Designation: D4749 – 87 (Reapproved 2012)

Standard Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size[1]

This standard is issued under the fixed designation D4749; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers procedures for determining the sieve analysis of coal and designating the size of coal from sieve analysis data. Raw as well as prepared (crushed, cleaned or screened) coals can be tested by this test method.

1.2 This test method explains how to designate coal sizes from the results of sieve analysis data in order to represent the condition of the coal as sold. In the case of special mixtures or coals with noncontinuous ranges of sizes, a sufficiently complete sieve analysis must be made to properly describe the size distribution.

1.3 This test method is not applicable for determining the sieve analysis nor for designating the size of pulverized coal. (See Note 1.) Size fractions down to and including 38 µm (No. 400 U.S.A. Standard Series) can be treated by the methods discussed in this test method. Methods for handling size fractions below 38 µm (No. 400) will be developed by this committee.

NOTE 1—For powdered or pulverized coal as is fired into steam boilers, refer to Test Method D197.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

1.5 *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:*[2]

D197 Test Method for Sampling and Fineness Test of Pulverized Coal

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

D388 Classification of Coals by Rank

D2013 Practice for Preparing Coal Samples for Analysis

D2234/D2234M Practice for Collection of a Gross Sample of Coal

D3302 Test Method for Total Moisture in Coal

D4371 Test Method for Determining the Washability Characteristics of Coal

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E323 Specification for Perforated-Plate Sieves for Testing Purposes

2.2 *Other Document:*

Specification C-80 Commonwealth of Pennsylvania, Department of General Services, Bureau of Purchases, Specification for Coal:Anthracite[3]

3. Descriptions of Terms Specific to this Standard

3.1 *as-mined coal*—same as ROM coal (3.8).

3.2 *as-shipped or produced coal*—raw or prepared coal in any state or condition at which it leaves the mine property or loading facility.

3.3 *bottomsize, nominal*—the sieve designating the lower limit or bottomsize shall be that sieve of the series given in Section 6 with the largest openings through which passes a total of less than 15 % of the sample. This defined bottomsize is not to be confused with the size of the smallest particles in the lot. (**Warning—**In the case of a commercial, double-screened product, for example, 37.5 by 9.5 mm (1½ by ⅜ in.),

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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] Available from Commonwealth of Pennsylvania, Dept. of General Services, Bureau of Purchases, 414 N. Office Building, Harrisburg, PA 17125.

this designation may *not* be valid. In such commercial or contractual situations, the amount of allowable material smaller than the bottomsize (for example, 9.5 mm) must be specified by the contract under which the coal is bought and sold.)

3.4 *dry sieving*—for the purposes of this test method, the test method for the sieving of coal after the sample has been air-dried under prescribed conditions; this is generally used when testing with coal particles larger than 600 µm. (No. 30 U.S.A. Standard Sieve Series.)

3.5 *opening*—for the purpose of this test method, openings and apertures shall be regarded as synonomous terms. Dimensions for round and square openings shall be determined as follows: for round holes, dimensions shall refer to the opening diameter; for square holes, dimensions shall refer to the distance between parallel wires.

3.6 *prepared coal*—any coal, regardless of its topsize, that has been manually or mechanically cleaned. This includes coal that has been processed over a picking table or air tables, through a breaker, jig, or other device which segregates according to size or density (specific gravity).

3.7 *raw coal*—any coal, regardless of its topsize, that has not been manually or mechanically cleaned. Crushed coal that has not been mechanically cleaned (including coal that has not been through a breaker which normally rejects oversize) is considered to be raw coal. Coal delivered to the surface from an underground mine is considered to be raw coal even when crushing and grinding is done underground. Coal removed from the pit of a surface mine is considered to be raw coal even when breaking and crushing facilities are provided *in the pit*.

3.8 *run-of-mine (ROM) coal*—in the case of an underground mine, it is that coal delivered to the surface by a slope belt, hoist, etc. In the case of a surface mine, it is that coal as it exists after it has been removed from the pit and placed into the initial means of transportation whether it be an on-the-road or off-the-road haul truck, dump hopper which feeds a pit-to-plant conveyor, etc. For both underground and surface mines, ROM coal is as-mined and has not been exposed to any treatment such as breaking, crushing, or cleaning except for that done by the normal operations used to extract the coal from the ground, that is, blasting, ripping, loading, cutting, etc.

3.9 *topsize, nominal*—the sieve designating the upper limit or topsize shall be that sieve of the series given in Section 6 with the smallest openings upon which is cumulatively retained a total of less than 5 % of the sample. This defined topsize is not to be confused with the size of the largest particle in the lot.

3.10 *wet sieving*—for the purposes of this test method, the test method for the sieving of coal that uses water as a medium for facilitating the segregation of the sample into particle sizes; this is generally used when testing coal particles 600 µm (No. 30 U.S.A. Standard Series) or smaller.

4. Significance and Use

4.1 This test method concerns the sieving of coal into designated size fractions for the purpose of characterizing the material as to its particle size distribution for further processing or for commercial purposes. This is covered in Part A of this standard. Raw, as well as prepared (crushed, cleaned, or screened), coals can be tested by this test method.

4.2 This test method is applicable for all types of coals, except for pulverized coals (see Method D197) such as fed into steam boilers. Low rank coals, that is, lignites, subbituminous, and high volatile bituminous C, must be dried with caution and handled with care to minimize deterioration or size degradation during sieving.

4.3 This test method is applicable for the wet or dry-sieving of coal at sizes from 200 mm (8 in.) to 38 µm (No. 400 U.S.A. Standard). Methods for sizing materials below 38 µm are outside the scope of this test method.

NOTE 2—The sizing of material that passes the 38 µm sieve is normally performed by optical microscopy, sedimentation, centrifugation, light scattering or obfuscation, surface area measurement, or other such methods. Subsieve techniques are also used sometimes.

4.4 This test method also concerns the designation of a coal sample as to its upper (nominal top-size) and lower (nominal bottom-size) limiting sizes for the purpose of characterizing the material for further processing or for commercial purposes. This is covered in Part B of this test method. Anthracite coal is further designated by a one word descriptive term (see 14.4).

4.5 Enough material may not be collected by this test method to meet subsequent test procedures, such as washability analyses (Test Method D4371).

PART A. SIEVE ANALYSIS OF COAL

5. Apparatus

5.1 *Sieves:*

5.1.1 *Wire Cloth Sieves:*

5.1.1.1 Standard test sieves that conform to Specification E11 shall always be used.

5.1.1.2 For most sieve tests, where the largest particle in the sample does not exceed 25 mm (1 in.), standard 203-mm (8-in.) diameter, 50-mm (2-in.) deep sieves or sieves with larger diameters (for example 300 mm (12 in.) or 450 mm (18 in.)) are recommended. For special cases, and with small samples, 75-mm (3-in.) and 150-mm (6-in.) diameter sieves are available.

5.1.1.3 Standard test sieves shall be made from either brass or stainless steel frames and either brass, phosphor bronze, or stainless steel cloth.

5.1.1.4 In general, these square mesh sieves are used when sizing with sieves with openings smaller than 6.3 mm (¼ in.). U.S.A. Standard Sieve Designations shall be used.

5.1.1.5 For more complete details of standard test sieves, including methods of checking and calibrating the sieves, see Specification E11.

5.1.2 *Perforated Plate Sieves:*

5.1.2.1 Perforated plate sieves, made to conform to Specification E323, are available with square apertures from 125 mm (5 in.) to 3.36 mm (0.132 in.) and with staggered round apertures from 125 mm (5 in.) to 1 mm (0.038 in.). The sizes of successive apertures in the series follow the same ratio as in Specification E11 for sieves.

5.1.2.2 Standard frames for perforated plate sieves with apertures 4.00 mm and larger are made of hardwood or steel to hold 300-mm (12-in.), 400-mm (16-in.), or 450-mm (18-in.) square sieve plates. For apertures smaller than 4.00 mm, 203-mm (8-in.) circular frames as well as the above larger square frames may be used.

5.1.2.3 In general, round hole sieves with staggered openings are used when sizing with sieves with opening diameters of 6.3 mm (¼ in.) or larger.

5.1.2.4 Where perforated sieves and wire cloth sieves are used in the same test (for example, in an analysis from 125 mm (5 in.) to 250 µm (No. 60)) or where results with perforated sieves are to be compared with results with wire cloth sieves, it is better to use only square aperture sieves.

NOTE 3—This action should be taken primarily while performing sieving analyses on noncommercial samples, as, for instance, in preparation plant component studies (see 6.5.1). In commerce, mixed series are still customary (see 6.1.1 and 6.3.1).

5.1.2.5 Results with a given square aperture and with the same diameter round aperture are not compatible. Therefore, all reports of sieve analysis data are incomplete without designation as to the type of sieves employed (round or square openings).

5.1.2.6 Aperture sizes of some sieves for anthracitic coal (6.3.2.1) do not conform to Specification E323.

5.2 *Mechanical Sieve Shaker:*

5.2.1 Mechanical sieve shakers are used in practically all laboratories where frequent tests are made. They not only eliminate tedious hand labor, but, when properly used, will produce more consistent results than hand sieving. They can, however, result in excessive sample degradation when proper precautions are not taken. Therefore it is important to establish and to monitor the sieving amplitude and the sieving time.

5.2.2 There are several general types of mechanical sieve shakers. One type is designed to simulate hand sieving by using a circular motion combined with a tapping action. This type of mechanical sieve shaker is acceptable.

5.2.3 A type of sieve shaker which will handle a stack of either round or rectangularly framed sieves and produces a vigorous agitation is especially suitable for handling large samples of coarse material. This type of mechanical sieve shaker is acceptable for handling large samples provided it is not overloaded and provided agitation time is limited so that degradation of the coal being sieved does not occur (see 11.3.5).

NOTE 4—Some manufacturers can supply machines with reduced amplitude of vibration or variable speeds, or both, for soft materials.

5.2.4 Mechanical sieve shakers can generally be classified into two types: batch (acceptable) and continuous (unacceptable).

5.2.4.1 *Batch*—Batch mechanical sieve shakers are those in which a controlled quantity of coal is placed into the apparatus and mechanical action is initiated. After a controlled time period, mechanical action is completed and the size fractions are removed from the horizontal sieves. These types of mechanical sieve shakers are acceptable.

5.2.4.2 *Continuous*—Continuous mechanical sieve shakers are unacceptable for the purpose of this test method. Continuous mechanical sieve shakers are those in which a continuous stream of coal is fed into the apparatus and over a set of inclined sieves. The retention time on these sieves depends upon the degree of inclination, the throw of the sieves, and the frequency of mechanical action. The various size fractions are collected in individual containers in a continuous stream.

6. Standard Series of Sieves

6.1 *Crushed Bituminous, Subbituminous, and Lignitic Coals:*

6.1.1 For crushed bituminous, subbituminous, and lignitic coals, the standard series of sieves shall utilize round-hole perforated plate sieves for sieves with opening diameters of 6.3 mm (¼ in.) or larger and wire-cloth (U.S.A. Standard) sieves with square openings for sieves with openings smaller than 6.3 mm (¼ in.).

6.1.2 For the purpose of simplifying communication between concerned parties, the following series of sieves shall be considered as the standard series for crushed bituminous, subbituminous and lignitic coals:

Round Hole Perforated Plate Sieves

200 mm (8 in.)	37.5 mm (1½ in.)
150 mm (6 in.)	31.5 mm (1¼ in.)
125 mm (5 in.)	25.0 mm (1 in.)
100 mm (4 in.)	19.0 mm (¾ in.)
75 mm (3 in.)	12.5 mm (½ in.)
63 mm (2½ in.)	9.5 mm (⅜ in.)
50 mm (2 in.)	6.3 mm (¼ in.)

Wire Cloth (U.S.A. Standard) Sieves with Square Openings

4.75 mm (No. 4)	300 µm (No. 50)
2.36 mm (No. 8)	150 µm (No. 100)
1.18 mm (No. 16)	75 µm (No. 200)
600 µm (No. 30)	38 µm (No. 400)

6.1.3 For crushed bituminous, subbituminous, and lignitic coals, an alternate standard series of sieves can utilize square-hole perforated plate or steel-wire sieves for sieves with openings of 6.3 mm (¼ in.) or larger and wire cloth (U.S.A. Standard) sieves for sieves with openings smaller than 6.3 mm (¼ in.). This alternate series shall use sieves with openings of the same dimensions as those given in 6.1.2. When this alternate series of square openings is used, the report must include this information.

6.1.3.1 Since round hole 6.3-mm (¼-in.) perforated plate sieves produce undersize of approximately the same amount as 4.75-mm (No. 4 U.S.A. Standard) wire cloth sieves, that is, these sieves are nearly equivalent, it is not necessary to utilize both 6.3-mm (¼ in. round) perforated plate and 4.75-mm (No. 4 U.S.A. Standard) wire cloth sieves simultaneously. The selection of either will be sufficient.

6.2 *Coal Used as Coke Oven Charge:*

6.2.1 For coal that will be used as a coke oven charge, the standard series of sieves shall utilize square-hole perforated plate or steel-wire sieves with openings of 6.3 mm (¼ in.) or larger and wire cloth (U.S.A. Standard) sieves for sieves with openings smaller than 6.3 mm (¼ in.).

6.2.1.1 Typical coke oven charge is 80 % minus 3.2 mm (⅛ in. round). For the purpose of identifying compliance

TABLE 1 Size Designation, Anthracitic Coal

Size	Size of Round-Hole Openings in Testing Sieves, mm (in.)	
	Passing	Retained On
Egg	83 (3¼)[A]	62 (2⁷⁄₁₆)
Stove	62 (2⁷⁄₁₆)	41 (1⅝)
Chestnut	41 (1⅝)	21 (¹³⁄₁₆)
Pea	21 (¹³⁄₁₆)	14 (⁹⁄₁₆)
Buckwheat #1	14 (⁹⁄₁₆)	8 (⁵⁄₁₆)[A]
Buckwheat #2 (Rice)	8 (⁵⁄₁₆)[A]	4.8 (³⁄₁₆)[A]
Buckwheat #3 (Barley)	4.8 (³⁄₁₆)[A]	2.4 (³⁄₃₂)
Buckwheat #4	2.4 (³⁄₃₂)	1.2 (³⁄₆₄)

[A] Listed in Specification E323, Table 1.

TABLE 2 Comparison Table of U.S.A. Standard with Tyler Sieve Series

U.S.A. Standard Series		Tyler
Standard	Alternate	
5.60 mm	No. 3½	3½ mesh
4.75 mm	No. 4	4 mesh
4.00 mm	No. 5	5 mesh
3.35 mm	No. 6	6 mesh
2.80 mm	No. 7	7 mesh
2.36 mm	No. 8	8 mesh
2.00 mm	No. 10	9 mesh
1.70 mm	No. 12	10 mesh
1.40 mm	No. 14	12 mesh
1.18 mm	No. 16	14 mesh
1.00 mm	No. 18	16 mesh
850 µm	No. 20	20 mesh
710 µm	No. 25	24 mesh
600 µm	No. 30	28 mesh
500 µm	No. 35	32 mesh
425 µm	No. 40	35 mesh
355 µm	No. 45	42 mesh
300 µm	No. 50	48 mesh
250 µm	No. 60	60 mesh
212 µm	No. 70	65 mesh
180 µm	No. 80	80 mesh
150 µm	No. 100	100 mesh
125 µm	No. 120	115 mesh
106 µm	No. 140	150 mesh
90 µm	No. 170	170 mesh
75 µm	No. 200	200 mesh
63 µm	No. 230	250 mesh
53 µm	No. 270	270 mesh
45 µm	No. 325	325 mesh
38 µm	No. 400	400 mesh

with this criteria of 80 % passing ⅛ in. round, it should not be necessary to use sieves larger than 4.75 mm (No. 4 U.S.A. Standard). To designate the topsize of this charge according to Part B of this test method (Section 14), it may be necessary to use larger sieves. It is recommended that sieving be done initially at 4.75 mm (No. 4 U.S.A. Standard), then progressively sieve the oversize through the next larger sieve until the 5 % criteria of 4.8 is met.

6.2.2 For the purpose of simplifying communication between concerned parties, the following series of sieves shall be considered as the standard series for coal that will be used as a coke oven charge:

Square Hole Perforated Plate Sieves

50.0 mm (2 in.)
37.5 mm (1½ in.)
25.0 mm (1 in.)
19.0 mm (¾ in.)
12.5 mm (½ in.)
9.5 mm (⅜ in.)
6.3 mm (¼ in.)

6.2.2.1 Smaller sizes shall conform to specifications for wire-cloth sieves (U.S.A. Standard) with square openings, and are the same as those in 6.1.2.

6.3 *Anthracitic Coal:*

6.3.1 For anthracitic coal, the standard series of sieves shall utilize round-hole perforated plate sieves.

6.3.1.1 Sieve plates mounted in hardwood or steel box frames 40.6 to 50.8 cm (16 to 20 in.) square are satisfactory for testing chestnut, pea, and buckwheat sizes of anthracitic coal. For egg and stove sizes (see Table 1), it is more convenient to use sieves with frames that are square or rectangular in shape having an area of 0.37 to 0.56 m^2 (4 to 6 ft^2).

6.3.2 For the purpose of simplifying communication between concerned parties, the following series of sieves shall be considered as the standard series for anthracitic coal:

Round Hole Perforated Plate Sieves

83 mm (3¼ in.)
76 mm (3 in.)[A]
62 mm (2⁷⁄₁₆ in.)
41 mm (1⅝ in.)
21 mm (¹³⁄₁₆ in.)
14 mm (⁹⁄₁₆ in.)
8 mm (⁵⁄₁₆ in.)[A]
4.8 mm (³⁄₁₆ in.)[A]
2.4 mm (³⁄₃₂ in.)
1.2 mm (³⁄₆₄ in.)

[A] Listed in Specification E323.

6.3.2.1 These standard anthracitic coal sieve sizes are those specified by Commonwealth of Pennsylvania Specification C-80.

6.4 *Additional Sieves*—Additional sieves are required if a discontinuity(ies) or deviation(s), or both, from a normal gradation of sizes is (are) found. For sieves below 6.3 mm (¼ in.), additional wire-cloth sieves can be selected from Table 1 of Specification E11. For sieves above 6.3 mm (¼ in.), additional round or square hole perforated plate sieves may be selected from Table 1 of Specification E323.

6.5 *Other Shapes*—Other opening shapes can more fully characterize the coal (oval, rectangular, etc.). They shall only be used by agreement between the concerned parties.

6.5.1 The use of round hole sieves in plant sizing operations has been a common practice and much data has been established. However, newer plants, most coking operations, and mathematical treatment of comminution studies use the square hole sieves. For comparison purposes, round hole openings

may be calculated to an approximation of the square opening in accordance with the following formula:

$$\frac{\text{round opening, mm}}{1.25} = \text{square opening, mm} \quad (1)$$

6.5.1.1 Due to differences in particle shape peculiar to individual coal types, 1.25 is not always the best factor to use when converting between round hole and square hole openings. The normal range for this factor varies from 1.17 to 1.26. It is best to determine this conversion factor for any coal in question by determining the sieve analysis alternatively using first round and then square openings.

6.5.1.2 When specifying preparation plant components that utilize wire mesh, Tyler mesh designations are often used rather than U.S.A. Standard. Table 2 shows the comparison of Tyler mesh designations with the U.S.A. Standard designation based on the aperture sizes of each type. U.S.A. Standard Series designations shall always be used. Tyler mesh designations are also to be given where necessary for clarity.

6.6 Frames conforming to criteria in Specification E11 or Specification E323 shall be used with applicable sieves.

6.7 Suitable pans and covers as applicable to fit specific sieves shall be used as required by Specification E11 or Specification E323.

7. Gross Sample

7.1 Collect the gross sample in accordance with the principles of Practice D2234/D2234M.

NOTE 5—ASTM methods for collection of gross samples from stockpiles, cartops, etc. (stationary sampling) are being developed. When these methods are available, application of those standards will be required for stationary sampling.

7.2 Accurate sampling is of the greatest importance and is the basic requirement for reliable sieve analyses. Take great care to obtain samples that are representative of the batch or lot being tested. The greatest cause of inconsistencies in test results is improper sampling that does not represent the material being tested. Therefore, once a sampling procedure has been established, this same procedure is followed during subsequent sampling.

7.3 The quantity or mass of a gross sample will depend on the character of the material and the form in which it is available and also on whether the test is to determine the particle size distribution of a pile, batch, shipment, day's production, or a short span of time for production control. The range of quantity or mass of a gross sample can be as much as several thousand kilograms or it may be as little as a fraction of a kilogram.

7.4 Collect increments regularly and systematically, so that the entire quantity of coal sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount shall be collected. Collect not less than the number of increments specified in Table 2 of Practice D2234/D2234M.

7.5 When the coal is passing over a conveyor or through a chute, take increments which include the full width and thickness of the stream of coal, either by stopping the conveyor and removing all coal from a transverse section of it, or by momentarily inserting a suitable container into the stream and withdrawing the sample. When it is impracticable to collect increments the full width and thickness of the coal stream, collect the increments systematically from all portions of the stream.

7.6 The method of collection of the gross sample shall be such as to produce a minimum of degradation.

7.7 The probability of collecting representative portions (samples) for sieve analysis is less from the surface of coal in piles or from loaded cars or bins than from a moving stream of coal. Where possible, sample such that the full volume of coal in the lot being sampled is represented in the final sample.

8. Weight of Gross Sample

8.1 The weight of the gross sample collected shall conform to the general principles of Practice D2234/D2234M. Usually the minimum masses to be collected are those given in Table 3. For lots of coal greater than 10 000 tons, the interested parties shall agree on the method to be used for collection and division of the gross sample prior to sieve analysis. In such cases, the following information shall be included on the analysis report:

8.1.1 Total weight of lot sampled.

8.1.2 Number of sampling increments taken.

8.1.3 Total weight of sample taken. (**Warning—**Enough material may not be collected by this method to meet subsequent test procedures, such as determining the washability characteristics of coal (Test Method D4371). See the weight required by proposed subsequent test methods prior to sampling for the sieve analysis.)

9. Preparation and Division of Gross Sample into Test Sample for Sieving

9.1 When necessary for proper handling and division, air-dry the gross sample in accordance with Method D2013.

9.2 In order to divide the gross sample into test samples, do sample division in accordance with the procedures outlined in Method D2013 or Practice D2234/D2234M. **Warning—** Never reduce the topsize of a sample to be used for size analysis, that is, decreasing the quantity of a sample is allowed as long as the remaining portion is representative of the material sampled, but reduction in topsize is never allowed.

TABLE 3 Gross Sample Quantity to be Collected for Crushed Coals Other than Anthracitic Coal[A]

Type of Coal	Minimum Mass Required
Run-of-mine-coal	Not less than 1800 kg (4000 lb)
Screened coal with upper limit larger than 100 mm (4 in.) round	Not less than 1800 kg (4000 lb)
Coal smaller than 100 mm (4 in.) round	Not less than 900 kg (2000 lb)
Coal smaller than 50 mm (2 in.) round	Not less than 450 kg (1000 lb)
Coal smaller than 25 mm (1 in.) round	Not less than 215 kg (500 lb)
Coal smaller than 12.5 mm (½ in.) round	Not less than 45 kg (100 lb)
Coal smaller than 2.36 mm (No. 8 mesh, U.S.A. Standard)	Not less than 4.5 kg (10 lb)
Coal smaller than 600 µm (No. 30 mesh, U.S.A. Standard)	Not less than 0.5 kg (1 lb).

[A] For anthracitic coal, see 9.4.

9.3 Samples may be divided according to the following schedule:

9.3.1 *Coal Larger than 25 mm (1 in.) Round*—Sieve without mixing or dividing.

9.3.2 *Coal Smaller than 25 mm (1 in.) Round*—Divide in amount to not less than 56.6 kg (125 lb) by riffling or by arranging the sample in a long, flat pile and successively halving it or quartering it by the alternate-shovel method as follows: Starting at one end of the long pile, take successive shovelfuls from the long pile using a flat, straight-edged shovel (advancing a distance equal to the width of the shovel for each shovelful), and retain alternate shovelfuls or every fourth shovelful for the sample (see Plate 1 of Method D346).

9.3.3 *Coal Smaller than 12.5 mm (½ in.) Round*—Divide to not less than 11.4 kg (25 lb) by passing it through a riffle or equally accurate dividing device, or by the alternate-shovel method as described in 9.3.2.

9.3.4 *Coal Smaller than 4.75 mm (No. 4) Sieve*—Divide to not less than 1000 g (2 lb) by riffling.

9.3.5 *Coal Smaller than 2.36 mm (No. 8) Sieve*—Divide to not less than 500 g (1 lb) by riffling.

9.4 For anthracitic coal, the laboratory samples for sieving shall consist of the following approximate minimum amounts:

Sample Quantity: Anthracitic Coal

Size (see Table 1)	Laboratory Sample Approximate Minimum Mass, kg (lb)
pea	22.7 (50)
buckwheat #1	11.3 (25)
buckwheat #2 (rice)	4.5 (10)

9.4.1 For sizes larger than pea, use Table 3.

9.4.2 For sizes smaller than buckwheat # 2 (rice) use Table 3.

10. Sample Preparation

10.1 When the test sample is not dry and free flowing because of moisture, dry in accordance with Test Method D3302. The air drying apparatus shall conform to Test Method D3302. For air-drying ovens, drying temperatures shall be maintained at 10 to 15°C (18 to 27°F) above room temperature with a maximum temperature of 40°C (104°F), unless ambient temperature is above 40°C (104°F) in which case ambient temperature shall be used.

10.1.1 Sufficient dryness for bituminous coals has been found to be that point during the drying process when all apparent wetness is gone and when dust appears when representative portions of the coal are dropped from a height of 150 mm (about 6 in.).

10.1.2 Where the temperature in 10.1 might have some adverse effect on the material, dry and handle with caution samples of low rank coal (for example, lignite, subbituminous, and high volatile C bituminous) (see Classification D388) to prevent degradation during sieving. Normally, the criteria given in 10.1.1 for air drying of bituminous coals is also acceptable for subbituminous coals.

10.2 In general, sieve air-dried material; however when difficulty is encountered in obtaining reproducible results on materials difficult to sieve, particularly finer coal, and when the material is not physically altered in water, accurate sieving may be made by the wet method.

10.3 When necessary, do sample division in accordance with the procedures outlined in Method D2013 or Practice D2234/D2234M.

10.4 When subsequent testing or analysis, or both, is required, use careful judgement to ensure that sufficient material is present in all fractions.

11. Procedure

11.1 *General Considerations:*

11.1.1 Accurately weigh the test sample before sieving. Weigh with a precision equal to or better than 0.5 % of the fraction being weighed.

11.1.2 Start with the sieve having the largest required aperture (for an exception see 11.1.8).

11.1.3 Limit the portion of coal used for each sieving so that all coal particles will be in direct contact with the aperture at the completion of sieving on each successive sieve.

11.1.4 Sieve until all portions of the sample are used. Combine all separately sieved material representing a particular size-fraction but obtained from sieving separate portions of the same sample.

11.1.5 Whenever sieving through a series of sieves and the larger particles have been sieved from the test sample and the weight of the smaller sieve fraction(s) exceeds the weight for that fraction(s) as given in 9.3, it is permissible to divide the remaining portion of the test sample (the smaller sieve sizes) to not less than that weight given in 9.3 before sieving at the smaller sieve sizes.

11.1.6 Continue sieving with successive sieves having the desired size apertures until the sieve having the smallest desired size aperture is used.

11.1.7 Sieving can be done by grouping sieves having the desired size apertures, thus accomplishing the sieving in one operation known as nesting.

11.1.8 When utilizing smaller mesh sieves, especially when wet-sieving, use the smallest sieve first in order to remove clays and other extremely small materials that may blind and clog the larger mesh sieves, that is, when both 150 µm (No. 100) and 75 µm (No. 200) sieves are used, use the latter first in order to facilitate sieving. Additionally, where larger particles are present that can adversely affect the size of the sieve openings, use a cover sieve (protective sieve of a larger mesh) to keep coarse particles off the finer sieves.

11.1.9 Where possible, use sieve covers on sieve apparatus to limit dust and particle loss.

11.1.10 Weigh each size fraction of sieved coal with a precision equal to or better than 0.5 % of the fraction being weighed.

11.1.11 Note that the objective of shaking, either manually or mechanically, is to place all of the pieces of a given size on the appropriate sieve and to avoid size degradation. Coal particles greater than 600 µm (No. 30) are particularly susceptible to attrition; therefore, avoid excessive sieving time and amplitude (see 11.3.5).

11.2 *Hand Sieving:*

11.2.1 Hand sieve with a reciprocating, horizontal motion so that a particle travels over a distance of not more than 200 mm (about 8 in.). The maximum particle travel distance shall be

100 mm (4 in.) or less for 203-mm (8-in.) diameter sieves and 37.5 mm (1.5 in.) or less for 75-mm (3-in.) diameter sieves. Take care to prevent any of the coal particles from fracturing upon impact with the sieve frame or with other coal particles.

11.2.2 Manual (hand) sieving is performed slightly differently depending on the size of the coal particles.

11.2.3 *For Coal Larger than 63 mm (2½ in.) Round*—Manipulate pieces of coal not passing readily through sieves 63-mm (2½-in.) round and larger to see if they will pass through the opening in any position. Do not shake sieves 63-mm (2½-in.) round and larger except for whatever jiggling may be necessary to clear the sieves of fine coal.

11.2.4 *For Coal Smaller than 63 mm (2½ in.) Round but Larger than 6.3 mm (¼ in.) Round*—Test coal passing the 63-mm (2½-in.) round sieve with sieves down to and including 6.3-mm (¼-in.) round as follows: Move the sieve horizontally a distance of about 200 mm (8 in.) at just a sufficient rate to cause the pieces of coal to tumble or roll on the sieve. Stop the motion of the sieve without impact. After ten such shakes (five in each direction), sieving of the increment is complete.

11.2.5 *For Coal Particles Smaller than 6.3-mm (¼-in.) Round*—Use wire cloth sieves with square openings (see Table 1). Place the test sample on a clean dry sieve with the pan attached. Make, or at least complete, the test on one sieve at a time (11.2.7). While holding the uncovered sieve and pan in both hands, sieve with a gentle rotary motion until most of the finer material has passed through and the residue looks fairly free of finer particles. This operation usually takes only 1 or 2 min for sieves coarser than 150 µm (No. 100) and 3 or 4 min for sieves 150 µm (No. 100) and finer.

11.2.5.1 When the residue appears to be free of finer particles, replace the cover on the sieve, then carefully separate the sieve from the pan. Place the sieve onto a second pan that is clean and dry. Temporarily cover and move the original pan with contents aside. Hold the sieve, cover and pan firmly, turn the assembly upside down on the table, and remove the pan. Then, with the sieve and cover inverted and held firmly in one hand, gently tap the side of the sieve with the handle of the brush used for cleaning sieves. Dust adhering to the sieve and particles in the mesh will be dislodged by this action. Brush the underside of the sieve. (**Warning—**Particles could be lost while inverting the sieve or be trapped or broken. As an alternate procedure, the underside can be brushed by tilting the sieve to about a 30° angle.)

11.2.5.2 Replace the empty pan onto the sieve and restore the assembly to an upright position. Tap the cover lightly and carefully remove the cover. Replace onto the sieve any coarse material remaining in the cover. Set the cover aside.

11.2.5.3 Continue the sieving without the cover, as described in 11.2.5.1 and 11.2.5.2, until not more than 1 mass percent of the material passes any sieve during 1 min of sieving operation. Combine any additional pan residue to the contents of the original pan temporarily set aside in 11.2.5.1 as product for eventual weighing. The gentle sieving motion involves no danger of spilling the residue, which is to be kept well distributed on the sieve. Continuously rotate the sieve during the sieving.

11.2.6 To determine when sieving is completed, perform the following End-Point Test: Hold the sieve, with pan and cover attached, in one hand at an angle of about 20° from the horizontal. Move the sieve up and down in the plane of inclination at the rate of about 150 times per minute, and strike the sieve against the palm of the other hand at the top of each stroke. To avoid losing particles that pass between the lid and the sieve, perform the sieving over a light-colored surface that will allow these particles to be seen and recovered. Return any material collecting on the surface to the sieve.

11.2.6.1 After every 25 strokes, turn the sieve one sixth of a revolution in the same direction. As an aid to proper sieve rotation, mark the sieve cover with three straight lines, intersecting at 60° through the center, with one of the lines marked with an arrowhead to indicate the starting point.

11.2.6.2 Continue the sieving operation until the additional material which passes through in 1 min of continuous sieving fails to change by more than 1.0 % the amount of material on that sieve. Remove material from the sieve as described in 11.2.5.1. Weigh and record the masses of these final sieve and pan products.

11.2.7 Hand sieving is the original basic method of making sieve analyses and can be used to check (calibrate) mechanical sieving results. In hand sieving, the tests are made, or at least completed, on one sieve at a time, that is, when a nest or stack of sieves is used initially, the test must still end with each individual sieve being treated in the manner prescribed in 11.2.6.2.

11.2.8 *Consistency Important to Hand Sieving*—The operator should try to be consistent with the hand sieving method to always reproduce the same circular motion and tapping action.

11.3 *Mechanical Dry Sieving:*

11.3.1 When sieving with the assistance of a mechanical sieve shaker, adhere to the general considerations given in 11.1.

11.3.2 When using mechanical sieve shakers, determine the length of sieving time best suited to the type of coal being tested, and, for shakers with variable controls, determine and establish the exact setting of the controller for best results, based on repeatability and completeness of sieving without degradation (see 11.3.5).

11.3.3 For routine plant control tests, 3 to 5 min is usually sufficient to give the desired result, while for other materials a sieving time of from 10 to 30 min is necessary. Avoid prolonged sieving time when testing friable materials subject to degradation (see 11.3.5).

11.3.4 To determine the sieving time necessary to produce acceptable analytical results, use the following procedure: from a gross sample, with the use of a sample divider, select four subsamples of a suitable mass or volume for the test. Sieve one of these samples for 4 min, a second for 10 min, a third for 15 min, and a fourth for 20 min. Tabulate the results of these tests by the percentages retained on each sieve, and the length of sieving time required to stabilize the sieving result will be readily apparent and can be established.

11.3.5 For most tests, a satisfactory time has been used when an additional 1 min of sieving fails to change by more than 1.0 % the mass on any of the sieves used.

11.3.6 Sieve tests where the ultimate in precision is desired can be set up on the basis of shaking the nest of sieves until not more than 0.5 % of the material on the finest sieve passes that sieve in a 5-min period. This is a good technique to follow when no control can be made on the type of mechanical sieve shaker to be used, or when hand and mechanical sieving are used interchangeably.

11.4 *Wet Sieving:*

11.4.1 Generally, do test sieving on air-dried (dry) material (9.1); however, if difficulty is encountered in obtaining reproducible results on materials below 600 µm (No. 30 U.S.A. Standard) and if the material is not altered physically in water, more accurate tests can be made by the wet method.

11.4.2 Wet sieving is required in any one of the following circumstances:

11.4.2.1 The material to be sieved cannot be dried because of expected deterioration or agglomeration.

11.4.2.2 The material is extremely fine and static electricity does not allow the material to be effectively dry-sieved.

11.4.2.3 Fine particles cling to coarse particles and the fine particles cannot be accurately sized with dry-sieving.

11.4.2.4 Clays are present.

11.4.3 In preparing for a wet sieve test, dry the sample to a constant mass at a temperature not to exceed 40°C (104°F) (see 10.1). Weigh to the nearest 0.1 g (for low rank coals, see 10.1.2). When the material readily mixes with water, place the test sample on the finest sieve, and wash it back and forth with a gentle stream from a hose in such a way that there is no loss by rising dust or splashing. For some coals, it may be necessary to use a wetting agent, such as isopropyl alcohol. When the water passing through the sieve is clear, dry the sieve containing the residue in an oven, if possible, to a constant mass and at a temperature not to exceed 40°C (104°F) (see 10.1). Avoid sample degradation that can be caused by overdrying (see 10.1.2). Weigh the residue to the nearest 0.1 g. Then, repeat this procedure on the coarsest sieve and then again on each sieve in descending size until the finest sieve again is reached. Combine the two segments passing the finest sieve.

11.4.4 This drying time will vary with the size of the sample and the characteristics of the coal and should be established by a series of weighing checks at intervals until no significant change occurs (less than 0.1 % of previous weight) (see Method D2013).

11.4.5 When the material does not mix well with water, first place the dried, accurately weighed sample into an appropriate container and fill the container about three quarters full of water. Shake contents vigorously to mix the material with the water. Pour this mixture onto the sieve and perform the washing process as described above. The use of a wetting agent, such as isopropyl alcohol, providing said reagent causes no interference with sieving, can avoid this operation.

11.4.6 It is possible to perform wet sieving with a nest of sieves with a mechanical sieve shaker by equipping the shaker so that a small stream of water can be received through the top and drained from the bottom pan after passing through the nest.

11.4.7 When wet sieving, adhere to the general considerations given in 11.1.

11.5 *Combined Wet and Dry Sieving:*

11.5.1 When a sieve analysis to be made with a nest of sieves cannot be done on a dry basis because of the presence of fine particles which either agglomerate, adhere to the coarser particles, or cause blinding to the sieve openings, remove the fine particles first by wet sieving and then perform the rest of the analysis on a dry basis.

11.5.2 In the combined wet and dry method, in order to remove clays and other materials that blind or clog the larger mesh sieves, test the sample first on the finest sieve using the wet method described in 11.4.3 (use a protective sieve of larger mesh above the finest sieve to prevent damage to the finest sieve). Dry the coarse residue in accordance with 10.1 and sieve while dry in accordance with the appropriate method in 11.2 or 11.3. Express percentage results in terms of the original dry mass of the test sample before wet testing.

12. Calculation

12.1 Calculate the sum of the size fraction masses (from 11.1.10) and call the sum the combined mass.

12.1.1 Convert all masses to the same units before calculation, that is, kilograms, grams, pounds, or ounces.

12.1.2 Convert and utilize the masses of the size fractions by both multiplying and making proper use of significant figures. For example, if a size fraction weighed 11.25 kg, another 204 g, and another 148 g, determine all the masses to the nearest 0.01 kg (since 11.25 kg is reported to the nearest 0.01 kg) before proceeding with calculations, as follows:

$$\begin{array}{r} 11.25\ \text{kg} \\ 0.20\ \text{kg} \\ \underline{0.15\ \text{kg}} \\ 11.60\ \text{kg} \end{array}$$

12.2 If the percentage mass loss or gain is over 2 %, reject the analysis and make another test. The formula for the calculation of the percentage mass loss or gain is as follows:

$$\left(\frac{\sum M_f - M_i}{M_i} \right) 100 = \%\ M \qquad (2)$$

where:

$\sum M_f$ = combined air-dried mass of the size fractions (12.1), g (oz),

M_i = air-dried mass of gross sample prior to sieving, g (oz), and

$\%\ M$ = % mass loss or gain upon sieving, g (oz).

A mass gain will result in a positive percent while a mass loss will result in a negative percent. (For subbituminous coals, incorporate inherent moisture into these calculations if required.)

12.2.1 If the variation is greater than the above tolerance of 2 %, recheck the figures for possible errors in determining mass, calculating, blinding of the sieve apertures, or accidental spillage. If a calculation, transcription, or other error is detected and correctable, correct the error. If the resulting variation from initial sample weight is within the 2 % tolerance, accept and report the corrected results. If the source of error is not detected or if it is detected but uncorrectable, repeat the test. (In wet-sieving, there is often a high volume of water-coal-mineral slurry passing through the finest sieve. In some cases, where it is appropriate, flocculants can be added to

the material passing the finest sieve during wet-sieving to facilitate settling of those solids.)

12.2.2 When working with small samples or when using 75-mm (3-in.) sieves, it is desirable to determine a tare mass for each sieve and pan to permit determination of masses without removal of the retained fractions. (Re-tare the sieves before each test.) There is great probability that loss of material during removal from the sieve will upset the precision of the test.

12.3 Convert the mass (11.1.10) of an individual size fraction to a percentage basis by dividing the mass of that portion by the combined fractional masses, or by the original mass and multiplying by 100. Calculate each mass (weight) percent to the nearest 0.01 % and then round to the nearest 0.1 %.

12.3.1 The sum of the fractional masses, rather than the original sample mass, can be used as a 100 % for calculation of the sieve analysis percentages. However, the percent mass loss or gain must be stated in the analytical report, and it must be stated that the sum of the fractional masses rather than the original sample mass was used to force the total of the fractional mass percentages to equal 100 %.

12.3.2 Alternatively, another common practice is to assume that a deficiency of up to a maximum of 0.5 % in the sum of the fractional masses compared to the mass of the original sample is lost as dust and can be added to the pan fraction. If this alternative practice is used, this assumption must be stated in the analytical report.

12.4 Calculate cumulative percent retained figures by adding the percentages of each individual size fraction from the largest size to the smallest size.

12.5 Calculate cumulative percent passing figures by adding the percentages of each individual size fraction from the smallest size to the largest size.

13. Graphic Presentation of Test Results

13.1 Sieve analyses often are presented graphically for comparison with specification requirements, or for general evaluation. By interpolation of the sieve analysis graph, percentage retained on or passing sieves not actually used in the test can be estimated. Similarly, the size of aperture which would theoretically retain or pass a selected percentage can be estimated, even though the sieve size was not used in the test or, for that matter, does not even exist. Determine at least six data points in order to make valid interpolations.

13.2 The abscissa of the sieve analysis graph usually represents the sieve sizes and the ordinate the cumulative mass percentages retained or passing. Scales used for the coordinates depend upon the use to be made of the results and the preferences of the user. The scale for sieve sizes can be linear (arithmetic) or logarithmic. The latter has the advantage of representing standard sieve sizes, which relate to one another by powers of the fourth root of two and an equally spaced scale (for example, the distances between the No. 4 and No. 8, the No. 8 and No. 16 and the 19-mm (¾-in.) and 9.5-mm (⅜-in.) are all the same since the larger sieve in each case has an aperture twice that of the smaller). The scale for percentages is usually linear but may occasionally be logarithmic. On the linear scale, equal differences in percentage are depicted as the same distance.

13.3 Among the several methods of graphical presentation of test results that have a wide acceptance are the Rosin-Rammler and the Gaudin-Schuhmann plots.

13.4 In the case of special mixtures, or where the sieve analysis indicates a substantial deviation from a normal gradation of sizes, a sufficiently complete sieve analysis to properly describe the size composition shall be made with sieves as indicated in 6.3 and the sieves used shall be reported as indicated in the following section, Part B "Designation of the Size of Coal from Sieve Analysis Data."

13.5 Report in accordance with Section 15.

PART B. DESIGNATION OF THE SIZE OF COAL FROM SIEVE ANALYSIS DATA

14. Size Designation

14.1 The size designation result applies only to natural continuous ranges of sizes as produced by mining, handling, crushing, screening, and beneficiation.

14.2 The designation shall indicate the range of the size by giving the upper and lower limiting sieves (topsize and bottomsize) between which 80 % or more of the sample is retained as determined by actual test data.

14.2.1 The sieve defining the upper limit shall be the smallest sieve of the series upon which is retained a total of less than 5 % of the sample.

14.2.2 The sieve defining the lower limit shall be at the largest sieve through which passes a total of less than 15 % of the sample.

NOTE 6—By contractual agreement, the percents used to designate topsize and bottomsize may be changed to meet specific requirements.

14.3 The terms for defining sizes shall be written with the upper limiting sieve first, followed by an "X" and finally the lower limiting sieve. The abbreviation "mm" or "in" shall follow the lower limiting sieve but may be omitted after the upper limiting sieve. For sieves of the U.S.A. Standard or Tyler sieve series (No. 4 and smaller), the abbreviation "No." or the word "mesh," respectively, shall be used each time a sieve is indicated.

NOTE 7—Care must be taken to designate the standard source of the sieve, for example, Tyler or U.S.A. Standard, in order to correlate the sieve number with the diameter of the openings.

14.3.1 When the total retained on the 200-mm (8-in.) sieve is 5 % or greater, the size shall be designated by reporting the lower limiting sieve preceded by "200 mm (8 in.) × " and followed by an expression in parentheses giving the percentage over 200 mm (8 in.) to the nearest 1 % (see the first two examples of 14.3.5).

14.3.2 The size fraction of material which passes through the smallest sieve of a series, or of material which has been crushed to a certain topsize, shall be designated by the word "minus" preceding its topsize (for example "minus 28 mesh, Tyler sieve series." This size fraction can also be referred to

synonomously as "–28 mesh, Tyler," "28 mesh x 0, Tyler," or "28 mesh by zero, Tyler").

14.3.3 The size fraction of material retained on the largest sieve of a series, or of material retained on any sieve in a series and all larger particles shall be designated by the word "plus" preceding the size designation (for example, "plus No. 30 U.S.A. Standard sieve series" refers to all material incapable of passing the No. 30 sieve. This size fraction can also be referred to as " +No. 30, U.S.A. Standard" or " +No. 30").

14.3.4 The type of perforated plate opening used for sizes of 6.3 mm (¼ in.) and larger shall be designated "rd" or "sq" to indicate round (rd) or square (sq) openings, respectively. This abbreviation of rd or sq shall follow the lower limiting sieve but may be omitted after the upper limiting sieve in a series where both sieves are round or square, for example, 75 mm x 12.5 mm sq.

14.3.5 The following examples illustrate the system of size designation:

200 mm x 12.5 mm sq (10 % over 200 mm)[8 in. x ½ in. sq (10 % over 8 in.)]
200 mm x 100 mm rd (24 % over 200 mm)[8 in. x 4 in. rd (24 % over 8 in.)]
100 mm x 50 mm sq (4 in. x 2 in. sq)
75 mm x 12.5 mm sq (3 in. x ½ in. sq)
50 mm sq x No. 4 (2 in. sq x No. 4)
100 x 200 mesh, Tyler
28 mesh by 0, Tyler
No. 4 x No. 30 U.S.A. Standard
25.0 mm sq x No. 50 (1 in. sq x No. 50)

14.4 Additionally, for anthracitic coal, size designation of the typically double-screened product can be defined by a descriptive, one-word term, as given in Table 1.

15. Report

15.1 Using the percentages calculated in Section 12, report the results to the nearest 0.1 %.

15.2 Use either the opening in millimetres (inches) or the number of the sieve. Designate the No. sieve by its standard source (that is, U.S.A. Standard or Tyler Series).

15.3 In the report, designate the type of perforated plate or steel-wire opening used for the sizes of 6.3 mm (¼ in.) and larger, either round or square (rd or sq).

15.4 The size designation as explained in Section 14 may be reported.

15.5 Further reports of calculations into cumulative percent passing and cumulative percent retained are also frequently requested and the analysis may be reported on this basis.

15.6 Further coal characterization tests are frequently required and these results may be reported beside the appropriate size portion percentage.

16. Precision and Bias

16.1 No precision statement (reproducibility) has been developed for this test method because of the impracticality of obtaining, transporting, and handling representative splits of the materials in the quantities that would be needed to establish the precision statement. The precision (repeatability) of this test method is being investigated by a task group. At this time, these values have not been determined. The lack of a reference material precludes a bias statement.

17. Keywords

17.1 coal size; sieve; sieve analysis