



Standard Test Method for Tumbler Test for Coke¹

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1. Scope

1.1 This test method describes a procedure for obtaining a relative measure of the resistance to degradation of coke by impact and abrasion.

1.2 *Standard Procedure*—This procedure uses a coke sample sized to -75 mm [-3 in.] and $+50$ mm [$+2$ in.].

1.3 *Alternative Procedure*—This procedure using coke sized 50 % of 63 by 50 mm [$2\frac{1}{2}$ by 2 in.] and 50 % of 50 by 37.5 mm [2 by $1\frac{1}{2}$ in.].

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*:²

D294 Method of Test for Tumbler Test for Coke; Replaced by D 3402 (Withdrawn 1975)³

D346/D346M Practice for Collection and Preparation of Coke Samples for Laboratory Analysis

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

¹ This test method is under the jurisdiction of ASTM Committee D05 on Coal and Coke and is the direct responsibility of Subcommittee D05.15 on Metallurgical Properties of Coal and Coke.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

3. Summary of Test Method

3.1 A sample of dry coke of designated size is tumbled in a rotating drum at a specified turning rate for a specified number of revolutions. Two indexes of its strength, the stability factor and the hardness factor, are determined by sieve analysis of the coke after treatment. Studies have indicated that there is no real difference in the stability factor as determined by the standard and alternative procedures. The alternative procedure produces hardness factor results averaging slightly higher than the standard procedure.

4. Significance and Use

4.1 Coke undergoes various degrees of degradation during removal from coke ovens, transportation, and its descent within a blast furnace to the combustion zone. These processes subject the coke to impact and abrasion. This test method is a relative measure of the resistance of coke to breakage when subjected to these degradation processes.

5. Apparatus

5.1 *Tumbler Machine* (see Fig. 1)—The tumbler machine consisting of a cylindrical steel drum 910 mm [36 in.] in inside diameter and 455 mm [18 in.] in inside width and made of plate at least 6 mm [$\frac{1}{4}$ in.] thick. The machine may be constructed as a double drum mounted on a common shaft so that duplicate coke samples may be tested at the same time. Two equally spaced 50 by 50 by 6 mm [2 by 2 by $\frac{1}{4}$ in.] steel angles extending across the width of each drum are solidly fastened inside each drum as shown. These angles are fastened to the shell so that the attached legs point away from the direction of rotation, thus giving a clear unobstructed shelf for lifting the coke. At least one door must be provided in each drum for charging and discharging the coke sample. This door preferably should extend nearly across the width of each drum. As an alternative, a door in the side of the drum is permissible. During the test the door must be fastened rigidly to the shell and must fit into the shell in order to have a smooth continuous inner surface. A dust-tight gasket must be provided to prevent loss of the abraded fines during the test. To provide for rotation, the drum is mounted on stub axles about 37.5 mm [$1\frac{1}{2}$ in.] in diameter by means of flanges welded or bolted to the ends of the drum providing smooth inner surfaces. It is desirable that the apparatus be fitted with a revolution counter and preferably be equipped with an automatic device to stop the drum after the

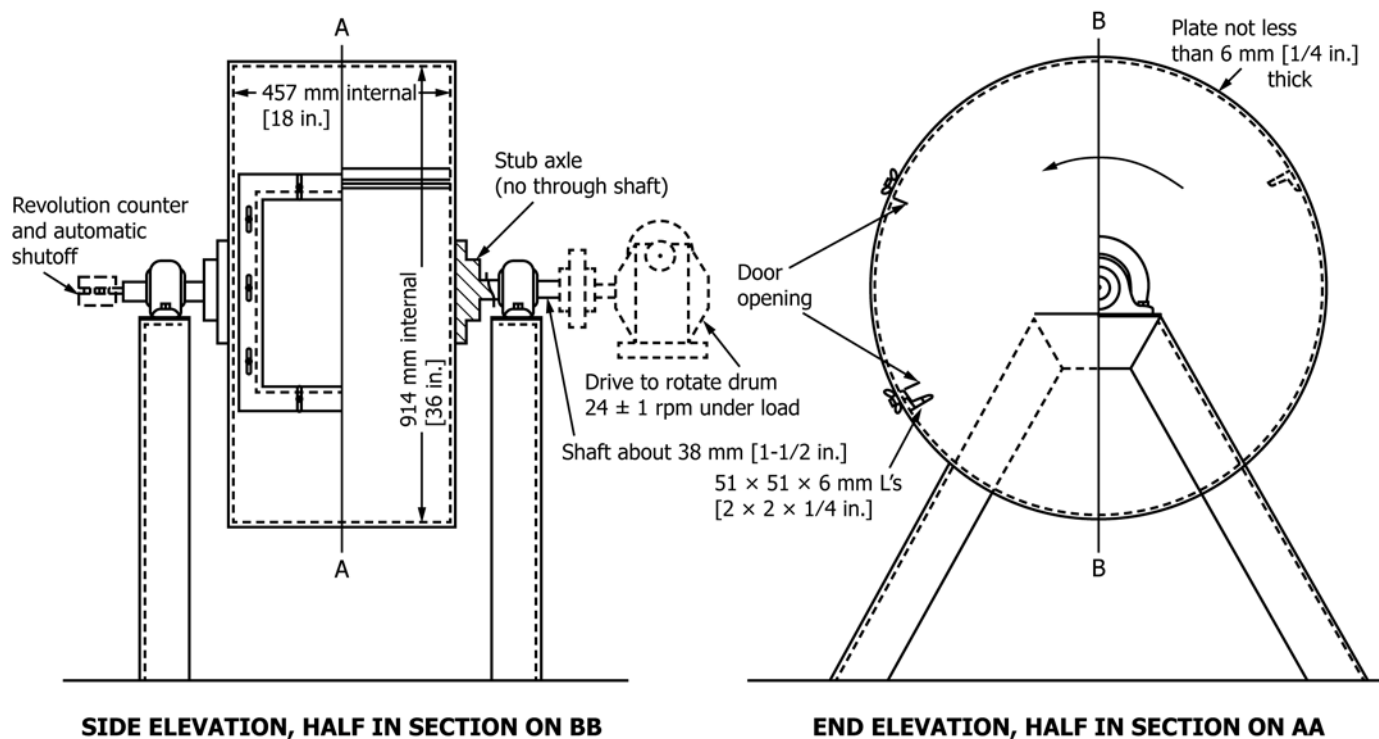


FIG. 1 Tumbler Test Apparatus

specified number of revolutions (1400). The tumbler drum must be replaced when the wear reduced the thickness to 3 mm [$\frac{1}{8}$ in.] in any area. The lift angles must be replaced when they wear to less than 48 mm [$1\frac{7}{8}$ in.].

5.2 *Sieves*, for sieving the coke before and after the tumbler test. Square-mesh sieves having 75 mm [3 in.], 63 mm [$2\frac{1}{2}$ in.], 50 mm [2 in.], 37.5 mm [$1\frac{1}{2}$ in.], 25 mm [1 in.], and 63 mm [$\frac{1}{4}$ in.] actual openings between the wires to be used. The sieves shall conform to Specification E11.

NOTE 1—User's attention is called to the fact that yields of certain sizes that determine the stability and hardness factors of 75 by 50 mm [3 by 2 in.] coke cannot be compared directly with results obtained by using sieves as specified prior to the 1950 revision of Method D294 (predecessor of D3402/D3402M). The stability factor (percent remaining on 25 mm [1 in.] sieve after tumbling) will be slightly higher than comparable previous results using the formerly specified 26.5 mm [1.06 in.] sieve.

5.3 *Weighing Scale*, capable of weighing 11 kg [25 lb], sensitive to 0.025 kg [0.05 lb].

6. Sampling

6.1 The gross sample of coke shall be collected in accordance with Practice D346/D346M.

6.2 For the standard procedure, the quantity must be sufficient to obtain approximately 34 kg [75 lb] of coke passing a 75 mm [3 in.] and retained on a 50 mm [2 in.] square-mesh sieve.

6.3 For the alternative procedure sample, the quantity must be sufficient to obtain approximately 17 kg [38 lb] of coke passing a 63 mm [$2\frac{1}{2}$ in.] and retained on a 25 mm [1 in.] square-mesh sieve and 17 kg [38 lb] of coke passing a 50 mm [2 in.] and retained on a 37.5 mm [$1\frac{1}{2}$ in.] square-mesh sieve.

7. Preparation of Sample

7.1 Size the standard procedure sample on 75 mm [3 in.] and 50 mm [2 in.] square-mesh sieves, without crushing the larger pieces, in order to obtain a sample that will pass the 75 mm [3 in.] sieve and be retained on the 50 mm [2 in.] sieve. In sizing the sample, hand place to determine whether in any position a piece of coke passes the sieve. If it is necessary to crush large coke (+75 mm or [+3 in.]) in order to obtain sufficient coke for testing it so note in the report. Dry the coke to less than 1 % moisture.

7.2 Size the alternate procedure sample by the same procedure as described in 7.1 but obtain two fractions, 63 by 50 mm [$2\frac{1}{2}$ by 2 in.] and 50 by 37.5 mm [2 by $1\frac{1}{2}$ in.].

8. Procedure

8.1 Accurately weigh to the nearest 0.025 kg [0.05 lb], 10 ± 0.25 kg [22 ± 0.5 lb] of the dried coke sample that has been sized in accordance with 7.1 or 5 ± 0.25 kg [11 ± 0.5 lb] of each of the sizes prepared in 7.2. Place the weighed sample in the drum of the tumbler machine. Rigidly fasten the cover and rotate the drum at 24 ± 1 rpm under load for a total of 1400 revolutions.

8.2 Remove all of the coke from the drum and sieve it using a 25 mm [1 in.] square-mesh sieve and a 6.3 mm [$\frac{1}{4}$ in.] square-mesh sieve. Shake the coke vigorously on the sieve in order to up-end the pieces until practically no more coke will pass through the openings (Note 2). Weigh the coke remaining on each of the sieves and the coke that passes through the 6.3 mm sieve.

TABLE 1 Limits for Repeatability (r) and Reproducibility (R) for the Hardness and Stability Factors of Coke using the Standard Preparation Procedure (75 by 50 mm Size Coke)
Units = mass fraction, %

Parameter	Range	Repeatability Limit (r)	Reproducibility Limit (R)
Hardness Factor	43.6 to 70.5	1.7	3.4
Stability Factor	43.4 to 65.0	2.2	4.5

NOTE 2—Mechanical sieving may be used providing it has been established that the method gives the same results as hand sieving.

8.3 If the loss in weight in any one test exceeds 0.07 kg [0.15 lb], reject that test.

9. Number of Tests

9.1 Conduct at least two tests on each coke sample.

9.2 If the difference in stability factor or hardness factor between two tests for a sample exceed the repeatability limits listed in the Precision and Bias Statement, make at least one additional test and report the mean value of all test results.

10. Calculations

10.1 Calculate the stability factor to the nearest 0.1 % the percentage of coke remaining on the 25 mm [1 in.] sieve for each test as follows:

$$\text{Stability Factor, \%} = W_2/W_1 \times 100 \quad (1)$$

where:

W_1 = total weight of coke loaded to the tumbler apparatus as described in 8.1.

W_2 = weight of coke retained on 25 mm [1 in.] sieve after tumbling as described in 8.2.

10.2 Calculate hardness factor to the nearest 0.1 % the cumulative percentage of coke remaining on the 6.3 mm [$\frac{1}{4}$ in.] sieve for each test as follows:

$$\text{Hardness Factor, \%} = W_3/W_1 \times 100 \quad (2)$$

where:

W_1 = total weight of coke loaded to the tumbler apparatus as described in 8.1.

W_3 = cumulative weight of coke retained on 6.3 mm [$\frac{1}{4}$ in.] sieve after tumbling as described in 8.2.

11. Report

11.1 Report the average results for the stability factor and the hardness factor.

11.2 Specify which procedure (standard or alternative) was used to determine the stability and hardness factors.

12. Precision and Bias⁴

12.1 *Precision*—The relative precision of this test method for test results of the hardness and stability factors of coke following the standard preparation procedure (75 by 50 mm size coke) is shown in Table 1. The precision characterized by the repeatability (S_r , r) and reproducibility (S_R , R) are described in Tables A1.1 and A1.2.

12.1.1 *Repeatability Limit (r)*—The value, below which the absolute difference between two single tests, carried out in the same laboratory by the same operator using the same apparatus on samples taken at random from a single quantity of 75 by 50 mm size coke, may be expected to occur with a probability of approximately 95 %.

12.1.2 *Reproducibility Limit (R)*—The value, below which the absolute difference between two reported test results carried out in different laboratories on samples taken at random from a single quantity of 75 by 50 mm size coke, may be expected to occur with a probability of approximately 95 %.

12.2 *Bias*—The lack of a reference material precludes a bias statement.

12.3 The information in Table 1 and Tables A1.1 and A1.2 was calculated using data from a commercially available inter-laboratory proficiency test program.

13. Keywords

13.1 abrasion; coke; degradation; hardness; impact stability; tumbler

⁴ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D05-1047.



ANNEX

(Mandatory Information)

A1. PRECISION EXAMPLE

A1.1 The precision of this test method, characterized by repeatability (S_r , r) and reproducibility (S_R , R) has been determined for the following coke samples as listed in **Tables A1.1 and A1.2**.

A1.2 Example: Repeatability

A1.2.1 Two single tests for coke stability factor within the same laboratory under repeatability conditions gave values of 63.4 % and 62.7 %. The repeatability interval $I(r)$ is 2.2 %. The difference between the two values is 0.7 % and does not exceed the $I(r)$ of 2.2 %. Therefore, these two values are acceptable at the 95 % confidence level and their average should be reported.

A1.3 Example: Reproducibility

A1.3.1 One laboratory reported a coke stability factor of 65.2 % and a different laboratory reported 59.5 %. The reproducibility interval $I(R)$ is 4.5 % and the difference between the two values is 5.7 %. Since this difference is greater than the $I(r)$ of 4.5 % these two values are not acceptable at the 95 % confidence level. Therefore, each of the laboratories should obtain an additional test result for comparison.⁵

⁵ ISO 5725-6: 1994 Accuracy of measurement methods and results – Part 6: Use in practice of accuracy values.

TABLE A1.1 Repeatability (S_r , r) and Reproducibility (S_R , R) Parameters used for Calculation of Precision Statement for Coke Hardness Factor using the Standard Preparation Procedure (75 by 50 mm Size Coke)
Units = mass fraction, %

Material	Average	S_r	S_R	r	R
TT0005	69.7	0.58	1.23	1.63	3.46
TT0006	68.4	0.33	1.13	0.92	3.15
TT0007	67.2	0.59	2.70	1.65	7.55
TT0008	68.2	0.47	0.96	1.31	2.69
TT0009	68.0	0.29	1.05	0.82	2.94
TT0010	68.5	0.71	0.71	1.99	1.99
TT0011	68.2	0.58	1.10	1.62	3.08
TT0012	68.6	0.48	0.77	1.34	2.17
TT0013	68.4	1.30	1.72	3.63	4.80
TT0014	69.6	0.62	1.04	1.73	2.91
TT0015	43.6	0.31	1.17	0.86	3.28
TT0016	69.3	0.64	0.89	1.80	2.50
TT0017	69.3	0.63	1.50	1.75	4.20
TT0018	69.4	0.59	1.11	1.66	3.11
TT0019	69.0	0.44	1.37	1.23	3.85
TT0020	68.7	0.52	1.13	1.45	3.17
TT0021	67.1	0.80	0.96	2.25	2.68
TT0022	70.5	0.97	1.54	2.72	4.32
TT0023	69.0	0.68	0.84	1.91	2.34
TT0024	68.8	0.44	0.89	1.23	2.50
TT0025	69.7	0.58	0.79	1.62	2.21
TT0026	70.0	0.60	0.94	1.68	2.64
TT0027	69.0	0.52	1.45	1.46	4.07
TT0028	68.9	0.69	1.46	1.94	4.09
TT0029	69.9	0.42	0.85	1.18	2.37
TT0030	69.4	0.69	1.09	1.94	3.04
TT0031	67.7	0.45	1.16	1.26	3.25
TT0032	67.4	0.76	1.25	2.13	3.50
TT0033	68.1	0.53	0.95	1.49	2.65
TT0034	68.5	0.52	1.65	1.47	4.63
TT0035	66.8	0.51	1.22	1.42	3.41
TT0036	69.1	0.60	0.72	1.68	2.03

TABLE A1.2 Repeatability (S_r , r) and Reproducibility (S_R , R) Parameters used for Calculation of Precision Statement for Coke Hardness Factor using the Standard Preparation Procedure (75 by 50 mm Size Coke)
Units = mass fraction, %

Material	Average	S_r	S_R	r	R
TT0005	61.7	1.1	1.4	3.06	3.81
TT0006	63.4	0.6	1.5	1.69	4.17
TT0007	61.6	0.8	1.3	2.36	3.69
TT0008	61.8	1.0	1.4	2.71	4.01
TT0009	63.5	1.3	1.6	3.53	4.40
TT0010	62.9	0.6	1.5	1.57	4.34
TT0011	63.9	1.1	1.4	2.97	3.96
TT0012	64.3	0.6	1.8	1.80	5.17
TT0013	59.1	0.8	1.7	2.16	4.89
TT0014	63.8	0.5	1.4	1.42	3.93
TT0015	43.4	0.6	2.4	1.75	6.64
TT0016	64.0	0.7	1.4	1.98	3.99
TT0017	63.1	0.6	1.4	1.71	4.02
TT0018	64.7	0.9	1.2	2.65	3.43
TT0019	62.6	0.5	1.2	1.54	3.39
TT0020	62.8	0.7	1.8	1.96	4.99
TT0021	61.6	1.1	1.9	3.13	5.26
TT0022	64.9	0.6	2.1	1.67	5.87
TT0023	59.9	1.0	1.4	2.81	3.79
TT0024	62.9	0.7	1.5	2.09	4.25
TT0025	62.9	0.6	1.2	1.70	3.34
TT0026	65.0	0.8	1.4	2.27	3.92
TT0027	63.2	0.8	1.6	2.19	4.57
TT0028	63.1	0.7	1.9	1.83	5.37
TT0029	62.4	0.8	1.4	2.28	3.80
TT0030	57.6	1.1	1.7	3.05	4.65
TT0031	61.6	0.4	1.4	1.16	3.99
TT0032	61.8	0.9	1.3	2.63	3.63
TT0033	63.0	0.6	1.9	1.58	5.34
TT0034	63.9	0.8	2.2	2.10	6.14
TT0035	61.8	0.7	1.3	1.95	3.53
TT0036	57.9	0.5	1.9	1.32	5.28

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