
Methods for
Analysis and testing of coal and coke

**Part 20. Determination of Hardgrove grindability
index of hard coal**

[ISO title: Hard coal—Determination of Hardgrove grindability index]

Méthodes d'analyse et d'essai du charbon et du coke

Partie 20. Détermination de l'indice de broyabilité de l'houille Hardgrove

Verfahren für die Analyse und Prüfung von Kohle und Koks

Teil 20. Bestimmung der Hardgrove'schen Mahlbarkeitszahl von Steinkohle

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National foreword

This British Standard, which has been prepared under the direction of the Solid Fuel Standards Committee, is identical with ISO 5074 'Hard coal — Determination of Hardgrove grindability index' published in 1980 by the International Organization for Standardization (ISO), and prepared by ISO/TC 27, Solid mineral fuels.

This British Standard is one of a series issued under the same number, BS 1016, dealing with methods for analysis and testing of coal and coke; the other Parts are as follows:

Part 1*	Total moisture of coal
Part 2	Total moisture of coke
Part 3	Proximate analysis of coal
Part 4	Moisture, volatile matter and ash in the analysis sample of coke
Part 5	Gross calorific value of coal and coke
Part 6	Ultimate analysis of coal
Part 7	Ultimate analysis of coke
Part 8	Chlorine in coal and coke
Part 9	Phosphorus in coal and coke
Part 10	Arsenic in coal and coke
Part 11	Forms of sulphur in coal
Part 12	Caking and swelling properties of coal
Part 13	Tests special to coke
Part 14	Analysis of coal ash and coke ash
Part 15	Fusibility of coal ash and coke ash
Part 16*	Reporting of results
Part 17	Size analysis of coal
Part 18	Size analysis of coke
Part 19	Determination of the index of abrasion of coal
Part 21	Determination of moisture-holding capacity of hard coal

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

The comma has been used throughout as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Where the words 'International Standard' appear, referring to this standard, they should be read as 'British Standard'.

Cross-references. The Technical Committee has reviewed the provisions of ISO 1988-1975, to which reference is made in clauses 2 and 6, and ISO 3310/1-1975, to which reference is made in clause 2 and 5.5.1, and has decided that they are suitable for use in conjunction with this standard. The related British Standards for ISO 1988 and ISO 3310/1 are BS 1017 'Methods for sampling of coal and coke' Part 1 : 1977 'Sampling of coal' and BS 410 : 1976 'Specification for test sieves' respectively.

NOTE. ISO 1988 and BS 1017 : Part 1 have some technical differences but both are under revision; it is expected that the BS will be identical with the ISO Standard when the revision is complete.

Additional information. The national Hardgrove machine (see Annex C) is located at the headquarters of the North East Area of the National Coal Board and national standard reference coal samples (see Annexes A and B) can be obtained from the Chief Scientist, NCB, North East Area, Scientific Control, Coal House, Team Valley, Gateshead, Co. Durham, NE11 0JD.

*Under revision.

British Standard Methods for

Analysis and testing of coal and coke

Part 20. Determination of Hardgrove grindability index of hard coal

1 Scope and field of application

This International Standard specifies the method for determining the grindability index of hard coal¹⁾ using the Hardgrove machine. It also specifies the procedure for calibrating the test machine and for preparing the standard reference coal samples.

2 References

ISO 1988, *Hard coal — Sampling*.

ISO 3310/1, *Test sieves — Technical requirements and testing — Part 1 : Metal wire cloth*.

3 Definition

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

hard coal : Coal having a gross calorific value of more than 24 MJ/kg on a moist and 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.

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 16 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 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.

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

1) The term "hard coal" is used here as an indication of maturity or rank in the coalification sequence and is not related to the physical properties of the coal.

25,4 mm. The balls shall be driven by an upper grinding ring rotated at $19 \text{ to } 21 \text{ min}^{-1}$. 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 $284 \pm 2 \text{ N}$, i.e. closely equivalent to a total mass of $29 \pm 0,2 \text{ kg}$. The machine shall be fitted with a revolution counter and an automatic device for stopping the machine after $60 \pm 0,25$ revolutions. It shall be calibrated by the method described in clause 8, before use for the determination of Hardgrove indices.

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

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 to 4,75 mm instead of to 10 mm. The gross sample shall be reduced to a final sample of about 1 kg by using a sample divider of suitable size and capacity (see 5.3).

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.

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. 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 to the crusher again set 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 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 — 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 Mix thoroughly the size fraction passing the 1,18 mm sieve and retained on the 600 μm sieve, take about 120 g using a sample divider and de-dust by sieving for 5 min on a 600 μm sieve using the sieving machine. Reduce the de-dusted material, using a sample divider (see 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 $50 \pm 0,01 \text{ g}$ of the de-dusted 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 $60 \pm 0,25$ 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.

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 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 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

Maximum acceptable differences between results obtained.

10.1 Repeatability

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 a 1,18 mm sieve and retained by a 600 μm sieve (see clause 7) should not differ by more than 2 units.