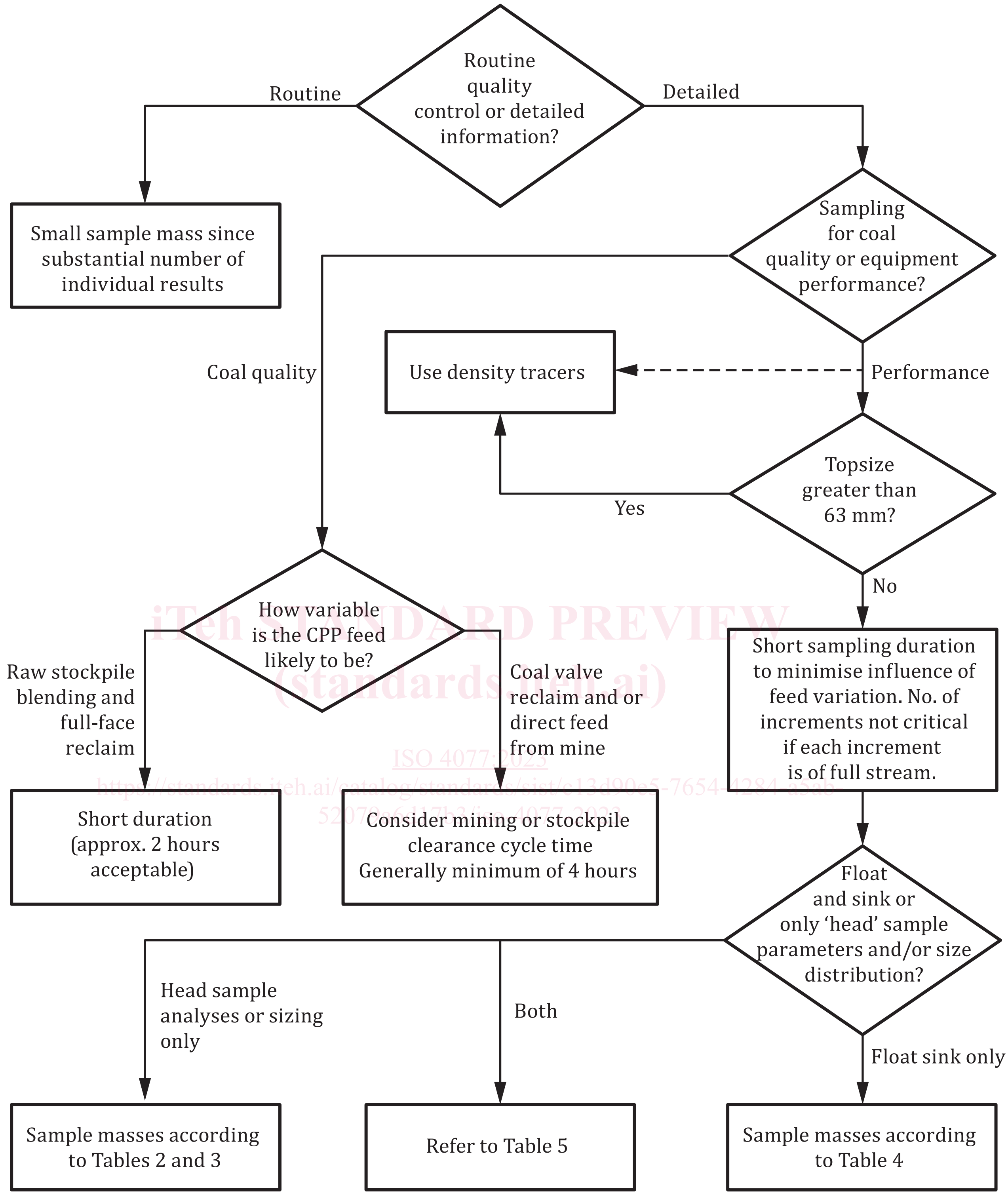

Figure 1 — Sampling decision tree

5 Design considerations

5.1 Principles

5.1.1 Solids sampling

When designing a sampling system for solids, the following aspects need to be considered:

a) in all stages of the design, consideration shall be given for the safety of operators, both in completing their tasks and egress;

b) the mass and number of primary increments required is calculated as for bulk coal in accordance with the ISO 13909 series;

c) sub-lot samples may be used;

d) cutter speed to be 0,6 m/s or less; some bias can be introduced if speeds exceed this value;

e) ensure the sample is not being contaminated;

f) plant should be designed to eliminate spillage or loss in any way, eliminate build ups in equipment and ensure that cutters do not choke the feed causing a “reflux” effect in which some material can be rejected from the cutter;

g) facilities for duplicate sampling should be incorporated into the plant to allow for checks on sampling precision.

5.1.2 Slurry sampling

When designing a slurry sampling system, in addition to the considerations listed for solids sampling, attention should be given to the following:

a) The mass of solids/volume of slurry contained in each increment obtained in one pass of the sample cutter is calculated from the mass of slurry collected and mass fraction of solids, expressed as a percentage.

b) When a reference sample is needed, divert the total stream into a container for a brief period.

c) Sampling of slurries in stationary situations, such as a settled or even a well-stirred slurry in a tank, holding vessel or dam is not recommended because it is virtually impossible to ensure that all parts of the slurry in the lot have an equal opportunity of appearing in the lot sample for testing. Instead, sampling should be carried out from moving streams as the tank, vessel or dam is filled or emptied.

d) Sampling should be undertaken at a point in the handling system where there is no apparent risk of errors due to a periodic variation in material feed or quality, e.g. away from pulsating slurry pumps or control valves.

e) The cutter should be of sufficient capacity to accommodate the entire increment at the maximum flow rate of the stream without any slurry loss due to reflux from the cutter aperture. Avoid spillage of the sample or loss of material due to dribbles or run-back on the outside of a cutter.

f) Sampling of moving slurry streams using probes, spears or by-line samplers is not recommended because they do not intercept the full cross-section of the slurry stream.

g) Sampling part of the stream with an in-stream point sampler or probe within a pipe or channel is always incorrect.

h) The cutter aperture should be at least three times the nominal top size of the particles in the slurry, subject to a minimum of 20 mm.

i) Restriction of the flow of the slurry increment through any device causing reflux and overflow should be avoided. This precaution is particularly important for reverse spoon cutters where the falling slurry stream is forced to change flow direction as it strikes the inside surface of the spoon.

j) Ascertain the nominal top size and particle density of the solids in the slurry for determining the minimum volume of slurry increment and the minimum mass of the solids in the sample.

k) Extract slurry increments of volume proportional to the slurry flow rate at the time of taking each increment.

l) Consider nominal top size, the expected solids mass concentration, density of the solids in the slurry, in the design to avoid blockages.

5.2 Systems for new plants and retrofitting

5.2.1 New plant mechanical sampling systems

It is recommended that during the design phase of coal preparation plants, mechanical sampling systems be included in the design to cover coal preparation plant feed, product, and total reject streams.

Mechanical systems shall be in accordance with the following minimum criteria:

a) that all cutters are taking full (stream) cuts from each stream [feed, product(s) and reject(s)] and feeding the cuts preferably to a sample conveyor belt;

b) that each sample conveyor should be capable of operating in both directions.

   1) Normal direction feeding an online crusher and secondary cutter to produce quality control samples.

   2) Reverse direction to produce uncrushed (physical) samples.

Sample containment should be provided to minimize evaporation of moisture, or ingress of rainfall, or contamination.

Other sampling plant designs are permissible if the system can produce both uncrushed samples and crushed samples for quality control from each of the feed, product and reject streams.

It is also recommended that automatic-mechanised, or mechanically assisted sampling systems be incorporated for unit processes within the CPP, especially for streams that are difficult to sample manually, and critical to monitoring coal and/or magnetite losses. Table 1 lists the systems that should be considered.

Table 1 — Streams recommended for automatic or mechanically assisted sampling

Stream	Sampling device
Desliming and drain and rinse (D&R) screen overflows	Slide or swing bucket (lever operated) with means to discharge sample or mechanical lift to raise bucket out of discharge chute
D&R screen underflows (drain media only)	Full-stream sampler or boil-box full-flow weir overflow [a]
Sump inflow (e.g. hydrocyclone or flotation feed sump)	Direct all inflows via a singular full-stream sampler or boil-box full-flow weir overflow, with room for safe personnel access [a]
Tailings	Full-stream sampler or boil-box full-flow weir overflow [a]
Flotation and hydraulic separator streams	Full-stream sampler or boil-box full-flow weir overflow [a]

[a] It is critical to use a full-stream sampler on the full primary slurry stream in order to procure a representative primary sample. It is far less useful to employ full-stream samplers for secondary or subsequent cuts in circumstances where the primary sample is not itself collected in a representative manner.

5.2.2 New plant manual sample points

In addition to mechanical sampling systems, it is recommended that other streams within the plant require safe access to representative sampling points and these sampling points should be included in the CPP design with examples as follows:

a) increase the width between the falling stream and launder at the discharge end of all screens to allow easier manual sampling;

b) have access doors on both sides of conveyor/discharge chutes at transfer points of intermediate products and rejects;

c) install tracks and make sampling scoops to fit, which will allow cuts to be taken manually at transfer points without the need to manually support the sampling scoop;

d) ensure sampling platforms are built adjacent to transfer points to provide safe access for sampling and sample handling;

e) where possible on slurry streams, install by-pass systems along pipelines to allow full-stream sampling (see 8.3.2.2.1).

Manual sampling methods represent a compromise from the point of view of precision. Wherever possible, mechanical sampling systems should be installed.

5.2.3 Existing plant with no mechanical system

It is recommended that mechanical systems be retrofitted as described in 5.2.1.

5.2.4 Manual sampling points in existing plants

It is recommended where possible that improvements be made to existing plants to meet the sampling criteria outlined in 5.2.2.

6 Planning for sampling

6.1 Pre-sampling inspection

To ensure an outcome of best possible sampling practice and adhere to relevant work health and safety laws, it is recommended to conduct a pre-sampling inspection. A pre-sampling inspection checklist list should consider the following:

a) is it possible to collect representative samples of all the samples nominated in the sampling plan;

b) is there safe access to all the sampling points;

c) do sample points allow for full-stream sampling;

d) can the sample be safely removed from the plant;

e) determine the sequence that samples should be collected, to facilitate simultaneous sampling where appropriate, and otherwise allow for the correct residence time (lag) between feed, product and reject streams, so as to generate the best possible data for mass-balance purposes;

f) check that the calculated sample increment masses/volumes are correct, and that the sampling implements for each sample point are fit for the purpose of taking the correct full-stream increments;

g) reach an agreement between relevant parties on expectations of precision and what is required to be achieved from the sampling and analysis program;

h) revise and finalize the sampling plan based on the pre-sampling inspection.

See example pre-inspection checklist in Annex B.

6.2 Personnel

It is recommended that the following criteria relating to numbers of personnel required, their training and supervision need to be considered:

a) determine the number of sampling personnel required based on technical and safety requirements;

b) ensure all the samples that need to be taken simultaneously are physically able to be taken at the same time;

c) ensure that the personnel are adequately trained for purpose, and each has clearly written instructions for the exercise to be carried out;

d) ensure adequate supervision during the sampling process;

e) ensure adequate and timely communications are available to notify sampling personnel in case of process upsets.

6.3 Containers

It is also recommended that the following criteria relating to the type of sample containers required, their labelling, their lids, and their handling be considered:

a) select suitable containers with respect to capacity to ensure the sample integrity is maintained;

b) prepare labels prior to sampling. both labels and ink should be water resistant;

c) liners are required for samples placed in drums;

d) drum lifters are recommended to handle drums;