



Standard Test Method of Drop Shatter Test for Coal¹

This standard is issued under the fixed designation D 440; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method of drop shatter test² covers the determination of the relative size stability and its complement, the friability, of sized coal. It affords a means of indicating the ability of coal to withstand breakage when subjected to handling at the mine and during transit to the consumer. The test method is serviceable for ascertaining the similarity of coals in respect to size stability and friability rather than for determining values within narrow limits in order to emphasize their dissimilarity. This test method is considered applicable for testing a selected single size of different coals, for testing different single sizes of the same coal, and for mixed sizes of the same or different coals.

NOTE 1—By single sizes is meant those with fixed upper and lower sieve opening limits, selected from those designated in 4.2; and by mixed sizes is meant either “slack” or a mixture of two or more single sizes.

1.2 This test method appears best suited for measuring the relative resistance to breakage of the larger sizes of coal when handled in thin layers such as from loader to mine car, from loading boom to railroad car, from shovel to chute, etc. While it may not be so well adapted for measuring the liability to breakage of coal when handled in mass, as in unloading open-bottom cars, emptying bins, etc., it is believed that the test method will serve also to indicate the relative size stability of composite sizes of coal where, in commercial handling, the smaller sized pieces have a cushioning effect which tends to lessen the breakage of the larger pieces of coal.

1.3 The values stated in inch-pound units shall be regarded as the standard. Mass may be expressed in metric values.

1.4 *This standard does not purport to address all of the safety concerns, 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:

D 410 Method of Sieve Analysis of Coal³

D 3038 Test Method for Drop Shatter Test for Coke⁴

E 11 Specification for Wire-Cloth Sieves for Testing Purposes⁵

E 323 Specification for Perforated-Plate Sieves for Testing Purposes⁵

3. Significance and Use

3.1 The values determined in this test method, when evaluated in terms of pertinent experience with other coals, may be used as indications of the extent to which coal will break in conventional transit and handling beyond the point of sampling.

4. Apparatus

4.1 *Shatter Test Machine*, which is the same as that described and illustrated in Test Method D 3038, shall consist of a box 18 in. (457 mm) in width, 28 in. (711 mm) in length, and approximately 15 in. (381 mm) in depth, supported above a rigidly mounted cast iron or steel plate not less than ½ in. (12.7 mm) in thickness, 38 in. (965 mm) in width, and 48 in. (1219 mm) in length. The inside of the bottom of the box shall be 6 ft (1.83 m) above the plate. The bottom of the box shall consist of two doors hinged lengthwise and latched so that they will swing open freely and not impede the fall of the coal. Boards about 8 in. (200 mm) in height should be placed around the plate so that no coal is lost. To prevent the breakage of coal, which may occur while placing the sample into the box, the box shall be constructed so that it can be lowered to a

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² For information concerning the development and utilization of this drop shatter test method for coal the following references may be consulted:

Smith, C. M., “An Investigation of the Friability of Different Coals,” University of Illinois, Engineering Experiment Station, *Bulletin No. 196* UIBBA (1929); “The Friability of Illinois Coals,” University of Illinois, Engineering Experiment Station, *Bulletin No. 218* UIBBA (1930).

Yancey, H. F., and Zane, R. E., “Comparison of Methods for Determining the Friability of Coal,” U.S. Bureau of Mines, *Report of Investigations 3215* (1933).

Gilmore, R. E., Nicolls, J. H., and Connell, G. P., “Coal Friability Tests,” Canadian Department of Mines, Mines Branch, *No. 762* (1935).

³ Discontinued; see 1988 *Annual Book of ASTM Standards*, Vol 05.05.

⁴ *Annual Book of ASTM Standards*, Vol 05.06.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

convenient level; this is best done by means of a pulley and counterweight. A convenient form of shatter test machine is shown in Fig. 1.

4.2 *Sieves*—Round-hole sieves selected from the following sizes, 8, 6, 4, 3, 2, 1½, 1, ¾, ½, ¼, and ⅛ in., shall be used. These sieves shall conform to Specification E 11 or Specification E 323. Frames for the sieves may be of either hardwood or metal, and may be square, rectangular, or circular. A nest comprising all the sieves in the series, with 2-ft (610-mm) square plates, that is, of 4-ft² (0.37-m²) area, is recommended, although plates with areas of 6 to 9 ft² (0.56 to 0.84 m²), are suitable.

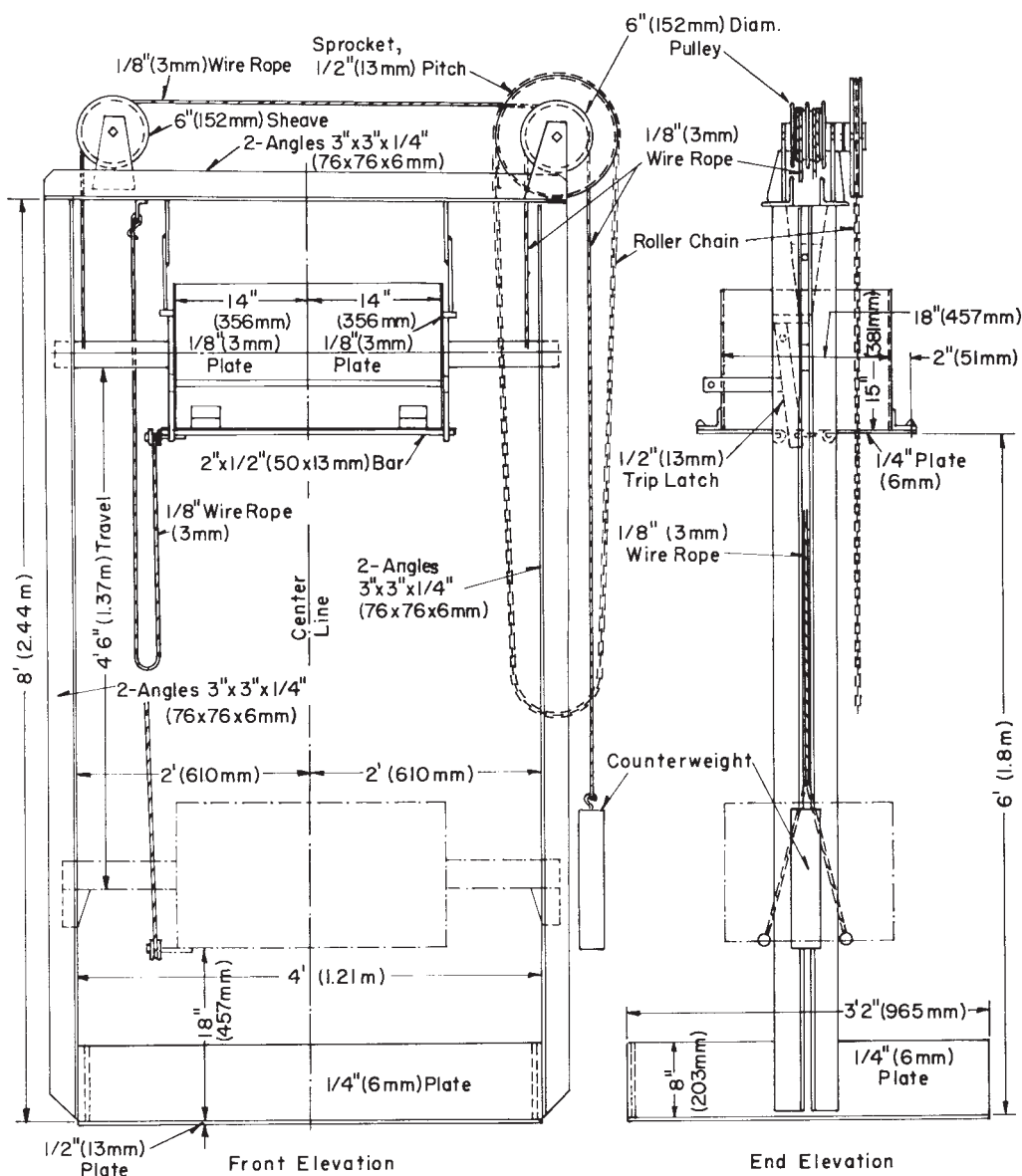
5. Samples

5.1 *Collection of Gross Sample*—Collect the gross sample in accordance with Sections 5 thru 7 of Method D 410. In order

that the entire quantity of the coal sampled will be represented proportionately in the gross sample, collect increments regularly and systematically. When testing coal as mined, take the sample at the mine before it is subjected to screening and to loading into cars at the tippie. When testing coals subsequent to mining, the sample may be taken at any stage in the transportation from the mine to the place at which it is to be used. For the correct interpretation of the shatter test results, note the elapsed time since mining as well as a record of the handling and storage of the coal.

5.2 Preparation of Laboratory Sample:

5.2.1 Using the sieves designated in 4.2, make a preliminary sieving of a representative portion or all of the gross sample and retain the sieved sizes separately. Sieve successive representative portions of the gross sample to obtain at least 200 lb (90 kg) of the single size selected for test. While the size or



NOTE 1—1 in. = 25.4 mm

FIG. 1 Shatter Test Machine

sizes to be selected for test are optional in this method, one or more of the sizes larger than 2 to 3 in. (50 to 75 mm) are suggested with preference for the 4 to 6-in. (100 to 150-mm) size (Note 2). In cases where difficulty is experienced in sieving this quantity, the amount obtained by the preliminary sieving may be augmented from larger pieces by dropping them in the shatter test apparatus. This procedure for obtaining from larger pieces an adequate quantity of a particular size selected for test is especially applicable to freshly mined coal.

NOTE 2—In the 1937 edition of this test method, the 2 to 3-in. (50 to 75-mm) single size was recommended as standard for testing.

5.2.2 Thoroughly mix the total quantity of the single size selected for test obtained as described in 5.2.1 and then resieve it to pass the upper limiting sieve opening and to be retained on the lower. Place only a thin layer of coal on the sieve so as to allow the pieces to be in direct contact with the sieve openings. Try individual pieces of coal not passing readily through either of the screens by hand to determine whether they will pass through the openings in any position without forcing.

5.2.3 For slack coals and mixed sizes, carefully prepare the sample either by the process of quartering or by reassembling the different sizes in the proportion obtained in the preliminary sieving of the lot of coal to be tested. For slack coals in which the largest pieces will not be retained on a sieve with $\frac{3}{4}$ -in. (19-mm) openings, quartering is satisfactory; while for larger sized slack coals and for blends of two or more single sizes, the reassembling method is recommended. Before dropping, sieve the samples prepared by quartering on the same set of sieves selected for the dropped coal.

6. Procedure

6.1 Give a 50-lb (23-kg) portion of the coal sample, prepared in accordance with Section 5, two drops. Place the coal into the box of the shatter test machine, level it, and then drop it a distance of 6 ft (1.8 m) onto the plate. Carefully return all the coal on the plate to the box and again drop it. After the second drop, separate the material into sized portions using the

sieves specified in 4.2. In sieving, care shall be taken to prevent further breakage of the coal. The sieving shall be carried out in such small increments as to permit satisfactory contact between the individual pieces of coal and the sieve. On the larger sieves, down to and including the sieve with 1-in. (25.0-mm) openings individual pieces of coal not readily passing through the sieves shall be tried by hand to determine whether they will pass through the openings in any position without forcing. When using the sieves with $\frac{3}{4}$ -in. (19.0-mm) openings and smaller, the coal shall come into intimate contact with the sieve either by shaking or rolling by hand without upending the individual pieces.

6.2 Weigh the coal remaining on each sieve, and that which passes through the bottom sieve either separately or in a cumulative manner on a scale sensitive to $\frac{1}{4}$ lb (100 g) or less. By the cumulative method, weigh the largest pieces into a tared container and add each successive smaller size to this. Weigh the total amount after each addition.

6.2.1 If the final net weight so obtained shows a loss of over 1 %, reject the test and make another. In each case where the loss is less than 1%, it shall be considered as material passing the $\frac{1}{2}$ in. (12.5 mm) or other bottom sieve used, and shall be included with this size.

6.2.2 Make at least two tests to obtain size stability results agreeing within 2 %. When three or more tests are considered advisable and are made, all the results within a maximum to minimum limit of 3 % may be averaged.

7. Calculation

7.1 Determine the weight percents of the material prior to and again after the test. Calculate to the nearest 0.1 % (See 6.2.1 for rejection criteria and the method for handling material loss).

7.2 Multiply the appropriate weight percents by their respective average sieve size openings (See Table 1).

7.2.1 The sum of these products before testing is designated as *S*. The sum of these products after testing is designated as *s*.

TABLE 1 General Form for Reporting Data and Calculations

Round-Hole Sieves, in. (mm)		Weight, %		Average of Sieve Openings, in.	Product of Weight Percentage and of Avg. Sieve Openings	
Retained on	Passing	Before Test	After Test		Before Test	After Test
8 (...)						
6 (...)	8 (...)	...	...	7.000	...	...
4 (100)	6 (...)	...	...	5.000	...	...
3 (75)	4 (100)	...	...	3.500	...	...
2 (50)	3 (75)	...	...	2.500	...	...
$1\frac{1}{2}$ (37.5)	2 (50)	...	...	1.750	...	...
1 (25.0)	$1\frac{1}{2}$ (37.5)	...	...	1.250	...	...
$\frac{3}{4}$ (19.0)	1 (25.0)	...	...	0.875	...	...
$\frac{1}{2}$ (12.5)	$\frac{3}{4}$ (19.0)	...	...	0.625	...	...
$\frac{1}{4}$ (6.3)	$\frac{1}{2}$ (12.5)	...	...	0.375	...	...
$\frac{1}{8}$ (3.35)	$\frac{1}{4}$ (6.3)	...	...	0.185	...	...
	$\frac{1}{8}$ (3.35)	...	...	0.060	...	...
Total passing $\frac{3}{8}$ (9.5)		...	...	0.185	...	...
Total passing $\frac{1}{4}$ (6.3)		...	...	0.125	...	...
					Total, <i>S</i>	Total, <i>s</i>
Average size of coal before and after test (two drops), in.					...	...
Size stability, % = $(100 \times s)/S$ =						
					(Friability, % = 100 – size stability)	

7.3 The size stability is calculated as a percent by dividing s by S and multiplying by 100 % (See Table 1). The friability is expressed as 100 % minus the size stability, that is, the size stability and the friability sum to 100 %.

7.3.1 Calculate the size stability and the friability to the nearest 0.5 %.

8. Report

8.1 Report the percentage weight sieve analysis to the nearest 0.1 %, and the percentage size stability to the nearest 0.5 % (See 6.2.2).

8.2 Numerical examples of tabulating the results and of calculating the size stability in percent and the friability in percent are shown in Table 1 and Table 2. The form shown in Table 1 is general and serviceable for both single and mixed sizes. The form in Table 2, in which the example shown is for

a 4 to 6-in. (100 to 150-mm) size, is serviceable for other single sizes. The sieve with 1/2-in. openings is suggested as the bottom sieve for testing single sizes, 2 to 3 in. (50 to 75 mm) and larger. For smaller single sizes, slack coals, and mixed sizes containing slack, two additional (bottom) sieves, with 1/4 and 1/8-in. (6.3 and 3.35-mm) openings, are recommended.

9. Precision and Bias

9.1 Data for repeatability and reproducibility do not exist but are being determined.

9.2 This is an empirical test method and no statement of bias is possible.

10. Keywords

10.1 breakage; coal; coal handling; drop shatter; friability; size stability

TABLE 2 Form and Example for Reporting Data and Calculations for a Selected Single Size

Round-Hole Sieves, in. (mm)		Weight Re- corded, lb (kg)	Weight, % (1)	Average of Sieve Openings		Product of (1) × (2)
Retained on	Passing			Inches	Normalizing Factor (2)	
SAMPLE						
4 (100)	6 (...)	50 (22.7)	100.0	5.000	1	100.00 = S
DROPPED COAL						
4 (100)	6 (...)	24¼ (11.0)	48.5	5.000	1	48.500
3 (75)	4 (100)	7½ (3.2)	15.0	3.500	0.7	10.500
2 (50)	3 (75)	6½ (2.9)	13.0	2.500	0.5	6.500
1½ (38.1)	2 (50)	3 (1.4)	6.0	1.750	0.35	2.100
1 (25.0)	1½	2½ (1.1)	5.0	1.250	0.25	1.250
¾ (19.0)	1 (25.0)	1½ (0.7)	3.0	0.875	0.175	0.525
½ (12.5)	¾ (19.0)	1½ (0.7)	3.0	0.625	0.125	0.375
	½ (12.5)	3¼ (1.5)	6.5	0.250	0.05	0.325
Total (Sum of products (1) × (2) for dropped coal)						70.075 = s
Size stability, % = (100 × s)/S = (100 × s)/100 = s = 70.1						
To be reported as: Size Stability, 70 %						
(Friability, % = 100 – 70 = 30)						

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