IS 436-1-2 (1976): Methods for sampling of coal and coke, Part I: Sampling of Coal, Section 2: Mechanical sampling [PCD 7: Solid Mineral Fuels]

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(Reaffirmed 2000)

Indian Standard
METHODS FOR SAMPLING OF COAL AND COKE
PART I SAMPLING OF COAL
Section 2 Mechanical Sampling

(Second Reprint MAY 1990)

UDC 662.66 : 620.113

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

Gr 4 *March* 1977

Indian Standard
METHODS FOR SAMPLING OF COAL AND COKE
PART I SAMPLING OF COAL
Section 2 Mechanical Sampling

(*Continued on page* 2)

(*Continued from page* 1)

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Indian Standard
METHODS FOR SAMPLING OF COAL AND COKE
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0. FOREWORD

0.1 This Indian Standard (Part I/Sec 2) was adopted by the Indian Standards Institution on 30 August 1976, after the draft finalized by the Solid Mineral Fuels Sectional Committee had been approved by the Chemical Division Council.

0.2 In view of increasing use of coal as fuel as a substitute for petroleum products in power generation and transport, and maintaining the tempo of industrialization in the country, it has become necessary to move and handle large quantities of coal. This calls for use of mechanical handling and sampling systems on a wide scale. Accordingly, a new section (Section 2) has been added to Part I which covered only manual procedures, to prescribe procedures for incremental sampling from moving stream of coal. Original Part I has been redesignated as Part I/Section 1. Wherever necessary, this standard should be used in conjunction with its Section 1.

0.3 In view of the possibility of use of various designs of equipment that could be used for the purpose, no specific designs have been recommended in this standard but only a few illustrations of increment samplers and sample dividers have been incorporated for the guidance of users. It is, however, felt that widespread use of mechanical sampling systems in coming years will make it possible to arrive at an optimum design of such an equipment, which would ensure maximum precision for a given supply of coal.

0.4 In the formulation of this standard assistance has been derived from the following publications:

ISO 1988-1975 Sampling of hard coals. International Organization for Standardization.

Draft BS 1017 : Part 1: Sampling of coal and coke: Part 1 Sampling of coal. British Standards Institution.

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard (Part I/Sec 2) prescribes the methods of sampling and sample preparation of coal using mechanical systems and lays down a procedure for the reporting of test results.

NOTE — Sampling and sample preparation of coal using manual methods have already been given in IS : 436 (Part I/Sec 1)-1964†.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 3810-1977‡ shall apply.

3. MECHANICAL SAMPLING SYSTEMS

3.0 General — An essential condition of sampling is that the whole bulk of coal to be sampled should be exposed, so that all parts are equally accessible to the sampling implement and have the same chance of being included in the sample. The most favourable situation in which the whole of the coal is exposed for sampling is when it is being conveyed on a belt or similar device so that it passes the sampling point in a stream. If the belt is stopped and a section of adequate length is taken across the whole width of the belt, all the coal particles in this section can be taken so that there will not be any significant bias. Sampling from a stopped belt is therefore the most satisfactory way of ensuring that the sample is free from bias and it is recommended as the reference method.

3.0.1 In many installations it is not possible to stop the belt without considerable interference with the work in the installation and other methods of sampling have therefore to be used. Alternatively, samples from the cross section of a moving stream are collected, to ensure that each increment is a representative of the cross section. It is this principle on which most of the mechanical sampling systems work.

3.1 Requirements of Mechanical Sampling Systems

3.1.1 The design of the systems for sampling and sample preparation should be guided by the type of coal to be sampled, test requirements to be

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*Rules for rounding off numerical values (*revised*).

†Methods for sampling of coal and coke: Part I Sampling of coal, Section 1 Manual sampling (*revised*).

‡Glossary of terms relating to solid mineral fuels: Part I Terms relating to coal and its preparation (*first revision*) and Part II Terms relating to coal sampling and analysis.

performed by the system, desired precision of test results and absence of significant bias.

3.1.2 The method of checking results of samples collected by any mechanical installation is by comparing the results of samples taken manually by skilled personnel to ensure freedom from bias.

3.1.3 From the initial stage of designing and constructing the system, due consideration should be given to the safety of the operators.

3.1.4 To maintain good control during the full period of sampling and sample preparation from a consignment, human surveillance should be available at all times. In the case of breakdown of the sampling installation, provision should be made for the mechanical operation to be replaced immediately by an alternate procedure within the framework of relevant methods.

3.1.5 It is recommended that the mechanical installation is arranged in such a way that the principal units may be operated individually.

3.1.6 The mechanical installation should be designed in a manner as would take care of:

a) spillage of sample material,

b) possibility of the sample clogging the equipment,

c) possible impedance in the flow of the sample material through the equipment,

d) retention of residual material, and

e) introduction of materials other than the sample.

3.1.7 Each part of the apparatus with which the sample comes in contact should be designed in such a way that the construction materials do not change the quality of sample either chemically or physically.

3.2 Working of Mechanical Samplers — Coal from the stockyard or unloading station moves on one or two parallel conveyor lines. At the transfer point prior to a special weighing belt an automatically operated sampler cuts increments from the main flow. This apparatus which collects the increments is called primary sampler and consists generally of automatically operated bucket moving with uniform speed into the falling coal stream at adjustable intervals of time. The primary sample taken from the passing flow is continuously prepared by crushing and dividing in 3 or 4 stages. The final sample is dried and ground to 212-micron size for chemical analysis. Sampling for the purpose of size determination is done by fully automatic equipment in conjunction with primary sampler which supplies batches of coal weighing 200 to 250 kg to the screens. The weighing of the sized fractions is done during no-load times of the screen.

4. SAMPLING EQUIPMENT

4.0 Sampling machine always behaves in the same way and eliminates the subjective influence of the sampler. There are a number of designs for mechanical sampling and sample preparation equipment. It is important that machines have their performance tested against a reference method (stopped belt method in this case) before they are put to actual use (*see* **3.0**).

4.1 A composite mechanical sampling equipment consists of appropriate sample collecting and sample preparation machines combined into a single unit by means of which coal increments are collected and prepared into samples as a continuous chain of operations. It is possible to have a large number of combinations of such equipment and hence a variety of composite designs. The optimum design has to be decided on the basis of a number of factors, such as cost, space available, volume of coal to be handled and the expected efficiency of the system.

4.2 Automatic Samplers for Collection of Increments

4.2.0 *General* — It is desirable to use a sampler which cuts through the full width of a falling stream of coal. However, where it is not possible, an alternate method is to scoop the sample from a moving conveyor belt. While using the alternate method it is important to have the sampler properly adjusted to the belt curvature across its width so that true cross section of the conveyed material is removed, including fine particles which segregate to the bottom of the material on the belt while in motion. The cutter employed should also not cause turbulence while sweeping through the stream of coal pushing aside large coal pieces and thus rejecting them. Therefore, its speed has also to be carefully adjusted to avoid taking a biased sample.

4.2.1 *Sampling from Falling Stream* — Machines for sampling from falling streams should have a bucket of width equal to the full width of the stream and cutting through it in a direction either parallel or at right angles to the movement of the belt. It is essential that the box passes through the stream at uniform speed and that the slotted width is properly related to the size of coal. Further, in this type of sampling system, the box usually passes through the stream twice to collect an increment (from front to back and reverse). Therefore, the container has to be of such a size that it is not completely filled at the end of its travel. The point of travel of the bucket in the reverse should be located where there is no falling coal. In this system the bucket usually tips at the end of each cycle of movement emptying the sample into a chute. Alternatively, the bucket may fill on one movement and then tip, or close on its return. Some of the common types of devices for sampling from the falling stream are described below,

4.2.1.1 *Breeches chute type sampler* — This device is designed to collect increments from a falling stream of coal by diverting the whole stream into the one or the other leg of the Breeches chute (*see* Fig. 1). Movement of the flap governing the direction of flow of coal stream is usually time-controlled and the ratio of the mass of the sample to that of the consignment depends on the period for which the flap is allowed to remain in a particular position. In the case of erratic rate of flow it may be necessary to control movement of the flap with the help of a belt weighing machine according to the specified masses of coal. In this type of sampler, the flap moves with a rapid 'snap' action so that the time taken by it to traverse the stream of coal is negligible. Such action is achieved either by the use of compressed air or, for full sized coal, by electromagnetic means.

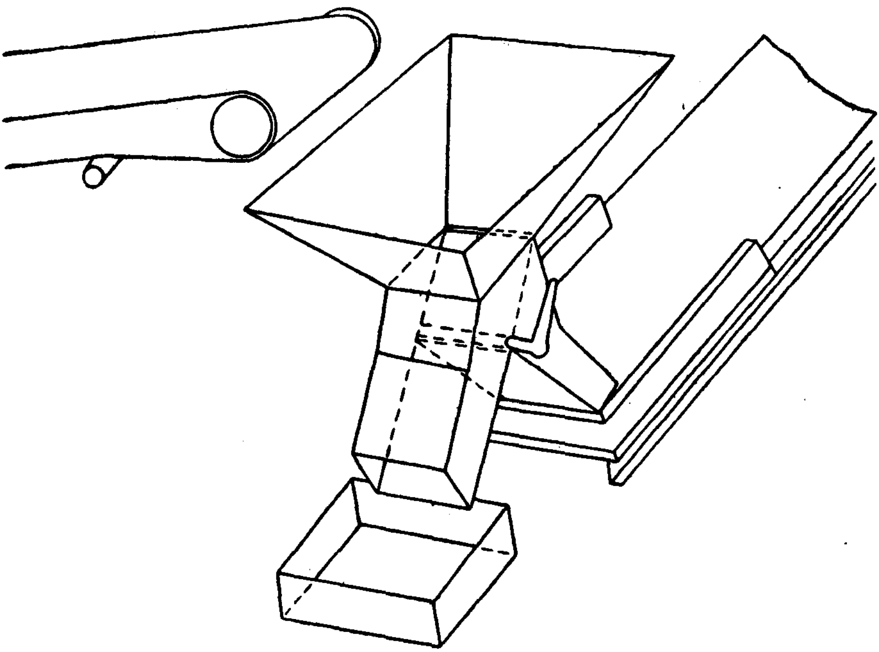


FIG. 1 FALLING STREAM BREECHES CHUTE TYPE SAMPLER

4.2.1.2 *Swinging arm type sampler* — This device is designed to collect increments from the discharge end of a conveyor and is suitable where vertical height or head room is limited. In this arrangement (*see* Fig. 2) a heavy bucket is allowed to swing once, like a pendulum, through the full width of the stream of coal. Power for the operation of this type of sampler is sometimes derived from the drum of the conveyor. The device may be set to operate automatically either at equal intervals of time or, if a belt weighing machine is incorporated, after specified masses of coal have passed.

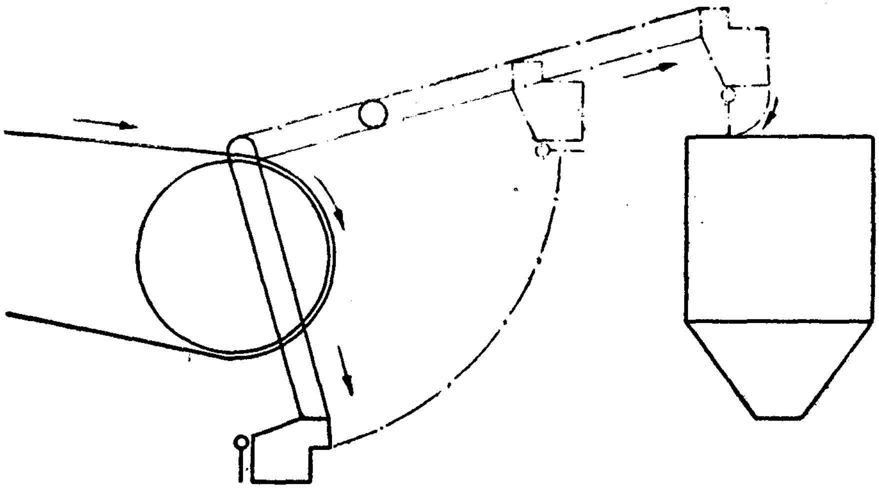


FIG. 2 FALLING STREAM SWINGING ARM TYPE SAMPLER

In another arrangement of this type of device a rectangular frame, with a number of holes of sufficient dimensions, is provided. The arm swings across the full width of the stream and the coal passing through the holes falls on to a small conveyor belt carried with the frame. This belt discharges coal into a chute or storage hopper.

4.2.1.3 *Chain bucket type sampler* — This device consists basically of a sampling bucket attached to a pair of roller chains (*see* Fig. 3) and is powered by an electric motor through reduction gears. In its rest position, the sampling bucket is clear of the coal stream at its sample discharge point. When a sample is to be taken, the bucket travels inverted through the stream of coal on the lower strand of the roller chain. It then travels on the upper strand of the chain with cutting edges uppermost thus taking the sample. The sample is automatically emptied into the collecting drum at the end of its run on the top strand of the chain.

4.2.2 *Sampling from Moving Belt* — Machines for sampling from moving belt should have a scraper arm which operates by sweeping off increments across the width of a conveyor belt. In this case the mass of the increment depends on the load on the belt and the width of the scraper. The device may be set to operate automatically either at equal intervals of time or, if a belt weighing machine is incorporated, after specified masses of coal have passed. A suitable device is illustrated in Fig. 4.

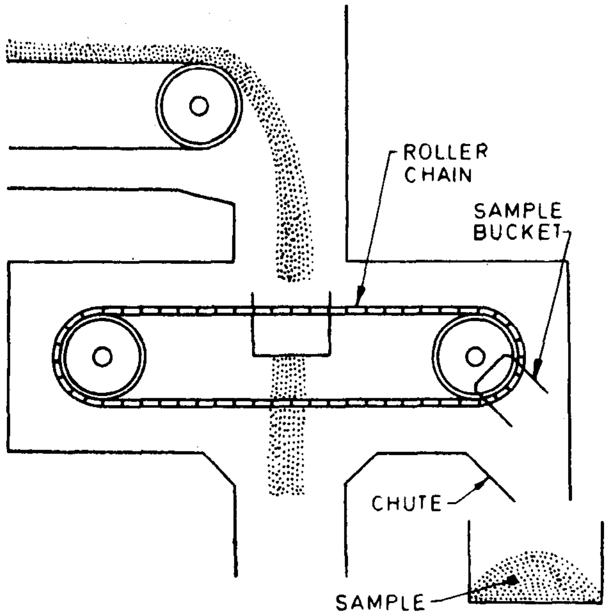


FIG. 3 CHAIN BUCKET TYPE SAMPLER

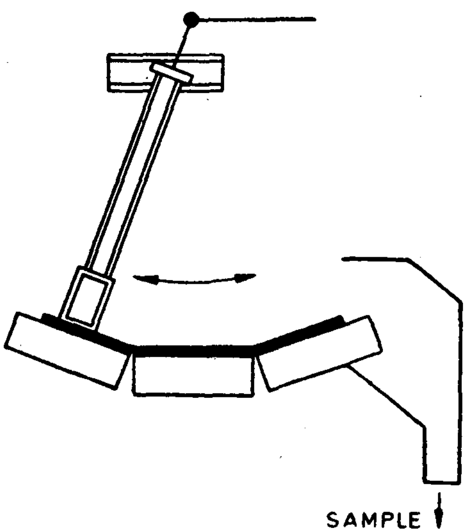


FIG. 4 SCRAPER ARM TYPE SAMPLER

4.3 Mechanical Equipment for Sample Preparation — Sample preparation equipment (excluding dryers) may be divided into the following three classes:

a) Size reduction apparatus,

b) Sample mixing apparatus, and

c) Sample dividing apparatus.

4.3.1 *Size Reduction Apparatus* — The equipment for reducing particle size is generally called ' mills '. High speed mills are desirable to ensure a product of specified size even from hard coals of high ash content or coals with shale. Reduction mills vary in type from jaw crushers to roll crushers and from plate mills to high speed impact pulverizers which are particularly suitable for the finer milling (0·2 mm).

4.3.1.1 All types of mills should be made of heat-resistant material. Those parts of mills coming into contact with coal should be of wear resistant material in order to prevent contamination of the samples and to avoid overheating, which would induce oxidation of the coal or loss of moisture from it. Mills should be easy to clean. High speed mills tend to become heated and samples shall not be allowed to remain in them long enough to be affected. If a mill is used for a series of samples, it should be allowed to cool between samples in order to avoid oxidation and loss of moisture in subsequent samples. Modern high speed mills are likely to be seriously damaged by presence of extraneous iron or other ferrous material in the sample. A magnetic separator placed in the chute leading to the machine is a convenient safeguard against this.

4.3.1.2 Although high speed pulverizers are most efficient with a wide range of coals, they entrain air with the samples due to the fanlike effect of the rotating hammer. To avoid the loss of fine coal particles or dust it is essential either to limit the air flowing through the mill by using closed inlet and outlet hoppers or by fitting a breather bag to the mill outlet.

4.3.1.3 The efficiency of mills used for grinding to 0·2 mm should ensure that at least 99 percent of the sample will pass the size. The efficiency of the mills will be hampered if they are not cleaned periodically. It is also desirable to clean mills before use for a different coal. The use of a stream of compressed air or an industrial type vacuum cleaner may be suitable for this purpose.

4.3.2 *Sample Mixing Apparatus* —The apparatus should neither cause breakage of coal nor produce dust or allow loss of moisture. It should be conditioned with the coal being used or with another coal of similar moisture content. Three types of mixers have been found satisfactory, namely, the paddle mixer, the drum mixer and the double cone mixer.

4.3.3 *Sample Dividing Apparatus* — Most mechanical sample dividers are of the rotary type in which a receiver is placed on a turntable, so as to intercept a falling stream of coal once or twice in each revolution or, alternatively, to collect a continuous ribbon from a falling stream of coal produced by allowing the coal to fall from the hopper on to the vertex of the cone. The slot or dimensions where the coal passes from the reservoir should be at least 2·5 times the upper particle size. Some of the common types of sample dividers are described below.

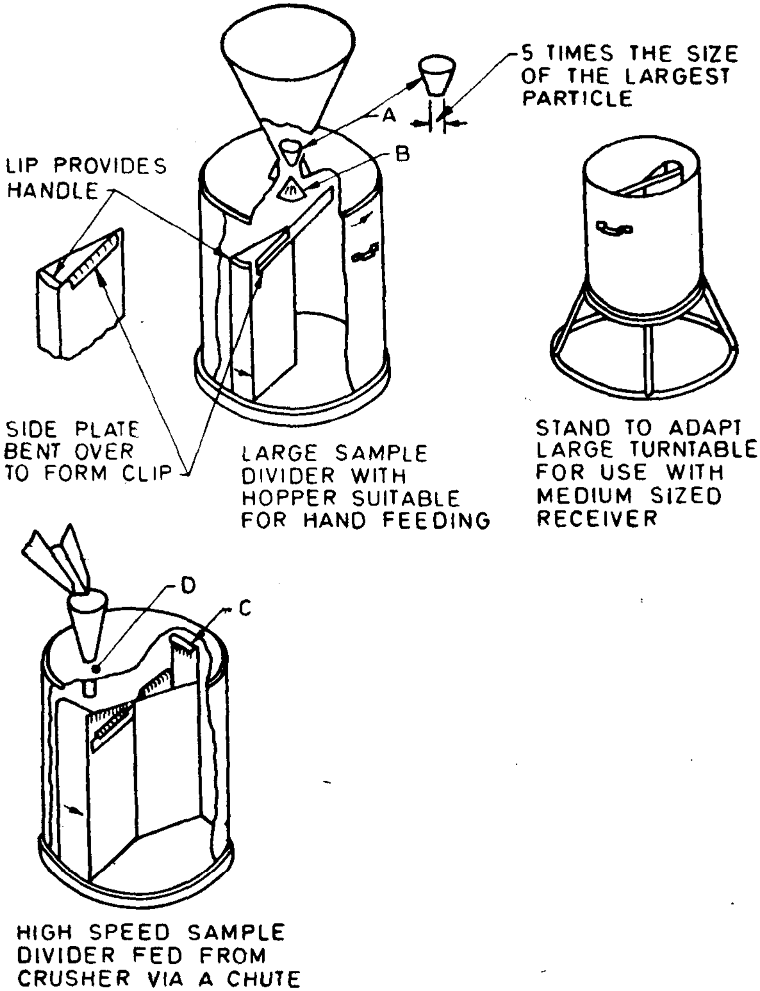
4.3.3.1 *Rotary sample divider* — This device consists of a number (for example 12) of containers shaped like segments (*see* Fig. 5A) mounted on a rotating turntable, revolving at about 60 rev/min. The bottom edge of the input reservoir should be large enough to prevent coal bridging the outlet. The minimum size of the opening at the point where it intercepts the coal should be at least 5 times the upper particle size of the coal. Thus a number of separate increments are collected in each revolution and the proportion of the sample retained may be chosen by taking the relevant number of containers. Thus to take 1/12 fraction one container is retained, and for ¼ fraction, three containers are retained.

4.3.3.2 An alternative device consists of two circular rotating plates. The feed is introduced on the top plate and spread by a number of baffles and finally discharged by another baffle. The lower plate (*see* Fig. 5B) has segment-shaped apertures cut into it. As the sample falls from the upper plate on to the lower plate, part of it passes through the apertures in the lower plate and forms the reduced sample and that retained on the lower plate is rejected. The reduced sample is discharged into chutes for further preparation while the remains are carried round on the lower plate to a point diametrically opposite where they are swept by a brush into another chute.

4.3.3.3 *Slotted belt sample divider* — This device is suitable for bulk sample reduction at the sampling point. A stream of coal is fed to a conveyor belt at a constant rate. The belt has slotted apertures in it (*see* Fig. 6). The material falls freely for a short distance before it reaches the belt. A complete cross section of the stream of coal passes through the slots in the belt and is collected as reduced sample for further processing. Coal falling on the unslotted part of the belt is conveyed away and rejected.

5. METHODS OF COLLECTING SAMPLES

5.1 Lot — Supply of coal is made either in the form of an isolated consignment or in a regular series of consignments. When the nature of coal supplied is not known or when it is known to be heterogeneous, each consignment should be treated as a lot and should not be mixed with previous or subsequent supplies. However, when coal is supplied in a regular series of consignments from the same source and is moved continuously, it is convenient to define lot in terms of time limit such as the coal moved during a specified period of supply.

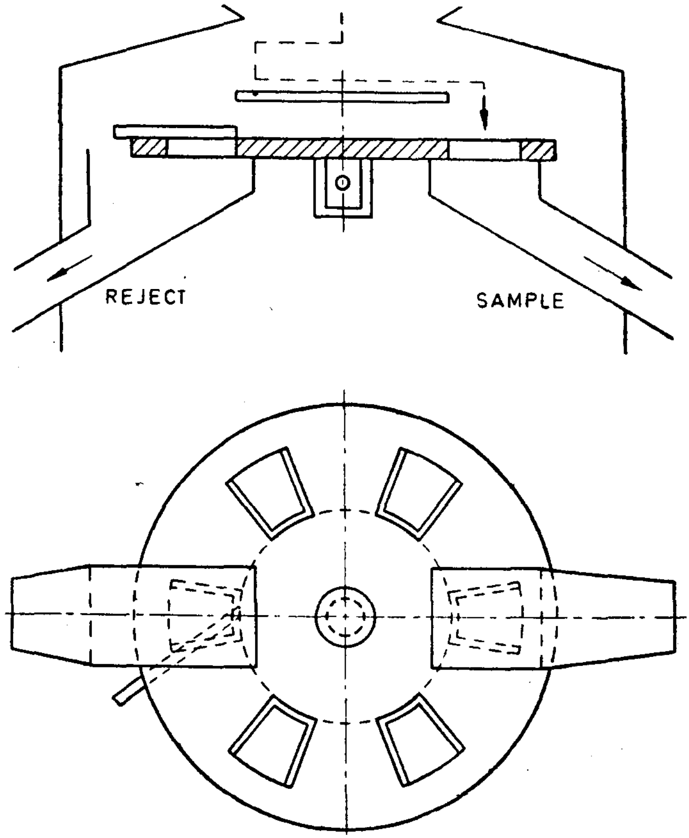


GUIDE TO DIMENSIONS

Capacity kg	Height of Receiver mm	Diameter of Receiver mm	Height of Container mm
35	450	450	400
7	280	300	190
1	150	130	150

5A Rotary Sample Divider

Fig. 5 Sample Dividers (*Contd*)



5B Rotary Sample Divider

Fig. 5 Sample Dividers

5.2 Sub-lots — For the purpose of sampling, a lot, while it is being discharged over a conveyor shall be divided into a number of sub-lots of approximately equal mass as specified in Table 1. In mechanical system of handling coal, the rate of discharge could be quite high and hence the size of the sub-lot should also be reasonably large to facilitate mechanical sampling.

5.3 Number of Increments — Under mechanical sampling the number of increments is subject to the limitation imposed by the mechanical system in terms of the fast rate of discharge, large increment size and minimum time interval between two consecutive increments. This time limit may vary from system to system. Table 2 gives the number of increments.

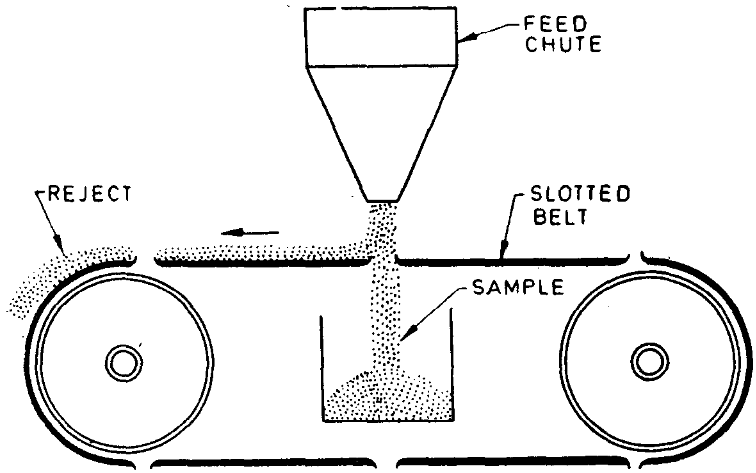


FIG. 6 SLOTTED BELT SAMPLE DIVIDER

5.4 Mass of the Increments — The mass of increments depends on the type of mechanical sampling system installed at the site of sampling. However, the increment shall not be less than 10 kg in mass for both unwashed and washed coal. Further, the increments shall be taken in such a manner as to ensure that they have an almost uniform mass. A measure of uniformity of mass is CV which is defined as the percentage of standard deviation relative to the mean value of the mass. For routine sampling purpose increments are considered to be uniform if the CV of their mass is less than or equal to 20 percent. It is essential to check the uniformity of the mass periodically by weighing at least 20 consecutive increments.

5.5 Collection of Increments by Mechanical Samplers

5.5.1 The most convenient method of taking increments from the flow of coal is by systematic sampling where the increments are spaced evenly in time or in position over the sub-lot. Care has to be taken, however, that periodic variation, if any, in the quality of coal does not coincide with the frequency of taking increments. There are two modes of taking systematic samples. One is the mass-basiss ampling and the other is time-basis sampling. Under mass-basis sampling, increments are taken at a fixed mass interval and under time-basis sampling, increments are taken at a fixed time interval.

5.5.2 *Mass-Basis Sampling* — If T denotes the mass interval between two successive increments, the following relationship shall always be satisfied:

$$T \leqslant \frac{Q}{n}$$

where

T = mass-interval between taking increments in tonnes,

Q = mass of the sub-lot, and

n = number of increments given in Table 2.

Example 1:

A consignment of 3 600 tonnes of run-of-mine coal is to be sampled on the mass-basis sampling.

According to Table 1 the number of sub-lots should be 6. Hence the consignment should be considered to be made up of 6 sub-lots each weighing about 600 tonnes. For this size of coal, the number of increments, according to Table 2, should be 35.

Hence the sampling interval on mass-basis sampling is $\frac{600}{35} = 17$ tonnes approximately.

TABLE 1 NUMBER OF SUB-LOTS/GROSS SAMPLES

(*Clauses* 5.2 *and* 5.5.2)

Mass of the Lot	No. of Sub-lots/Gross Sample
(1)	(2)
tonnes	
Up to 3 000	5
3 001 ,, 5 000	6
5 001 ,, 10 000	7
10 001 and above	8

TABLE 2 MASS OF GROSS SAMPLE AND NUMBER OF INCREMENTS

(*Clauses* 5.3 *and* 5.5.2)

Sl No.	Consignment	Mass of Gross Sample, *Min*	Mass of Increments, *Min*	Number of Increments, *Min*
(1)	(2)	(3)	(4)	(5)
		kg	kg	
i)	Run-of-mine coal	350	10	35
ii)	Large coal	180	10	18
iii)	Small coal	80	10	8
iv)	Washed coal:			
	0·75 mm	200	10	20
	0 to 10 mm	50	10	5

5.5.3 *Time-Basis Sampling* — If t is the time interval between two increments by mechanical sampler, the following relationship shall be satisfied:

$$t \leqslant \frac{60\,Q}{G\,n}$$

where

t = time interval between two increments, in minutes;

Q = mass of the sub-lot in tonnes;

G = maximum flow rate of belt conveyor in tonnes/hour; and

n = the number of increments.

Example 2:

If the consignment given in Example 1 is to be sampled on time-basis, and if the maximum flow rate of coal is known to be 800 tonnes/hour, then the sampling interval on time-basis sampling shall be:

$$t \leqslant \frac{60 \times 600}{800 \times 35} = 1{\cdot}3 \text{ minutes}$$

5.5.4 From practical point of view, time-basis sampling is easy to operate and will be adequate if the flow of coal is fairly uniform. If the flow rate is not uniform and is subject to wide fluctuations, the increments collected on time-basis will not be representative and their mass also is likely to be varying.

5.5.5 Increments under either mode of sampling shall be taken from the whole width and thickness of the coal stream. The width of the section of sampler shall be at least 2·5 times the maximum size of the coal. Increments shall be taken while there is a normal load on the belt at the point of sampling. For this reason they shall not be drawn just at the beginning or at the end of the flow.

6. SAMPLE PREPARATION

6.1 The increments collected from a sub-lot as described in **5** shall be mixed together to form the gross sample for the sub-lot. The gross sample so formed may be prepared either manually or mechanically or a combination of these two methods.

6.1.1 For the general procedure for reduction of gross sample and preparation of moisture and laboratory samples, IS : 436 (Part I/Sec 1)-1964* shall be followed.

7. REPORTING OF TEST RESULTS

7.1 For reporting of test results, reference shall be made to IS : 436 (Part I/Sec 1)-1964*.

*Methods for sampling of coal and coke: Part I Sampling of coal, Section 1 Manual sampling (*revised*).

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