BRITISH STANDARD

BS 1016-112: 1995
ISO 5074:1994

Methods for

Analysis and testing of coal and coke —

Part 112: Determination of Hardgrove grindability index of hard coal

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee SFI/3, Analysis and testing of coal and coke, upon which the following bodies were represented:

British Cement Association
British Coal Corporation
British Gas plc
British Steel Industry
Electricity Association
GAMBICA (BEAMA Ltd.)
Power Generation Contractors Association PGCA (BEAMA Ltd.)

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Contents

National foreword

This British Standard has been prepared by Technical Committee SFI/3 and is identical to ISO 5074:1994 *Hard coal — Determination of Hardgrove grindability index*, published by the International Organization for Standardization (ISO) and in the preparation of which the United Kingdom played a full part.

This British Standard is a revision of BS 1016-20 which is withdrawn. BS 1016-20 is renumbered as Part 112 under a scheme for rationalizing and restructuring BS 1016. The Parts numbered from 1 to 21 are gradually being withdrawn and replaced by Parts in the new series. The full list of Parts in the new series, together with corresponding numbering of the old series and related ISO standards is given in BS 1016 *Analysis and testing of coal and coke* — Part 100:1994 *General introduction and sampling report*.

Cross-references. A British Standard related to ISO 1988:1975 is BS 1017-1:1989 *Methods for sampling of coal*. ISO 1988 is being revised in conjunction with ISO 2309 *Coke — Sampling,* ISO 9411 *Solid mineral fuels — Mechanical sampling from moving streams* — Part 1: *Coal* and Part 2: *Coke*. This revision will be published in eight Parts, and it is intended to implement these Parts as identical British Standards superseding BS 1017.

A British Standard related to ISO 3310-1:1990 is BS 410:1986 *Specification for test sieves*.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 7 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This International Standard specifies the method for determining the grindability index of hard coal[1)] using the Hardgrove machine. It also specifies the procedure for calibrating the test machine and for preparing the standard reference coal samples.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1988:1975, *Hard coal — Sampling.*

ISO 3310-1:1990, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth.*

3 Definition

For the purposes of this International Standard, the following definition applies.

3.1
hard coal

coal having a gross calorific value of more than 24 MJ/kg on a moist, ash-free basis

4 Principle

Treatment of a prepared sample of coal of limited size range under defined conditions in a laboratory apparatus of standardized design (calibrated Hardgrove machine). Derivation of the grindability index from sieve analysis of the ground product and by reference to a calibration chart prepared from standard reference material.

5 Apparatus

5.1 *Balance,* capable of weighing up to 100 g to an accuracy of 0,01 g.

5.2 *Balance,* capable of weighing up to 1 500 g to an accuracy of 1 g.

5.3 *Sample divider,* as specified in **A.6.3** of ISO 1988:1975.

5.4 *Crusher,* a laboratory crusher capable of reducing 4,75 mm coal particles to 1,2 mm with the production of a minimum of material finer than 600 µm. In the case of a plate mill, the plates shall be serrated and about 100 mm in diameter, the distance between the plates being adjustable and the relative frequency of rotation of the plates not exceeding 200 min^{-1}. Roll mills or hammer mills shall not be used.

5.5 *Sieves*

5.5.1 *Wire-cloth test sieves,* complying with the requirements of ISO 3310-1, Series R 40/3, of aperture sizes 1,18 mm, 600 µm and 75 µm respectively, and having a cover and receiver of diameter about 200 mm.

5.5.2 *Protective sieve,* with round or square apertures in the range 6 mm to 19 mm, capable of nesting in the test sieves. A plate sieve with round holes is recommended; if a standard wire cloth sieve is used, it may become distorted through use as a protective sieve and should, therefore, be marked as unsuitable for test sieving.

5.6 *Mechanical sieving machine,* capable of accepting an assembly of vertically nested sieves and a cover and receiver of diameter about 200 mm. The machine shall be able to simulate the motions of hand sieving. This may be achieved by imparting a horizontal oscillatory motion of amplitude 25 mm to 30 mm at a frequency of approximately 300 min^{-1}, whilst striking the top of the oscillating assembly with a mass of 1,9 kg, moving through a vertical distance of about 25 mm under the influence of gravity, at a frequency of approximately 150 blows per minute.

Alternatively, the nest of sieves, cover and receiver may be vibrated by an electromagnetic device, provided the sieving performance is equivalent to the mechanically vibrated machine described.

[1)] In this International Standard, the term "hard coal" is used as an indication of maturity or rank in the coalification sequence and is not related to the physical properties of the coal.

5.7 *Hardgrove grindability machine,* as shown in Figure 1 and with the essential tolerances shown in Figure 2. It includes a stationary grinding bowl, of hardened iron or steel, with a horizontal track in which run eight steel balls, each of diameter 25,4 mm. The balls shall be driven by an upper grinding ring rotated at 20 r/min ± 1 r/min. The upper grinding ring, which shall be of similar material to the bowl, shall be connected to a spindle and shall be driven by an electric motor through reduction gears. A load shall be added to the spindle so that the total vertical force on the balls due to the top ring, gear, load and spindle is 284 N ± 2 N, i.e. closely equivalent to a total mass of 29 kg ± 0,2 kg. The machine shall be fitted with a revolution counter and an automatic device for stopping the machine after 60 ± 0,25 revolutions. It shall be calibrated by the method described in clause **8**, before use for the determination of Hardgrove indices.

NOTE 1 The grinding bowl, balls and top grinding ring should be protected from rusting when not in use.

5.8 *Soft brush*

6 Sampling

The gross sample shall be collected and prepared in accordance with the requirements of ISO 1988, except that the initial crushing shall be up to 4,75 mm instead of up to 10 mm. The gross sample shall be reduced to a final sample of about 1 kg by using a sample divider (**5.3**) of suitable size and capacity.

NOTE 2 Initial crushing should be performed by a mill that does not produce too much fine material which could lead to bias.

7 Preparation of test sample

7.1 Air-dry the final sample (see ISO 1988) and determine the mass of the dried sample to the nearest gram.

Since the Hardgrove grindability index, especially for coals with a high content of inherent moisture, varies depending on the moisture content of the coal, air-drying should take place at a relative humidity of 30 % to 70 %. If this has not been done, a determination of the moisture content of the air-dried sample shall be made, and the result shall be reported.

Sieve the dried sample on a nest of sieves consisting of a 1,18 mm aperture sieve on top of a 600 µm aperture sieve, by sieving batches of about 200 g for 2 min in the sieving machine, followed by gentle brushing of the oversize material with a soft brush (**5.8**), to assist the passage through the sieve. Crush the material retained on the 1,18 mm sieve with the crusher (**5.4**) adjusted so that only the largest particles are crushed; sieve the crushed material for 3 min and return the oversize material to the crusher again, readjust to crush only the largest particles. Continue crushing and sieving until all the material passes through the 1,18 mm sieve.

7.2 Discard that part of the portion passing through the 600 µm sieve and weigh, to the nearest gram, the coal passing through the 1,18 mm sieve and retained on the 600 µm sieve. If the yield in this size range is less than 50 % of the dried sample, the coal thus prepared shall be discarded and another final sample of about 1 kg shall be taken from the gross sample and the sample preparation repeated.

NOTE 3 If, after careful crushing of softer coals (those with a Hardgrove grindability index greater than 80), less than 50 % is retained on the 600 µm sieve, proceed with the test and qualify the result.

7.3 Thoroughly mix the size fraction passing through the 1,18 mm sieve and retained on the 600 µm sieve, take about 120 g using a sample divider and dedust by sieving for 5 min on a 600 µm sieve using the sieving machine. Reduce the dedusted material, using a sample divider (**5.3**) to not less than 50 g.

8 Procedure

8.1 Clean the grindability machine (**5.7**) thoroughly and space the balls as evenly as possible around the grinding bowl.

8.2 Weigh a test portion of 50 g ± 0,01 g of the dedusted material, distribute it evenly in the grinding bowl and smooth the surface. Assemble the top grinding ring to the bowl and fasten the bowl in position to the driving spindle, making sure that the load is evenly applied. Preset the counter and adjust the automatic stopping device so that the machine will operate for 60 ± 0,25 revolutions. Start the apparatus.

8.3 When the rotation has stopped, switch off the machine and dismantle the bowl assembly. Brush any adherent coal dust onto the protective sieve (see **5.5.2**) nested on the 75 µm sieve and receiver. Empty the grinding balls and ground coal onto the protective sieve. Brush any coal from the bowl and the balls into the protective sieve and set them aside. Brush any coal and dust from the inside and underside of the protective sieve into the 75 µm sieve and set it aside.

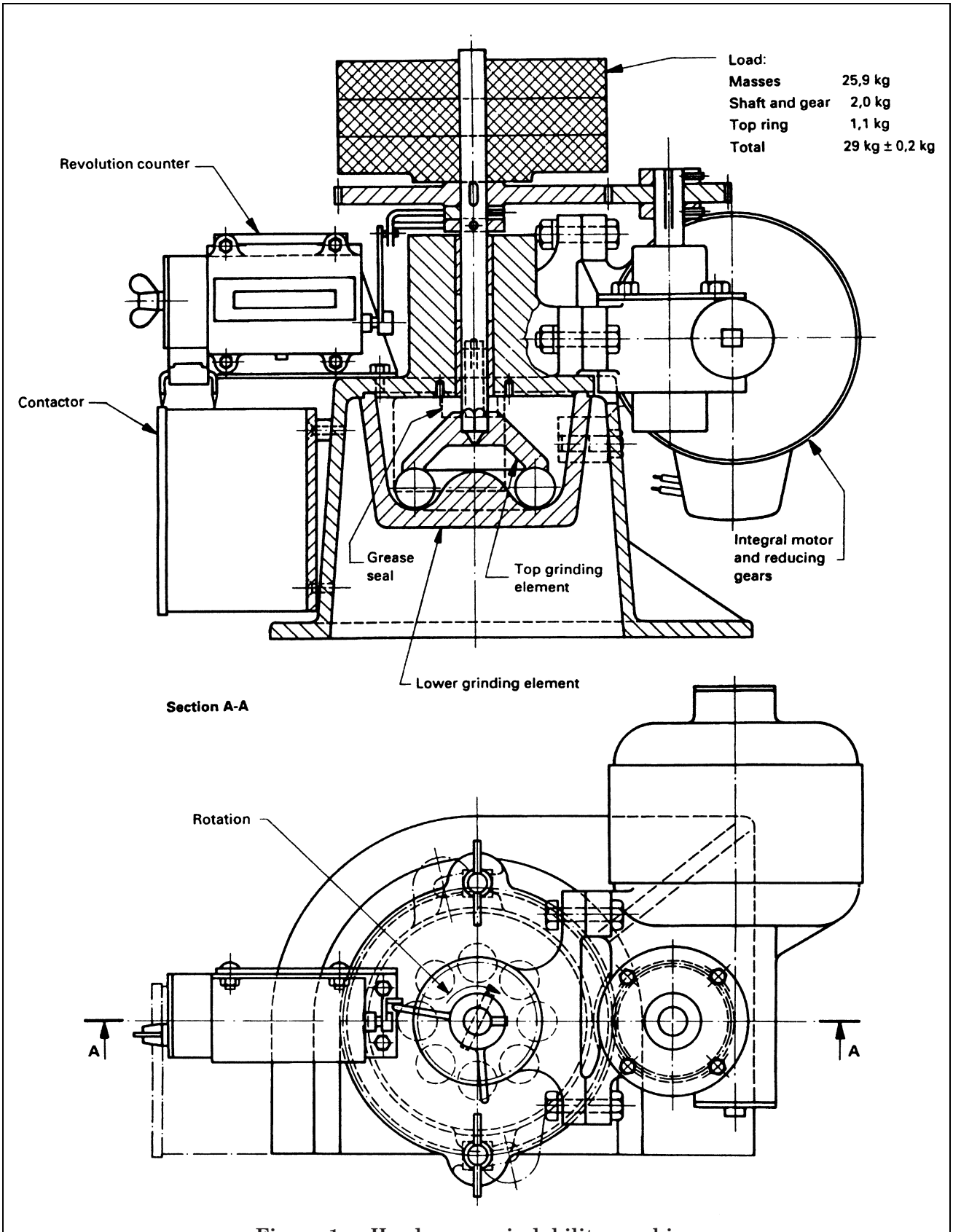


Figure 1 — Hardgrove grindability machine

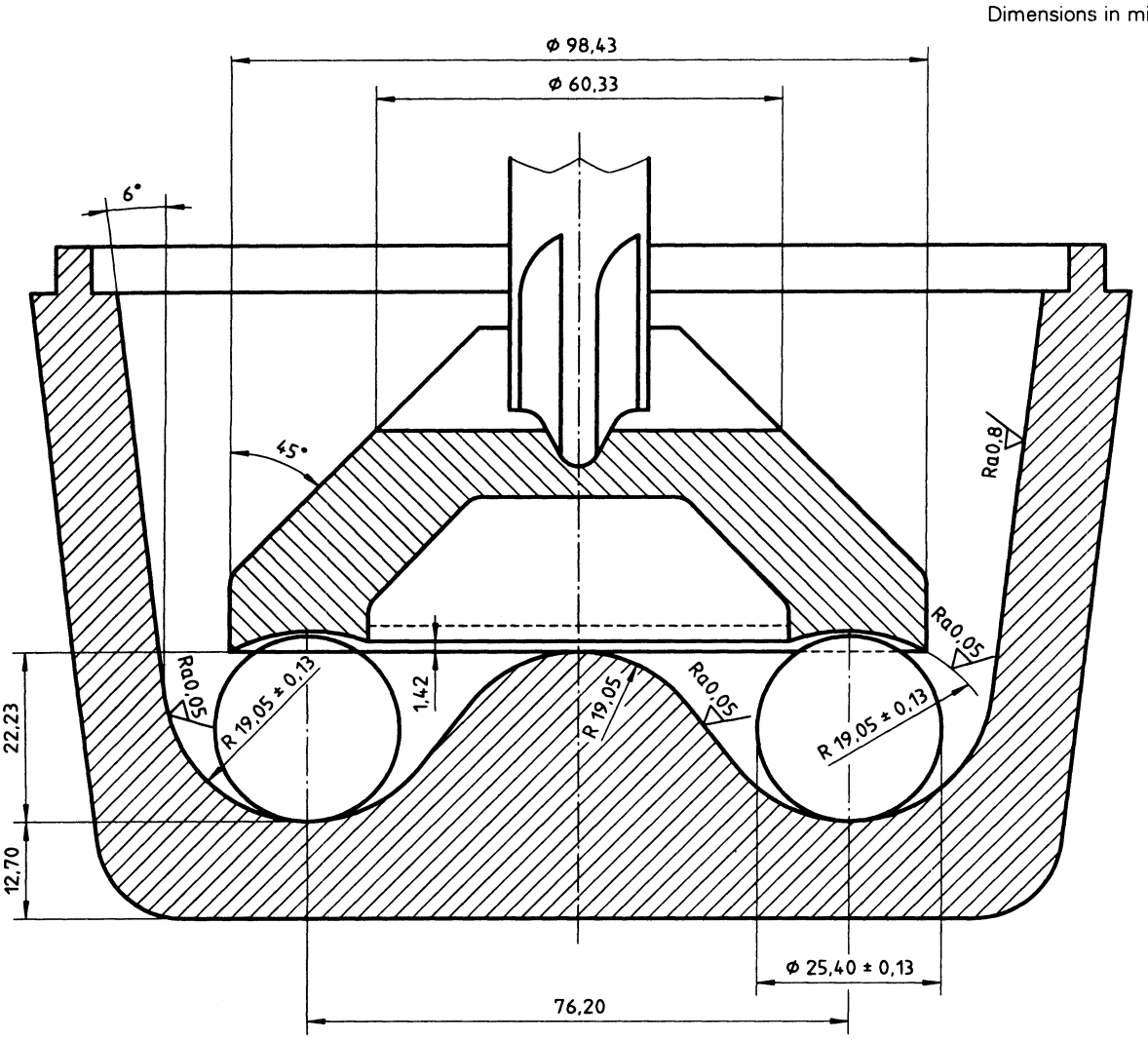


Figure 2 — Sectional view of the grinding elements with an indication of the essential tolerances

8.4 Replace the cover on the 75 µm sieve and shake the assembled receiver, 75 µm sieve and cover for 10 min in the sieving machine. Invert the sieve over a collector and carefully brush along the warp and weft of the cloth so that all the coal on the sieve enters the collector. Return the cleaned sieve to the nest, add the coal from the collector and sieve for a further 5 min. Repeat this operation. Finally clean the sieve by brushing so that the coal retained on the sieve and in the apertures enters the collector, while all the coal that has passed through the apertures enters the undersize receiver.

8.5 Weigh separately, to the nearest 0,01 g, the coal brushed off the 75 µm sieve and the coal passing through the 75 µm sieve. If the sum of these masses differs by more than 0,5 g from the initial mass of the test portion, the result shall be rejected and the test repeated.

9 Expression of results

9.1 Calculate the mass m, in grams, of the test portion passing through the 75 µm sieve, using the formula

$$m = 50 - m_1$$

where m_1 is the mass, in grams, of test portion retained on the 75 µm sieve.

Record the grindability index from the calibration chart (see Annex A).

9.2 Carry out duplicate determinations on test portions taken from the 1,18 mm to 600 µm fraction. Report the mean of the two determinations, rounded to the nearest whole number, as the Hardgrove grindability index (HGI).

10 Precision

10.1 Repeatability limit

The results of duplicate determinations carried out at different times in the same laboratory by the same operator with the same apparatus, on test portions taken from the same sample passing through a 1,18 mm sieve and retained by a 600 µm sieve (see clause **7**) should not differ by more than 2 units.

10.2 Reproducibility limit

The means of the results of duplicate determinations carried out in each of two different laboratories on test portions taken from the same gross sample of 4,75 mm coal should not differ by more than 5 units.

11 Test report

The test report shall include the following information:

a) complete identification of the sample tested;

b) the number of this International Standard;

c) the results obtained;

d) any operating conditions not specified in this International Standard, together with any other circumstances which may have influenced the results.

Annex A (normative)
Calibration charts

A.1 Extensive tests have shown that the reproducibility of the test method (see clause **10**) can be achieved only if machine variables are reduced by the use of a calibration chart.

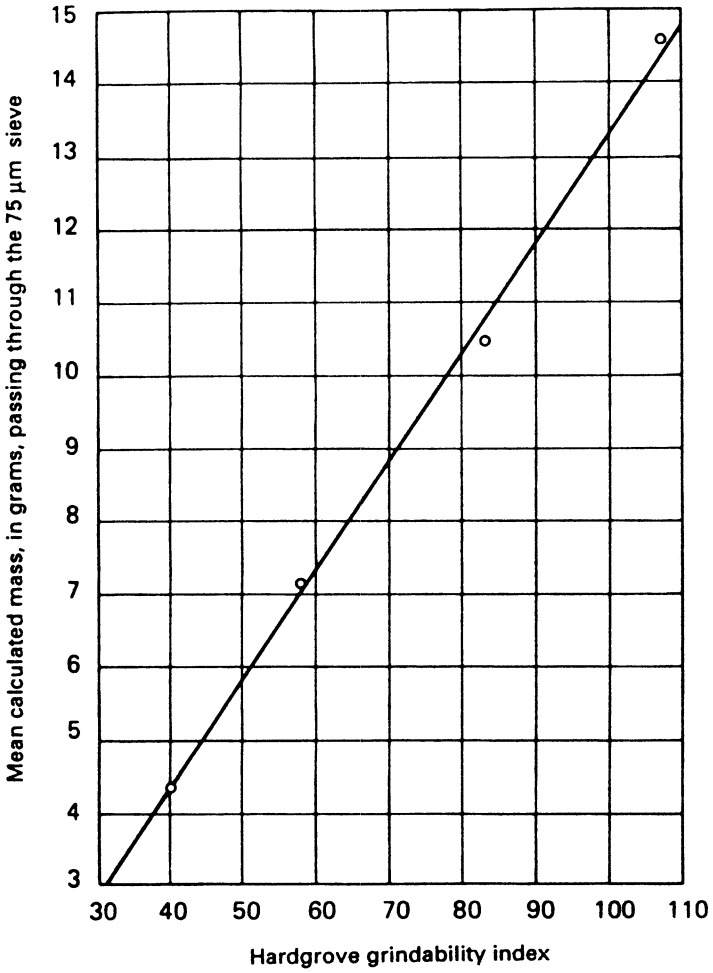
A.2 A set of four international or national standard reference coal samples (see Annex B) shall be used for the preparation of the calibration chart. They shall have certified Hardgrove grindability indices of about 40, 60, 80 and 110. Prepare and test each sample in duplicate in accordance with the procedures specified in clauses **7** and **8**.

NOTE 4 Information on the availability of national or international standard reference coal samples may be obtained from national standards institutes (see Annex B and Annex C).

A.3 Plot, on linear-scale coordinates, the mean calculated mass (m) passing the 75 µm sieve against the certified grindability index for each sample. Draw a straight line through these four points by the method of least squares. (See the specimen calibration chart in Figure A.1.)

NOTE 5 In calibrating the Hardgrove grindability machine, a correlation coefficient of at least 0,98 should be achieved.

A.4 Calibration charts shall be checked whenever equipment is renewed or repaired, or if the machine is suspected of being defective.



NOTE 1 This is a specimen chart only and shall not be used for determining the Hardgrove grindability index (HGI).

NOTE 2 The test results used in plotting the specimen calibration chart were as follows:

HGI (certified)	m (test result)
40	4,35
58	7,14
83	10,44
107	14,53

Figure A.1 — Specimen calibration chart

Annex B (normative) Preparation of national standard reference coal samples with certified Hardgrove grindability indices (see note 4 to **A.2**)

B.1 Collect four coal samples, each of mass about 80 kg, having grindability indices of about 40, 60, 80 and 110. Treat each sample as follows.

B.2 Air-dry the sample for 24 h to 48 h. Using the crusher specified in **5.4**, crush the entire sample to pass through a 4,75 mm sieve. Mix the sample thoroughly and divide into 24 equivalent subsamples (mixing and subdivision shall be carried out by mechanical means).

B.3 Take two of the subsamples from the batch of 24 and halve each to produce four test samples. Determine the Hardgrove grindability index of each of the four test samples by the procedures described in this International Standard, using the national Hardgrove machine and its calibration chart based on the international standard reference coal samples (see Annex C).

B.4 The mean of the four grindability indices, expressed to the nearest whole number, shall be the certified grindability index for the remaining 22 samples from the batch, which shall then become national standard reference coal samples.

B.5 Standard reference coal samples shall be stored in a cool place in sealed containers in an atmosphere of argon or nitrogen (oxygen-free).

NOTE 6 If only a small number of Hardgrove machines are available in a country, the preparation of national standard reference coal samples may not be necessary. In these circumstances, individual users may calibrate their Hardgrove machines by the procedure described in Annex A, using the international standard reference coal samples.

Annex C (informative) Calibration of national Hardgrove machines (see note 4 to **A.2**)

C.1 A national Hardgrove machine shall be calibrated against international standard reference coal samples, before being used in connection with the preparation of national reference coal samples.

C.2 A set of four international standard reference coal samples should be obtained from an internationally recognized laboratory[2)] by the national testing laboratories nominated for this purpose.

C.3 The national Hardgrove machine shall be calibrated using the procedure set out in Annex A, except that four determinations shall be made on each sample rather than duplicate determinations as specified in **A.2**.

C.4 When calibrated, the national Hardgrove machine shall be reserved exclusively for the determination of the grindability indices of national standard reference coal samples.

[2)] Such a laboratory is the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103, USA.

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