International Standard

ISO 5074

Hard coal — Determination of Hardgrove grindability index

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5074 was developed by Technical Committee ISO/TC 27, *Solid mineral fuels*, and was circulated to the member bodies in November 1978.

It has been approved by the member bodies of the following countries :

Australia	Denmark	Romania
Austria	France	South Africa, Rep. of
Belgium	Germany, F. R.	Spain
Bulgaria	India	United Kingdom
Canada	Japan	USA
China	Korea, Rep. of	USSR
Czechoslovakia	Netherlands	Yugoslavia

No member body expressed disapproval of the document.

Hard coal — Determination of Hardgrove grindability index

1 Scope and field of application

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 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

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[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 to 21 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 ± 2 N, i.e. closely equivalent to a total mass of 29 ± 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 — 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 ± 0,01 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 ± 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.

10.2 Reproducibility

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 3 units.
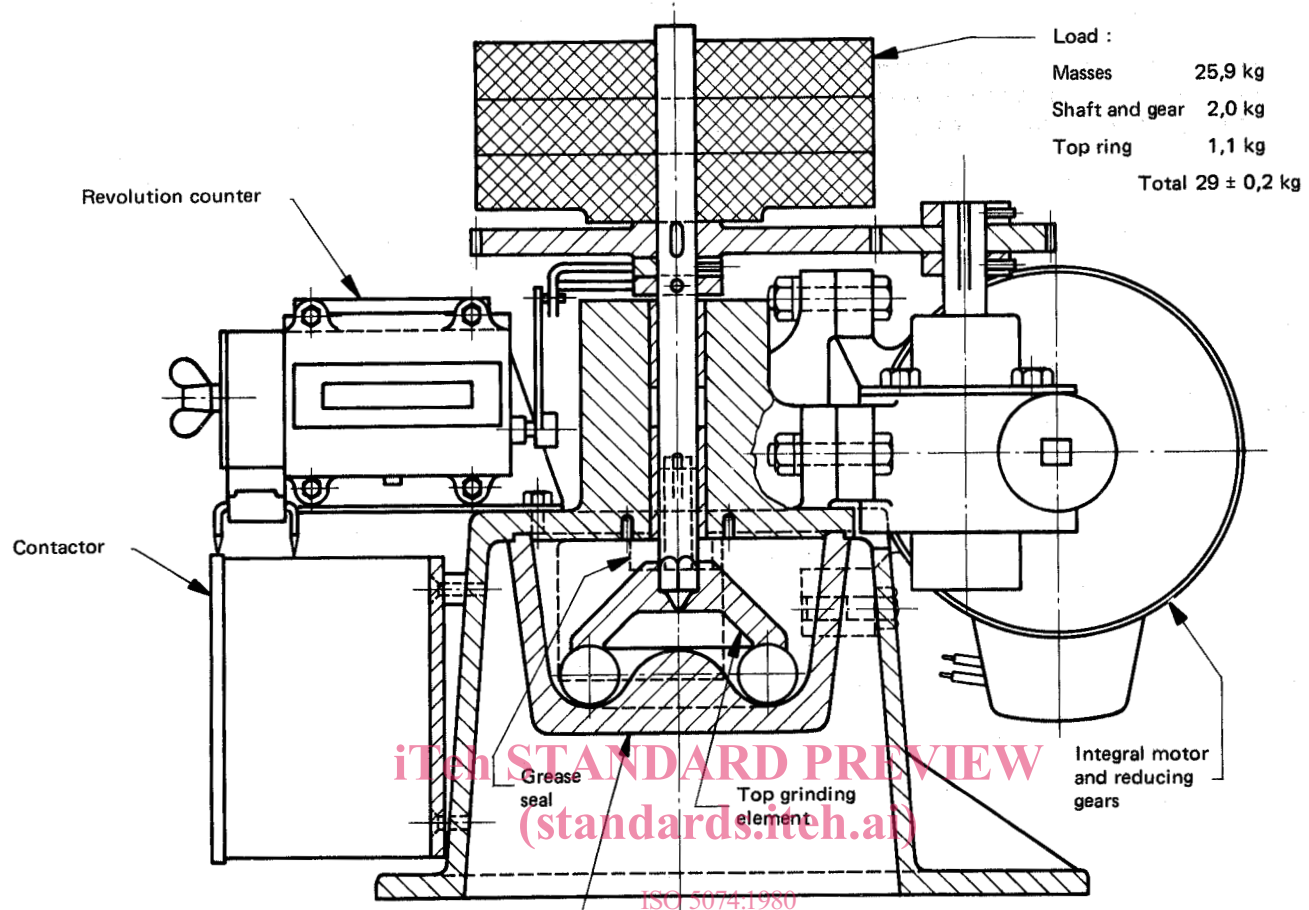
11 Test report

The test report shall include the following information :

a) complete identification of the sample tested;

b) the number of this International Standard and the results obtained;

c) any operating conditions not specified in this International Standard or regarded as optional, together with any other circumstances which may have influenced the results.

Load :

Masses 25,9 kg

Shaft and gear 2,0 kg

Top ring 1,1 kg

Total 29 ± 0,2 kg

Revolution counter

Contactor

Grease seal

Top grinding element

Integral motor and reducing gears

Lower grinding element

Section A-A

Rotation

A

A
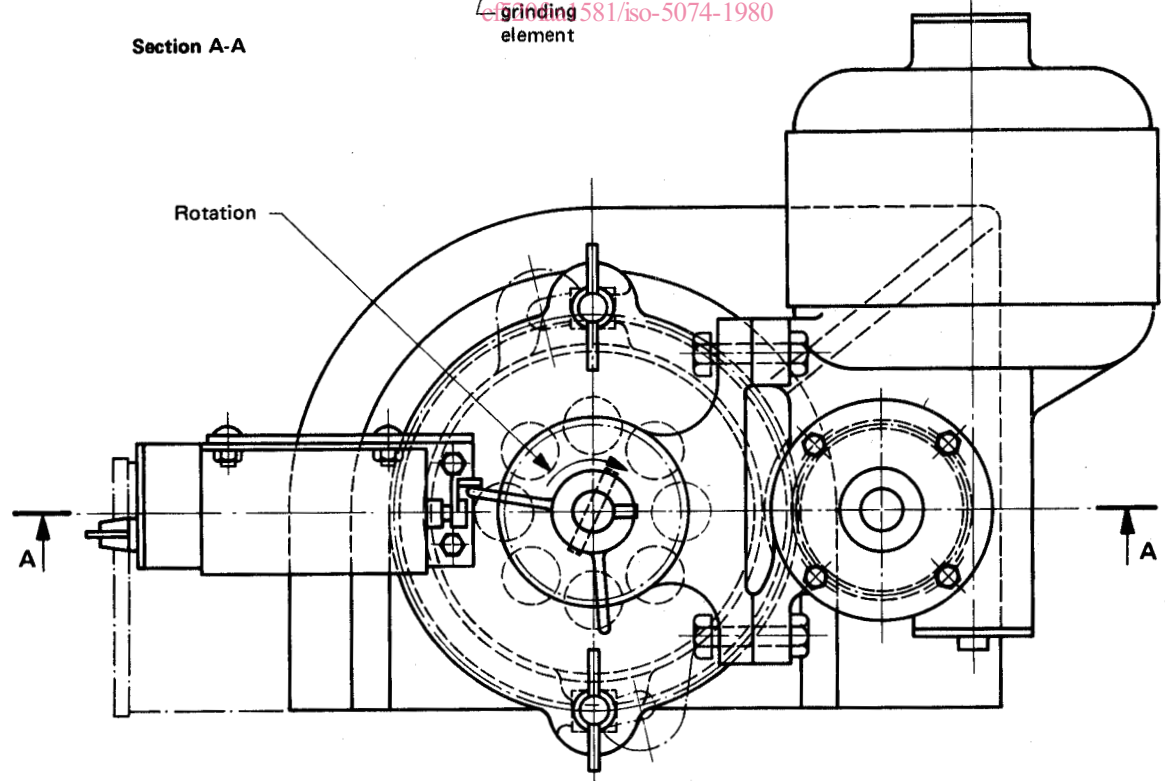
Figure 1 — Hardgrove grindability machine

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Dimensions in millimetres

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

Annex A

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 — Information on the availability of national or international standard reference coal samples may be obtained from national standards institutes.

A.3 Plot, on linear-scale co-ordinates, 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, figure 3.)

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

NOTES TO FIGURE 3

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

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

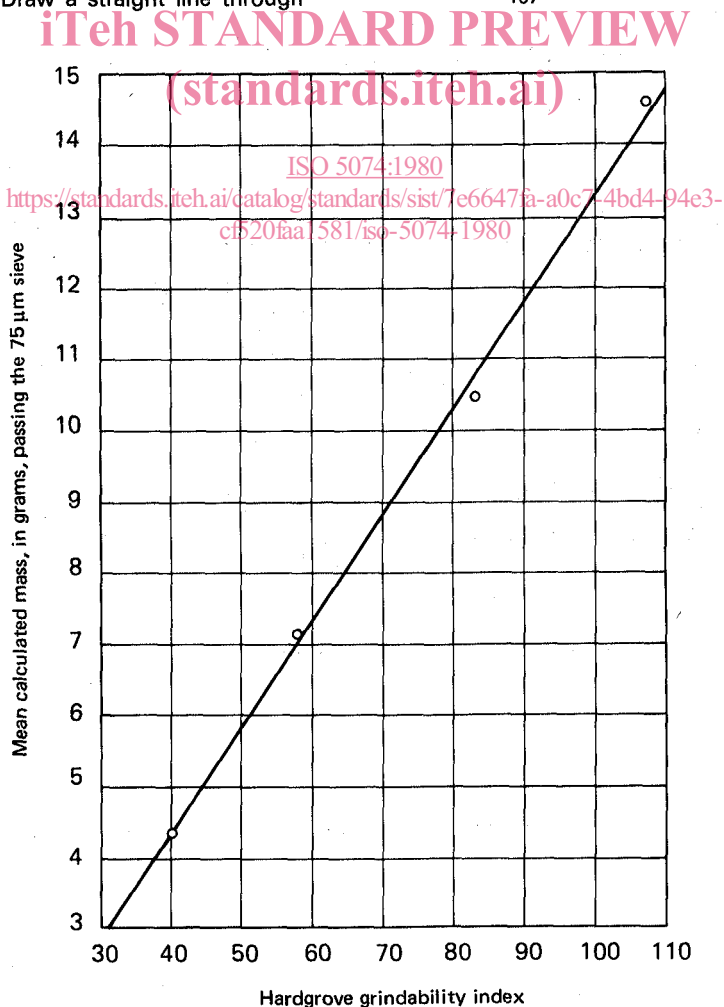| HGI (certified)	m (test result)
40	4,35
58	7,14
83	10,44
107	14,53

Figure 3 — Specimen calibration chart

Annex B

Preparation of national standard reference coal samples with certified Hardgrove grindability indices (see the note to A.2)

B.1   Four coal samples, each of mass about 80 kg, having grindability indices of about 40, 60, 80 and 110 shall be collected. Treat each sample as follows.

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

B.3   Take two of the sub-samples 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 — 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.