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## Coal — Guidance for sampling in coal preparation plants

*Charbon — Recommandations relatives à l'échantillonnage dans les ateliers de préparation du charbon*

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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](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://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](http://www.iso.org/members.html).

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# 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<sub>50</sub>**

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).

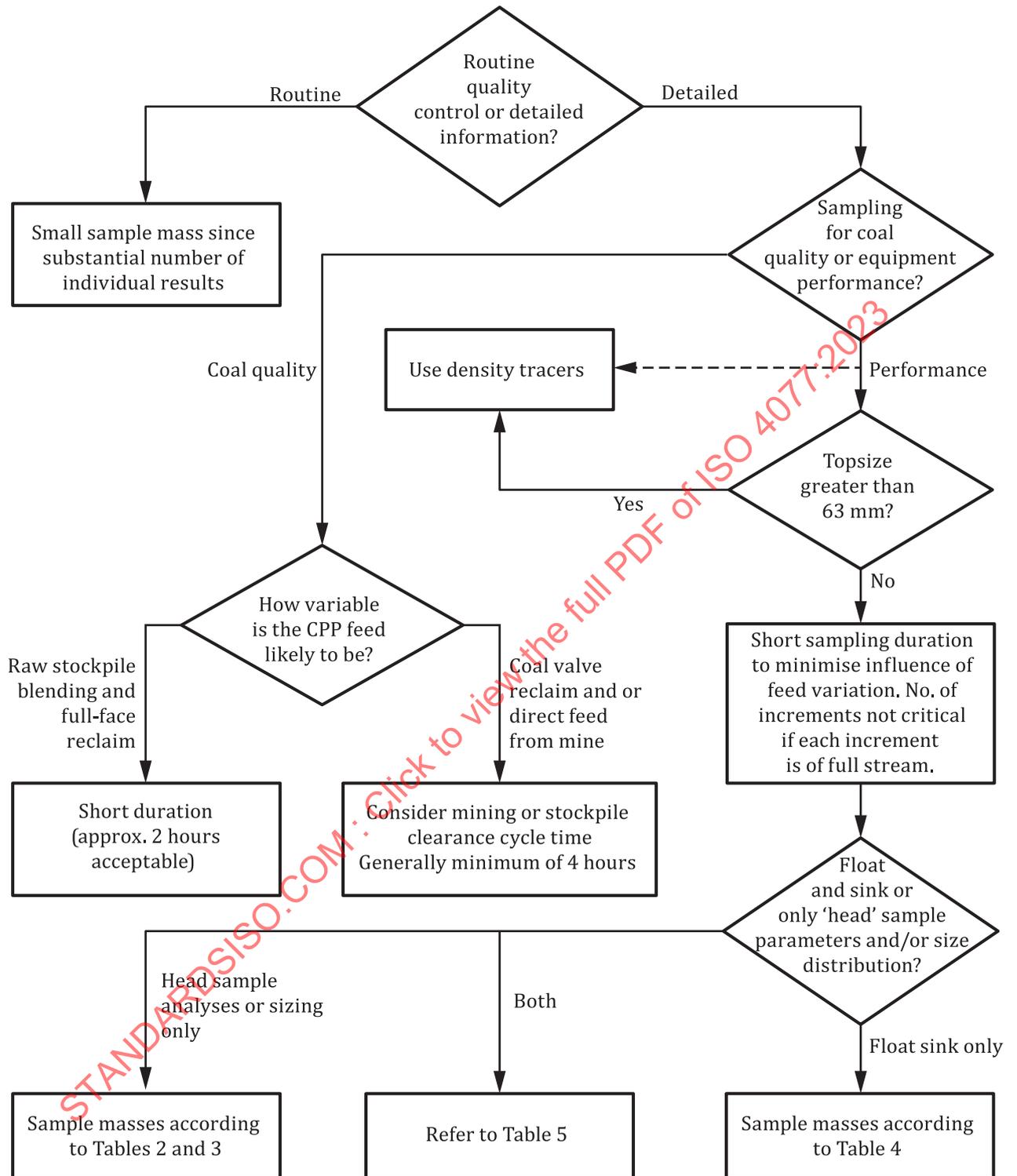


Figure 1 — Sampling decision tree

## 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 <sup>a</sup>
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 <sup>a</sup>
Tailings	Full-stream sampler or boil-box full-flow weir overflow <sup>a</sup>
Flotation and hydraulic separator streams	Full-stream sampler or boil-box full-flow weir overflow <sup>a</sup>

<sup>a</sup> 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;

- e) ensure the containers are clean with closely fitting lids. lids on buckets should be taped in position prior to sample transport;
- f) mass of full containers (buckets) should be in accordance with manual handling requirements to prevent injuries when they are moved or carried.

## 6.4 Method

### 6.4.1 Overview

It is recommended that the variability of the coal should be considered when establishing a sampling plan, since quality fluctuations typically exist in all streams in a CPP. Much of the variation is ultimately due to the variability in the CPP feed itself. The variability may be both short-term and long term, for a given CPP. The presence of periodic variations can be determined by a variogram (see ISO 13909-7). If periodic variability is present, then stratified random sampling should be performed. An alternative is to significantly reduce the source of the periodic variations.

The number of increments taken from a lot to achieve a specified precision is a function of the variability of the quality of the stream irrespective of the mass of the lot. The minimum mass in a sample is dependent on the nominal top size of the coal, the precision required for the parameter concerned and the relationship of that parameter to the particle top size. The attainment of this mass will not, of itself, guarantee the required precision, because precision is also dependent on the number of increments in the sample and the variability. Hence the required sample mass can be significantly higher than the minimum masses listed in this document. The precision achieved for a lot may be measured using the procedures given in ISO 13909-7.

An example of a sampling plan is given in [Annex D](#).

### 6.4.2 Sampling Time

The minimum sampling time depends on the purpose of sampling. It can be differentiated between:

- a) sampling time for coal quality data;
- b) sampling time for determination of equipment performance.

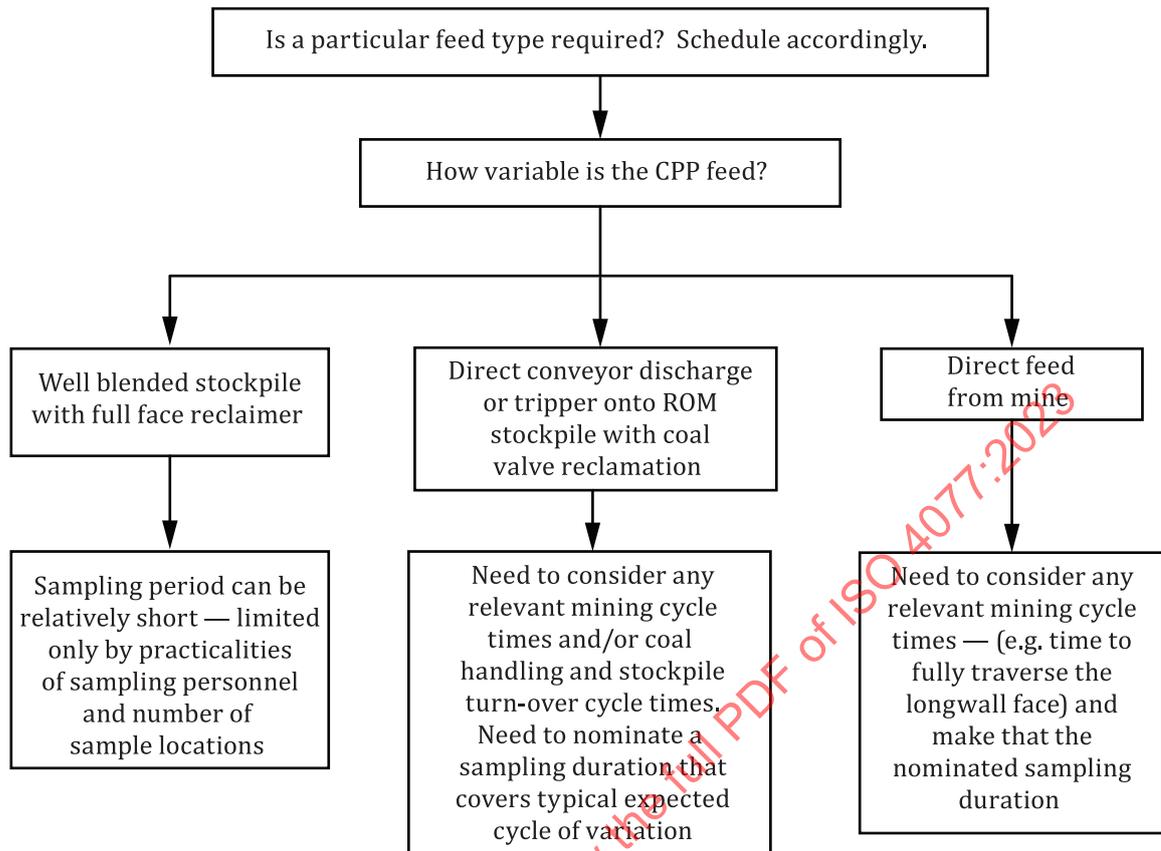
It is also recommended that, for assessing equipment performance, the sampling time should be kept as short as possible to minimize the effect of any feed coal cycle time or accumulation/depletion within the unit operation itself (e.g. hindered bed separator (HBS) with intermittent reject discharge). The sampling time for coal quality analysis will be longer and largely influenced by CPP feed configuration and stockpile reclamation system.

The sampling time will also depend on:

- how quickly the required mass can be collected (personnel and equipment resources);
- how much sample is needed.

### 6.4.3 Sampling for feed quality characterization

Several factors need to be considered when sampling the coal feed to a preparation plant. [Figure 2](#) outlines that there can be various locations where the raw coal is sourced. Each location will have its own degree of variability with regards to sampling, and the sampling method should be adjusted accordingly.

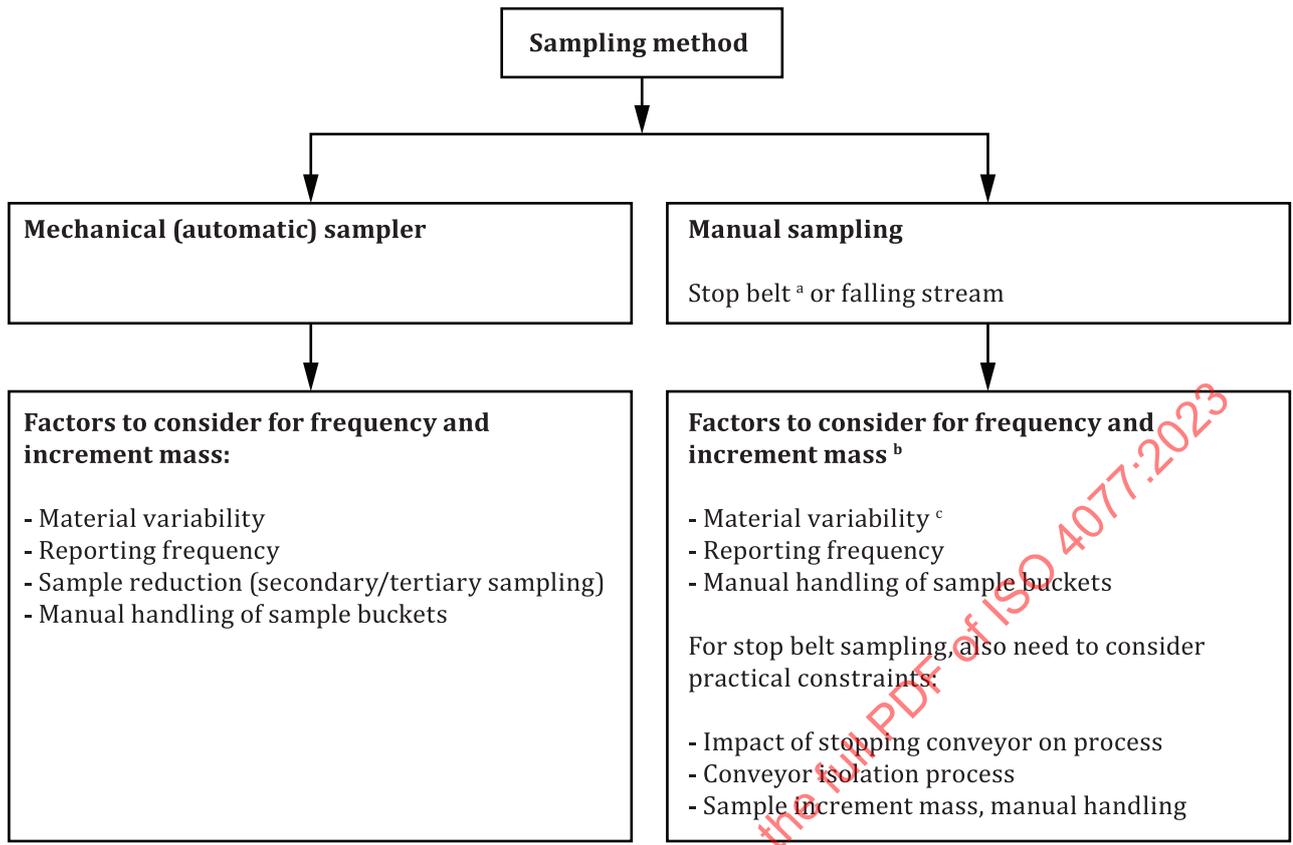


NOTE ROM means Run of mine.

**Figure 2 — CPP feed sample source considerations**

#### 6.4.4 Sampling for quality monitoring and control

In coal preparation plants, there are typically two types of sampling as outlined in the flow chart in [Figure 3](#). As previously given in [6.4.3](#), several factors need to be considered when sampling the coal feed to a preparation plant. [Figure 3](#) outlines that there can be various locations where the raw coal is sourced. Again, each location will have its own degree of variability with regards to sampling and the sampling method should be adjusted accordingly. Some factors to be considered are common to all forms of sampling while others refer only to one form of sampling.



<sup>a</sup> Manual sampling apart from stop-belt sampling should only be used for non-critical streams and as a back-up for failures of a mechanical sampler.

<sup>b</sup> See ISO 13909-2 and ISO 18283 for additional information on the factors that affect frequency and increment mass.

<sup>c</sup> See ISO 20904 for more information on material variability.

**Figure 3 — Sampling types for quality monitoring and control**

[Annex A](#) provides further information on manual sampling locations and options.

**6.4.5 Sampling for equipment performance**

In the case of equipment performance, the goal of sampling is to measure the separation efficiency due to the unit operation(s) as opposed to understanding a particular coal quality. Hence, the sampling duration needs to be as short as possible (target 30 min or less). The sampling duration is limited only by the number of sampling locations, number of sampling personnel and sample volumes required.

Consideration should be given to the following:

- a) Is a particular feed type required (e.g. low or high density cut, low or high near-gravity material assessment)? If so, schedule accordingly.
- b) How variable is the CPP feed? It is necessary to arrange the feed coal to be as constant as possible for the sampling duration. Note that a CPP which receives feed from a coal valve/dozer push system is likely to exhibit ongoing variation in particle size distribution which will impact on the assessment.

Many coal preparation plants source feed coals from different areas and each can have different qualities and washing characteristics. It is recommended that when sampling for equipment evaluation, the plant draw raw coal from one area only.

## 6.4.6 Sample mass

### 6.4.6.1 General

The mass of sample to be collected strongly depends on the top size of coal, its heterogeneity and the sampling purpose. In addition, the mass will be affected by the type of analysis to be conducted, namely:

- a) general analysis and total moisture sample only;
- b) sizing only;
- c) float-sink analysis (f/s);
- d) analysis combinations.

In circumstances where multiple types of samples are required, e.g. general analysis, sizing and float/sink, then the actual gross sample mass requirement needs careful planning. Subsampling for different types of analyses may be considered. However, typically, the best approach is to avoid any need for subsampling of samples with a top size larger than 16 mm.

NOTE In this document, “general analyses” refers to analysis carried out on a minus 212 µm sample in the laboratory such as proximate, calorific value and total sulfur.

### 6.4.6.2 General analysis and total gross sample mass

The minimum mass of gross sample for general analysis should be determined from [Table 2](#), which requires the nominal top size (95 % passing aperture) of the coal to be known or determined.

Alternatively, if the coal has been previously characterized by float-sink analysis on every standard size fraction (≥ 63 mm, -63 mm + 31,5 mm, -31,5 mm + 16 mm, -16 mm + 8 mm, etc.), the technique of Lyman described in Monograph Volume II, Australian Coal Preparation Society,<sup>[3]</sup> may be used.

The sample masses for general analysis and total moisture listed in [Table 2](#) are derived from Gy's formula [see [Formula \(1\)](#)] and are based on low ash (washed product of low heterogeneity), low density coal particles and assume an acceptable relative sampling error (at one standard deviation) of 0,01 %, which, for a coal with a mass fraction of 10 % ash, is 0,1 % ash. Given precision is normally defined as plus and minus two standard deviations, the absolute precision of the ash mass fraction result would be expected to be within ±0,2 % in this case.

Gy's formula is as follows:

$$M_S = \left( \frac{c f g d^3}{\sigma_{FE}^2} \right) \quad (1)$$

where

$M_S$  is the sample mass in g;

$c$  is the mineralogical composition factor, in g/cm<sup>3</sup>, given by:

$$\frac{(1 - a_L)}{a_L} [(1 - a_L) \rho_C + a_L \rho_{mm}]$$

$a_L$  is the mass fraction of the component of interest, e.g. ash = 0,1 (10 %);

$\rho_C$  is the density of the critical component, e.g. ash in coal (typically 1,2) g/cm<sup>3</sup>;

$\rho_{mm}$  is the average density of the non-critical component, i.e. the mineral matter (typically 2,8) g/cm<sup>3</sup>;

$L$  is the liberation factor when  $d > d_1$ ;

$= \sqrt{\frac{d_1}{d}}$  when the nominal topsize,  $d$  is less than the liberation size  $d_1$  in cm, liberation is complete with respect to the component of interest.

if the material is not fully liberated,  $d_1$  being the nominal top size (cm) for complete liberation of the critical component from the non-critical component (coal from mineral matter);

= 1 (dimensionless);

if the material is fully liberated or  $d_1$  is unknown (a conservative assumption);

$f$  is the particle shape factor of particles (usually 0,5 for rounded particles) (dimensionless);

$g$  is the size range (granulometric) factor (dimensionless);

= 0,25 for a wide distribution from fine to large particle sizes;

$d$  is the nominal top size of the material being sampled (linear dimension factor), in cm;

$\sigma_{FE}$  is the fundamental error for sampling as a fraction.

For sampling in coal preparation plants, streams other than low-ash products will be more heterogeneous, which means that:

- a) larger sample masses are required to achieve a similarly narrow range of precision; or
- b) larger ranges of precision (wider error bars) need to be accepted.

Every coal is different, so its contribution to heterogeneity will vary between different coals. It is therefore not always possible to provide separate mass tables to cover specific situations. [Table 2](#) should be used as a guide for minimum masses, and the method of Lyman or Gy should be used if relevant minimum masses are required to be quantified for a particular coal.

As an indication, the precision range can easily increase to a magnitude of  $\pm 1,5$  % ash (absolute) for very heterogeneous samples such as a 40 % ash raw coal, which can contain a wide distribution and quantity of particle types - from low-ash, low density "coal" particles, through to composite (middling) particles, and to high-ash, high density mineral matter particles.

If the material to be sampled is very heterogeneous, such as feed coal to a separator or a coal preparation plant, then the sample mass will need to be increased significantly to achieve the same level of sampling precision. If the decision is made to reduce the sample mass significantly compared to that given in [Table 2](#), then the relative error of the subsequent analysis, can be significantly affected. This takes on more importance when the analytical results are used to calculate mass balances and those mass balances are used to estimate separator efficiencies and unit operation yields.

Conversely, if a higher level of measurement uncertainty is acceptable, then the sample mass may be reduced.

It should also be noted that the relative error associated with the minimum masses listed in [Table 2](#) relates to the sampling error only and does not include sample preparation error and analytical error.

$$\sigma_{Total} = \sqrt{\sigma_s^2 + \sigma_p^2 + \sigma_T^2} \tag{2}$$

where

$\sigma_{\text{Total}}$  is the standard deviation of total relative error (total measurement uncertainty, as a fraction of the true value);

$\sigma_S$  is the standard deviation of sampling error;

$\sigma_P$  is the standard deviation of sample preparation error;

$\sigma_T$  is the standard deviation of testing and analysis error.

NOTE The measurement uncertainty, or the error-bar extent, is usually represented as twice the standard deviation, which in turn encompasses a 95-percentile confidence interval for a normal distribution.

### 6.4.6.3 Size analysis gross sample mass

The minimum mass of gross sample shall be determined using [Table 2](#), which requires the nominal top size of the material being sampled to be known. Hence, if the likely size distribution of the stream is not known, the nominal top size (95 % passing aperture of that stream) first needs to be estimated.

**Table 2 — Minimum gross sample mass for general analysis, total moisture and sizing**

Nominal top size of coal mm	General analysis and total moisture kg	Total moisture only kg	Size analysis only kg
300	15 000	3 000	13 500
200	5 400	1 100	4 000
150	2 600	500	1 700
125	1 700	350	1 000
90	750	125	400
75	470	95	250
63	300	60	125
50	170	35	70
45	125	25	50
38	85	17	30
31,5	55	10	15
22,4	32	7	6
16,0	20	4	2
11,2	13	2,50	0,70
10,0	10	2,00	0,50
8,0	6	1,50	0,25
5,6	3	1,20	0,25
4,0	1,50	1,00	0,25
2,8	0,65	0,65	0,25
2,0	0,25	0,65	0,25

This document covers sampling of material less than 63 mm only. Larger sizes are quoted for reference only, and manual sampling is not recommended above 63 mm.

NOTE 1 Refer to ISO 13909-2 and ISO 18283 for more information on gross sample mass.

NOTE 2 The masses in this table use the following parameter values in Gy's formula: ash = 0,1 = 10 % ad, nominal top size = 0,01 cm, density of mineral matter = 2,8 g/cm<sup>3</sup>,  $f = 0,5$ ,  $g = 0,25$  and  $\sigma_{FE} = 0,01$ .

NOTE 3 These values are applied to maintain a minimum practical mass.

NOTE 4 Masses for float-sink analysis are outlined in [Table 3](#) and [Table 4](#).

**Table 2 (continued)**

Nominal top size of coal mm	General analysis and total moisture kg	Total moisture only kg	Size analysis only kg
1,0	0,10	0,65	0,25

This document covers sampling of material less than 63 mm only. Larger sizes are quoted for reference only, and manual sampling is not recommended above 63 mm.

NOTE 1 Refer to ISO 13909-2 and ISO 18283 for more information on gross sample mass.

NOTE 2 The masses in this table use the following parameter values in Gy's formula: ash = 0,1 = 10 % ad, nominal top size = 0,01 cm, density of mineral matter = 2,8 g/cm<sup>3</sup>,  $f = 0,5$ ,  $g = 0,25$  and  $\sigma_{FE} = 0,01$ .

NOTE 3 These values are applied to maintain a minimum practical mass.

NOTE 4 Masses for float-sink analysis are outlined in [Table 3](#) and [Table 4](#).

**6.4.6.4 Float-sink (F/S) analysis**

**6.4.6.4.1 Determination of gross sample mass**

If the likely size distribution of the CPP feed is not known, the full-size distribution first needs to be estimated at least down to 8 mm.

If the size distribution is reasonably known, the default masses as listed in [Table 3](#) and [Table 4](#) may be used.

**Table 3 — Recommended minimum sample mass in each standard size fraction for float and sink testing**

Size fraction	Recommended mass, kg		
	Raw coal	Clean coal	Reject
-125 mm + 63 mm	2 150	1 810	2 680
-63 mm + 50 mm	300	250	370
-50 mm + 31,5 mm	230	190	280
-31,5 mm + 16 mm	40	34	50
-16 mm + 8 mm	5,2	4,4	6,5
-8 mm + 4 mm	2,0	2,0	2,0
-4 mm + 2 mm	2,0	2,0	2,0
-2 mm + 1 mm	2,0	2,0	2,0
-1 mm + 0,5 mm	2,0	2,0	2,0
-0,5 mm + 0,25 mm	1,0	1,0	1,0
-0,25 mm + 0,125 mm	1,0	1,0	1,0
-0,125 mm + 0,038 mm	1,0	1,0	1,0

**Table 4 — Indicative minimum gross sample masses to provide enough material for float and sink testing**

Size fraction for F/S testing	Indicative minimum gross sample mass, kg		
	Raw coal	Clean coal	Reject
<b>Dense medium cyclone (DMC) samples</b>			
-63 mm + 2 mm	1 400	1 200	1 700
-50 mm + 2 mm	1 400	1 200	1 700
-31,5 mm + 2 mm	200	175	250
-16 mm + 2 mm	25	20	30

Table 4 (continued)

Size fraction for F/S testing	Indicative minimum gross sample mass, kg		
	Raw coal	Clean coal	Reject
-4 mm + 2 mm	4,0	4,0	4,0
<b>Fines circuit samples</b>			
< 2 mm	2,0	2,0	2,0
< 1 mm	2,0	2,0	2,0
< 0,5 mm	1,0	1,0	1,0
<b>CPP Feed (20 % minus 2 mm)</b>			
63 mm nominal tosize	1 750	1 500	2 130
50 mm nominal tosize	1 750	1 500	2 130
<b>CPP Feed (40 % minus 2 mm)</b>			
63 mm nominal tosize	2 340	2 000	2 830
50 mm nominal tosize	2 340	2 000	2 830
31,5 mm nominal tosize	340	300	420

In the case of 50 mm nominal tosize, the -50 mm + 31,5 mm fraction becomes a non-standard size fraction. However, in many cases, 50 mm only refers to the nominal tosize, and there may be up to 5 % of the raw sample above that size. In that case, the “true” maximum particle size is closer to 63 mm. In that case, it is most relevant to regard the maximum size fraction as -63 mm + 31,5 mm. In the event the maximum size is 50 mm, then it is not necessary to have a minimum of 2 000 particles in the -50 mm + 31,5 mm fraction. In that case, when the maximum size is 50 mm, the relevant size fraction series becomes -50 mm + 25 mm, -25 mm + 12,5 mm etc. It is not necessary to list the minimum masses that would apply to those size fractions. It is sufficient to state that where a sample tosize is intermediate within a size fraction, then for minimum mass purposes it should be treated as being the tosize of that standard size fraction.

The particle sizes shown in [Table 3](#) and [Table 4](#) may be supplemented or replaced by other particle sizes provided that:

- the number of discrete particles in any single standard size fraction (from a 2x series) is not less than 2 000;
- the number of particles within each relative density fraction is not less than 10;
- the mass contained in any relative density fraction is not less than 20 g.

#### 6.4.6.4.2 Option for reduction in sample mass

Large sample masses are required when the float-sink determination needs to be conducted on particles larger than 31,5 mm. Hence, an option is to size out (eliminate) the > 31,5 mm material after collecting the gross sample, and only subject the < 31,5 mm fraction to float-sink analysis.

The separation efficiency for +16 mm material is usually very high. Consequently, partition data for > 31,5 mm material may be estimated by using the partition data for the -31,5 mm + 16 mm size fraction.

#### 6.4.6.4.3 Warning

The minimum gross sample mass may not simply be determined by adding the minimum mass required for each size fraction (see [Table 3](#)). The minimum gross sample mass should be determined by calculation based on the minimum required mass in each size fraction, with the minimum mass required in the largest size fraction generally determining the minimum gross sample mass required.

For instance, if raw coal float-sink analysis is required at 50 mm top size and the stream to be sampled is expected to have, for example 15 % of the -50 mm + 31,5 mm fraction, then the minimum gross sample mass will be  $230 \times \frac{100}{15} = 1533$  kg where the 230 kg is taken from [Table 3](#).

#### 6.4.6.4.4 Head samples

Generally, the minimum gross sample mass needs to be doubled if a raw or “head” sample is required to be subdivided prior to sizing for float-sink analysis. When dealing with particle sizes larger than 16 mm, the entire gross sample should be dry sized at least down to 16 mm and each size fraction > 16 mm individually subsampled using a rotary sample divider. Taking a “head” sample can bias the remaining sample.

#### 6.4.6.4.5 Minimizing float sink testing time and cost

The float and sink testing mass may be reduced by first sizing the sample and then F/S testing separate size fractions.

For example, assume a F/S test is required on a DMC feed sample of -50 mm + 2 mm. If that sample were to be subjected to F/S testing as a single sample, approximately 1 400 kg of material may need to be tested.

However, if the sample were first sized at 31,5 mm, 16 mm, 8 mm, and 4 mm, individual size fractions could be subjected to F/S testing as follows:

- a) 230 kg of - 50 mm + 31,5 mm;
- b) 40 kg of - 31,5 mm + 16 mm;
- c) 5,2 kg of - 16 mm + 8 mm;
- d) 2 kg of - 8 mm + 4 mm;
- e) 2 kg of - 4 mm + 2 mm.

In other words, if the size fractions are subjected to F/S testing separately, then the total mass that needs to be tested reduces dramatically down to 280 kg. Note however that the gross sample (as collected) still needs to be at least 1 400 kg to procure enough material in the +31,5 mm fraction. Size fractions below 31,5 mm may be representatively subsampled prior to F/S testing. It is preferred that rotary sample dividers are used for subsampling.

This approach also provides the minimum gross sample mass solution of both size analysis and F/S testing being required.

#### 6.4.6.5 Analysis combinations

For determining gross sample mass where two or more forms of analysis are required, the volume/mass of sample required for a specific purpose is generally related to the number of particles required to render the test statistically significant.

The bulk density of the raw material to be sampled is usually estimated to calculate the required mass/volume. In addition, the minimum mass of sample to be taken will depend on the material variability and the required precision for the test.

NOTE The bulk density of as-sampled raw or product material is generally relatively low (approximately 850 kg/m<sup>3</sup>). Therefore, the maximum mass accommodated by one 200 l drum will typically be 150 kg.

Any form of subsampling at large top size is likely to introduce differences between the various subsamples. Several options are available to minimize the potential errors.

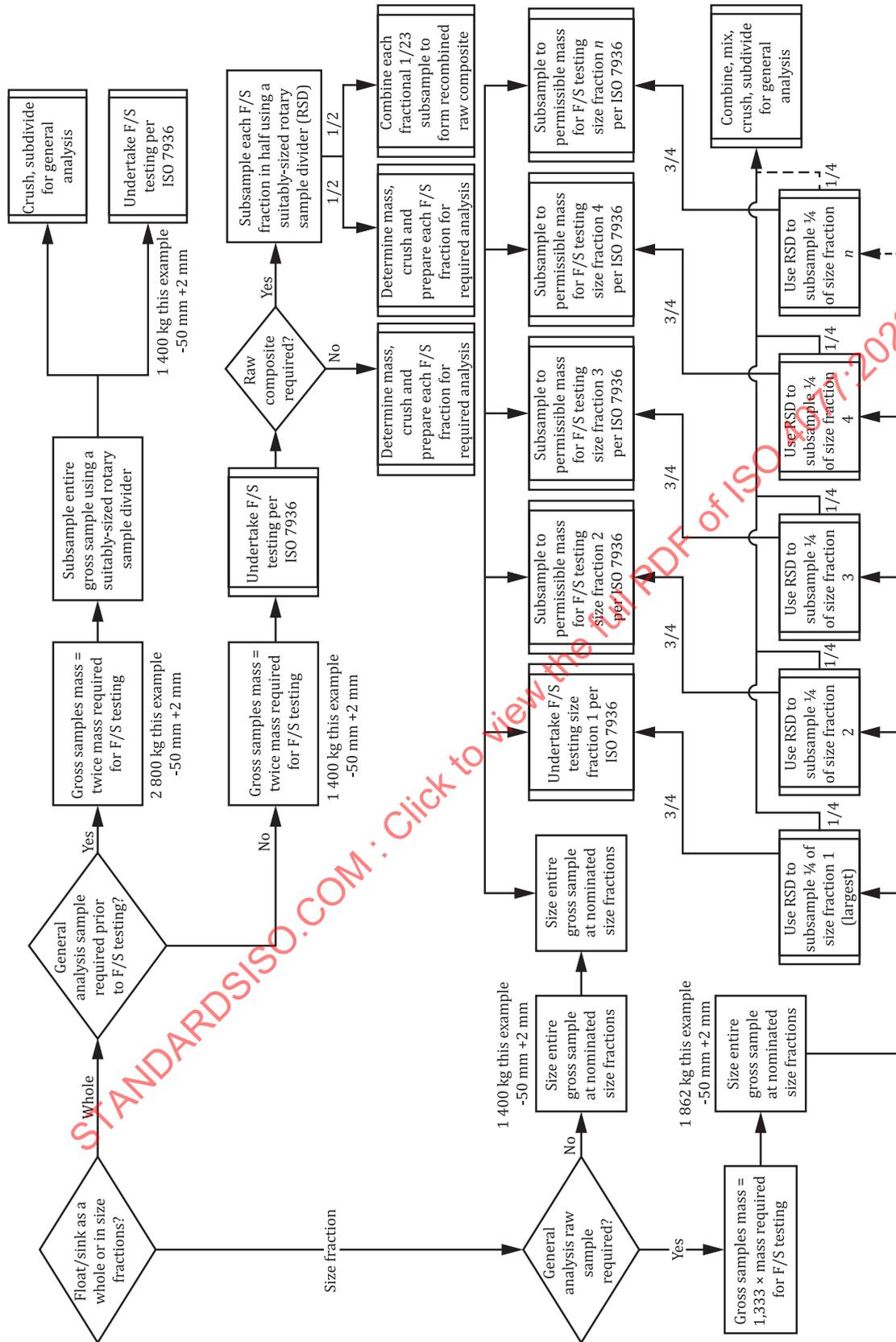
Consider the case of DMC feed above, where 1 400 kg is required for F/S testing alone. The term “head sample” is frequently used to describe a general analysis sample which is meant to represent an analysis subsample of the primary gross sample. [Table 5](#) shows two different options for determining the gross sample mass required for the combined analysis, i.e. F/S testing and head sample testing.

**Table 5 — Example of options for determining gross sample mass for combined analysis sample when 1 400 kg is required for F/S testing**

Option A: Double the required gross sample mass	Option B: Subsample from individual size fractions prior to F/S testing
Assume the DMC feed sample requires a raw general analysis sample as well as F/S testing.	The entire sample is sized through one or more sieves, and then each size fraction is carefully subsampled to enable compilation of a raw coal composite from the individual size fractions.
<p>In that circumstance, 2 800 kg should be collected (twice the “base” minimum sample mass for F/S testing), and carefully subjected to subdivision in half.</p> <p>One half is to be used for the general analysis sample and the remainder for the F/S testing.</p>	<p>In this circumstance, the gross sample mass may be reduced to 1,333 × the F/S gross sample mass (<math>1,333 \times 1\,400 = 1\,862</math> kg in this case) so that 1/4 of each size fraction may be subsampled for the raw coal composite, while maintaining sufficient residual material for the F/S testing. The benefits of this approach are that the size distribution information is generated, and smaller top size portions of the sample (after sizing) may be subdivided in order to reduce the float/sink testing mass for that size fraction, (providing it is not recombined with larger material).</p>
Samples of multi-size fraction composition at large top size should not be subsampled in any portion less than half.	

The advantage of option B, over just taking a 1/4 subsample from the original gross sample, is that the propensity for size-bias between the subsamples will be reduced. [Figure 4](#) presents a summary of the available options.

[Annex C](#) provides further information on laboratory analysis requirements for various streams in the CPP.



NOTE RSD stands for Rotary Sample Divider.

Figure 4 — Testing options for float sink testing and general analysis

## 7 Sampling management

### 7.1 Consideration of process

Sampling needs to occur when a process has reached “steady-state”. Elements to consider when looking for steady state are:

- a) steady supervisory control and data acquisition (SCADA) scheme information;
- b) stabilization of non-magnetics if density of the media is below 1,4 relative density, RD;
- c) stabilization of densities;
- d) no changes in flocculent or reagent addition;
- e) consistent throughput;
- f) consistency of pressures.

The requirement for steady state can differ depending on what is being sampled. DMC circuits, in terms of coal and reject, may be in steady state within 60 min of CPP start-up. However, if the non-magnetic material in the medium is of importance, that will take approximately four hours after start-up to stabilize.

To account for the elements above, clear communication between CPP personnel and all sampling personnel needs to be established. The CPP operators need to set the plant up so these elements are in place and the plant is in a stable operating situation. They need to be aware where all the sampling team members are located so that if the plant conditions change significantly, they can quickly contact the sampling personnel in order to stop sampling until the plant returns to a steady situation. A risk assessment needs to be undertaken with representatives of both the CPP and the sampling team involved. In many cases, members of the CPP team may also be involved in the sampling exercises, so they need to know the risks involved in sampling within their CPP and ways to mitigate these risks.

### 7.2 Handling of samples after collection

The following actions are recommended during and after samples have been collected:

- a) properly seal all containers, especially if total moisture is a critical element of analysis;
- b) tape around lids of slurry buckets to avoid losses during transport;
- c) where practical, determine the mass of the samples on-site prior to transport to cross-check laboratory as-received masses and identity losses in transit;
- d) where practical, collect replicate samples and store replicates on-site until laboratory data have been received and validated, and consider storage requirements for samples of coals prone to self-heating and have those analysed as quickly as possible;
- e) if part of the sample has been lost during transport, it is possible that the sample is no longer representative and needs to be discarded.

## 8 Sampling from a slurry stream

### 8.1 Slurry flow regimes

In slurry pipeline systems, three main flow regimes describe the solids distribution in the pipe ([Table 6](#)). The solids distribution will affect the method of sampling and quality of result. In a horizontal slurry pipeline carrying solids with a range of sizes and/or densities, the smallest particles may be in the symmetric concentration flow pattern, the intermediate sized particles will be in the asymmetric pattern and the largest may slide on the pipe bottom. Hence, the sampling method should ensure that

the entire cross-section of the pipe is being sampled, and as a minimum, the entire vertical cross-section should be sampled.

While planning for the sampling of slurry, consideration should be given to the mass of solids required, since the quantity of solids collected will depend on the solids mass fraction of the slurry. For instance, hydrocyclone overflows and flotation tailings are usually very dilute (< 5 % solids). Hence, larger volumes of slurry will need to be collected.

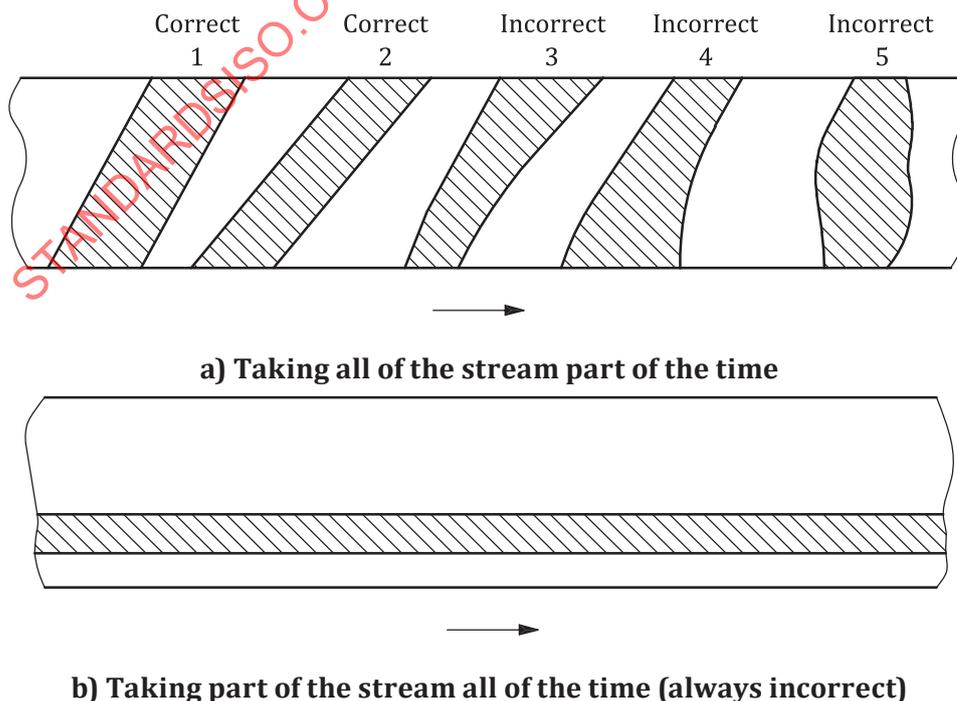
**Table 6 — Slurry flow regimes**

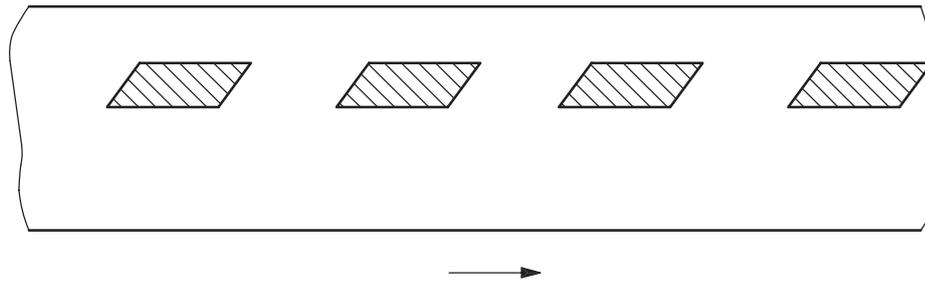
Flow regime	Characteristics
Homogeneous (e.g. vertical pipe down with gravity flow; at least 4 × internal diameter as length of straight pipe)	All solids in suspension Solids distributed symmetrically across pipe cross-section Solids travel at same velocity as fluid
Heterogeneous (e.g. pumped vertical flow and pumped inclined pipes)	All solids in suspension Solids distributed asymmetrically across the pipe cross-section Solids travel slightly slower than fluid
Sliding bed (e.g. horizontal or inclined flow and some gravity flow)	Portion of the solids sliding along the bottom of the pipe Travel at lower speeds than fluid

**8.2 Sampling locations**

Samples should be collected from a falling stream where possible (ISO 20904). In those cases where this cannot be done, the best method is to sample from a vertical pipe. Samples should not be taken from a horizontal pipe if it can be avoided. When sampling from pipes using a point sampler (single port tube or tapping at wall of pipe), it should be accepted that there can be a significant bias (error) in the samples taken. Slurry pipe sampling methods are shown schematically in Figure 5. Figure 5 outlines the problems in taking samples from pipes using a point sampler and what should be avoided. Figure 5 a) outlines the dangers of biasing the sample at 3, 4, and 5 and better outcomes during sampling at 1 and 2. Figure 5 b) shows clearly that taking part of the stream all of the time is always incorrect, and similarly in Figure 5 c), taking part of the stream part of the time is always incorrect also.

Annex A provides further information on manual sampling locations and options.





c) Taking part of the stream part of the time (always incorrect)

Figure 5 — Slurry pipe sampling methods

Table 7 lists the sampling methods shown in Figure 5 and nominates the sample delimitation correctness. The use of point samplers can introduce errors.

Table 7 — Delimitation correctness for slurry pipe sampling methods

Sampling method	Examples	Delimitation correctness
Taking the whole stream part of the time	From pipe discharge or over a weir	Correct
Taking part of the stream all of the time	In-stream point sampler	Incorrect
Taking part of the stream part of the time	In-stream point sampler	Incorrect
Taking part of the stream part of the time	Correctly designed spear or slot that crosses the full diameter of the stream to be sampled	Incorrect, but best pragmatic outcome if full stream not accessible

The best and preferred practice for sampling slurries is to mechanically cut freely falling streams. The cutter should collect slurry from the full cross-section of the stream on every traverse.

Where access to a falling stream is not available, it is often possible to engineer one, and options include:

- a) redesign pipe entries into tanks;
- b) incorporate steps or weirs in launders, sluices and flumes;
- c) build a by-pass system which incorporates pipe flow into a tank or boil-box.

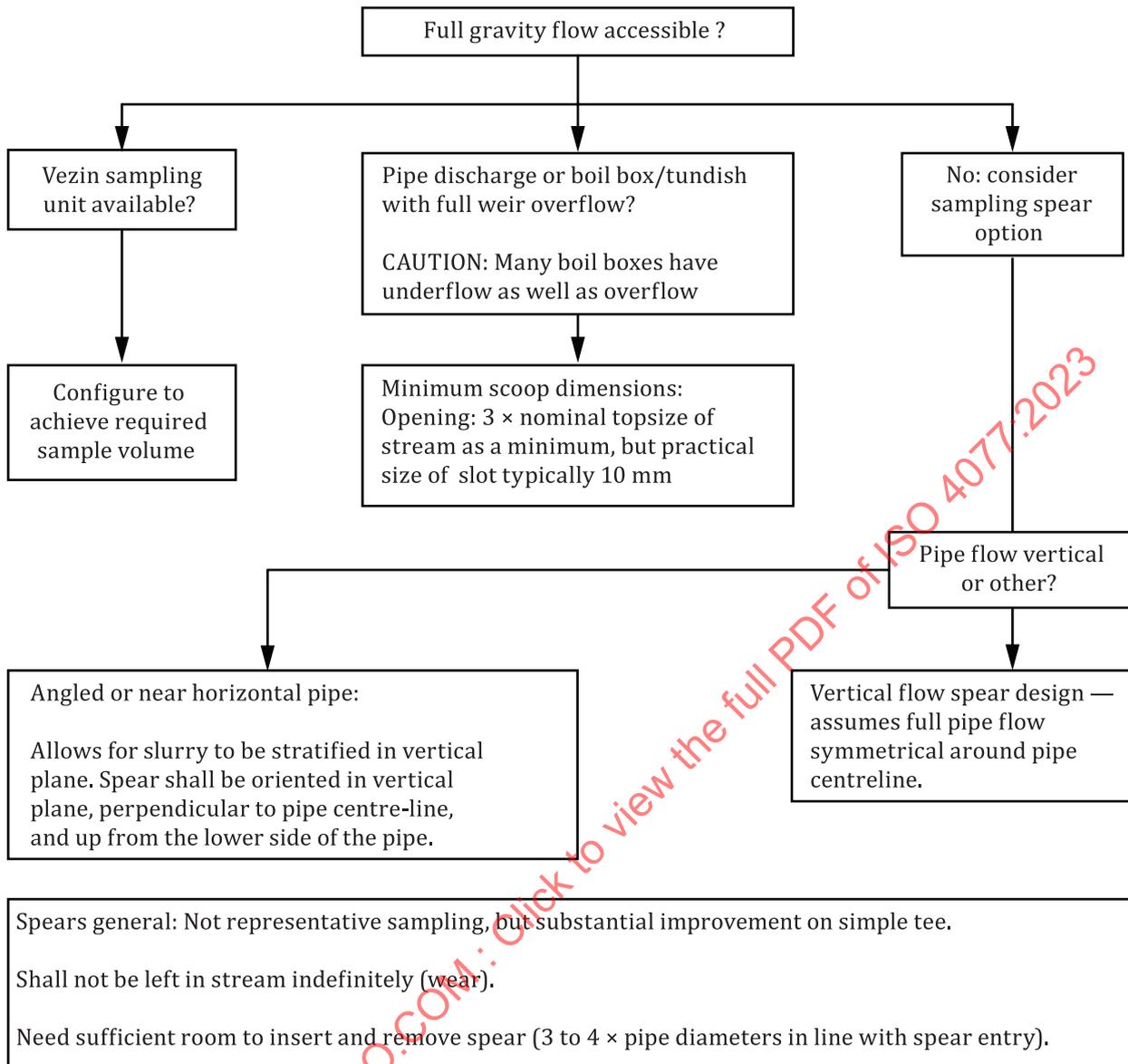
In slurry channels such as launders, heterogeneous flow is almost always present, and this non-uniformity in coal particle mass fraction is usually preserved in the discharge over a weir or step. However, sampling at a weir or step allows complete access to the full width and breadth of the stream, thereby enabling all parts of the slurry stream to be collected with equal probability.

Sampling slurries from tanks or sumps is not recommended as it is not possible to ensure that all portions of the total slurry have an equal chance of being sampled; additionally, the devices used to sample from set depths can be problematic in their use.

## 8.3 Slurry sampling methods

### 8.3.1 Considerations for sampling of slurry streams

The selection of sampling method for fines slurry can be made using the decision tree in Figure 6. Refer to ISO 20904 for additional details and background information.



NOTE In this context, a boil-box or tundish is defined as a small-volume (relative to flow), vigorously agitated tank into which the entire stream enters and then discharges via an overflow lip that is fully accessible for sampling.

Figure 6 — Slurry stream sampling method decision tree

The following sampling methods are recommended:

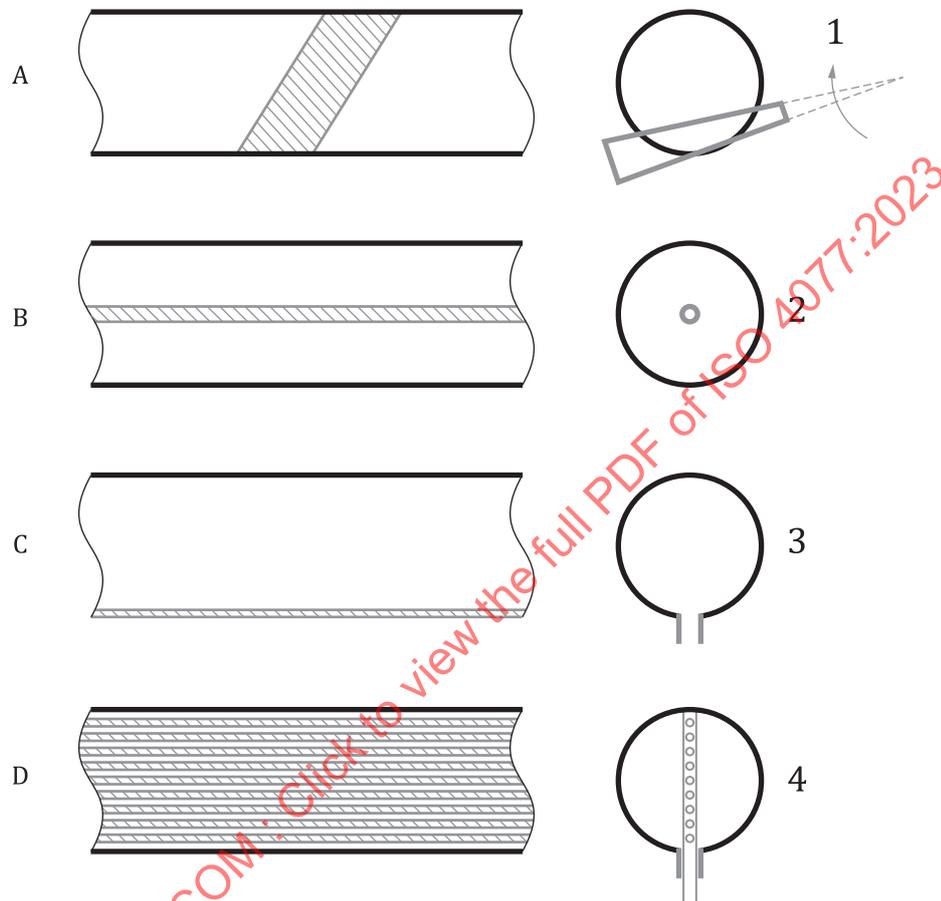
- Sampling at pipe discharge is acceptable if safely accessible and a scoop that covers its full diameter can be traversed under the discharge (see [Figure 7](#)).
- Using full-stream samplers is preferred on full pipe discharge (gravity flows).
- Using properly designed full-diameter sample spears or slot samplers is acceptable if full-stream access is unavailable. Note that this method is not preferred.

The following methods are not recommended:

- Using simple tees directly from a pipe. Serious errors in particle size distribution and errors in solids mass fraction can arise unless the particles are fine, the mass fraction is high, and a very high

sampling velocity (off-take velocity) is used. In terms of routine sampling of coal slurries, serious errors can be expected. This sampling situation is described further in Reference [2].

- Sampling from “shark-fin” (plain slot) protrusions into circular pipes or circular channels.
- Using any device where the sample outlet cross-section area (e.g. 25 mm diameter connection) is smaller than the sample collection (sample entry) cross-section area.



#### Key

- 1 constant speed of rotation (Vezin-type) full-stream cut (fully representative)
- 2 'point' sampler (single fixed aperture such as an inserted tube) (always non-representative)
- 3 tee off side of pipe (always non-representative)
- 4 full-diameter spear (always non-representative), but a significant improvement on B or C. Hole profile tailored to progressive cross-section change across pipe

**Figure 7 — Pipe-flow sampling methods**

### 8.3.2 Manual sampling

#### 8.3.2.1 General

When carrying out manual sampling of a slurry, the following aspects shall be considered:

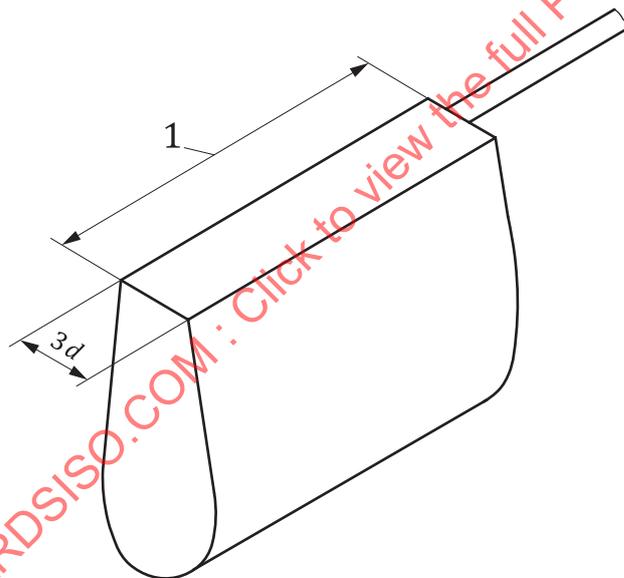
- a) safety of operators and ease of access to sampling location;
- b) slurry flow presented in a manner that the increment mass can be safely handled by the operator;
- c) ease of access to the full slurry stream;

- d) an opening of the sampling implement greater than three times the coal nominal top size and 20 mm minimum;
- e) a width of the sampling implement longer than the width of the slurry stream to ensure the full width is sampled in each pass;
- f) a manual cutter operated in accordance with the same design criteria as mechanical cutters e.g. constant traverse speed, maximum 0,6 m/s, sufficient cutter volume; and splash resistant.

### 8.3.2.2 Manual sampling procedures

#### 8.3.2.2.1 Flowing stream

The increment should be taken in a single operation, moving the sampling implement across the full width of the slurry stream at a uniform speed, avoiding overflow of the implement before it leaves the slurry stream. The cutting aperture of the implement shall be three times the nominal top size ( $d$ ) and shall be near-perpendicular to the slurry stream. The implement shall cut a complete cross-section of the slurry stream, with both the leading and trailing edges clearing the stream in the same path. Alternate increments should be taken by traversing the stream in opposite directions. One ladle design recommended for the sampling of slurries is shown in [Figure 8](#). It is important that the ladle is made large enough to handle the volume of sample produced by traversing the full width of the stream without overflowing the ladle.

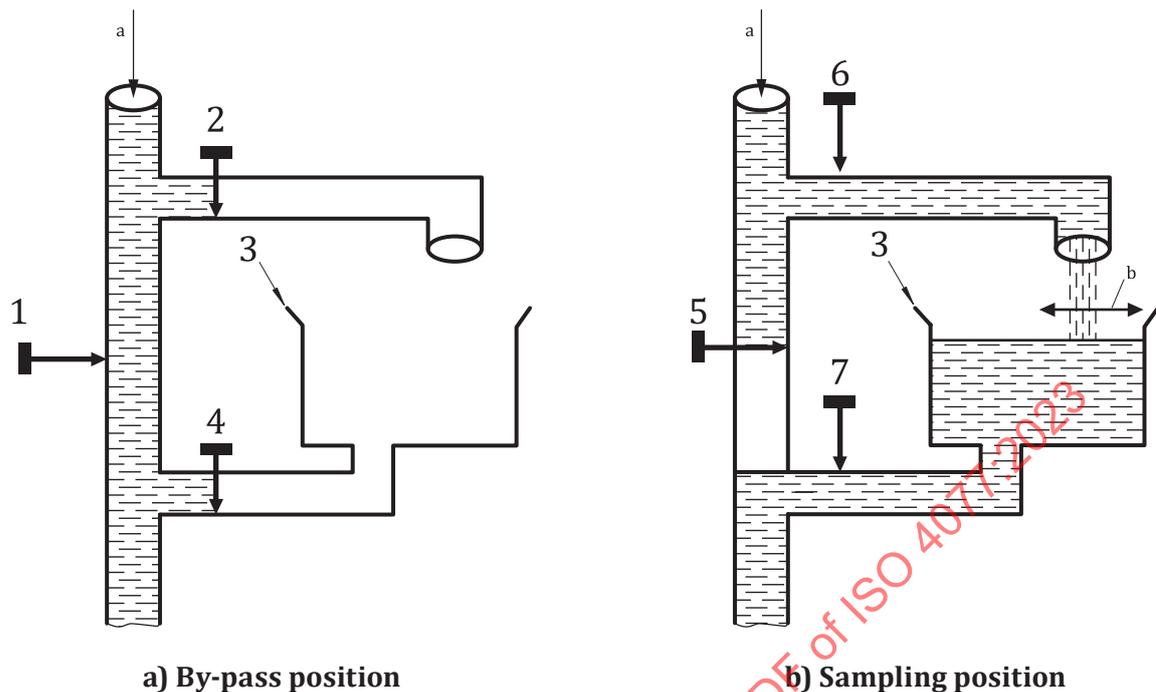


#### Key

- 1 to exceed the depth of the falling stream

**Figure 8 — Scoop for slurry sampling**

A representative sampling point for slurries that traverse through pumps and pipes cannot always be found. In that case, a by-pass sampling point can be created by using a system of gate valves and receiving tank as outlined in [Figure 9](#). The sampling point in this example is a falling stream into a tank. Alternatively, the “holding tank” can have a weir system and a sample taken from the full width of the stream at the weir.

**Key**

- 1 gate valve A open
- 2 gate valve B closed
- 3 holding tank
- 4 gate valve C closed
- 5 gate valve A closed
- 6 gate valve B open
- 7 gate valve C open
- a Slurry flow.
- b Motion of manual sampling implement.

**Figure 9 — Sample by-line for manually sampling slurry in a pipe**

### 8.3.2.2.2 Sampling of bulk slurries

Sampling from bulk slurries is discouraged. Even with good mixing, the solids in a tank or process vessel will be significantly stratified. In the case where samples are needed for special investigation purposes, care shall be taken to ensure that samples are collected from a range of locations within the overall vessel volume sufficient to identify the nature of the stratification that is present.

A common case of this form of sampling is from a flotation feed distributor. Sampling of bulk slurries is sometimes carried out from a flotation feed distributor using a pipe or sample inlet device of some sort installed within the distributor. There are several design criteria that apply in the same manner as for a pipe spear. The sum of the areas of openings in the sample collector should not be larger than the minimum area of the outlet of the sample collector, to avoid back-pressure and preferential (biased) flow. For example, if the sample outlet is a 25 mm internal diameter hose (which is typical), then the sample collecting device can only accommodate a maximum of 25 holes each of 5 mm diameter, or 6 holes each of 10 mm diameter, as specific examples. Slotted sample collection devices rarely if ever meet this fundamental criterion since the area of the slot is usually much larger than the area of the outlet. In practice, the design of the sample outlet needs to be carefully reviewed since fittings will frequently limit the outflow diameter to something less than the nominal outlet diameter.

The openings in the sample collector need to be sufficiently large (preferably 3 × nominal topsize) to avoid pegging. The lowest practical dimension is generally of the order of 3 mm.

NOTE “Pegging” refers to one or more particles from the source stream bridging and blocking, or partially blocking, one or more sample collection orifice or slot.

Table 8 provides typical sample volumes required for various slurry streams in the coal preparation plant.

**Table 8 — Typical minimum volume for slurry sampling**

Stream	Typical volume per stream	Comments
Spirals/HBS	1 × 20 l bucket	Assumes > 15 % solids all streams
Classifying /Thickening cyclone feed	2 × 20 l bucket	Assumes < 10 % solids
Classifying/Thickening cyclone underflow	1 × 20 l bucket	Assumes > 20 % solids
Classifying /Thickening cyclone overflow	3 × 20 l bucket	Assumes < 5 % solids
Thickener underflow	1 × 20 l bucket	Assumes > 20 % solids
Flotation feed	2 × 20 l bucket	Assumes < 10 % solids
Flotation concentrate	1 × 20 l bucket	Assumes > 15 % solids, otherwise 2 buckets
Flotation tailing	3 × 20 l buckets	Assumes < 5 % solids
Medium samples	1/2 × 20 l bucket	
Centrifuge effluent/centrate/filtrate	3 × 20 l buckets	Assumes < 5 % solids
Filtrate	3 × 20 l buckets	
Fines dewatering screen discharge	1/2 × 20 l bucket	
Filter cake discharge	1/2 × 20 l bucket	

NOTE There is rarely adequate access spiral discharges under the launders. Hence overall samples of product, middling and reject are preferred. Mathematical mass-balancing based on stream ash and % solids is typically very difficult since with three or more products, there are usually more than one permutation to achieve balance. Consequently, it is very beneficial if timed samples of each product, middling and reject are collected during sampling (bucket and stop-watch) from one or more starts. Feed flows determined by temporarily installing a by-pass hose/pipe off one outlet of the spiral feed distributor. Sampling needs to identify whether the full stream sample is total fresh flotation feed or incorporating a recycled stream.

**8.3.2.2.3 Concentrate lip sampling**

The following criteria should be considered when sampling from overflow lips.

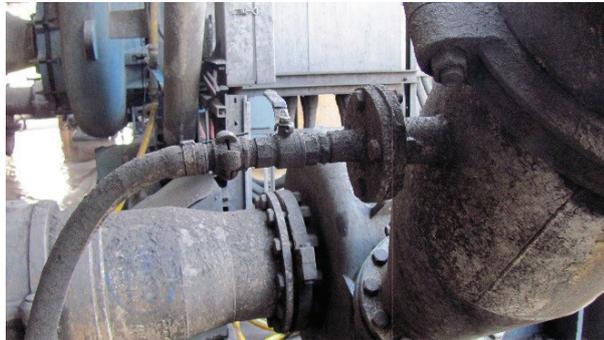
- a) Flotation concentrates may be sampled directly from the discharge lip of each flotation cell. In that case it is important to make sure that the entire discharge lip length is sampled on a representative basis, to the extent possible. For this application, a flexible, thin walled container can be most useful to press against the wall of the cell and collect the overflow.
- b) If concentrate lip sampling is employed, the full lip length needs to be accessible (there is anecdotal evidence, for example, that the concentrate reporting to the inner launder of a cell can be different to that at the outer launder).

**8.3.2.2.4 Medium sampling**

Several different sampling points and equipment used to sample the correct medium, depending on the CPP configuration, are outlined below.

- a) Pipe outlets from ports in pipes such as that shown in Figure 10 are common. This type of sampling point is not ideal as it collects from the wall of the pipe and does not sample the full stream. If

measuring the density using a density device, or other known volume vessel for the measurement of density, it is important that medium is not spilled from the vessel as this will lead to erroneous results.



**Figure 10** — Example of an “in-pipe” sampling system (poor sample)

- b) Splitter boxes are often an ideal location to sample the correct medium, as they are normally areas of turbulent flow and can contain a discharge lip that provides for full stream access for increments. Sample scoops may need to be designed to suit a particular installation. [Figure 11](#) shows a typical splitter box found in a coal preparation plant and the special sample scoop fabricated for this sample point.



**Figure 11** — Splitter box and specifically designed sample scoop

- c) Drain mediums can be the most difficult to sample as access to these mediums is limited. Modern multi-slope screens have access ports in the rear of the screens which allow access to medium falling through the screen. However, in order to cover the full width of the stream, special samplers need to be constructed such as those shown in [Figure 12](#) and [Figure 13](#). Even with devices of this nature, there is no guarantee that the full stream can be accessed, and the preferred option is to design for suitable sampling access to the drain underflow pipe from each screen separately. Samples are often taken from the side of the screen where the drain section flows into the discharge chute, and experience has shown that careful sampling in this area can provide access to a reasonable sample. The container shall not be allowed to overflow in any way during sampling, and to achieve this, sampling cups such as those in [Figure 14](#) should be used.



Figure 12 — Roller support clamped to side port of drain - Section of a multi-sloped screen



Figure 13 — Sampling scoop to sample the drain section medium through the rear access ports

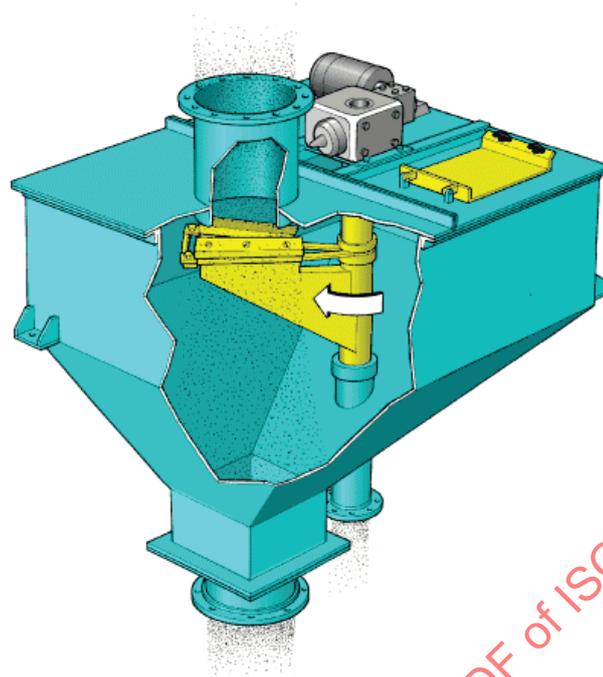


Figure 14 — Sampling cups used for sampling medium from the side of the screen

### 8.3.3 Automatic slurry samplers

#### 8.3.3.1 Full stream sampler

For automatic sampling of slurries, a full stream sampler is normally used (see [Figures 15](#) and [16](#)).



**Figure 15 — Full stream sampler** (figure reproduced with permission from Heath and Sherwood, Ltd., Ontario, Canada)

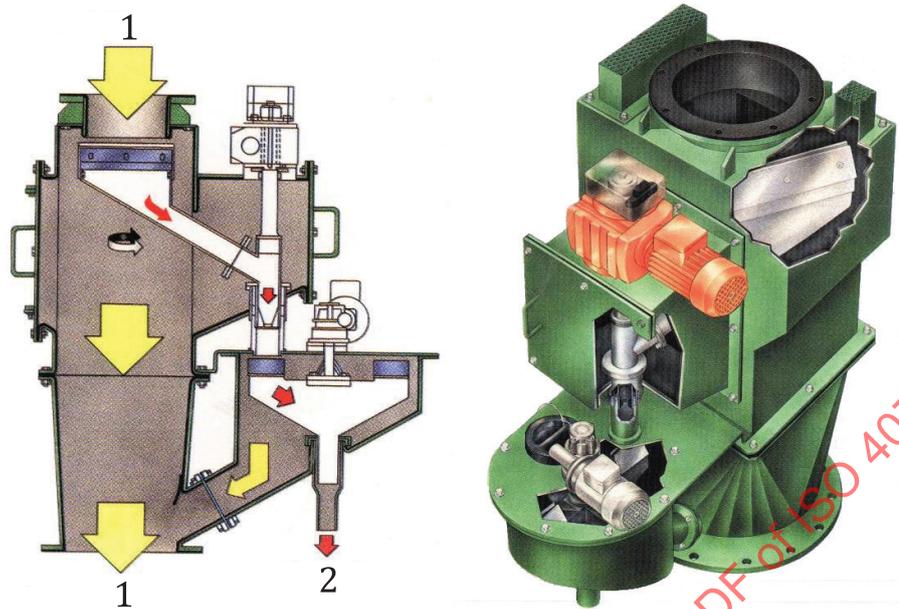


**Figure 16 — Simple full stream subsampler**

### 8.3.3.2 Two-in-one slurry sampler

Similar to bulk materials sampling, because of the very high sample volumes that can be obtained by correct sampling of a process stream, a secondary sampler can be required. One space-saving option is for a “two-in-one” sampler as shown in [Figure 17](#). This design can suffer from the fact that the primary increment discharges too rapidly past the secondary cutter resulting in possible bias in the secondary stage. There can also be a problem with the resistance to flow in the piping, leading to back up and overflow of the primary cutter. Therefore, such a sampler shall be unbiased at the flow rates to be encountered before its results can be validated. The preferred manner of sampling slurry in two

stages is to use a regulated flow between the stages, providing sufficient time for numerous secondary increments to be collected from each primary increment.



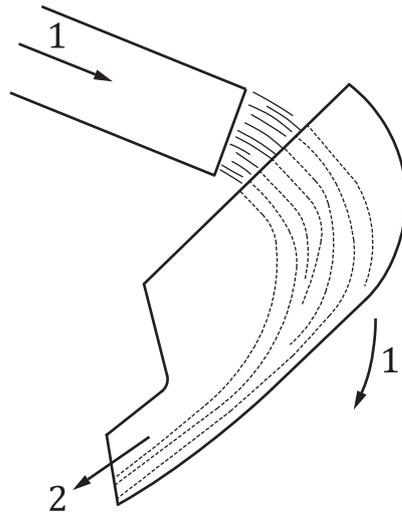
**Key**

- 1 process
- 2 sample

**Figure 17 — Two-in-one slurry sampler** (figure reproduced with permission from Multotec, Kempton Park, Gauteng, South Africa)

**8.3.3.3 Diverter type**

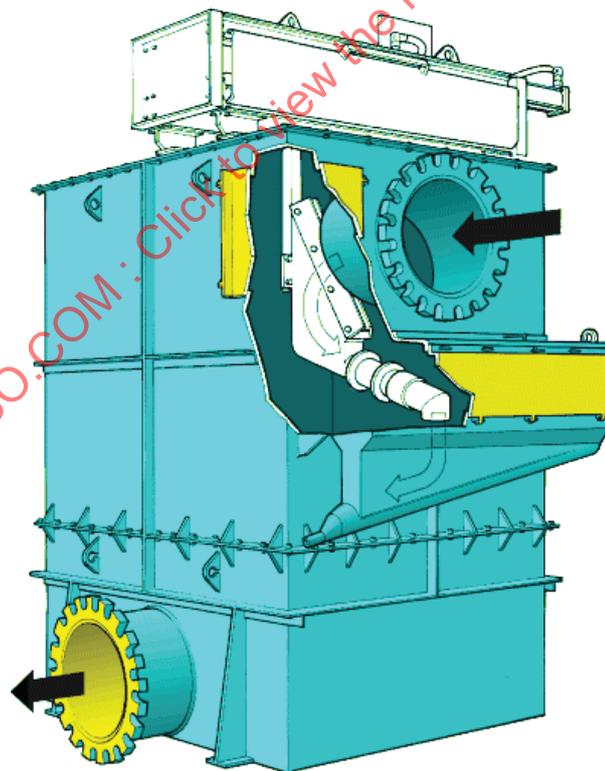
The diverter type of sampler (see [Figure 18](#)) is also similar to its bulk materials counterparts and available in a number of styles. The most common of which is the linear moving cutter sampler (see [Figure 19](#)) which is widely used in the minerals industry.



**Key**

- 1 stream
- 2 increment

**Figure 18 — Diverter type sampler**



**Figure 19 — Example of linear moving cutter sampler** (figure reproduced with permission from Heath and Sherwood, Ltd., Ontario, Canada)

### 8.3.3.4 Point samplers

Point samplers are probes or pipes which collect only a small portion of the cross-section of the slurry as a sample. Although these samplers do not follow representative sampling principles in general, they are widely used in the coal industry, and for this reason some types and limitations are discussed.

There is a variety of point type samplers commercially available, some are completely automatic and are propelled into the slurry stream when a sample is required.

Point sampling is not recommended as an unknown bias is almost always introduced due to the heterogeneity of the liquid-particle-air mixture inside the pipe.

In those situations where point sampling is the only alternative, the following guidelines shall be followed:

- a) For pressure systems, install in vertical pipes only.
- b) Employ isokinetic sampling techniques (i.e. calculate or measure the slurry velocity and extract the sample at such a rate that this is the velocity at the inlet of the sampler). Most importantly, ensure the samples discharge does not impose any backpressure at the sample inlet from the main stream.
- c) Locate the sampling point in a straight run of pipe not less than 10 pipe diameters from any upstream or downstream fittings, except for any turbulence inducing fittings which have been incorporated into the pipeline specifically for the purpose of providing a homogeneous slurry for sampling.
- d) Use a second system to check the validity of the primary system. The second system may be periodic checks using manual sampling techniques or a manually operated sampling probe of a different type than the first, utilized at a completely different location (in the same pipe) compared to the first. This second system will highlight problems if the results differ significantly. Unfortunately, similar results will not “prove” the sample is representative, but the degree of confidence will increase substantially if two different methods of sampling produce a similar analytical outcome.
- e) Ensure sufficient flushing of sample pipes is carried out before collecting a sample, and discard or by-pass the slurry used to flush the sample lines for collection of each increment.

One version of the point sampler involves a probe being inserted through a pipe wall and sampling only a small cross-section of the stream. There are many variations:

- single sample collection (1 hole only for sample collection);
- multi sample collection (> 1 hole for sample collection);
- probe permanently in pipe;
- probe inserted at periodic times (auto or manual) through a seal.

Periodic insertion probe samplers are widely used for the sampling of fluids but are not commonly used for slurries.

The common variant for the coal industry is for the point sample to be flush mounted to the pipe (i.e. equivalent to a simple tee), and this is strongly discouraged.

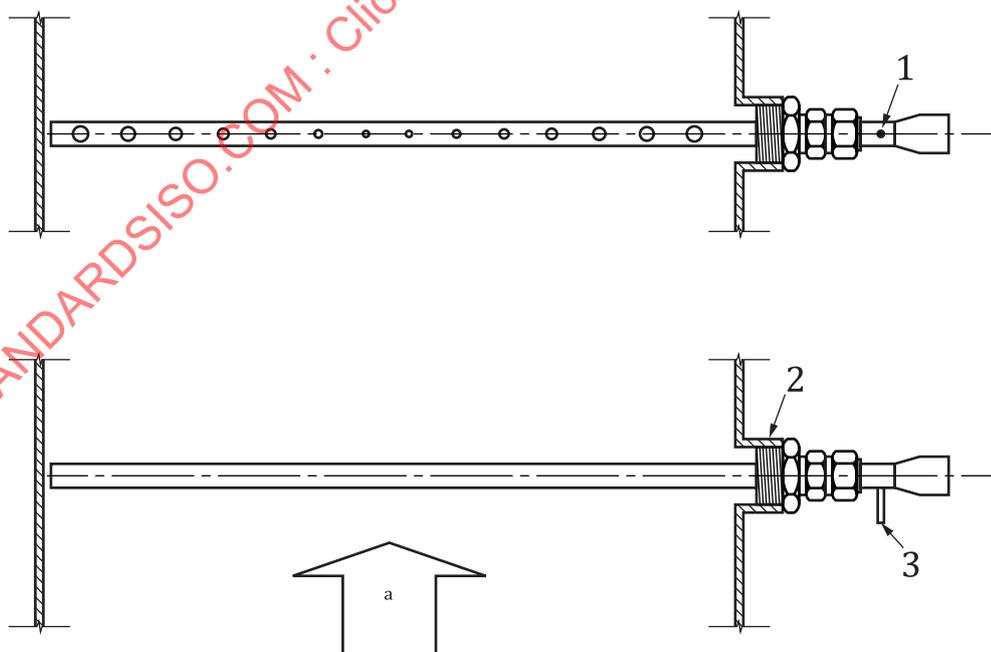
If a full stream sampler is not feasible, then the pragmatic preference is to incorporate a “spear” which protrudes across the full diameter of the pipe. The spear should include as many inlets as possible, with the hole pattern specifically designed to account for expected flow profile variation and/or segregation in the pipe.

Many permutations of spear design have been attempted. One example is shown in [Figure 20](#) where the hole diameters in the spear have been calculated to correspond proportionately to the pipe area cross-section to be represented by that hole. Theoretically, the spear itself should be tapered so as to provide the equivalent head loss within the spear from any hole to the spear discharge, but that is typically

an ideal rather than a practically feasible option. Consideration of using a spear in vertical pipe flow requires the assumption that the flow profile will be the same, on average, across any diameter of the pipe.

The primary attributes of spear design include the following.

- Use as many holes across the diameter as possible. The practical limitation is that the larger the number of holes, the smaller they need to be to avoid back-pressure at the spear outlet. Holes smaller than 3 mm will typically be prone to blockage as a result of coarser particles lodging (pegging) in the aperture. Typically, 10 to 14 holes are employed.
- If the holes are at fixed spacing, the holes need to be varied in diameter across the pipe diameter, to account for the varied flow proportion that any specific location across the diameter represents. Alternatively, if the holes are of the same diameter, the spacing needs to vary across the diameter. For vertical pipes, the flow can be considered as a set of symmetrical “donuts”. For inclined or near-horizontal flow, the flow profile needs to be considered as a sequence of layers in the vertical plane.
- The sum of areas of the sampling apertures (holes) in the spear shall not exceed the smallest cross-sectional area of the exit pipework from the spear to its receiving device or container. Otherwise, back-pressure will result at the spear outlet and short-circuiting of sample will result through the holes closest to the spear outlet.
- The pipework/hose between the spear and the receiving device or container shall not have any flow restrictions (e.g. a partially closed valve) during sample collection.
- Pipework from the exit of a spear shall be directed to vertical downward as soon as possible, and always at a minimum of 45° downward, to minimize the opportunity for blockage, especially for streams containing coarse particles and/or high mass fraction of solids.
- Special attention to materials selection needs to be made for pressurized streams and for streams that are likely to be abrasive (e.g. tailings streams). For pressurized streams, the total number of holes, or their diameters, will possibly be reduced to limit the sample volume flow.



**a) Schematic of sample spear**



**b) Photograph of sample spear**

**Key**

- 1 pin on spear (outside of pipe) shows hole orientation
- 2 50 mm BSP socket
- 3 pin to show hole orientation
- a Slurry flow.

NOTE BSP stands for British Standard Pipe.

**Figure 20 — Example of sample spear**

In [Figure 20](#), the top spear is designed for a vertical pipe orientation (larger holes toward the outside of the pipe diameter represent a larger cross-sectional area of the pipe), whereas the bottom spear is designed for a horizontal or inclined pipe configuration (where larger holes in the middle of the pipe diameter represent a larger cross-sectional area in the layers in the middle of the pipe).

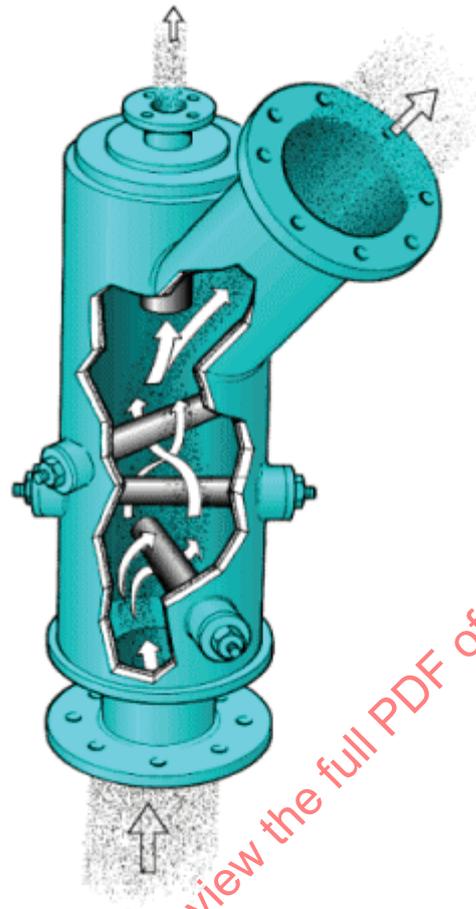
A key advantage of spears of this nature is that they are relatively cheap to procure and easy to install. Their disadvantage is that they are more prone to wear and consequently need to be considered as a consumable. In low-wear situations (low velocity stream or very fine size distribution slurry) they can last for years, but in very abrasive streams their lifetime can only be a month or shorter, depending on materials selection and thickness.

**8.3.3.5 Pressure pipe samplers**

Splitters are used in pressurized pipe systems (i.e. when the pipe cannot be opened). They take a portion of the main flow as the sample and are installed in a vertical position at a point where the slurry is well mixed (see [Figure 21](#)).

These devices are likely to generate a sample whose representativeness will be between that of a simple point spear and a full-diameter spear. Many of the limitations of point spears remain, and the only change is that some attempt is made to mix the slurry in the flow so as to try to make the flow profile uniform.

This type of sampler can be fabricated in heavy-duty wear-resistant materials which is suitable for spirals/hindered bed settlers (HBS) applications, such as teetered beds, reflux units and hydrosizers. These samplers should not be used for metallurgical accounting, because of their propensity to introduce bias but may be used for monitoring trends.



**Figure 21 — Pipe splitters** (figure reproduced with permission from Heath and Sherwood, Ltd., Ontario, Canada)

#### 8.3.3.6 Slot sampler for near horizontal launders and pipes

These samplers are used for taking samples from near horizontal launders (see [Figure 22](#)) and pipes (see [Figure 23](#)) with the slurry flowing under gravity. The sample taken by these devices will only have a chance of being representative if:

- a) they are in a square section of pipe (not circular);
- b) the combined open area of the slots is less than or equal to the cross-section area of the discharge pipe/hose (narrowest constriction).



Figure 22 — Double shark fin slot cutter

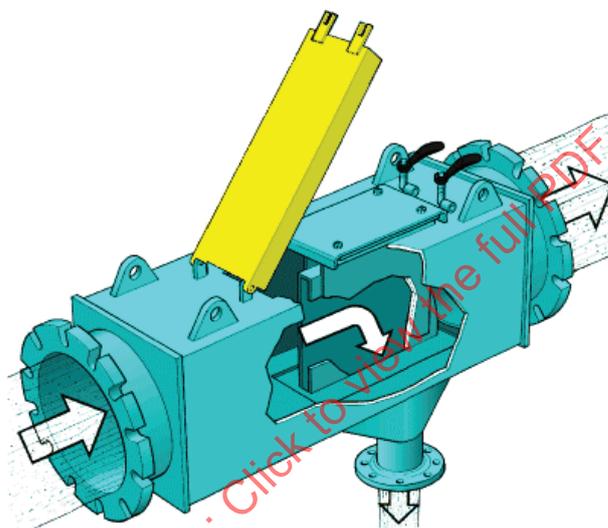


Figure 23 — Example of slot sampler (figure reproduced with permission from Heath and Sherwood, Ltd., Ontario, Canada)

The cross-section, and hence the flow of sample, can be quite high because of the use of a slot in these devices (typically 10 mm or 20 mm wide, across the full pipe section). The downstream pipe delivery system needs to be very carefully designed so that no flow restrictions result at the sampler itself. If any restrictions are evident, short-circuiting of flow closest to the slot outlet will result.

The advantage of this type of sampler is that it is feasible to fabricate the sampler in heavy-duty wear-resistant materials.

Secondary samplers are almost always required for this type of sampler, because of the large sample stream flow.

#### 8.4 Secondary sampling of slurry streams

On occasions, the primary slurry sample flow can itself be too voluminous to use for sample collection. In that case, a representative subsample of the primary sample flow needs to be considered. Secondary samples may be collected using a full-stream sampler.

## 9 Considerations for screen discharge sampling

When sampling the discharge of screens in a preparation plant the following should be considered:

- Over the duration of gross sample collection, increments should be collected from across the entire width of screen discharge.
- Each individual increment may be collected from a singular location. However subsequent increments need to be collected randomly (or systematically) from across the entire screen width.
- If systematically collected, ensure that the same number of increments is collected from every lateral position on screen discharge.
- Ensure that the entire falling stream front to back is sampled without over-filling of the scoop.
- Ensure that the scoop can pass fully through the falling stream in both directions. If this is not possible, the use of a collapsible scoop should be considered for a single direction of pass-through stream. [Figure 24](#) demonstrates the collapsible scoop.

It is possible that a conventional square or rectangular aperture scoop cannot clear the back of the falling stream in its forward pass, thereby over-sampling the back of the falling stream. It is likely to over-fill by passing the stream twice, especially when sampling from highly loaded multi-slope screens.

NOTE [Figures 24](#) and [25](#) demonstrate how a collapsible scoop avoids the deficiencies of a conventional scoop.

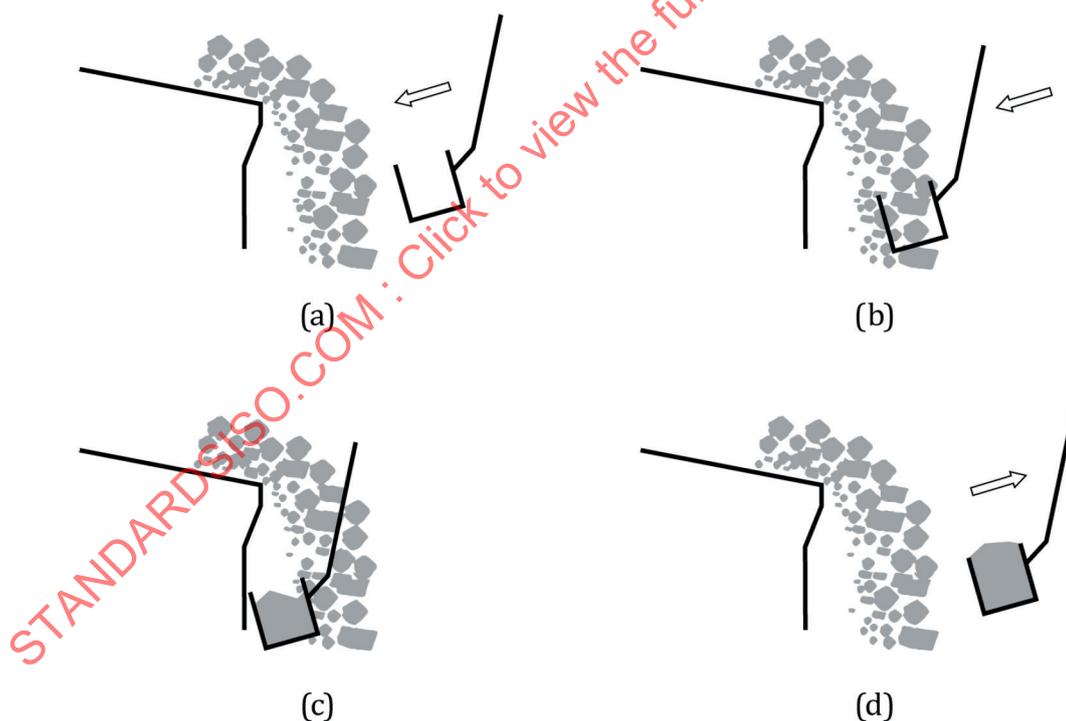


Figure 24 — Schematic showing issues with conventional scoop

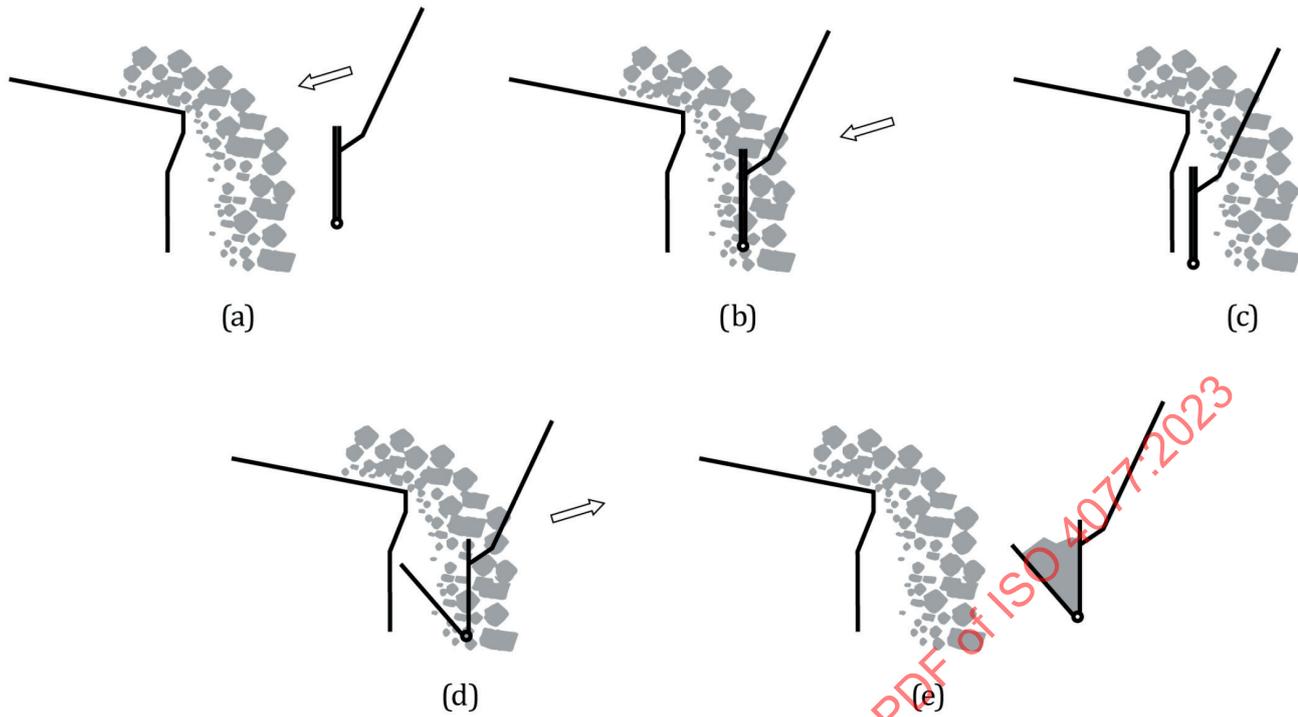
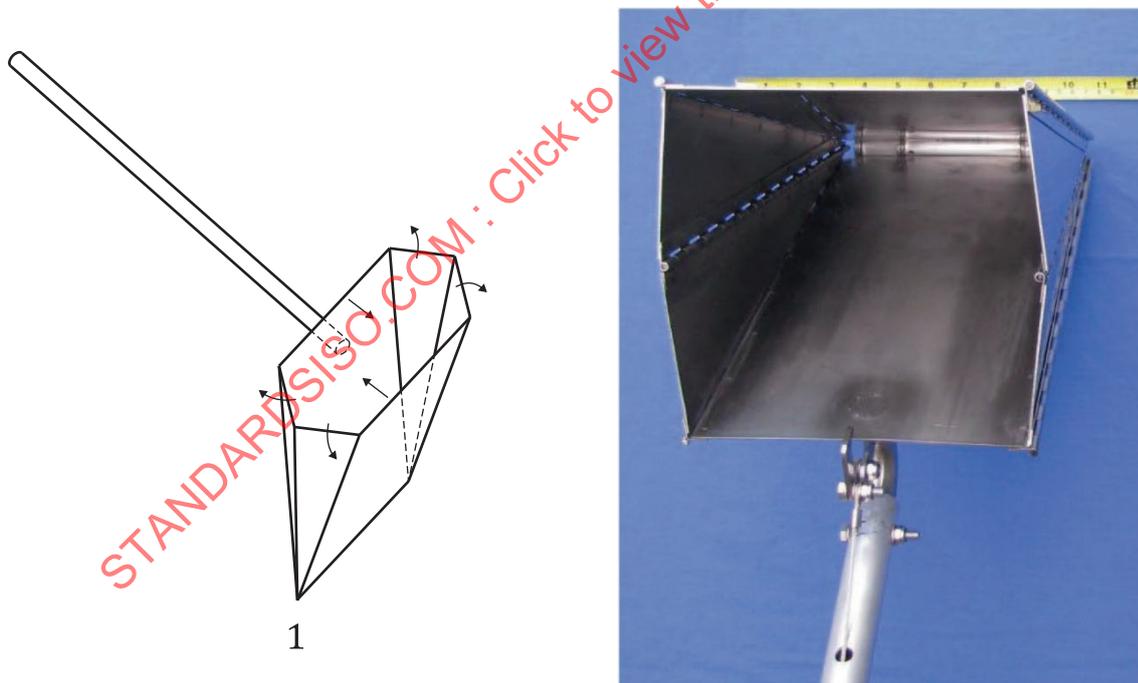


Figure 25 — Schematic showing collapsible scoop



**Key**  
 1 collapsing action

Figure 26 — Schematic and photograph of collapsible scoop

Conventional square scoops are generally acceptable for sampling of low head screens or screens with material discharge of < 16 mm nominal topsize. Collapsible scoops (see [Figure 26](#)) are recommended where bed depths are greater than 150 mm.

Any scoops used for sampling screen discharge shall have a minimum opening of three times the nominal topsize of the stream. The scoop volume is determined by the rate of screen discharge to be captured across the scoop opening.

## 10 Sampling of magnetite received in bulk

The sampling of bulk magnetite is outlined in ISO 8833. Magnetite can be received as bulk samples in bags or delivered loose by a truck. Australian coal preparation plants, in general, have their magnetite delivered by tip truck.

Although not representative, spear sampling of bags and piles is the most practical method of sampling bulk magnetite. A typical sample spear used for sampling bulk magnetite is shown in [Figure 27](#).



Figure 27 — Example of a spear sample tube used to sample bulk magnetite

## 11 Sampling report

There are two aspects of reporting associated with any sampling program. The first aspect is simply the reporting of analytical results from the laboratory. This is only a subset of the information required to address the purpose of the sampling program. The second aspect of reporting incorporates any information relevant to the time and place of the sampling program. It is therefore just as important to plan and execute the recording of all information relevant to the sample program. This recording includes but is not limited to the following:

- a) date and time of sampling;
- b) coal type;
- c) SCADA records for the period of sampling (e.g. feed rate, belt scales, pressure and flow sensors, amp readings on equipment motors);
- d) sampling plan (e.g. sample list for each sampling location, number of increments per stream, number of personnel used);
- e) whether the sampling plan was followed;
- f) condition of equipment, e.g. actual measured screen apertures;
- g) any other observation (e.g. weather conditions at time of sample, equipment noise or vibration, stability of the plant operation during the sampling process, presence of clay-balls, etc).

Combined with the analytical results, the context provided by the additional information allows conclusions, recommendations and actions to be made.

## Annex A (informative)

### Recommended manual sampling locations and options

**Table A.1 — Recommended manual sampling locations and options**

Process unit (e.g. location name)	Sampling location (e.g. CPP)	Sampling options	Document cross-reference
Dense medium bath	Manual sampling not generally considered feasible within CPP due to large particle tosize	Automatic mechanised samplers only	<a href="#">Figure 1, Clause 2</a>
Dense medium cyclone – solids	Feed desliming screen  Product drain and rinse screen  Reject drain and rinse screen	Scoop for screen overflows:  Conventional scoop if bed depth ≤ 150 mm  Collapsible scoop if bed depth > 150 mm	<a href="#">Clause 3, Clause 4, Clause 5</a> and <a href="#">Clause 7</a>  <a href="#">Annex B, Annex C</a> and <a href="#">Annex D</a>
Dense medium cyclone – correct medium	Correct medium splitter box  Correct medium pump discharge	Scoop at weir overflow  Full-diameter spear	<a href="#">Clause 3, Clause 4, Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B, Annex C</a> and <a href="#">Annex D</a>
Dense medium cyclone – overflow medium	D&R product screen and D&R reject screen		<a href="#">Clause 3, Clause 4, Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B, Annex C</a> and <a href="#">Annex D</a>
Dense medium cyclone – Underflow medium	Drain medium pipe off drain underpan boil box-weir overflow  Drain medium from underside of screen  Fall-back: medium discharge pipes	Full-stream automated sampler or scoop from weir  Access doors under sides/rear of screen with long-handled-scoop  Full diameter spear on discharge pipe	
Hydrocyclone overflow	Preferred: boil box with weir overflow  Fall-back: facilitating sampling by full diameter spear on pipe	Safe access and scoop to access full width of weir  Full diameter spear on pipe	<a href="#">Clause 3, Clause 4, Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B, Annex C</a> and <a href="#">Annex D</a>

Table A.1 (continued)

Process unit (e.g. location name)	Sampling location (e.g. CPP)	Sampling options	Document cross-reference
Magnetic separator	Feed distributor	Scoop sized to suit	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
	Underflow discharge	Full-stream automated sampler on underflow preferred	
	Fall-back (feed and/or underflow): overflow discharge	Full diameter spear on feed pipe Scoop sized to suit	
Hydrocyclone feed	Preferred: boil box with weir overflow receiving all sump streams overhead feed sump	Safe access and scoop to access full width of weir	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
	Fall-back: facilitating sampling by full diameter spear on pipe	Full diameter spear on feed pipe	
Hydrocyclone underflow	Preferred: combined underflow pipe discharge	Full-stream automated sampler	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
	Next best: combined underflow discharge to boil box with weir overflow	Safe access and scoop to access full width of weir	
	Fall-back: direct from cyclone underflows	Slot-style slurry scoop	
Sieve bend feed	Preferred: boil box with weir overflow	Safe access and scoop to access full width of weir	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
	Fall-back: relevant upstream process		
Sieve bend overflow	Overflow discharge	Safe access and scoop to access full width of discharge	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Sieve bend underflow	Preferred: underflow pipe discharge	Full-stream automated sampler	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
	Next best: underflow discharge to boil box with weir overflow	Safe access and scoop to access full width of weir	

**Table A.1 (continued)**

Process unit (e.g. location name)	Sampling location (e.g. CPP)	Sampling options	Document cross-reference
	Fall-back: direct from underflow	Slot-style slurry scoop	
Hindered bed separator feed	Preferred: boil box with weir overflow  Fall-back: relevant up-stream process	Safe access and scoop to access full width of weir	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Hindered bed separator overflow	Preferred: launder pipe discharge  Next best: discharge launder to boil box with weir overflow  Fall-back: direct from discharge perimeter	Full-stream automated sampler  Safe access and scoop to access full width of weir  Soft-sided scoop	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Hindered bed separator underflow	Preferred: underflow pipe discharge  Next best: underflow discharge to boil box with weir overflow  Fall-back: direct from underflow pipe discharge	Full-stream automated sampler  Safe access and scoop to access full width of weir  Slot-style slurry scoop Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Flotation feed  Attention should be given to whether the stream required is “fresh” flotation feed or total feed inclusive of any recycle streams.	Fall-back: from discharge pipe  Preferred: boil box with weir overflow receiving all sump streams overhead sump  Fall-back: from feed pipe	  Safe access and scoop to access full width of weir  Full diameter spear on feed pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Flotation concentrate	Preferred: launder pipe discharge  Next best: discharge launder to boil box with weir overflow  Fall-back: direct from cell perimeter	Full-stream automated sampler  Safe access and scoop to access full width of weir.  Safe access and scoop to access full width of weir	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a>  <a href="#">Table 8</a>  <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>

Table A.1 (continued)

Process unit (e.g. location name)	Sampling location (e.g. CPP)	Sampling options	Document cross-reference
Flotation tailing	Preferred: boil box with weir overflow  Fall-back: facilitating sampling by full diameter spear on pipe	Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Thickener feed	Preferred: boil box with weir overflow receiving all sump streams above sump  Fall-back: facilitating sampling by full diameter spear on pipe	Safe access and scoop to access full width of weir  Full diameter spear on feed pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> , <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Thickener overflow (if no visible significant suspended solids that may be settleable)	Clarified water tank discharge	Valve on tee off pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Thickener overflow (with significant settleable suspended solids)	Preferred: boil box with weir overflow receiving all sump streams overhead sump  Fall-back: facilitating sampling by full diameter spear on pipe	Safe access and scoop to access full width of weir  Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Thickener underflow	Discharge pipe	Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Filter Feed (product or tailings)	Preferred: boil box with weir overflow receiving all feed streams  Fall-back: facilitating sampling by full diameter spear on pipe	Safe access and scoop to access full width of weir  Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Filter cake (product or tailings)	Direct from discharge	Soft-sided scoop (so as to not damage filter cloth)	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>

**Table A.1 (continued)**

Process unit (e.g. location name)	Sampling location (e.g. CPP)	Sampling options	Document cross-reference
	Direct from discharge chute	Safe access to purpose-built access hatch on side of chute with purpose-built scoop	
Filter filtrate (product or tailings)	Preferred: underflow pipe discharge  Next best: underflow discharge to boil box with weir overflow Fall-back: direct from underflow pipe discharge Fall-back: discharge pipe	Full-stream automated sampler  Safe access and scoop to access full width of weir Slot-style slurry scoop Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Centrifuge feed	Preferred: boil box with weir overflow receiving all feed streams  Fall-back: facilitating sampling by full diameter spear on pipe	Safe access and scoop to access full width of weir  Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Centrifuge product	Direct from discharge chute	Safe access to purpose-built access hatch on side of chute with purpose-built scoop	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Centrifuge centrate or filtrate	Preferred: underflow pipe discharge  Next best: discharge to boil box with weir overflow Fall-back: direct from pipe discharge Fall-back: discharge pipe	Full-stream automated sampler  Safe access and scoop to access full width of weir Slot-style slurry scoop Full diameter spear on pipe	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
Spiral feed  (Helpful to time the flow from individual spiral start to estimate mass balance)	Preferred: boil box with weir overflow receiving all feed streams  Alternative: diversion pipe from one spiral start (e.g. feed distributor)	Safe access and scoop to access full width of weir  Slot-style slurry scoop or full-stream flexible hose direct to bucket	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>

Table A.1 (continued)

Process unit (e.g. location name)	Sampling location (e.g. CPP)	Sampling options	Document cross-reference
	Fall-back: facilitating sampling by full diameter spear on pipe	Full diameter spear on pipe	
Spiral product, middling or reject	Preferred: pipe discharge	Full-stream automated sampler	<a href="#">Clause 3</a> , <a href="#">Clause 4</a> , <a href="#">Clause 5</a> and <a href="#">Clause 6</a> <a href="#">Table 8</a> <a href="#">Annex B</a> , <a href="#">Annex C</a> and <a href="#">Annex D</a>
(Need to time the flows from individual spiral sets/starts in order to estimate mass balance split between product, middling and reject)	Next best: discharge to boil box with weir over-flow  Fall-back: direct from discharge Fall-back: discharge pipe	Safe access and scoop to access full width of weir  Slot-style slurry scoop Full diameter spear on pipe	

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## Annex B (informative)

### Checklist examples

#### B.1 Pre-sampling inspection checklist

Table B.1 shows an example of a pre-sampling inspection checklist.

**Table B.1 — Examples of a pre-sampling inspection checklist**

Item	Issues/Comments	Equipment implications	Outcome
<b>Evaluate objectives for audit</b>			
Equipment performance? Minimum sampling duration should be used.	Extended sampling durations will cause the variability in coal to increasingly mask “instantaneous” equipment performance.		
Coal quality evaluation? Extended sampling is required to obtain “average” coal quality information.	Need to consider mining/ROM delivery/CPF feed cycle (e.g. time to cut full longwall length).		
<b>Site requirements</b>			
Induction requirements – Generic			
Induction requirements – Generic (medicals)			
Induction requirements – Site specific			
Task-risk assessments	What can be done in advance?  What needs to be undertaken on the day?  Time implications?		
Other?			
<b>Samples</b>			
<b>CPP feed</b>			
Automatic sampler (physical sample)?  Manual stopped-belt sampling?  Special procedures required?	Need to allow estimation of loading to DMC.  Sampling frame required to suit belt profile?  Consider whether to stop belt only before or after CPP sampling or during sampling with adequate process recover delay times?	Sampling frame.  Shovel(s), brush.	
<b>Desliming screen discharge</b>			
Single sample or separate modules?		Scoop minimum 3 × nominal top size	
Trash screen in place? Can it be readily removed?		Lifting gear?	

Table B.1 (continued)

Item	Issues/Comments	Equipment implications	Outcome
Area for 200 l drums? Access to remove full drums?		Lifting gear or trolley?	
Consequences of dropped scoop/sampling apparatus?	Method for prevention?	Rope securely attached to scoop handle?	
<b>D&amp;R screen discharge</b>			
Single sample or separate modules?		Scoop minimum aperture 3 × nominal top size of screen discharge	
Area for 200 l drums? Access to remove full drums?		Lifting gear or trolley?	
Consequence of dropped scoop/sampling apparatus?	Method for prevention?	Rope securely attached to scoop handle?	
<b>Reject D&amp;R screen discharge</b>			
Single sample or separate modules?		Scoop minimum aperture 3 × nominal top size of screen discharge	
No other streams (e.g. spiral reject) added to screen?		Temporary pipe diversion?	
Area for 200 l drums? Access to remove full drums?		Lifting gear or trolley?	
Consequence of dropped scoop/sampling apparatus?	Method for prevention?	Rope securely attached to scoop handle?	
<b>Correct medium</b>			
Single sample or separate modules?		Slurry scoop or spear and valve and hose	
Sample point operable? Consequences of dropped scoop/sampling apparatus?	Access for spear? Spear correctly designed? Method for prevention? Location of emergency stop button.	Rope securely attached to scoop handle?	
<b>Product D&amp;R screen drain medium</b>			
Single sample or separate modules?		Slurry scoop or spear and valve and hose	
Sample point operable?	Access for spear? Spear correctly designed?		
Via pipe or hatch at back of screens?		Tool(s) to open hatch	
Consequences of dropped scoop/sampling apparatus?	Method for prevention? Location of emergency stop button.	Rope securely attached to scoop handle?	
<b>Reject D&amp;R screen drain medium</b>			

**Table B.1 (continued)**

Item	Issues/Comments	Equipment implications	Outcome
Single sample or separate modules?		Slurry scoop or spear and valve and hose	
Sample point operable?	Access for spear? Spear correctly designed?		
Via pipe or hatch at back of screens?		Tool(s) to open hatch	
Consequences of dropped scoop/sampling apparatus?	Method for prevention? Location of emergency stop button.	Rope securely attached to scoop handle?	
<b>Clean coal centrifuge product</b>			
Single sample or separate modules?		Scoop minimum aperture 3 × nominal top size of centrifuge product	
Consequence of dropped scoop/sampling apparatus?	Method for prevention?	Rope securely attached to scoop handle?	
<b>Clean coal centrifuge effluent</b>			
Single sample or separate modules?		Scoop minimum 3 × maximum particle size	
Consequence of dropped scoop/sampling apparatus?	Method for prevention?	Rope securely attached to scoop handle?	
Raw magnetite		Sample spear	
<b>Resource requirements for sampling</b>			
Method to transfer 200 l drums from delivery truck to screen floor?		Crane	
Method to shift full 200 l drums from sampling location to loading position?		Trolley	
Method to transfer full 200 l drums from loading position to delivery truck?		Crane	
Sampling staff	Dependent on sampling duration, sample volume, distance between sampling locations.  Induction requirements. For equipment performance determinations, best to minimize sampling duration and therefore dedicate single sampler to each major stream.		
Supervisory staff	Sampling method integrity.  Frequency of increments, avoid over-filling of scoops, regulate separate sampling staff to similar sampling rate.		