Designation: C 20 – 00

Standard Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water[1]

This standard is issued under the fixed designation C 20; 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 the determination of the following properties of burned refractory brick:

1.1.1 Apparent porosity,

1.1.2 Water absorption,

1.1.3 Apparent specific gravity, and

1.1.4 Bulk density.

1.2 These test methods are not applicable to refractories attacked by water.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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:*

C 134 Test Methods for Size, Dimensional Measurements, and Bulk Density of Refractory Brick and Insulating Firebrick[2]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[3]

3. Significance and Use

3.1 Apparent porosity, water absorption, apparent specific gravity, and bulk density are primary properties of burned refractory brick and shapes. These properties are widely used in the evaluation and comparison of product quality and as part of the criteria for selection and use of refractory products in a variety of industrial applications. These test methods are used for determining any or all of these properties.

3.2 These test methods are primary standard methods which are suitable for use in quality control, research and development, establishing criteria for and evaluating compliance with specifications, and providing data for design purposes.

3.3 Fundamental assumptions inherent in these test methods are that the test specimens are not attacked by water, the test specimens conform to the requirements for size, configuration, and original faces, the open pores of the test specimens are fully impregnated with water during the boiling treatment, and the blotting of the saturated test specimens is performed as specified in a consistent and uniform manner to avoid withdrawing water from the pores. Deviation from any of these assumptions adversely affects the test results.

3.4 In laboratory studies involving castable specimen, a bias was noted between formed 2 X 2 X 2–in. (50 X 50 X 50–mm) and specimens that were quartered from larger 9 X 4.5 X 2.5 (228 X 114 X 64 mm) cast specimens. Additionally, an error in the apparent porosity determination on castables was found whenever the specimens were heated to 1500°F (816°C) and then exposed to water as a saturation media (Test Method C 830). The error was attributed to reactivity of cement with water and subsequent re-hydration of cement phases. The higher the cement level of the castable, the greater the error noted. It was concluded that an erron in porosity values could occur for refractory materials having a potential to form hydrated species with water. Supporting data were filed at ASTM headquarters and can be obtained by requesting Research Report 1014.

3.5 Certain precautions must be exercised in interpreting and using results from these test methods. All four property values are interrelated by at least two of the three base data values generated during testing. Thus, an error in any base data value will cause an error in at least three of the property values for a given test specimen. Certain of the properties, that is, apparent specific gravity and bulk density, are functions of other factors such as product composition, compositional variability within the same product, impervious porosity, and total porosity. Generalizations on or comparisons of property

[1] These test methods are under the jurisdiction of ASTM Committee C-8 on Refractories and are the direct responsibility of Subcommittee C08.03 on Physical Tests and Properties.

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[2] *Annual Book of ASTM Standards*, Vol 15.01.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

values should only be judiciously made between like products tested by these test methods or with full recognition of potentially inherent differences between the products being compared or the test method used.

4. Test Specimens

4.1 When testing 9-in. (228-mm) straight brick, use a quarter-brick specimen by halving the brick along a plane parallel to the 9 by 2-½ or 3-in. (228 by 64 or 76-mm) face and along a plane parallel to the 4-½ by 2-½ or 3-in. (114 by 64 or 76-mm) face. Four of the surfaces of the resultant quarter-brick specimen include part of the original molded faces.

4.2 When testing other refractory shapes, cut, drill, or break from each shape a specimen having volume of approximately 25 to 30 $in.^3$ (410 to 490 cm^3). The specimen shall include interior and exterior portions of the shape.

4.3 Remove all loosely adhering particles from each specimen.

5. Procedure

5.1 *Dry Weight, D*:

5.1.1 Dry the test specimens to constant weight by heating to 220 to 230°F (105 to 110°C) and determine the dry weight, *D*, in grams to the nearest 0.1 g.

5.1.2 The drying procedure may be omitted only when the test specimens are known to be dry, as may be the case with samples taken directly from kilns.

5.1.3 The drying of the specimens to constant weight and the determination of their dry weight may be done either before or after the saturation operation (Section 6). Usually, the dry weight is determined before saturation. However, if the specimens are friable or evidence indicates that particles have broken loose during the saturating operation, dry and weigh the specimens after the suspended weight, *S*, and the saturated weight, *W*, have been determined, as described in Sections 5.3 and 5.4. Use this second dry weight in all appropriate calculations.

5.2 *Saturation:*

5.2.1 Place the test specimens in water and boil for 2 h. During the boiling period, keep them entirely covered with water, and allow no contact with the heated bottom of the container.

5.2.2 After the boiling period, cool the test specimens to room temperature while still completely covered with water. After boiling keep the specimens immersed in water for a minimum of 12 h before weighing.

5.3 *Suspended Weight, S:*

5.3.1 Determine the weight, *S*, of each test specimen after boiling and while suspended in water in grams to the nearest 0.1 g.

5.3.2 This weighing is usually accomplished by suspending the specimen in a loop or halter of AWG Gage 22 (0.643-mm) copper wire hung from one arm of the balance. The balance shall be previously counter-balanced with the wire in place and immersed in water to the same depth as is used when the refractory specimens are in place.

5.4 *Saturated Weight, W*—After determining the suspended weight, blot each specimen lightly with a moistened smooth linen or cotton cloth to remove all drops of water from the surface and determine the saturated weight, *W*, in grams by weighing in air to the nearest 0.1 g. Perform the blotting operation by rolling the specimen lightly on the wet cloth, which has previously been saturated with water, and then press only enough to remove such water as will drip from the cloth. Excessive blotting will induce error by withdrawing water from the pores of the specimen.

6. Calculation

6.1 *Exterior Volume, V*—Obtain the volume, *V*, of the test specimens in cubic centimetres by subtracting the suspended weight from the saturated weight, both in grams, as follows:

$$V,\ cm^3 = W - S \tag{1}$$

NOTE 1—This assumes that 1 cm^3 of water weighs 1 g. This is true within about 3 parts in 1000 for water at room temperature.

6.2 *Volumes of Open Pores and Impervious Portions*—Calculate the volume of open pores and the volume of the impervious portions of the specimen as follows:

$$\text{Volume of open pores, } cm^3 = W - D \tag{2}$$

$$\text{Volume of impervious portion, } cm^3 = D - S \tag{3}$$

6.3 *Apparent Porosity, P*—The apparent porosity expresses as a percentage the relationship of the volume of the open pores in the specimen to its exterior volume. Calculate *P* as follows:

$$P, \% = [(W - D)/V] \times 100 \tag{4}$$

6.4 *Water Absorption, A*—The water absorption, *A*, expresses as a percentage the relationship of the weight of water absorbed to the weight of the dry specimen. Calculate *A* as follows:

$$A, \% = [(W - D)/D] \times 100 \tag{5}$$

6.5 *Apparent Specific Gravity, T*—Calculate the apparent specific gravity, *T*, of that portion of the test specimen which is impervious to boiling water as follows:

$$T = D/(D - S) \tag{6}$$

6.6 *Bulk Density, B:*

6.6.1 The bulk density, *B*, of a specimen in grams per cubic centimetre is the quotient of its dry weight divided by the exterior volume, including pores. Calculate *B* as follows:

$$B,\ g/cm^3 = D/V \tag{7}$$

6.6.2 This test method of determining bulk density is useful for checking bulk density values obtained by direct measurement of Test Methods C 134.

NOTE 2—While it is more accurate than the direct measurement method, and generally gives higher values (by about 0.02 to 0.04), the direct measurement method is better suited for plant and field testing, since it is a less involved technique. The present method is preferable for specimens that are branded deeply or irregular in contour.

7. Report

7.1 For each property, report the individual values obtained.