Designation: C 92 – 95 (Reapproved 2005)

Standard Test Methods for Sieve Analysis and Water Content of Refractory Materials[1]

This standard is issued under the fixed designation C 92; 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 Department of Defense.

1. Scope

1.1 These test methods cover a wet and a dry method for sieve analysis of refractory materials.

1.1.1 *Wet Sieve Analysis*—Water promotes the slaking of clays and helps to separate fine particles, washing them from the larger grains. This method is recommended for use with materials that require water addition, and that slake in normal industrial use.

1.1.2 *Dry Sieve Analysis*—The dry method is not as effective as the wet method in determining the amount of material present in the smaller particle sizes. It is recommended (*1*) for clays, when the slaking action of water is undesirable, (*2*) when the material is in the form of coarsely ground grog and calcine, and (*3*) when the clay is to be used in such a way that the ultimate particle size is of secondary importance.

1.2 These test methods also cover determination of the water content of refractory materials in the wet condition and of air-dried samples as received, so that the sieve analysis can be calculated on the dry basis. Included is a method for obtaining the water content of other refractory materials, such as plastic refractories and wet mixes.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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:* [2]

C 429 Test Method for Sieve Analysis of Raw Materials for Glass Manufacture

E 11 Specification for Wire-Cloth and Sieves for Testing Purposes

E 105 Practice for Probability Sampling Of Materials

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for Characteristic of a Lot or Process

2.2 *Other Document:*

ASTM STP 447 *Manual on Test Sieving Methods*[3]

3. Significance and Use

3.1 Particle size distribution has a major affect upon most of the refractory properties. These test methods provide a means of measuring the distribution for the purpose of comparison to the desired distribution.

3.2 These test methods also cover determination of the water content of refractory materials in the wet condition and of air-dried samples received, so that the sieve analysis can be calculated on the dry basis.

3.3 These methods can produce data for specification acceptance, design purposes, manufacturing control, and research and development.

3.4 A reference set of standard matched or calibrated sieves[4] shall be provided for use in checking the set of sieves used in the actual sieve analysis of samples. The sieves for use in sieve analysis may also be standard matched sieves or may be unmatched sieves conforming to the Specification Table in Specification E 11, provided that such sieves will give results that differ by no more than 5 % from those obtained with the reference set when the two sets are compared in accordance with the section of Test Method C 429 on testing of sieves and samples splitters.

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[1] These test methods are under the jurisdiction of ASTM Committee C08 on Refractories and are the direct responsibility of Subcommittee C08.03 on Physical Properties.

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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 ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

[4] The sole source of supply of matched sieves known to the committee at this time is W. S. Tyler, Inc., Mentor, OH 44060. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

4. Apparatus

4.1 ASTM sieves, or the equivalent Tyler Series listed in Table 1, shall be used. The wire cloth for the sieves, described in Specification E 11, shall be woven (not twilled) and mounted without distortion or looseness in 8-in. (200-mm) diameter circular frames. Pans and covers shall be provided for the sieves.

5. Sampling, Test Specimens, and Test Units

5.1 A representative sample of the material to be tested shall weigh at least four to five times the required weight of the actual test specimen. Material on which the water content is to be determined shall be packed in a watertight container.

5.2 *Water Content*:

5.2.1 *Wet-Type Air-Setting Refractory Mortars*—Remove approximately 50 g of the material immediately after opening the original container and after carefully mixing the contents. To facilitate handling the specimen, place it on a tared piece of waxed paper or aluminum weighing dish. Weigh the test specimen to the nearest 0.1 g both before and after drying for 24 h at 220 to 230°F (105 to 110°C). Calculate the percentage of water to the nearest 0.1 % on the as-received basis.

5.2.2 *Materials Other Than Wet-Type Air-Setting Refractory Mortars* (ground fire clays, fireclay mortars, dry-type air-setting mortars, plastic refractories, and similar materials)—If the material is shipped in the wet condition, prevent loss of water before obtaining a test specimen of approximately 250 g. Weigh the test specimen to the nearest 0.1 g both before and after drying for 3 h at 220 to 230°F (105 to 110°C). Calculate the percentage of water to the nearest 0.1 % on the as-received basis. The dried specimen may be required for further tests (see Sections 6 and 7).

WET SIEVE ANALYSIS

6. Dry Materials

6.1 If the material is received in the dry condition, the test specimen (Note 1) shall consist of the dried and weighed test specimen prepared in accordance with 5.2.2.

NOTE 1—The size of the test specimen may be changed by reason of the nature of the material. For example, some clays tend to pack or cake on the sieves when ground to exceedingly fine particle size, in which case a 100-g sample may be used. For plastic refractories or coarsely ground mixes, the weight of the specimen could be increased to 500 g.

TABLE 1 ASTM Sieves and the Equivalent Tyler Standard Series

ASTM Sieves (U.S. Standard Series) No.	Tyler Standard Series (Mesh Designation)	Sieve Opening
0.265 in.	3	6.7 mm
4	4	4.75 mm
6	6	3.35 mm
8	8	2.36 mm
12	10	1.70 mm
16	14	1.18 mm
20	20	850 µm
30	28	600 µm
40	35	425 µm
50	48	300 µm
70	65	212 µm
100	100	150 µm
140	150	106 µm
200	200	75 µm

7. Wet Materials

7.1 Materials prepared with water (plastic refractories, wet-type high-temperature bonding mortars, etc.) shall be tested as received. Take two test specimens immediately after opening the original container and, in the case of mortars, after carefully mixing the contents. Use one specimen for determining the water content in accordance with either 5.2.1 or 5.2.2. Obtain approximately 250 g of the other specimen (Note 1) for sieve analysis. Weigh the test specimen to the nearest 0.1 g and transfer to the 1-dm^3 container (see Section 8). Wash the utensils used during weighing (to which a small part of the sample may adhere) with a small jet of water from a ¼-in. (6-mm) hose to ensure a quantitative transfer of the weighed specimen to the container.

8. Procedure

8.1 Place the test specimen into a container of about 1-dm^3 capacity. Add sufficient water to form a slurry. Allow slaking to proceed for 1 h, after which a further addition of water may be necessary. Then transfer the test specimen (without loss) to the finest sieve to be used in the analysis. Wash with a small jet of water from a ¼-in. (6-mm) rubber hose until the water passing through the sieve contains only traces of the specimen. Exercise care during washing to prevent loss by splashing. It may be necessary to break up lumps by gently rubbing between the fingers, but never by rubbing or pressing against the sieve. Then dry the washed residue in the sieve to constant weight at 220 to 230°F (105 to 110°C). This usually requires about 2 h. If desired, a preliminary drying period at a lower temperature may be used. Then transfer the dried residue to the top or coarsest sieve of the series to be used. Complete the sieving and weighing operations in accordance with Section 10 or 11.

9. Calculation and Report

9.1 Calculate the wet sieve analysis for the test specimen on the dry weight, and report the results to the nearest 0.1 % of the material retained on each sieve (Note 2). Report the percentage passing the finest sieve as the difference between 100 % and the sum of the percentages retained on the other sieves.

NOTE 2—As an alternative, the results of sieve analysis may be reported on the cumulative basis, either as the total percentage retained on or passing each sieve.

DRY SIEVE ANALYSIS

10. Mechanical Sieving

10.1 When the sieving is to be done mechanically, arrange the sieves in the order of size with the coarsest sieve at the top of the series. The specimen for sieving (Note 1) shall consist of a dried and weighed material prepared in accordance with 5.2.2. Transfer the specimen to the top sieve of the series, and mechanically sieve until less than 0.1 g passes through each sieve after hand sieving for 1 min, as described in Section 11. The machine-sieving operation usually requires about 15 min. Then carefully separate the sieves and determine the amount of material retained on each by weighing to the nearest 0.1 g.

11. Hand Sieving

11.1 The specimen for sieving (Note 1) shall consist of a dried and weighed material prepared in accordance with 5.2.2. Use one sieve at a time beginning with the coarsest and then successively to finer sizes. Alternately tap and rotate the sieve, with pan and cover attached, while holding it in a slightly inclined position so that the test sample will be well distributed over the sieve. Continue the operation until less than 0.1 g of the material passes through each sieve during 1 min of continuous sieving. Determine the amount of material retained on each sieve by weighing to the nearest 0.1 g.

12. Calculation and Report

12.1 Calculate the dry sieve analysis for the test specimen on the dry weight, and report the results to the nearest 0.1 % of the material retained on each sieve (Note 2). Include dust loss with the material passing the finest sieve.

13. Precision and Bias

13.1 *Interlaboratory Testing*—An interlaboratory study was conducted among seven laboratories in 1986. The same samples of −2.5, +28 mesh tabular alumina and −14 mesh silicon carbide were tested by each laboratory to eliminate sampling variability. A third material, wet bauxite mortar, was split into separate samples for each laboratory for wet sieve analysis and moisture content tests.

13.1.1 The sponsoring laboratory used matched sieves and ran the initial and final dry sieve analyses on the tabular alumina and the silicon carbide samples in order to evaluate sample loss or sample breakdown in the repeated runs. The total specimen loss at this end of the study was 3.7 % of the tabular alumina and 4.3 % of the silicon carbide. Each of the other 6 laboratories, with one exception, ran two repetitions on each specimen. Thus, a total of seven sets of data with two replicates each and one set of data with one replicate were analyzed.

13.1.2 The wet mortar results consisted of one set of data from each of six laboratories. Each set of data included sieve analyses and water content on two separate samples split from the main sample received by each laboratory.

13.1.3 Analysis of the sieve analyses data was based on the positive accumulated difference (PAD), which is the sum of the absolute values of the difference between the percent held on each sieve in one repetition and the grand average of the percent on each sieve for all repetitions. The PAD divided by the total number of sieves within the particle size range of the particular material gave the average PAD per sieve. Hereafter, the value will be referred to as the average difference.

13.1.4 As shown in Table 2 and Table 3, the standard deviations within and between laboratories for the average difference was similar for the dry tabular alumina and silicon carbide. The standard deviations of the average difference were slightly greater for the dry-sieved portion (+150 mesh) and much greater for the wet-sieved portion (−150 mesh) of the wet mortar.

13.2 *Precision*:

13.2.1 Precision is based on the average difference only. For dry sieve analyses in one laboratory, the average difference for two materials is significantly different at a probability of 95 % ($t = 1.96$) if it exceeds the repeatability (I_r) listed for precision in Table 2 or for relative precision (% I_r) in Table 3. That is, the average difference between two sieve analysis on the same material obtained in the same laboratory will be expected to exceed the I_r value only about 5 % of the time. If the average difference exceeds I_r, there is reason to question the test results. Likewise, the average difference for two materials obtained by two laboratories is considered to be significantly different if it exceeds the applicable reproducibility intervals (IR and % IR) in Table 2 and Table 3.

TABLE 2 Precision

Material	Average Difference from Grand Average X	Standard Deviation Within-Between		Repeatability-Reproducibility Intervals	
		Sr	SL	*Ir*	IR
Tabular alumina (−2.5× 28 m)	0.74	0.064	0.293	0.18	0.85
SiC (−14 m)	0.70	0.059	0.306	0.17	0.88
Grand average	0.72	0.062	0.300	0.175	0.865
Wet mortar (28 × 150 m)	0.35	0.123	0.0221	0.35	0.35
(−150 m)	1.25	0.860	0.700	2.40	3.10
	Average				
Water content	12.4	0.11	1.15	0.31	3.25

TABLE 3 Relative Precision

Material	Coefficient of Variation Within-Between		Repeatability-Reproducibility Intervals	
	Vr	VL	% *Ir*	% *IR*
Tabular alumina	8.7	39.8	24.7	115.1
SiC	8.4	43.7	23.7	125.8
Average	8.6	41.8	24.2	120.5
Wet mortar				
(28 × 150)	34.7	5.9	98.2	99.6
(−150 m)	68.6	56.0	194.0	250.4
H_2O content	0.88	9.2	2.5	26.2

13.2.2 The precision of the sieve analysis of wet materials is treated in two parts, the dry-sieved +150 mesh and the wet-sieved −150 mesh. For dry sieve analyses in one laboratory, the average difference for two materials is significantly different at a probability of 95 % ($t = 1.96$) if it exceeds the repeatability intervals listed for precision in Table 2 or for relative precision in Table 3. Likewise for comparing the average differences of two wet materials tested in two laboratories.

13.2.3 The precision and relative precision for the water content of wet materials are shown in Table 2 and Table 3, respectively, and are used in the same fashion as described in 13.2.2.

13.3 *Bias*—No justifiable statement on bias can be made since the true values for particle size and water content of different materials cannot be established by an accepted reference method.

14. Keywords

14.1 dry sieve analysis; refractories; water content; wet sieve analysis