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Coke — Determination of shatter indices

Coke — Détermination des indices de chute

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FOREWORD

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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 616 was developed by Technical Committee ISO/TC 27, *Solid mineral fuels.*

It was submitted directly to the ISO Council, in accordance with clause 6.12.1 of the Directives for the technical work of ISO. It cancels and replaces ISO Recommendation R 616-1967, which had been approved by the member bodies of the following countries :

Australia	India	Romania
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France
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Coke — Determination of shatter indices

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies a method of determining the strength of coke by the shatter test.

2 PRINCIPLE

A representative sample of the coke above a certain specified size is dropped under standard conditions, the resistance to breakage being measured by the percentage of the coke which remains on sieves of different sizes after the test, or by a mathematical expression of these values.

3 APPARATUS

3.1 Shatter test apparatus (see figure 1), mounted on a concrete base and consisting of the following parts :

3.1.1 Box

The box is 710 mm long, 460 mm wide and 380 mm deep. It is supported by pulleys and wire ropes so that the inside of the bottom is exactly 1 830 mm above the base plate (3.1.2) when the coke is dropped.

The bottom of the box consists of two doors, hinged lengthwise and provided with a latch for rapid opening. The doors are of 6 mm steel plate and swing open rapidly so as not to impede the fall of the coke. A suitable form of latch, which prevents movement of the box on lifting the latch, is illustrated in figure 1.

The sides of the box are made of steel plate at least 3 mm thick. Guides, fastened to the end plates of the box, engage with the main vertical side supports of the apparatus which are fastened to the side plates surrounding the base plate.

3.1.2 Base plate

It is essential that the base plate be rigid; a steel plate not less than 13 mm thick, 1 220 mm long and 970 mm wide is suitable. Plates at least 200 mm high and 10 mm thick are fitted on all sides to prevent loss of coke during the test.

The back plate (see note) and side plates are rigidly fixed and the front plate is removable so as to facilitate shovelling the coke from the base plate into the box after each drop; for convenience, it may be hinged and fitted with latches.

NOTE — For the purpose of describing the apparatus, it is viewed from the "front" when the counterweight appears to the right (as depicted in figure 1).

Rigidity of the base plate is ensured by one of the following two methods, of which the first is the simpler :

a) The base plate is supported solidly on concrete, and the side and back plates and the vertical supports are welded to it.

b) The base plate is suspended above the ground, and is welded or riveted to a lower framework of 75 mm × 75 mm × 10 mm angles; the side and back plates are welded or riveted to this framework and also to a vertical piece of angle-iron at each of the two back corners.

3.1.3 Framework, comprising the following elements :

3.1.3.1 Vertical supports and box guides

The main vertical supports are fastened to the outside of the side plates of the base plate (3.1.2) and also to a top plate supporting the pulleys from which the box is suspended. The vertical supports are kept outside the base plate to facilitate shovelling the coke after each drop. If the plate is supported on a framework of angle-iron, the vertical supports should be riveted or welded to the angle-iron to increase rigidity. Guides, approximately 250 mm long, are fitted to the end plates of the box to engage with the main vertical supports.

Each vertical support may be built up in either of two ways, as follows. In one type, each vertical support consists of a T-section 150 mm wide with a 60 mm web, in which case the box guides are double to run on either side of the web of the T-section, the web of which is removed where it is fastened to the side plate of the base plate. Alternatively, the vertical support consists of two 75 mm × 75 mm angles set 13 mm apart so that a 6 mm guide plate from the box can move in the slot between the two angles.

3.1.3.2 Top plate and counterweights

The top plate is 150 to 200 mm wide and 6 mm thick; it supports two pulleys, from which the box is suspended by two wire ropes fastened to the box guides near the side supports, so as to interfere as little as possible with the reloading of the box after each drop (see note). A counterweight is suspended from the other ends of the two wire ropes, so that a double pulley is necessary at the right-hand end and a single pulley at the left-hand end. The counterweight consists of a fixed weight, of mass equal to that of the box, and two 12,5 kg removable weights which are slotted on to a rod which passes through the centre of the fixed weight.

NOTE — Central suspension of the box is not advised because this would interfere with the reloading operation.

3.1.3.3 Box stops

Stops are fitted to ensure that the inside of the bottom of the box is exactly 1 830 mm from the base plate when the box is raised and to prevent the box from falling onto the coke when the box is lowered. A convenient distance between the bottom of the box and the base plate for reloading is 460 mm.

These stops may consist of plates filling the slot between the double angles, when these are used as the main vertical support. Alternatively, when the side supports consist of T-sections, the distance piece fixing the width of the slot between the double guides may be extended vertically to form a stop with the top plate; the stop to prevent the box falling on the coke is fixed on the web of the section.

3.2 Sieves (see figure 2)

The sieve plates are machine-stamped from mild steel plate with parallel rows of square apertures. The sieve plates are made 500 mm (approximately) square and supplied with 19 mm hardwood sides screwed to the plates and armoured with horizontal angle plates to prevent wear (see figure 2). The dimensions of the sieves are given in table 1. For foundry cokes single apertures of a larger size may also be required.

3.3 Containers (see figure 3)

A suitable container of capacity 60 litres, made of 1,5 mm galvanized sheet, to hold 25 kg of shattered coke, is illustrated in figure 3. A smaller container of capacity 17 litres, made of the same material, is also illustrated in figure 3; this is suitable for holding separate single fractions in the size analysis if a good concrete floor is not available. A set of three large and three small containers is convenient. Each container should have its approximate mass marked on it, the actual mass being checked each time before use.

3.4 Weighing machine

A counter-platform weigher, reading to an accuracy of at least 25 g, is required. The machine should turn with a mass of 10 g even though the minimum reading is 25 g, and should be re-calibrated regularly.

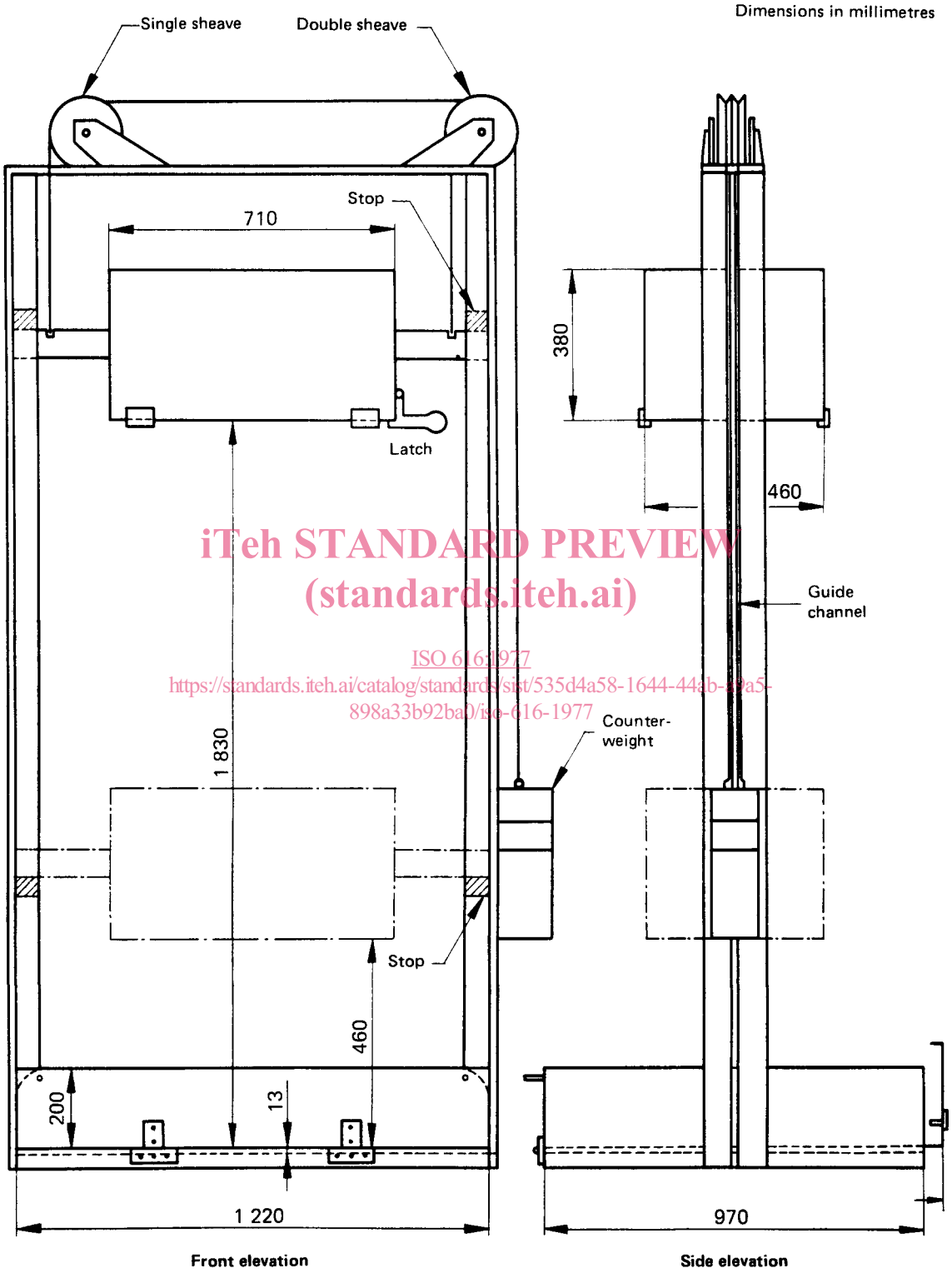


FIGURE 1 — **Apparatus for determination of shatter indices**

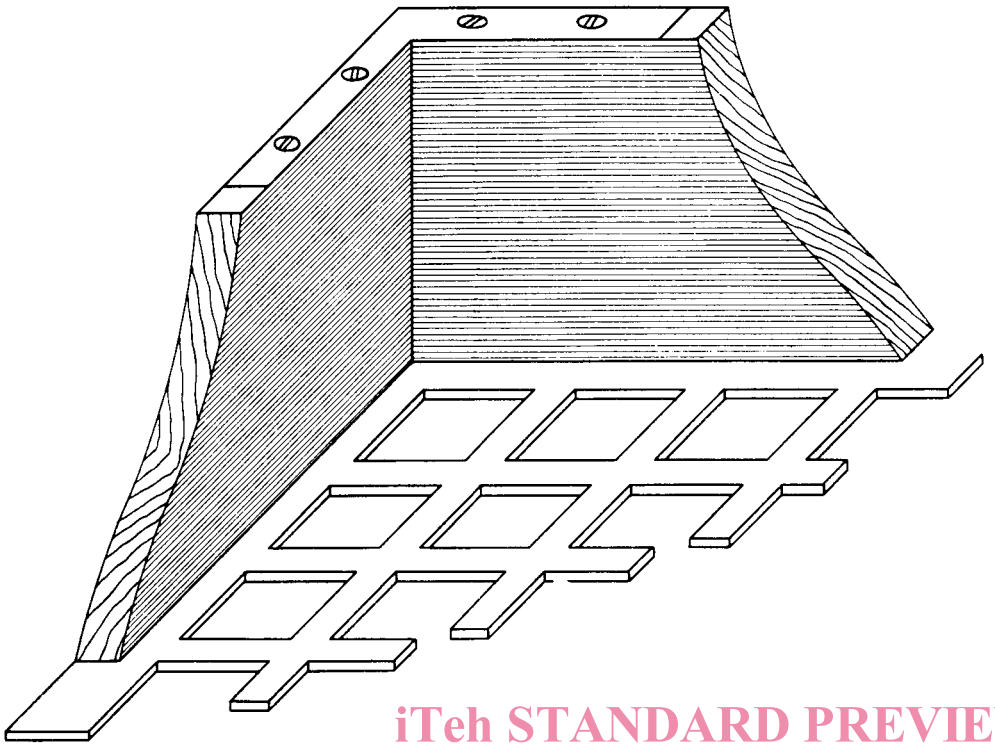


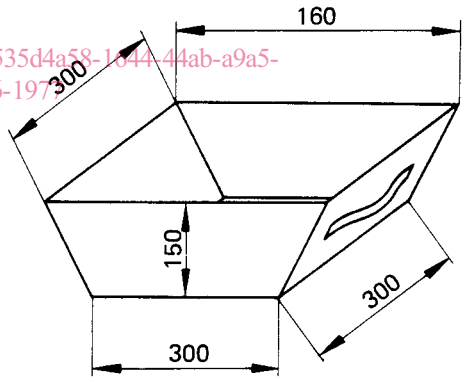
FIGURE 2 – **Detail of sieve**

Dimensions in millimetres

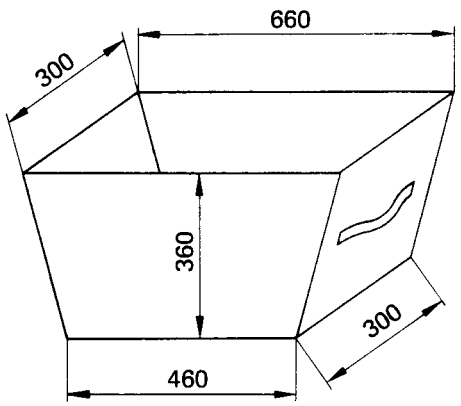
TABLE 1 – **Dimensions of sieves**

Aperture (square)[1]	Preferred thickness of plate	Preferred nominal pitch	Depth of side frame
mm	mm	mm	mm
125	3	160	125
100	3	125	125
80	3	100	125
63	3	80	100
50	3	63	100
40	2	50	100
25	2	31,5	75
12,5	1,5	16	75

1) When the wear on any aperture exceeds 2 %, the aperture shall be blanked off or the test sieve changed.



Capacity 17 litres



Capacity 60 litres

FIGURE 3 – **Suitable containers**
Material : Galvanized sheet 1,5 mm

4 SIZE ANALYSIS BEFORE THE SHATTER TEST

The coke used for the shatter test shall be over 50 mm (square apertures) in size, but the distribution in sizes shall be the same as found in a preliminary size analysis of the whole of the gross sample.

If the coke contains 5 % (*m/m*) or more of moisture, it shall be dried to less than this amount because, when coke is wet, small particles under 1 mm may adhere to larger particles and lead to weighing errors (see note 1).

The size analysis shall be carried out, for the most part, by hand-placing, a process in which each piece of coke is handled and counted as undersize if it will, in some position and without forcing, pass through the sieve.

It is usually convenient to start with a nest of sieves of 125 mm, 100 mm, 80 mm, 63 mm, 50 mm, 40 mm, 25 mm and 12,5 mm aperture. Should the "over 100 mm" fraction exceed 5 % of the gross sample, it shall be hand-placed on 125 mm or larger apertures until not more than 5 % is ungraded oversize.

The "over 100 mm", "on 80 mm", "on 60 mm" and "on 50 mm" fractions shall be weighed and placed in separate piles on the floor, the net mass of each being recorded. These are the fractions from which the shatter test sample shall be made up. The remainder of the gross sample shall then be hand-placed "on 40 mm". Finally, the size analysis shall be completed by hand-shaking "on 25 mm" and "on 12,5 mm" (see note 2). The net masses, including that of the "through 12,5 mm" coke, shall be recorded. The "under 50 mm" fraction may then be discarded.

The masses shall be recorded as cumulative percentages, starting with the largest size.

NOTES

1 On the other hand, a very wet coke will break differently from the same coke when dry. Since a coke of over 5 % (*m/m*) moisture content should be rare, it is preferable to overcome the error due to adherence of small particles to larger fractions.

2 It becomes necessary to hand-shake the coke in two (or more) portions when using 25 mm or 12,5 mm sieves, if the quantity of coke staying on the sieve in question after 100 movements is such that it would otherwise cover more than 75 % of the sieve area.

5 SAMPLE

A minimum total mass of 110 kg of coke over 50 mm (square aperture) is required and shall be collected from the consignment of coke. Each 25 kg sample for testing shall be selected so as to contain all sizes of coke over 50 mm in approximately the same proportions as they are present in the gross sample (see clause 4).

A large container shall be weighed, and the appropriate quantity of "over 100 mm" coke (or "100 mm to 125 mm" and "over 125 mm" coke, see note below) placed in it by taking sufficient pieces at random from the pile(s) on the floor. The appropriate quantities of "on 80 mm" and "on 63 mm" coke shall be added to the container, and finally sufficient of the "on 50 mm" fraction to make up exactly 25 kg of coke.

The moisture content of the coke as tested shall not exceed 5 % (*m/m*).

NOTE – If the "over 100 mm" fraction exceeds 5 % of the original gross sample, it will have been separated into "100 mm to 125 mm" and "over 125 mm" fractions and these fractions shall be used in proportion.

6 PROCEDURE

Empty the 25 kg of "over 50 mm" coke carefully into the box (3.1.1) of the shatter test apparatus, either by inserting the container (3.3) into the box and allowing the coke to slide out, or by removing the coke and placing it in the box by hand.

Raise the box to the standard height, close and latch the front plate of the base and displace the latch of the shatter test box to allow the coke to fall on to the base plate (3.1.2).

Close the bottom doors of the box and replace the latch (see note 1). Lower the box until the lower stop halts it. Drop the front plate (see note 2) and shovel the coke from the base plate into the box, taking care to place the coke into the box without dropping. Return the whole of the coke over 12,5 mm in size from the base plate to the box; this can be done by using the shovel, but without sweeping at this stage. Repeat the process until four drops have been made; some form of indicator is helpful in avoiding error in the number of drops.

Arrange a nest of sieves (3.2) of 100 mm, 80 mm, 63 mm, 50 mm, 40 mm, 25 mm and 12,5 mm square aperture, with the sieve of largest aperture at the top. Shovel the coke from the base of the apparatus on to the top sieve and complete the emptying of the base plate by sweeping up all the dust. Shake the top sieve vertically to allow most of the undersize to pass through and hand-place the residue on the sieve until no more will pass. Transfer the "over 100 mm" coke into the container, weigh it and record its mass.

Shake the 80 mm sieve and hand-place the residue on the sieve until no more will pass. Add the "on 80 mm" coke to the same container and re-weigh. Repeat for sieves of 63 mm, 50 mm and 40 mm.

Hand-shake the residue on the 25 mm sieve, add the "on 25 mm" coke to the container and again weigh.

Hand-shake the residue on the 12,5 mm sieve, add the "on 12,5 mm" coke to the container and again weigh.

Sweep the "through 12,5 mm" fraction on to the shovel, transfer to the container and obtain the final mass. Check that the total mass is 25 ± 0,025 kg (see note 3). If the total is less than 24,90 kg, the results shall be rejected.

NOTES

1 The operator should not stand on the coke to perform this operation.

2 To avoid the possibility of injury, it is important that the operator should stand to one side before the heavy plate falls.

3 It is important to be able to determine the 12,5 mm shatter index with an accuracy of the order of 0,1 % (40 g on 25 kg) and to obtain this value directly. It is, therefore, necessary to avoid numerous weighing errors (such as would be obtained if the mass of the "over 12,5 mm" coke were obtained as the sum of the masses of seven fractions) and to weigh all fractions in one container to obtain the cumulative percentage with only one weighing error.

7 EXPRESSION OF RESULTS

The 80 mm, 50 mm, 40 mm, 25 mm and 12,5 mm shatter indices shall be reported, and preferably also the mean size of the coke before and after the test. For the calculation of mean size (see note), the percentages by mass of coke remaining on the 100 mm and 63 mm sieves are required as well as those remaining on the 80 mm, 50 mm, 40 mm, 25 mm and 12,5 mm sieves.

After recording the cumulative masses remaining on each sieve, the loss during the test (not greater than 100 g, see clause 6) shall be distributed more or less uniformly between the different fractions, and not attributed to one fraction only.

The adjusted percentage masses remaining on the 80 mm, 50 mm, 40 mm, 25 mm and 12,5 mm sieves, rounded off to one decimal place, shall then be recorded as the 80 mm, 50 mm, 40 mm, 25 mm and 12,5 mm shatter indices respectively.

The mean results of three tests (or four tests, see 8.3) shall be reported; the moisture content of the coke sample before test shall be stated in the report.

NOTE — The mean size of the coke is calculated from the size analyses before and after the test. One method of calculation is as follows :

Let

$a, b, c, \ldots, h, j, k$ be the complete series of sieve apertures used;

$A, B, C, \ldots, H, J, K$ be the cumulative percentage masses remaining on these sieves;

$A = 0$ (i.e. select sieve a arbitrarily above the top size of the coke);

$K = 100$ (i.e. K represents an imaginary sieve of zero aperture);

M = mean size.

Then

$$M = \frac{B(a-c) + C(b-d) + \ldots + J(h-k) + 100j}{200}$$

Alternative methods of calculation or graphical methods may be used and may give slightly different results; for purposes of comparison, therefore, the same method should be used.

8 PRECISION OF DETERMINATION

TABLE 2 — **Precision**

Shatter index	Maximum acceptable differences between results obtained	
	repeatability	reproducibility
40 mm	4,0 % absolute	(see 8.2)
12,5 mm	1,0 % absolute	(see 8.2)

8.1 Repeatability

The range of the results of the three tests, carried out in the same laboratory, by the same operator with the same apparatus on three representative portions taken from the same gross sample, should not exceed the amounts shown in table 2.

8.2 Reproducibility

No tolerance is quoted for determinations carried out in different laboratories because the transport of a coke sample involves the risk of breakage and thus alteration of the size distribution and the shatter indices.

8.3 Number of tests

At least three tests shall be carried out on each coke sample. If the range of the results for the 40 mm index exceeds the above amount, further tests shall be carried out until three results are obtained which do fall within the required range. If, after four tests, rejection of either the highest or the lowest result for the 40 mm index leaves the three remaining results within the required range, then all four results shall be used for calculation of the means for all the indices, and also for calculation of the mean size where this is required.

9 TEST REPORT

The test report shall include the following particulars :

a) the reference of the method used;

b) the results and the method of expression used;

c) any unusual features noted during the determination;

d) any operation not included in this International Standard or regarded as optional, which may have influenced the results.