Designation: C 357 – 07

Standard Test Method for Bulk Density of Granular Refractory Materials[1]

This standard is issued under the fixed designation C 357; 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 covers a procedure for determining the bulk density of granular refractory materials, commercial products which usually have particles that are retained on a 0.265-in. (6.7-mm) or coarser sieve.

NOTE 1—This test method is not suitable for materials that hydrate in boiling water.

1.2 *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]

E 11 Specification for Wire Cloth and Sieves for Testing Purposes

3. Significance and Use

3.1 Granular refractory materials may be either refractory grain raw materials that are used in the manufacture of finished refractory products, or bulk granular refractory materials that are sold, with or without some degree of processing, to refractory consumers for various uses. In either case, characterizing the properties of a granular refractory material is essential in evaluating its quality or consistency of quality and in determining suitability for end use. One of the important properties is bulk density because of its relationship to end product quality, usage, and performance.

3.2 The refractories producer can use this test method as one of the quality-control tests for his manufactured or mined refractory grain raw materials or for evaluating potential refractory grain raw materials.

3.3 For the refractories consumer, the principal use of this test method is in the evaluation of the quality or the consistency of quality of the granular material in purchased refractory mixes or in bulk granular refractory materials used by the consumer.

3.4 This is a primary test method, and thus is suitable for use in specifications, quality control, and research and development. It can also serve as a referee test method in purchasing contracts or agreements and as a base for development of more rapid, secondary test methods for use in quality control on manufactured refractory raw materials.

3.5 Fundamental assumptions inherent in this test method are that the sample is representative of the material in general, the particle size of the sample is within the range specified by the test method, the material is not readily hydratable, and the size and quantity of pores in the material permits removal of surface water without drainage from the pores themselves. Deviation from any of these assumptions negates the usefulness of the test results.

3.6 In interpreting the results of this test method, it must be recognized that the specific gravity of the material as well as the porosity affects the value obtained for bulk density. Thus, comparisons of results should only be made between like materials or with full recognition of inherent differences between the materials being compared.

4. Apparatus

4.1 *Laboratory Jaw Crusher or Rolls*, for crushing samples to pass a 0.265-in. (6.7-mm) sieve.

4.2 *Standard Sieves, 0.265-in. and No. 8 (2.36-mm) with Pan and Cover (Note 2)*—The sieves shall conform to Specification E 11.

4.2.1 The coarser sieve may be the No. 4 (4.75 mm) and the finer sieve may be the No. 6 (3.35 mm) or No. 12 (1.70 mm), if tests indicate that the range in particle size is not critical.

NOTE 2—The 0.265-in., No. 4, No. 6, No. 8, and No. 12 ASTM sieves are equivalent to 3, 4, 6, 8, and 10-mesh, respectively, of the Tyler Standard Series.[3]

4.3 *Drying Oven*, adjustable to 220 to 230°F (105 to 110°C).

[1] This test method is under the jurisdiction of the ASTM Committee C08 on Refractories and is the direct responsibility of Subcommittee C08.03 on Physical Properties.

Current edition approved Oct. 1, 2007. Published November 2007. Originally approved in 1955. Last previous edition approved in 2002 as C 357–94 (2002)ε1.

[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] World Screening, Suite 30–148, Huntsville, AL 35802, Tel: 800-749-7999; Macon Wire, 2913 Joycliff Road, Macon, GA 31211, Tel: 800-768-9155; Gilson Company, P.O. Box 200, Lewis Center, OH 43035, Tel 800-444-1508, www.globalgilson.com; Fisher Scientific, 2000 Park Lane, Pittsburgh, PA 15275, Tel. 412–490–8300, www.fishersci.com.

4.4 *Riffle*, with six or more ½ to ¾-in. (13 to 19-mm) troughs with pans, or a smooth plate at least 15 in. (381 mm) square and a 300-mm blade spatula or trowel for sample quartering.

4.5 *Balance*, capacity 200 g, sensitivity 0.01 g.

4.6 *Hot Plate*.

4.7 *Beakers*, 250 mL.

4.8 *Buret*, 50 mL, calibrated to 0.1 mL.

4.9 *Le Chatelier Specific Gravity Bottle*, 250 mL capacity.

5. Test Samples

5.1 The sample consists of at least 5.5 lb (2.5 kg) carefully selected to represent the material being tested.

5.2 When possible, take three or more such samples to represent proportionate parts of the material, and test these separately.

6. Preparation of Test Sample

6.1 Crush each sample when necessary and screen dry to pass the 0.265-in. (6.7-mm) sieve and be retained on the No. 8 (2.36-mm) mesh sieve (Note 2). Take care to adjust the crusher so as to obtain some particles that will be retained on the 0.265-in. sieve, thereby increasing the amount retained on the finer sieve. The portion not passing the coarser sieve may be recrushed until it passes. The sieving may be carried out in a mechanical device or by hand.

6.2 After the sieving, treat various types of materials as follows:

6.2.1 With material that has been calcined and cooled not more than 2 h prior to testing, blow free of dust with clean air (moisture- and oil-free).

6.2.2 Wash other materials in a stream of tap water for at least 5 min or until all dust is removed. Oven-dry overnight at 220 to 230°F (105 to 110°C).

7. Procedure

7.1 Divide the sample by quartering or riffling to obtain a portion for testing of about 25 cm^3 in bulk and weighing between 60 and 90 g, depending upon the bulk density. Weigh this sample to the nearest 10 mg and record as the dry weight.

7.2 Place the test sample in a beaker of water and boil for 1 h during which the grains shall be completely covered with water. Cool the sample to room temperature by running cold water into the beaker or by a similar method.

7.3 Rinse the clean buret (Note 3) thoroughly and introduce approximately 25 mL of distilled water at room temperature. Allow it to stand until drops of water on the sides settle into the body of liquid.

NOTE 3—Clean the burette or the Le Chatelier Specific Gravity Bottle frequently with a good cleaning solution such as liquid soap to ensure complete drainage without drops of water forming on the inside walls.

7.3.1 Alternately rinse the clean specific gravity bottle and fill with distilled water at room temperature as close to the 0 mark as possible. Allow it to stand until drops of water on the sides settle into the body of liquid. Take a clean piece of sponge that is hooked to a stainless steel or copper wire and is long enough to reach to the bottom of the straight section. Insert the sponge into the bottle and with circular motion try to mop up any excess water from the sides. Make sure that the sponge surface does not touch the top of the water meniscus. Record the level of water in the bottle to the nearest 0.05 mL indicating if the level is below or above the 0 mark. If the level is at 0 mark then record that.

7.4 Totally saturate blotting cloth (smooth linen or lint free cotton) with water, then gently wring out to a no-drip condition. Spread out damp cloth (landscape orientation) and pour wet grain carefully onto cloth, with no loss of particles. With a small metal spatula, spread grain over left half of cloth to a single grain layer. Fold right half of cloth over top of grain and gently pat to blot, without abrading any grain edges if possible. Open cloth and, using edges, roll grain into center, then onto left half of cloth; repeat these steps as necessary until grains have lost their sheen and no grains are adhering together. Care should be taken to avoid excessive blotting that will induce error by withdrawing water from the pores of the specimen. Open cloth and roll grain into center, using metal spatula to assist in grain transfer.

7.5 Record the water meniscus level in the buret to the nearest 0.05 mL. Pour grains into the buret and shake so as to cause the grains and drops of water to submerge into the water, with no air bubbles attached. Read the new position on the meniscus to the nearest 0.05 mL without delay and record the difference between the first and second readings as the volume of the grains.

7.5.1 Alternately pour grains into the specific gravity bottle slowly and shake slightly so as to cause the grains and drops of water to submerge into the water, with no air bubbles attached. Read the new position on the meniscus to the nearest 0.05 mL without delay. If the original reading was above 0 then subtract that from the second reading. If the original reading was below 0 then add that to the second reading to obtain the volume of the grains.

7.6 Test materials that may hydrate in boiling water for ignition loss, to learn whether hydration has taken place. Use two portions of the sample, one taken immediately before boiling and the second after the volume measurement in the buret.

8. Report

8.1 State in the report how the sample (or samples) was taken and the grain size limits employed. Divide the dry weight of the sample by the volume and report the bulk density as megagrams per cubic metre. If more than one sample was tested, state the number and report the average value as well as the range between the highest and lowest values obtained.

8.2 If the loss on ignition has been determined in accordance with 7.6, report the values for dry and volume-tested material. When the loss for the boiled material is higher than that of the dry material by more than 0.50 %, the results shall be discarded and the test method considered inapplicable.

9. Precision and Bias

9.1 *Interlaboratory Data*—An interlaboratory study was conducted in 1990 in which a sample of tabular alumina was split and tested in five laboratories. Three operators in each laboratory tested the material four times each for a total of twelve tests per laboratory.

TABLE 1 Precision Statistics

Precision:	
Average, *x*	3.53
Standard within, S_r	0.0164
Deviation between, S_R	0.0182
Repeatability interval, *r*	0.0459
Reproducibility interval, *R*	0.0510
Relative Precision:	
Average, *x*	3.53
Coefficient of Variation	
Within lab, V_r	0.46
Between lab, V_R	0.52
Relative Repeatability, % *r*	1.30
Relative Reproducibility, % *R*	1.45

9.2 *Precision*—Precision and relative precision data at the 95 % confidence level are given in Table 1.

9.3 *Bias*—No justifiable statement on bias can be made since the true value cannot be established by an accepted reference method.

10. Keywords

10.1 blotting cloth; boiling; bulk density; buret; granular refractor; material; non-hydratable; sheen