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Coke — Size analysis by sieving

Cok — Analyse granulométrique par tamisage

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 27, *Coal and coke,* Subcommittee SC 3, *Coke*.

This fourth edition of ISO 728 cancels and replaces ISO 728:1995 and ISO 2325:1986, which have been technically revised.

The main changes compared to the previous edition are as follows:

— the coke size analysis of the minus 20 mm fractions has been moved to this document;

— low impact mechanical sieving was added to the scope;

— hand placing of coke was introduced from 125 mm down to 22,4 mm to be consistent with coal sizing ISO 1953;

— ISO 728 now incorporates ISO 2325;

— the coke mean size calculation was modified, moved from an annex to the main document and a worked example added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Coke — Size analysis by sieving

1 Scope

This document specifies procedures for the size analysis of coke by manual and/or low impact mechanical sieving, using square or round holed sieves of aperture sizes between 125 mm and 0,5 mm. Guidance on handling the sampling and sizing of coke products greater than 125 mm is given in Annex A.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. The latest edition of the referenced document (including any amendments) applies.

ISO 579, *Coke — Determination of total moisture*

ISO 1213-2, *Solid mineral fuels — Vocabulary — Part 2: Terms relating to sampling, testing and analysis*

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

ISO 3310-2, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*

ISO 13909-5, *Hard coal and coke — Mechanical sampling — Part 5: Coke — Sampling from moving streams*

ISO 13909-6, *Hard coal and coke — Mechanical sampling — Part 6: Coke — Preparation of test samples*

ISO 18283, *Hard coal and coke — Manual sampling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1213-2 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Principle

A sample of coke with less than 5 % moisture is subjected to a process of size analysis by a specified manual and or mechanical sieving, and the results are expressed in terms of the cumulative percentage by mass of the coke remaining on sieves of different sized openings.

5 Apparatus

5.1 Test sieves, in accordance with ISO 3310-1 and ISO 3310-2.

The set of sieves used shall have exclusively round holes or exclusively square holes. It is important to check the sieves from time to time, using the methods specified in ISO 3310-1 and ISO 3310-2, to ensure that the hole dimensions are within the specified tolerances. Worn or damaged sieves can give rise to serious errors in size analysis and shall be discarded. The test sieves should be selected according to the requirements of the test and the characteristics of the sample. If possible, the series of sieves should

be selected so that the mass of coke in any size fraction does not exceed 25 % of the total mass of sample being sieved. For ungraded cokes, an example of a series of test sieves of nominal hole sizes in Table 1 are outlined. Other sieves of various nominal hole sizes can also be chosen. For samples containing pieces with a particle size greater than 125 mm, single-hole gauges may be used instead of test sieves.

5.2 Balance or scale, capable of measuring the mass of each size fraction to the nearest 0,1 %.

5.3 Receivers or bins, for collecting material passing through the sieve.

5.4 Trays, smooth, of non-corrodible material, of at least 400 mm × 400 mm, depending on the mass of sample and number of analysis required.

5.5 Lids, to fit the test sieves.

5.6 Flat brush, for cleaning the sieves and for brushing dust from the trays.

5.7 Hardwood block, about 150 mm long with a 10 mm × 10 mm cross-section, for tapping the sieve.

5.8 Shovel or scoop.

5.9 Vibratory sieve shaker for mechanical sieving, (see example Figure 2). Small low impact vibratory sieve shakers may be used, providing that their action does not break the coke and that the results are known to be not biased with respect to the results obtained by hand shaking.

6 Sampling and preparation of sizing sample

The sieving shall be carried out on samples having less than 5,0 % moisture as per the following procedures.

a) For unknown cokes, two gross samples shall be sampled in accordance with ISO 13909-5 or ISO 18283. Each gross sample shall be prepared in accordance with ISO 13909-6 or ISO 18283 and meet the minimum masses as quoted in Table 1. Prepare one of these samples for total moisture determination in accordance with ISO 579. If the total moisture is higher than 5,0 % (as sampled), dry the other sample sufficiently to reduce the total moisture content to lower than 5,0 % (as sampled). After the initial drying if the total moisture is still above 5,0 % further drying will be necessary until the sample moisture is less than 5,0 %. The final dried sample less than 5,0 % moisture is used for the test.

b) For known cokes with less than 5,0 % moisture from the same plant or same supplier, no further pre-treatment is required. If the moisture is above the 5,0 % level, the drying time to reach less than 5,0 % (as sampled) may be determined by taking the average drying time over 10 lots. Alternatively, drying most coke samples for 12 h or more at 100 °C to 200 °C should render the sample suitable for sizing only. If only size analysis is required, it is permissible to take one gross sample for sizing and use the determined period or the longer 12 h drying time at 100 °C to 200 °C to prepare the gross sample for sizing.

Table 1 — Minimum mass of coke samples for general analysis, determination of total moisture content and sizing

Nominal top size of coke mm	Minimum mass kg
Plus 125	2 000
125	1 000
100	650
90	500
75	320
63	250
50	200
45	125
31,5	60
22,4	30
16,0	15
11,2	8
10,0	6
8,0	4
5,6	2
4	1

See ISO 18283

7 Procedures

7.1 Sizing sample of particle size greater than 22,4 mm but less than 125 mm

The sieves outlined in the procedure described in this subclause (7.1) are used as an example in how to size a test sample for all the sieves in Table 1. Other sieve sizes may be used between 125 mm and 22,4 mm.

a) Determine the mass of the coke sample to be sized to the nearest 0,1 % of the mass of the sample.

b) Arrange a set or nest of 450 mm sieves (125 mm, 100 mm, 90 mm and 75 mm) (maximum 4 sieves are recommended at one time) in order of sieve aperture size with the smallest at the bottom over an empty tared receiver or bin made from plastic to minimize breakage or place on a sieve shaker similar to Figure 1.

c) Place a portion of the coke test sample at a time on the top sieve small enough that not more than 75 % of the sieve area is covered and shake manually to allow most of the undersize to pass. Hand place the remaining particles of coke in turn. If it passes through the sieve opening in any position and without forcing it, it is designated as passing 125 mm. Alternatively, a low impact mechanical sieve shaker (see Figure 1) can be used to assist this process on a stop start basis. Hand place each particle with the sieve shaker in the “off” position. Collect the plus 125 mm size fraction in a tared empty bin and record its mass in kg. Repeat this process through 100 mm, 90 mm and 75 mm screens, and record the mass of these size fractions.

d) Repeat the process in c) for size fractions 63 mm, 50 mm, 45 mm and 31,5 mm, and record the mass of these size fractions.

e) Repeat the process in c) for 22,4 mm and redetermine the mass of that size fraction and the minus 22,4 mm fraction.

NOTE 1 The minus 22,4 mm fraction from 7.1 e) is sized as per 7.3 or 7.5.

The 22,4 mm sieve in this document has been used to indicate that in the size fractions above this size each particle shall be hand placed. However, it is permissible to use a similar screen in the 19 mm to 25 mm range for this function.

NOTE 2 "Hand placing" refers to the operation defined in ISO 1213-2.

Figure 1 — Example of a large low impact vibratory mechanical sieve shaker

7.2 Division of coke minus 22,4 mm

Divide the sample (minus 22,4 mm fraction from 7.1 e) to the required minimum mass in Table 1 by means of a suitable mechanical sample divider or riffle avoiding size degradation and loss of dust. Alternatively, for division, use either the flattened heap method or the strip mixing method described in ISO 13909-6 and ISO 18283. Determine the mass of all the coke not included as part of the test sample and retain it until all analyses and calculations are complete.

7.3 Sizing sample of maximum particle size between 22,4 and 4 mm — Manual method

a) Determine the mass (of the divided minus 22,4 mm fraction from 7.2) of the sample to the nearest 0,1 %.

b) Position the largest aperture size sieve in the set over an empty receiver or bin. Move the sieve horizontally to and fro, with the displacement not exceeding 100 mm in either direction, to cause the pieces of coke to tumble or roll on the sieve.

c) Continue the sieving motion until eight movements in each direction (a total of 16 movements) have taken place after the last undersize piece passes through the sieve. Avoid any impact when stopping the motion.

d) Place the coke remaining on the sieve in a tared receiver and determine the mass of the size fraction.

e) Sieve the undersize again by repeating the above process for each sieve down to and including the 4,0 mm aperture size sieve and redetermine the mass of each size fraction including the minus 4,0 mm fraction.

The mass of the minus 4,0 mm fraction from 7.3 e) may also be reduced in a similar fashion to 7.2 before proceeding to 7.4.

7.4 Sizing sample of particle size less than 4,0 mm — Manual method

a) Determine the mass [of the divided minus 4,0 mm fraction from 7.3 e)] to the nearest 0,1 %.

b) Place the smallest aperture size sieve in the set on a receiver or bin. Brush the sample onto the sieve, fit the lid and sieve continuously for a 5 min (minute) period, as described in item c), to remove the undersize. If the sample is large, sieve it as separate portions so that not more than 75 % of the area of the sieve is covered at the end of each sieving operation.

c) Hold the receiver fitted with the sieve and its lid in the left hand so that the surface of the sieve is inclined downwards towards the left at an angle of about 30° to the horizontal. Tap the higher side of the sieve frame six to eight times with the hardwood block. While maintaining the inclination of the sieve, shake the assembly to and fro several times, also rotating it in the plane of the sieving surface through an angle of approximately 60°.

d) Continue the operations of tapping and shaking alternately for a further 5 min period.

e) At the end of the further 5 min sieving period, allow the suspended fines to settle for 2 min, carefully remove the lid and lift the sieve from the receiver or bin. Invert the sieve over a tray, tap the higher side of the sieve frame with the hardwood block, and then carefully brush the uppermost surface of the inverted sieve with the flat brush. Turn the sieve the right way up and add any loose particles dislodged during brushing to the oversize on the tray.

f) Invert the receiver over a second tray, tap the receiver with the hardwood block and brush out any adherent fines.

g) If there are any fines still visible in the oversize, replace the sieve on the receiver and transfer the oversize from the first tray to the sieve, replace the lid and re-sieve for a further 5 min period. Separate the sieve and the receiver and again, clean the sieve. Add the fines to the material which passed through the sieve during the first and second 5 min periods.

h) Assemble the appropriate sieves in a nest, in descending order of aperture size, and fit a receiver or bin. Place the sample on the top sieve. Shake the nest of sieves for a further 5 min period.

i) At the end of the 5 min period, clean each sieve in turn, starting with the smallest aperture size sieve, by inverting it over a tray, tapping the higher side of the sieve frame with the hardwood block and carefully brushing the uppermost surface of the inverted sieve with the flat brush. Turn the sieve the right way up and add any loose particles dislodged during the brushing to the oversize on the tray. Return the sieve to the nest and transfer the material on the tray back to the sieve.

j) Repeat the process described in above Items h) and i) twice, but after the final cleaning of the sieves transfer the material from the trays and determine the mass of each size fraction. Add the undersize obtained from the initial separation to that from the final sieving before weighing.

k) After determining the mass of each individual size fraction, repeat the sieving cycle described in items h) and i) and then redetermine the mass of each size fraction. Continue this process until the difference between the two mass determinations for any size fraction, after consecutive sieving cycles, does not exceed 0,2 % of the total mass of coke being sieved.

7.5 Sizing sample of particle size between 22,4 and 4,0 mm — Mechanical method

a) Determine the mass (of the divided minus 22,4 mm fraction from 7.2) of the sample to the nearest 0,1 %.

b) Assemble the appropriate sieves in a nest, in descending order of aperture size, and fit a receiver or bin. Place the sample on the top sieve and fix a sieve lid. Shake the nest of sieves mechanically for 5 min period.

c) At the end of the 5 min period, clean the underside of each sieve in turn with a flat brush and carefully add any loose particles dislodged during the brushing to the oversize of the immediate sieve below in the nest. Return all the sieves to the nest.

d) Repeat the process described in items b) and c) twice, then after the final cleaning of the sieves transfer the material from the sieves and determine the mass of each size fraction. After determining the mass of each individual size fraction, return it to the corresponding sieve.

e) Repeat the sieving cycle described in items b) and c), and then redetermine the mass of each size fraction as described in item d). Continue this process until the difference between the two mass determinations for any size fraction, after consecutive mechanical sieving cycles, does not exceed 0,2 % of the total mass of coke being sieved.

The mass of the minus 4,0 mm fraction from 7.5 e) may also be reduced in a similar fashion to 7.2 before proceeding to 7.6.

7.6 Sizing sample of particle size minus 4,0 mm — Mechanical method

a) Determine the mass (of the divided minus 4 mm fraction from 7.5 e) of the sample to the nearest 0,1 %.

b) Assemble the appropriate sieves in a nest, in descending order of aperture size, and fit a receiver or bin. Place the sample on the top sieve and fix a sieve lid. Shake the nest of sieves mechanically for 5 min period.

c) At the end of the 5 min period, clean the underside of each sieve in turn with a flat brush and carefully add any loose particles dislodged during the brushing to the oversize of the immediate sieve below in the nest. Return all the sieves to the nest.

d) Repeat the process described in items b) and c) twice, then after the final cleaning of the sieves transfer the material from the sieves and determine the mass of each size fraction. After weighing, return each individual size fraction to the corresponding sieve.

e) Repeat the sieving cycle described in items b) and c), and then redetermine the mass of each size fraction as described in item d). Continue this process until the difference between the two weighing's for any size fraction, after consecutive mechanical sieving cycles, does not exceed 0,2 % of the total mass of coke being sieved.

8 Expression of results for all sizes

If necessary, calculate the cumulative mass on each sieve starting with the sieve with the largest size of holes, or the cumulative mass passing through each sieve starting with the sieve with the smallest size of holes, from the masses of the individual size fractions.

Calculate the apparent loss, i.e. the difference between the total mass of the test sample before sieving and the total mass of coke collected afterwards. If the loss is greater than 0,4 % of the original mass of the test sample, reject the results and carry out a further test. Otherwise, add the apparent loss to the mass of the smallest size fraction.

Convert each cumulative mass to a percentage of the total mass of the test sample. Report the cumulative masses to the nearest 0,1 kg and the cumulative percentages to the nearest 0,1 %.

An example of the results of a size analysis of coke, in terms of the cumulative oversize, is given in Table 2.

Table 2 — Example of size analysis of an unknown coke

Nominal size of hole (square hole) mm	Mass of fraction kg	Cumulative mass kg	Cumulative percentage oversize %
Plus 125	64,1	64,1	3,2
100	185,2	249,3	12,4
80	508,4	757,7	37,8
71	352,0	1 109,7	55,4
63	303,5	1 413,2	70,5
50	230,5	1 643,7	82,0
40	166,8	1 810,5	90,3
31,5	80,3	1 890,8	94,3
20	44,4	1 953,2	96,5
10	36,3	1 971,5	98,3
Minus 10	29,0 + 4,2 = 33,2	2 004,7	100,0
Sum = 2 000,5 kg Original mass = 2 004,7 Loss in mass = 4,2 kg or 0,2 % of original mass ∴ The loss in mass, being less than 0,4 % of the original mass, is added to the fraction of the smallest size (minus 10 mm).			

9 Determination of mean coke size from results in Table 2

9.1 Calculation of mean coke size

Table 3 shows the calculation of mean coke size taken from the data in Table 2.

Table 3 — Calculation of mean coke size

Designation of hole sizes	Nominal size of hole (square hole)	Calculate mean screen for calculation	Mean size	Designation of mass on screen	Mass on screen	Cumulative mass	Cumulative mass	Mass
—	mm		mm	—	kg	kg	%	kg
a	150	—	—	*A*	0,0	0,0	0,0	0,0
b	125	$(a + b)/2$	137,5	*B*	64,1	64,1	3,20	8 813,8
c	100	$(b + c)/2$	112,5	*C*	185,2	249,3	12,44	20 835,0
d	80	$(c + d)/2$	90,0	*D*	508,4	757,7	37,80	45 756,0
e	71	$(d + e)/2$	75,5	*E*	352,0	1 109,7	55,35	26 576,0
f	63	$(e + f)/2$	67,0	*F*	303,5	1 413,2	70,49	20 334,5
g	50	$(f + g)/2$	56,5	*G*	230,5	1 643,7	81,99	13 023,3
h	40	$(g + h)/2$	45,0	*H*	166,8	1 810,5	90,31	7 506,0
i	31,5	$(h + i)/2$	35,8	*I*	80,3	1 890,8	94,32	2 870,7
j	20	$(i + j)/2$	25,8	*J*	44,4	1 935,2	96,53	1 143,3
k	10	$(j + k)/2$	15,0	*K*	36,3	1 971,5	98,34	544,5
l	0	$(k + l)/2$	5,0	*L*	33,2	2 004,7	100,00	166,0
Total					∑=2 004,7			∑=147 569,0

NOTE 1 *a, b, c, d, ... h, k, l* are the hole sizes, in millimetres of successive sieves.

NOTE 2 *A, B, C, D, ... H, J, K, L* are the masses on the individual screens.

NOTE 1 When considering the size analysis in Table 2 before commencing the mean size calculation, there is one assumption to be made. There is not a sieve recorded with a hole size through which all coke passes. In this example, it is designated as the 150 mm sieve.

NOTE 2 The sieve with a hole size "*a*" is the smallest size through which all the coke passes. (i.e. $A = 0$ %).

NOTE 3 The sieve with the hole size "*l*" is a hypothetical sieve through which no coke will pass. (i.e. $l = 0$ mm and $L = 100$ %).

9.2 Calculation of coke mean size from data in Table 3

$$\frac{\{B((a + b)/2)+C((b + c)/2) + D((c + d)/2) + E((d + e)/2) + F((e + f)/2) + G((f + g)/2) + H((g + h)/2) + I((h + i)/2) + J((i + j)/2) + K((j + k)/2) + L((k + l)/2)\}}{\{\sum \text{ of Mass on screen}\}}$$

$$\frac{\{64{,}1(137{,}5) + 185{,}2(112{,}5) + 508{,}4(90{,}0) + 352{,}0(75{,}5) + 303{,}5(67{,}0) + 230{,}5(56{,}5) + 166{,}8(45{,}0) + 80{,}3(35{,}8) + 44{,}4(25{,}8) + 36{,}3(15{,}0) + 33{,}2(5{,}0)\}}{\{2\,004{,}7\}}$$

$$\frac{\{8\,813{,}8 + 20\,835{,}0 + 45\,756{,}0 + 26\,576{,}0 + 20\,334{,}5 + 13\,023{,}3 + 7\,506{,}0 + 2\,870{,}07 + 1\,143{,}3 + 544{,}5 + 166{,}0\}}{\{2004{,}7\}}$$

$$\frac{\{147\,569{,}0\}}{\{2\,004{,}7\}}$$

Mean coke size = 73,6 mm