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British Standard

Sampling of coal and coke

Part 1. Methods for sampling of coal

Echantillonnage du charbon et du coke
Partie 1. Méthodes d'échantillonnage du charbon

Kohle und Koks; Probenahme
Teil 1. Verfahren zur Probenahme von Kohle

Foreword

This revision of this Part of BS 1017 has been prepared under the direction of the Solid Mineral Fuels Standards Policy Committee. It supersedes the 1977 edition, amended in 1978 and 1981, which is withdrawn.

The previous edition of this standard was published in order to bring UK practice into line with the procedures outlined in the international standard on coal sampling (ISO 1988). This policy is continued in this edition with the further improvement and expansion of the coverage of methods of mechanical sampling.

The opportunity has also been taken to simplify the lay-out of the standard and to re-emphasize the principles of sampling, particularly the importance of minimizing bias, throughout the document. References to the British Standards for coal analysis and testing are included in table 1. Sampling from the holds of ships and/or barges is not covered in this edition.

Part 2 of this standard deals with methods for the sampling and sample preparation of coke.

The methods of coal sampling included in this Part of BS 1017 were devised primarily to satisfy commercial requirements. Their application should enable the producer or distributor to monitor and regulate supplies to meet contract specifications and the customer to check compliance with such specifications.

Sampling is normally carried out to determine the average value of one or more characteristics (e.g. ash or total moisture) for a lot of coal and whether this value lies between specified or agreed limits.

To obtain the best possible estimate of any characteristic from such a heterogeneous material as coal would require a very large number of samples to be collected and analysed independently. It is necessary to strike a balance between obtaining the best possible estimate and practical considerations, including costs.

The methods given here are based on a great deal of information on sampling practices collected from national and international sources. They were devised to cover the wide variation in commercial grades produced in the UK, the diversity of sampling situations likely to be encountered and the requirements of both industrial and domestic consumers.

In existing installations not constructed exactly as detailed in this Part of BS 1017 it may not be practicable to carry out the recommended methods of sampling exactly as described. Results obtained in this circumstance need not be biased or invalid provided trials have shown that for a particular condition e.g. particle size distribution or moisture, the levels of bias and precision are within acceptable limits.

Attention is drawn to the provisions of the Health and Safety at Work etc. Act 1974 and the need to ensure, from the initial stage of design and construction, that appropriate precautions are taken to ensure the safety of personnel carrying out the provisions required by this Part of BS 1017.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Section one. General

1 Scope

This Part of BS 1017 describes methods for the sampling of coal and the preparation of test samples for the determination of total moisture, general analysis and size analysis. It also describes procedures for testing for sampling precision and sampling bias and for measuring errors in sample preparation.

NOTE. The titles of publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 1017, the definitions given in BS 3323 apply, together with the following.

2.1 sample. A representative portion of coal taken from a larger mass of coal whose properties are to be determined.

NOTE. For a sample to be representative all particles have to have an equal chance of being included (see 3.1.2).

2.2 lot. A discrete quantity of coal for which the overall quality to a particular precision needs to be determined.

2.3 sampling unit. A quantity of coal, the sampling of which results in one gross sample.

NOTE. There may be one or more sampling units per lot.

2.4 increment. A portion of coal collected by a single operation of the sampling instrument.

2.5 primary increment. The increment taken at the first stage of sampling, before subsequent division and/or reduction.

2.6 gross sample. The quantity of coal consisting of all the increments taken from a sampling unit, either in the condition as taken or after having been individually crushed and/or divided as necessary.

2.7 test sample. A sample which is prepared to meet the requirements of a specific test.

NOTE. Table 1 lists the test samples that may be required and gives references to British Standards for sample preparation and methods of testing and analysis.

2.8 common sample. A gross sample from which two or more test samples are prepared.

2.9 general analysis sample. A gross sample taken specifically for general analysis.

2.10 total moisture sample. A gross sample taken specifically for determination of total moisture.

Table 1. Test samples that may be required for coal analysis according to British Standards

Test sample	Property	Sample preparation	Method of analysis or testing
Total moisture (a) 1 kg < 12.5 mm (b) 60 g to 300 g < 2.8 mm	Total moisture	BS 1017 : Part 1	BS 1016 : Part 1
General analysis 60 g to 300 g < 0.212 mm	Proximate analysis* Calorific value Ultimate analysis† Chlorine Phosphorus Arsenic Forms of sulphur Caking and swelling Coal ash analysis Ash fusion Moisture holding capacity	BS 1017 : Part 1	BS 1016 : Part 3 BS 1016 : Part 5 BS 1016 : Part 6 BS 1016 : Part 8 BS 1016 : Part 9 BS 1016 : Part 10 BS 1016 : Part 11 BS 1016 : Part 12 BS 1016 : Part 14 BS 1016 : Part 15 BS 1016 : Part 21
Size analysis (see section four)	Size analysis	BS 1017 : Part 1	BS 1016 : Part 17
Index of abrasion (see clause 22.3.3)	Index of abrasion	BS 1016 : Part 17 BS 1016 : Part 19	BS 1016 : Part 19
Hardgrove grindability index (clause 22.3.2)	Hardgrove grindability index	BS 1016 : Part 20	BS 1016 : Part 20
Petrography 50 g to 100 g < 1 mm	Petrography	BS 6127 : Part 2	BS 6127 : Parts 3 and 5

*Moisture, volatile matter, ash and fixed carbon.

†Carbon, hydrogen, nitrogen, sulphur and oxygen.

2.11 size analysis sample. A gross sample taken specifically for the determination of particle size analysis.

NOTE. The relationships between the various gross samples are illustrated in figure 1.

2.12 sub-sample. A sample consisting of fewer primary increments than a gross sample spaced evenly over the unit.

2.13 partial sample. A sample representative of a part of the whole sampling unit constituted in order to prepare laboratory or test samples. This may be obtained by combining the increments from a sampling unit into two or more sets each set being composed of consecutive increments the number of which need not be the same in all sets.

NOTE. The constitution of partial samples and gross samples is illustrated in figure 2.

2.14 replicate sampling. The taking of increments from the sampling unit which are combined in rotation into different containers to give two or more sub samples of approximately equal mass each being representative of the whole.

2.15 duplicate sampling. A particular case of replicate sampling with only two replicate samples.

NOTE. A plan of duplicate sampling is illustrated in figure 3.

2.16 regular sampling. The sampling of the same coal handled regularly at a given point.

NOTE. There are two forms of regular sampling: continuous sampling and intermittent sampling.

2.17 continuous sampling. The taking of a gross sample from every sampling unit so that increments are taken at regular intervals whenever the coal is handled at the point of sampling.

2.18 intermittent sampling. The taking of gross samples from only certain units of coal (e.g. from one shift per day).

2.19 time basis sampling. The method of spacing the increments in uniform time intervals throughout the unit of coal to be sampled, each increment having a mass proportional to the flow rate at the time of sampling.

2.20 nominal top size. The smallest sieve aperture in the range included in the R 20 series (see table 3 of BS 410 : 1986, square hole) such that not more than 5 % of the sample is retained.

2.21 maximum particle size. The smallest sieve aperture in the ranges given in table 3 and table 4 of BS 410 : 1986, square hole, through which not less than 99 % of the material will pass.

2.22 sample preparation. The process whereby a test sample is obtained from a gross sample, partial sample or primary increment by particle size reduction, mixing and sample division in successive stages.

2.23 stage (of sample preparation). The group of operations comprising particle size reduction, mixing and sample division.

2.24 particle size reduction. The process of milling, crushing or grinding the sample to reduce the particle size.

2.25 sample division. The process in sample preparation whereby a representative part of the sample is retained whilst the remainder may be rejected.

2.26 pass (in sample division). The passage of all the sample retained at a given stage through the sample division system.

2.27 stratified random sample. A sample taken for investigation from a particular strata of a lot.

NOTE. The strata may be selected before sampling by any convenient method of subdivision such as time, space or mass.

2.28 manual sampling. The collection of increments by human effort.

2.29 mechanical sampling. The collection of increments by mechanical means.

2.30 divided increment. The functional part obtained from the division of the primary increment, without particle size reduction, in order to decrease its mass.

2.31 constant mass division. The method of increment or sample division in which the portions retained are of uniform mass.

2.32 fixed rate division. The method of increment or sample division in which the portions retained each have a mass proportional to the mass of the increment or sample.

2.33 laboratory sample. A sample prepared from the gross or partial sample as delivered to the laboratory and from which further samples are prepared for test purposes.

2.34 on-line sample preparation. Sample preparation by mechanical equipment integral with the sampling system.

2.35 off-line sample preparation. Sample preparation performed manually or by mechanical equipment not integral with the mechanical sampling system.

2.36 precision. A measure of the way in which observations within a set agree with each other.

NOTE. For the purposes of this standard the numerical value of precision is taken to be $\pm t.s$, where t is the appropriate value of Students' t at the 95 % confidence limit and s is the standard deviation.

2.37 accuracy. The closeness of agreement between an observation and the true value. The accuracy of a method is the measure of the ability of the method to provide true results.

NOTE. The accuracy of a result or method should not be confused with its precision. A determination may be made with great precision and the standard deviation of a number of determinations on the same limit may therefore be low, but the results will be accurate only if they are free from bias.

2.38 deviation. The difference between an experimental result and an arbitrary central value, usually the experimental mean value.

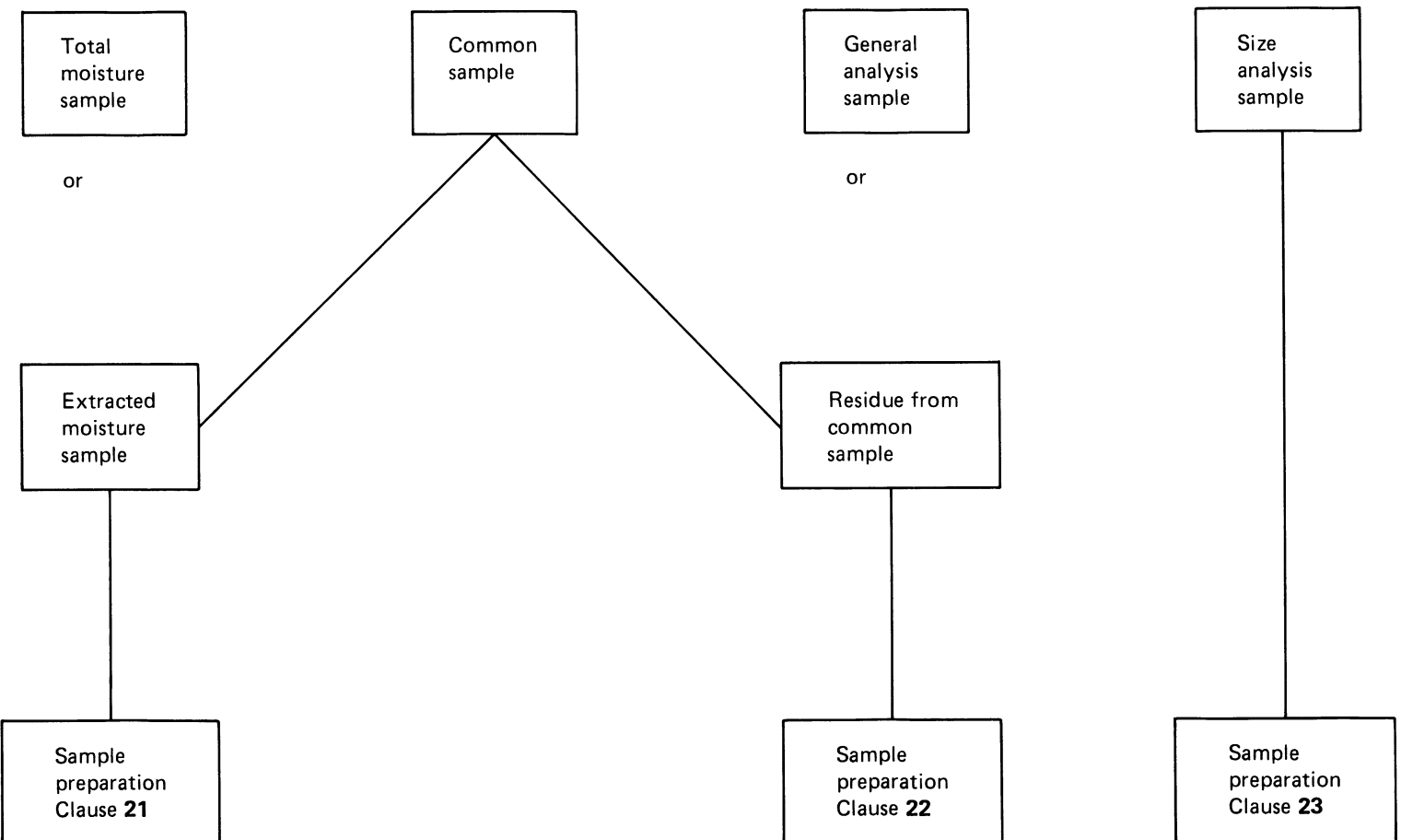


Figure 1. Relationships between the various gross samples taken from a sampling unit

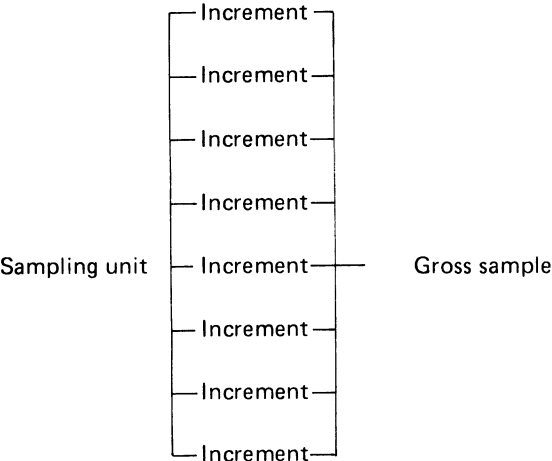
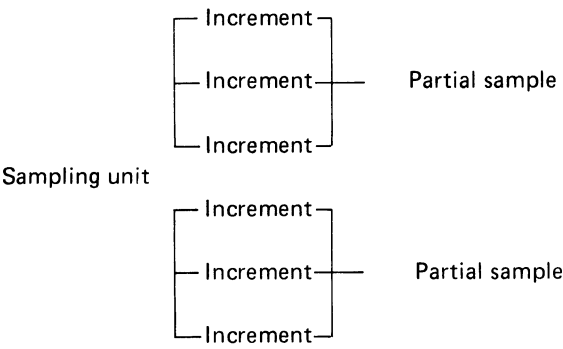
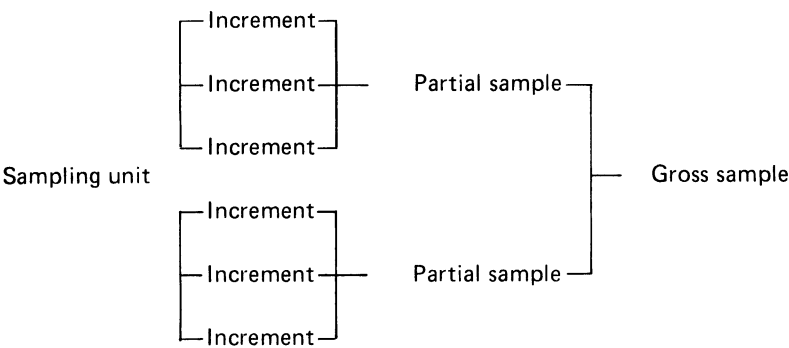


Figure 2. Constitution of partial samples and gross samples

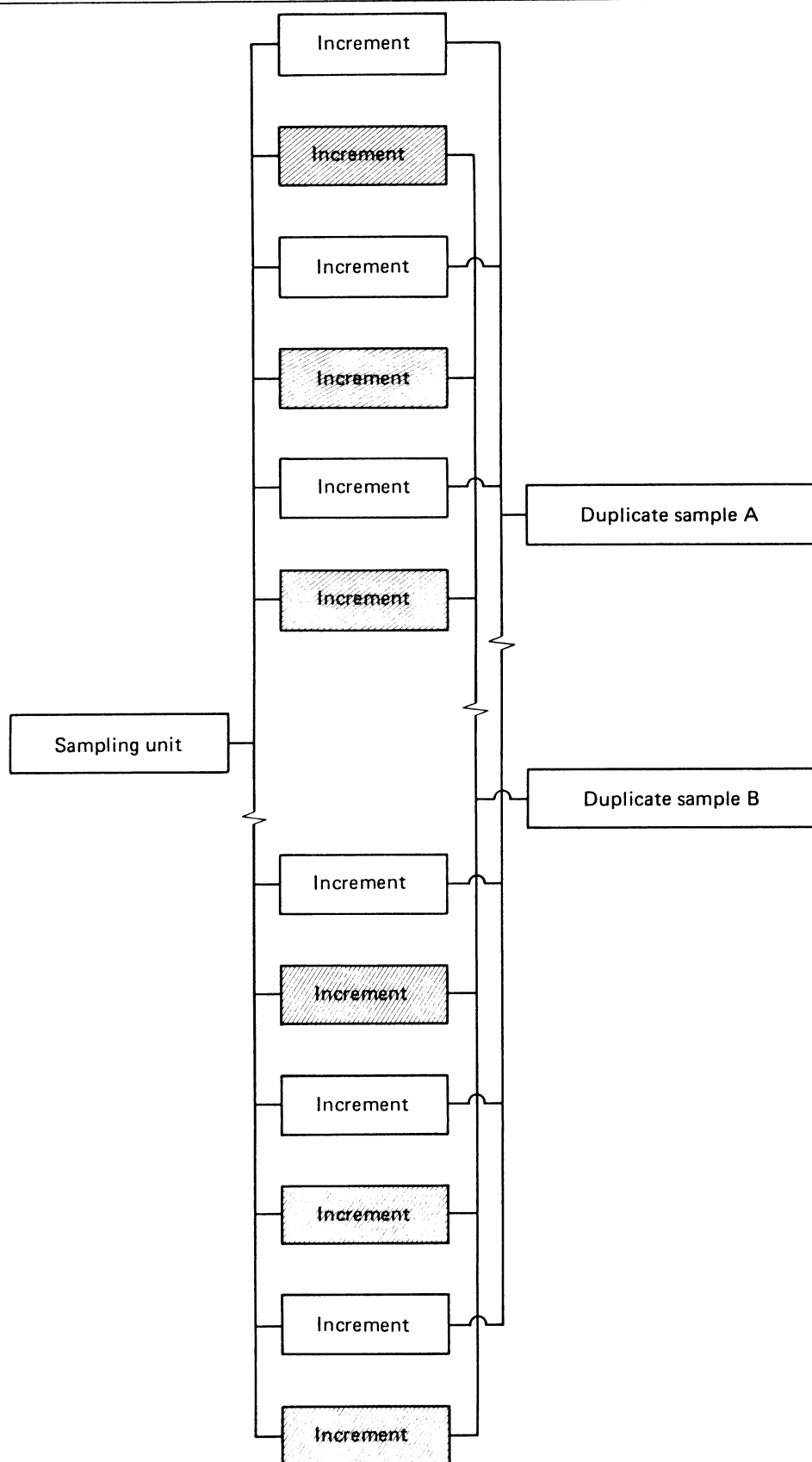


Figure 3. Example of a plan of duplicate sampling

2.39 variance. The sum of the squares of deviations from the mean divided by one less than the number of results i.e.:

$$\text{variance} = \frac{\sum (x - \bar{x})^2}{n - 1}$$

where

x is the sample value;

$\bar{x}$ is the mean sample value;

n is the number of results.

2.40 standard deviation (s). The square root of the variance i.e.:

$$s = \left\{ \frac{\sum (x - \bar{x})^2}{n - 1} \right\}^{1/2}$$

NOTE. Also,

$$s = \left[\frac{1}{n - 1} \left\{ \sum x^2 - \frac{(\sum x)^2}{n} \right\} \right]^{1/2}$$

2.41 bias

(1) The tendency to obtain a value which is either persistently higher or persistently lower than the true value.

(2) The numerical value of the difference between the true value and the mean result obtained from a large number of determinations using a biased method.

2.42 relevant bias. Bias of practical importance.

2.43 error. The differences between the observations and the true figures which can be designated systematic (i.e. bias), or random.

NOTE. The procedures of sampling, sample preparation and analysis are necessarily imperfect and the observations will be dispersed about the true figures.

2.44 random error. Error that has an equal probability of being positive or negative.

NOTE. The mean of the random errors resulting from a series of observations tends towards zero as the number of observations increases.

2.45 coefficient of variation (ν). The standard deviation, s , expressed as a percentage of the absolute value of the arithmetic mean, $\bar{x}$.

$$\nu (\%) = \frac{s}{\bar{x}} \times 100$$

2.46 range. The difference between the greatest and least values of a number of observations.

2.47 rogue result. A result which appears to be in disagreement with others from the same case and which arouses suspicion that there has been a mistake in the sampling, sample preparation, or analysis.

2.48 large coal. Coal with a nominal top size of not less than 75 mm and a lower size limit of 50 mm or more.

3 Fundamentals of sampling

3.1 General

3.1.1 The object of sampling is to obtain, from a unit of coal, a quantity of coal adequate for analysis and/or testing and in which the proportions of the various constituents present accurately represent the proportions in the unit as a whole. To achieve this, increments are taken at pre-determined intervals that are uniformly spaced in time throughout the unit of coal being sampled. This is known as systematic sampling and is the basis of this Part of BS 1017. However, for systematic sampling to be truly representative it is necessary that the chosen sampling intervals do not coincide with known or visible periodic variations in either the quality (e.g. size distribution or moisture) or quantity (i.e. flow rate) of the coal being sampled.

NOTE. A method of random sampling is also described (see 7(b) and clause 10).

3.1.2 The fundamental rules of coal sampling are as follows.

- Every particle of coal in the unit being sampled is equally accessible to the sampling device and has the same chance of being included in the sample.
- The dimensions of the sampling device used are sufficient to allow the largest particles present to pass freely into it.
- The number of primary increments taken are adequate to cover the variations in quality within the unit and so achieve the desired precision.
- The minimum mass of a gross sample is sufficient to enable the particles to be present in the same proportions as in the mass of coal from which it is taken.

3.1.3 Figure 4 shows a guide to the sampling procedures covered by this Part of BS 1017 and can be used to draw up simple schemes to cover most of the different sampling situations that may be encountered when sampling for moisture and/or general analysis.

The sampling and sample preparation of coal for size analysis are separately described in sections four and five.

NOTE 1. Wherever regular sampling is employed both continuous and intermittent sampling are permitted.

NOTE 2. Test samples for petrography, Hardgrove grindability index and index of abrasion are obtained from the general analysis sample or the residue from the common sample as described in clause 22. However, full details of the sample preparation for these tests are described in other British Standards (see table 1).

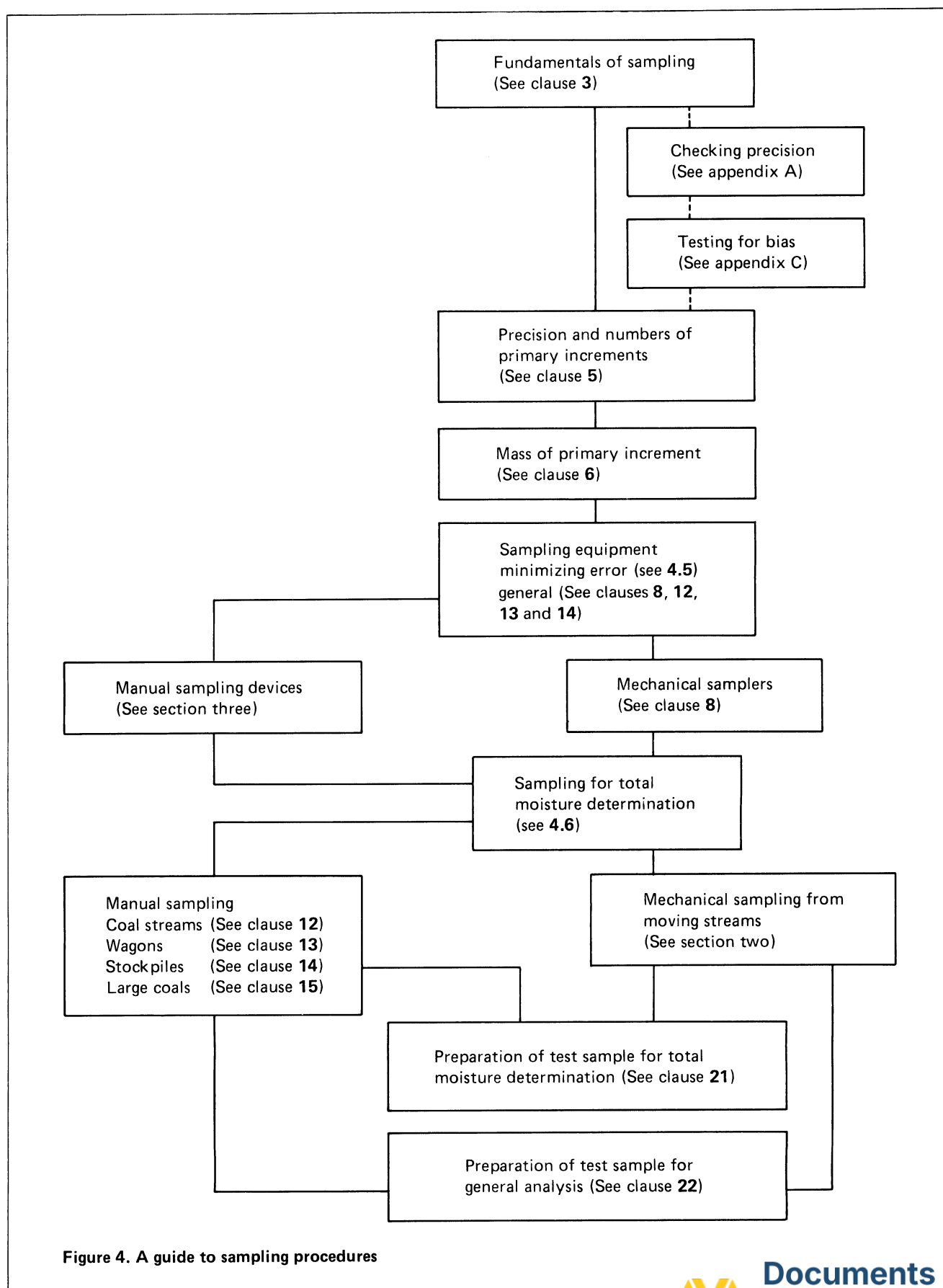


Figure 4. A guide to sampling procedures

3.2 Avoidance of bias

The main sources of bias in sampling can be avoided in the following ways:

- (a) by choosing the most suitable location for the sampling point (see 4.2);
- (b) by only using types of sampling equipment which meet the necessary specifications (see 4.5, clause 8 and specific details in section three);
- (c) by taking any necessary special precautions if sampling for a specific purpose, e.g. avoiding the loss or gain in moisture when sampling for total moisture (see 4.6) and minimizing breakage when sampling for size analysis (see section four).

NOTE. Only when a method is completely free from bias is the precision equivalent to the accuracy, i.e. a measure of the scatter of random errors about the true value.

4 Basic requirements of sampling systems

4.1 Safety of mechanical samplers

A mechanical coal sampler is potentially an extremely dangerous piece of equipment. It is therefore essential that it is adequately guarded and is incapable of operating if the guards are removed.

4.2 Location of sampling point

Although this standard covers a number of different sampling situations, in practice the best methods involve the collection of a complete cross section of the appropriate mass through a stream of coal. The most accurate method of doing this is the stopped belt method (see 12.2) although it is not often practicable in modern installations. The next best alternative is to sample a falling stream using an unbiased mechanical sampler at the loading or discharge point where the quality is to be determined (see section two).

However, for all sampling situations it is necessary for the location of the sampling point to be such that there is access to the whole of the mass of coal being sampled.

4.3 Provision for checking the level of precision (see appendix A)

4.3.1 Mechanical sampling. The sampling system should be designed so that duplicate samples can be collected to check the precision of regular sampling procedures either by directing alternate increments along different paths automatically or by alternating the sample containers manually.

4.3.2 Manual sampling. There should be sufficient space available at the sampling point for two or more sample containers so that duplicate or replicate samples can be taken to check the precision of regular or isolated lot sampling respectively.

4.4 Provision for checking the level of bias (see appendix C)

In order to check the level of bias in a proposed sampling scheme it can be tested against a reference method that is intrinsically unbiased. The stopped-belt method (see 12.2) is the most satisfactory way of ensuring that a sample is free from bias and is therefore recommended as the reference method in all cases. In installations where it is not possible to stop the belt without seriously disrupting working procedures a new sampling procedure may be tested against some other procedure which has previously been shown to be free from bias against the stopped-belt method.

4.5 Minimizing error

All sampling equipment (i.e. both fully integrated sampling systems and individual units such as primary samplers, dividers and crushers) need to be purposely designed and then adequately maintained to minimize the likely sources of error. Particular care should be taken to avoid the following.

- (a) Spillage of the sample material.
- (b) Impedance of the flow of sample material through equipment (e.g. narrow passages may become choked up with moist coal). The free flow of coal through the system should be maintained at all times.
- (c) Contamination of the sample.

NOTE. The use of appropriately enclosed systems should prevent contamination from the local environment or atmosphere and the use of self-clearing equipment should prevent contamination from previous samples.

- (d) Loss of moisture or material (e.g. both moisture and fine coal may be lost if there is excessive air flow through the system).

4.6 Sampling for total moisture determination

The accurate determination of total moisture depends on the avoidance of unmeasured changes in moisture content in the interval between the taking of primary increments and the analysis of the test sample. Such changes can be kept to a minimum by transferring the sample (either as taken or prepared to a particular stage of sample division) to the test laboratory as quickly as is practicably possible. In order to reduce the effect of delays in sample collection and also to provide adequate protection for the sample, suitable containers and storage facilities should be made available (see clauses 11 and 16).

One of the main factors affecting the moisture content of coal is its exposure to the prevailing climatic conditions: surface evaporation will lead to moisture loss but rain or snow will lead to a gain in moisture. However, these effects can be minimized by using suitable equipment for sampling and sample preparation. The rate of evaporation of moisture from a mass of coal depends on several factors including particle size, its ventilation, the temperature and humidity. For example, special care should be taken

in the preparation of coals containing a high proportion of fines, both the air flow through the system and the heat generated by sample reduction equipment should be reduced to a minimum. The procedures for the preparation of a test sample for the determination of total moisture are given in clause 21.

5 Precision and numbers of primary increments

NOTE. Further explanation and a simplified derivation of the formulae used in this clause are contained in appendix D together with worked examples of the calculation for the number of sampling units and the number of increments.

5.1 General

The number of primary increments to be taken from a lot of coal, from a single source, to achieve a specified precision, is a function of the variability of the coal. The main factors involved in the determination of numbers of primary increments to be taken are the primary increment variance (V_I) (see 5.2) and the variance of preparation and testing (V_{PT}) (see 5.3).

The sampling of single lots to the levels of precision normally desired often requires excessive and unmanageable

numbers of increments and so each lot is normally divided up into a number of sampling units. The initial minimum number of sampling units is calculated from an equation (see 5.4) but this may be increased (see 5.5.1) if it still results in an excessive number of primary increments per unit.

sampling unit is described in 5.5. If the primary increment variance is known, the number of increments can be calculated directly (see 5.5.1), but if not, assumptions need to be made about the value of V_I (see 5.5.2) from which the initial number of increments can then be calculated.

The procedure for checking the precision of a sampling scheme is given in appendix A.

5.2 Primary increment variance

NOTE. Methods for estimating the primary increment variance are described in appendix E.

The primary increment variance, V_I , is dependent on the type and size of the coal, the degree of pretreatment and mixing, together with the absolute value of the parameter to be determined.

Examples of primary increment variances for different grades of coal are given in tables 2 and 3 for ash and moisture respectively.

Table 2. Examples of the values of the primary increment variance for ash			
Grade	Typical range of mean ash content	Primary increment variance (V_I)	
		Expected values for: regular lots homogenous coals	Assumed values for: isolated lots heterogeneous coals
Untreated, part-treated or blended smalls	% 10 to 20	< 20	25
Washed smalls	5 to 15	< 5	10
Graded coal	< 10	< 5	10

Table 3. Examples of the values of the primary increment variance for moisture			
Grade	Typical range of mean moisture content	Primary increment variance (V_I)	
		Expected values for: regular lots homogeneous coals	Assumed values for: isolated lots heterogeneous coals
Untreated, part-treated or blended smalls	% 5 to 20	< 2	3
Washed smalls	10 to 20	< 4	5
Graded coal	< 10	< 2	3

5.3 Variance of preparation and testing

The variance of preparation and testing, V_{PT} , is the combined variance of sample preparation according to this standard and analysis and testing according to the relevant Parts of BS 1016.

For the purposes of calculating the number of primary increments V_{PT} may be approximated as $V_I/50$ for ash or $V_I/10$ for moisture subject to a minimum value of 0.05 and a maximum of 0.2. In operational systems the value of V_{PT} may be calculated using the method given in appendix B.

5.4 Number of sampling units

Calculate the minimum number of sampling units, m , to be taken from a lot of coal from equation (1):

$$m = \left(\frac{L}{5000} \right)^{1/2} \tag{1}$$

to the nearest whole number above
where

L is the mass of lot (in t).
NOTE. This number may be increased so that the sampling unit coincides with a suitable mass or time interval or when it is necessary to achieve a specified precision (see 5.5.1).

5.5 Number of primary increments

5.5.1 Coals for which primary increment variance is known. Calculate the initial number of primary increments, n , to be taken from each sampling unit from equation (2):

$$n = \frac{4 V_I}{m p^2 - 4 V_{PT}} \tag{2}$$

subject to a minimum of 10
where

V_I is the primary increment variance;
 V_{PT} is the variance of preparation and testing (see 5.3);
 m is the number of sampling units (from 5.4);
 p is the required precision.
If the number of primary increments calculated from equation (2) is either unmanageable or meaningless (i.e. infinity or a negative number) then decide upon a reasonable figure and re-calculate the number of sampling units, m , using equation (3):

$$m = \frac{4 V_I + 4 n V_{PT}}{n p^2} \tag{3}$$

NOTE. When sampling for both ash and moisture use the primary increment variance for ash in equations (2) and (3) as it is invariably greater than the increment variance for moisture (see 5.2).

5.5.2 Coals for which the primary increment variance is unknown. For most coals in the UK the primary increment variance for ash and moisture will fall within the range for regular lots and homogeneous coals given in table 2 and table 3 respectively. It is therefore recommended that for the following categories of 'unknown' coals the upper

values of V_I for regular lots be used to calculate the initial number of primary increments.

- (a) New grades resulting from changes in coal preparation procedures applied to existing products.
- (b) New grades resulting from the opening of a new face in a seam that has already been worked elsewhere.
- (c) Single product stockpiles which have been properly constructed and do not show significant signs of weathering.

However, for complete unknowns use the values of V_I for isolated lots given in table 2 or table 3 to calculate the initial number of primary increments. Examples of such coals are.

- (1) Products from a completely new seam.
- (2) Coals from very mixed or old stockpiles.
- (3) Imported coals on which there is no previous information.

5.6 Checking the precision of a sampling scheme

The number of primary increments to be taken will sometimes be an overestimate, whether calculated directly from the primary increment variance (see 5.5.1) or by using an estimate for it (see 5.5.2). For this reason check the precision of the sampling scheme and adjust, if necessary the number of increments/samples by the methods given in appendix A.

6 Mass of primary increment

6.1 Minimum mass of primary increment

Calculate the minimum mass of the primary increment, taken at the mean flow rate for the unit being sampled from equation (4):

$$M_I = D^2 \times 10^{-3} \tag{4}$$

where
 M_I is the minimum mass of primary increment (in kg) subject to a minimum of 0.5 kg;
 D is the nominal top size (in mm).

Examples of minimum increment masses are given in table 4 and the equation (4) is illustrated graphically in figure 5.

Table 4. Examples of minimum masses of increment	
Nominal top size, D	Minimum increment mass, M_I
mm	kg
100	10.0
50	2.5
25	0.6
12.5	0.5
6.3	0.5
2.8	0.5

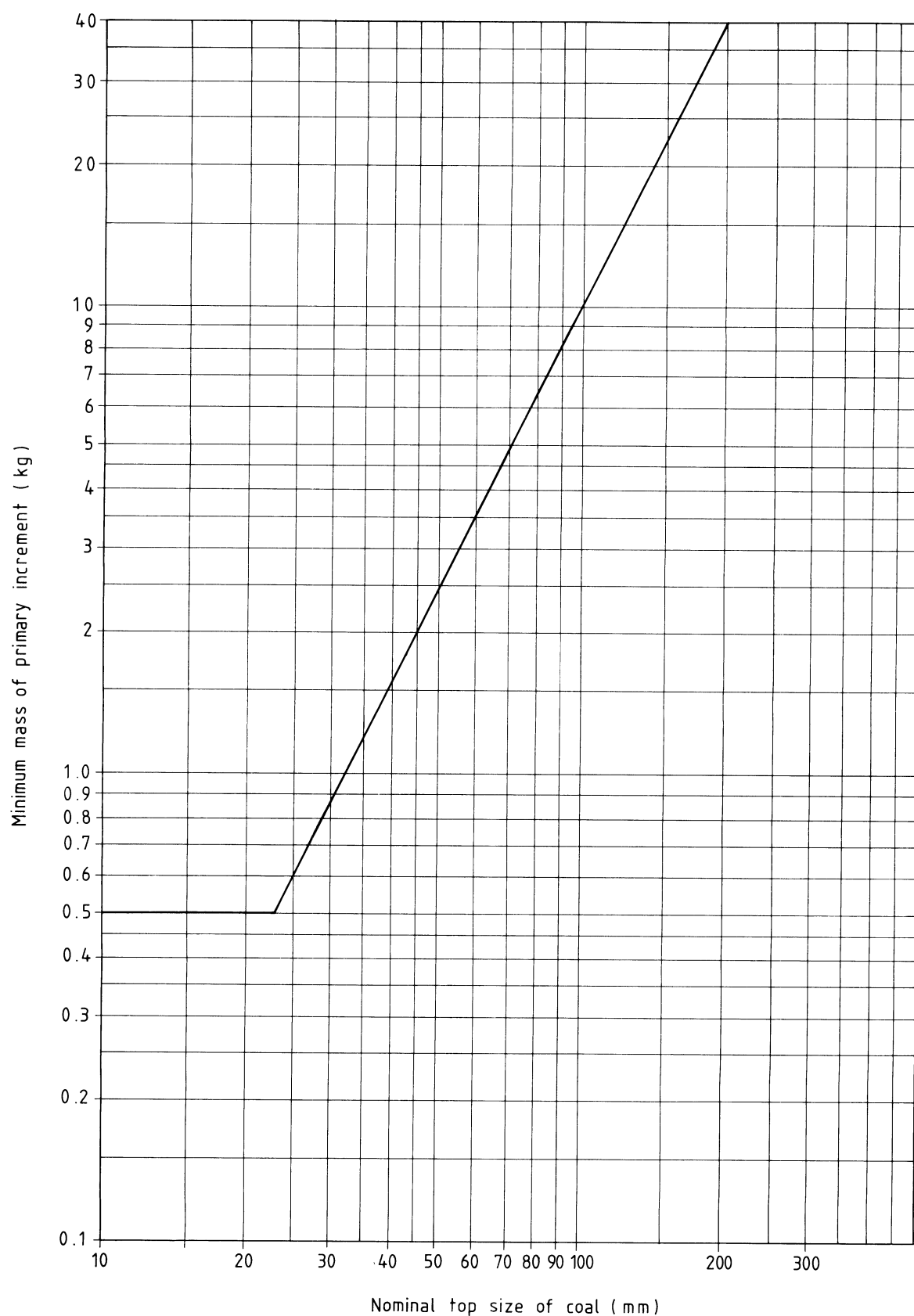


Figure 5. Minimum mass of primary increment

6.2 Average mass of primary increment from a mechanical sampler

Calculate the average mass of a primary increment taken by a mechanically driven cutter from a moving stream of coal from equation (5):

$$\bar{M}_1 = \frac{FA}{3.6S} \quad (5)$$

where

$\bar{M}_1$ is the average mass of primary increments (in kg per cut);

F is the average flow rate of stream (in t/h);

A is the cutting aperture of the sampler (in m);

S is the cutter speed of sampler (in m/s).

NOTE. 3.6 is a constant, the reciprocal of which converts tonnes per hour to kilograms per second.

Section two. Mechanical sampling from moving streams

7 General

Mechanical sampling from moving streams can be carried out either by systematic time basis sampling or by stratified random sampling (within fixed time intervals).

(a) *Systematic sampling.* The method of systematic sampling described in this Part of BS 1017 is by time basis sampling (see clause 9).

(b) *Stratified random sampling.* When periodic variations in quality are suspected and it is not practicable to eliminate the possibility that these may coincide with the taking of increments, then stratified random sampling (see clause 10) shall be employed.

Since the system will have a finite increment handling time, in practice precautions need to be taken to ensure that an increment is not taken before the preceding one has cleared the system. This may be achieved either by delaying the taking of increments until the system is clear or by the use of a more sophisticated random number generator which can take into account the amount of sampling interval remaining available for sampling. When the sampling interval is equivalent to the increment handling time, random sampling cannot be achieved.

8 Equipment

8.1 General

The basic requirements for mechanical samplers, in addition to those outlined in 4.1 and 4.5, are as follows.

(a) To avoid bias resulting from the exclusion of large particles, the width of the cutting aperture shall be at least 2.5 times the nominal top size of the coal being

sampled subject to a minimum dimension entry of 30 mm.

(b) The capacity of the sampling device shall be such that, during collection of increments, it shall be not more than three quarters full.

(c) The sample cutter shall be of the self-clearing type.

(d) The cutter shall cut a complete cross section of the coal stream, both the leading and trailing edges clearing the stream in the same path.

(e) The design of the cutter aperture shall be such that all parts of the stream are exposed to the aperture for the same length of time.

(f) The design of the sampler shall be such that bias is not introduced by inadvertently deflecting particles or part of the main stream into the sample.

(g) The sampler shall be designed so that the cutter can be inspected safely both in its rest position and in its trajectory through the coal stream.

8.2 Falling-stream samplers

In addition to those given in 8.1, the following requirements apply.

(a) The cutter shall cut the coal stream either in a plane perpendicular to, or along an arc normal to, the mean trajectory path of the stream.

(b) The cutter shall travel through the coal stream at a uniform velocity, i.e. the velocity shall not deviate more than $\pm 5\%$ from the preselected reference velocity at any point.

NOTE. Practical experience has shown that cutter velocities of up to 1.5 m/s can be used without producing relevant bias.

Examples of falling-stream samplers are illustrated in figures 6 to 10.

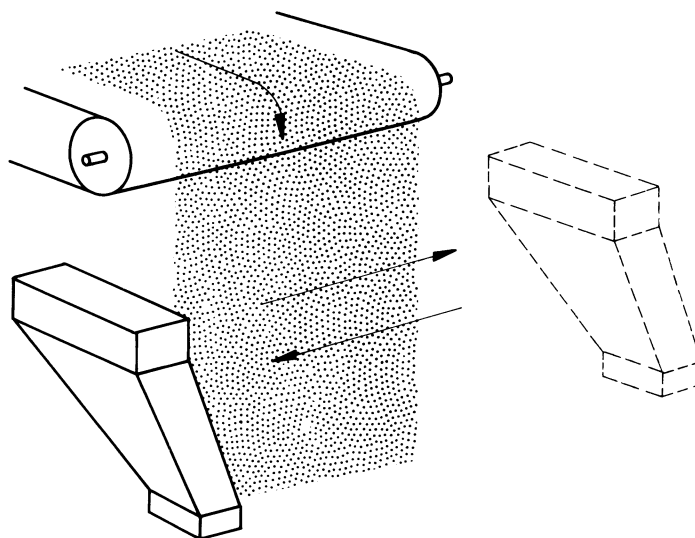


Figure 6. Falling-stream sampler: stream-traversing, cutter-chute type

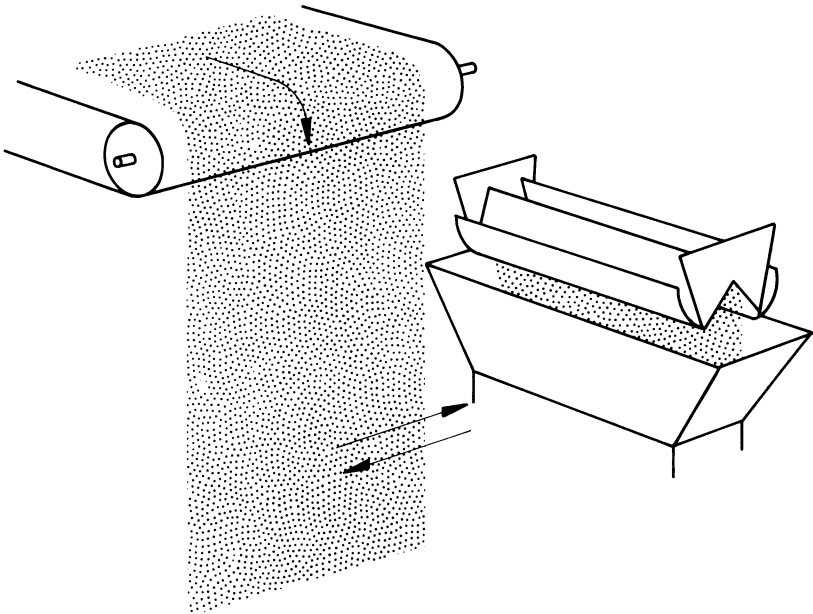


Figure 7. Falling-stream sampler: stream-traversing, cutter-bucket type

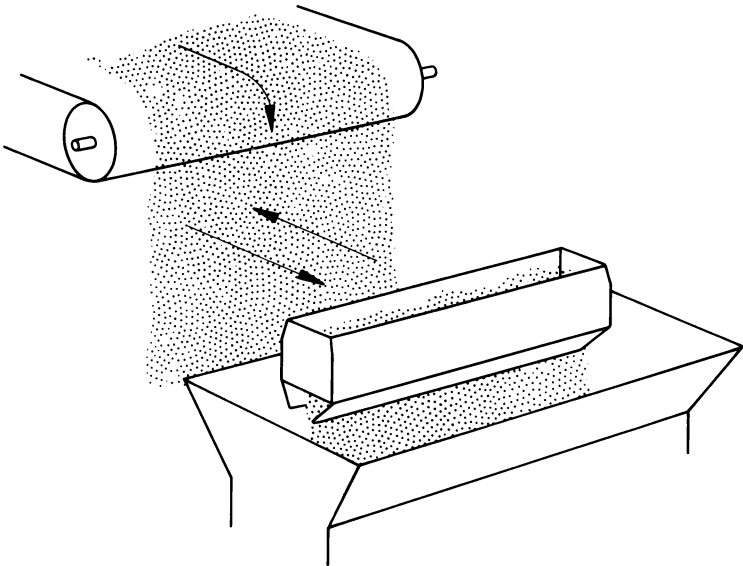


Figure 8. Falling-stream sampler: through-stream, cutter-bucket type

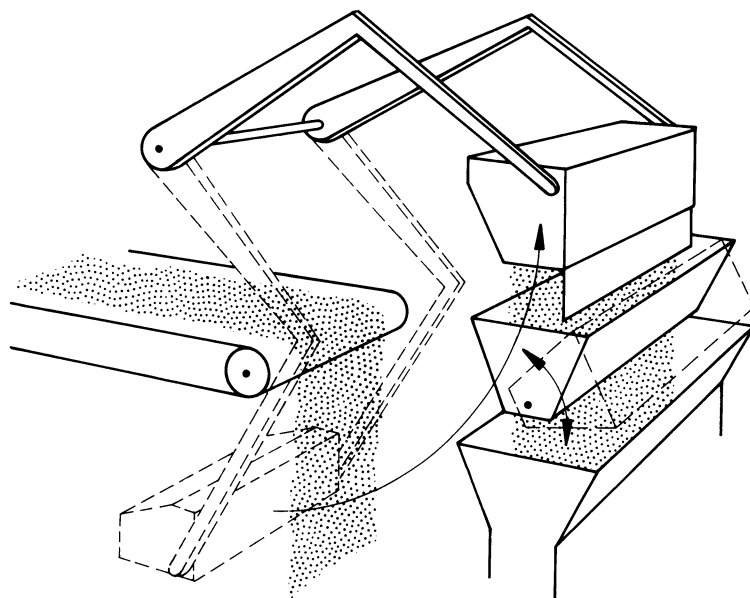


Figure 9. Falling-stream sampler: swing-arm type

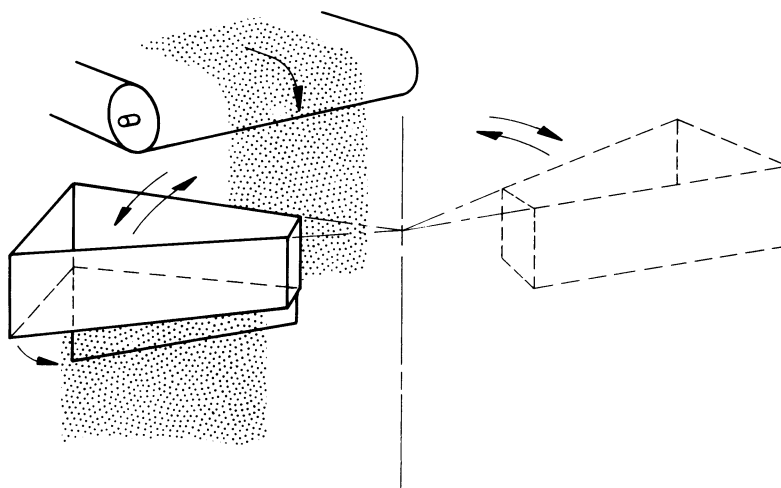


Figure 10. Falling-stream sampler: radial-sector type

8.3 On-the-belt samplers

An on-the-belt sampler operates by sweeping off increments across the width of a conveyor belt. Since it is possible that fines may be segregated to the bottom of the material on the belt, it is essential that the belt curvature is correctly adjusted across the width to match the scraper arm and so avoid taking a biased sample. In sampling from a moving stream, increments shall be taken from its complete width at right angles to the flow, or at an angle to the stream axis so that the sampling device does not create a 'bow wave' in front of itself.

In addition to those given in 8.1, the following requirements apply.

- (a) Any flexible blades or skirts shall be regularly adjusted so that they maintain close contact with the surface of the moving conveyor belt to ensure the complete coal section in the path of the cutter is swept from the belt.
- (b) The load on the belt shall not exceed the design capacity of the sampler.
- (c) The cutter shall travel through the coal stream at a uniform velocity, i.e. the velocity shall not deviate more than $\pm 5\%$ from the preselected reference velocity at any point.

NOTE. The design of the machines should be such as to ensure that the width of the cutter aperture and the cutter speed are both sufficient in order to give an effective cutting action.

Examples of on-the-belt samplers are illustrated in figures 11 and 12.

9 Methods of systematic time basis sampling

9.1 General

This method involves the following two steps:

- (a) spreading the required number of primary increments on a uniform time basis throughout the unit of coal to be sampled;
- (b) extracting at the end of each time interval a mass of coal proportional to the flow rate at the primary stage which can either be added to a gross sample (or partial sample) or separately prepared.

9.2 Sampling interval

Determine the maximum interval, t , in minutes, between taking increments by time basis sampling from equation (6):

$$t = \frac{60Q}{Gn} \quad (6)$$

where

- Q is the mass of sampling unit or lot (in t);
- G is the maximum flow rate (in t/h);
- n is the number of increments (see appendix D).

9.3 Taking of increments

Take each increment during a single cycle of the sample cutter so that a full cross section of the coal stream is taken. This does not preclude the sampler taking both a

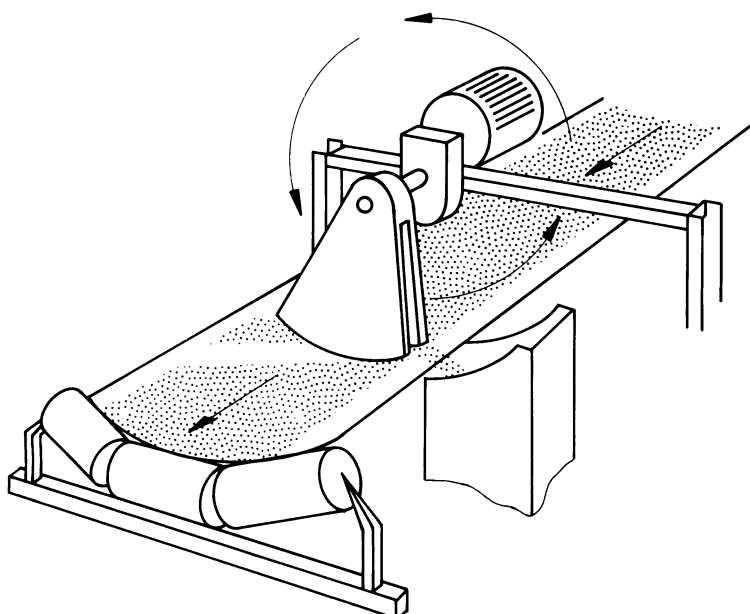


Figure 11. On-the-belt sampler: normal-sweep (angled-cut) type