Designation: C 559 – 90 (Reapproved 2000)

An American National Standard

Standard Test Method for Bulk Density by Physical Measurements of Manufactured Carbon and Graphite Articles[1]

This standard is issued under the fixed designation C 559; 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 the determination of the bulk density of manufactured articles of carbon and graphite of at least 500 mm^3 volume. The bulk density is calculated to an accuracy of 0.25 %, using measurements of mass and dimensions in air at 25 ± 5°C.

1.2 *This standard does not purport to address 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:*

IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI) (the Modern Metric System)[2]

3. Terminology

3.1 *Definition of Term Specific to This Standard:*

3.1.1 *bulk density* —the mass of a unit volume of material including both permeable and impermeable voids.

4. Significance and Use

4.1 Bulk density as determined by this test method is a basic material property of importance in manufacturing and application of carbon and graphite.

4.2 This test method can be used for quality and process control, material characterization and description, and other purposes.

5. Preparation of Test Specimens

5.1 Machine test specimens from the manufactured article in the form of a rectangular parallelepiped or a right circular cylinder. The minimum mass of the specimen shall be 2000 times the sensitivity of the balance used to weigh the specimen, and the volume of the specimen shall not be less than 500 mm^3. The minimum dimension of the specimen shall be the larger of:

5.1.1 Ten times the length of the largest visible particle and

5.1.2 2000 times the resolution of the device used for measuring the dimension.

5.2 During the machining operation, use no lubricant having a boiling point above 100°C. All corners, edges, and faces of the specimen should be free of chips or gouges. Ensure that the specimen is free of any residue from the machining operation. Dry the specimen for a minimum of 2 h at 110°C, and then allow it to cool to 25 ± 5°C in a desiccator. The specimen shall not be removed from the desiccator until immediately prior to weighing.

6. Procedure

6.1 Weigh the specimen to an accuracy of 0.05 % using a balance or scale. During the weighing operation, handle the specimen with soft-tipped tongs.

6.2 Measure each dimension of the test specimen to an accuracy of 0.05 %.

6.2.1 If the specimen is a rectangular parallelepiped, make four measurements of the length (longest dimension). Take each measurement along the center of each of the four long faces of the specimen. Measure the width and thickness at each end and at two intermediate points along the length of the specimen. Determine the mean of each dimension.

6.2.2 If the specimen is a right circular cylinder, measure the length at four points, 90° apart on the periphery of the circular end faces. Make two sets of diameter measurements. Each set shall consist of four measurements, one at each end and two at intermediate points along an axial line. These sets shall lie at 90° to each other. Determine the mean length and the mean of each of the two sets of diameter measurements.

7. Calculation

7.1 Convert the mass to milligrams and the dimensions to millimetres, or convert the mass to megagrams and the dimensions to metres. Conversion factors are available in IEEE/ASTM SI-10.

7.2 The volume of the specimen may be calculated as follows:

For a rectangular parallelepiped:

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[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.F on Manufactured Carbon and Graphite Products.

Current edition approved Mar. 30, 1990. Published May 1990. Originally published as C 559 – 68 T. Last previous edition C 559 – 85.

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

$$V = l\,wt \quad (1)$$

where:
V = volume, mm^3(or m^3),
l = mean length, mm (or m),
w = mean width, mm (or m), and
t = mean thickness, mm (or m).

For a right circular cylinder:

$$V = (\pi d_1 d_2 l)/4 \quad (2)$$

where:
d_1, d_2 = mean diameters, mm (or m).

7.3 The bulk density of the specimen may be calculated as follows:

$$D = M/V \quad (3)$$

where:
D = bulk density, mg/mm^3(or Mg/m^3),
M = mass, mg (or Mg), and
V = volume, mm^3(or m^3).

8. Report

8.1 Report the following:

8.1.1 Type, source, grade, and form of the sample, and

8.1.2 Densities of the individual specimens and the mean.

9. Precision and Bias

9.1 No numerical statement can be made on the intralaboratory or interlaboratory precision of this test method, since such tests have not been run. The resultant density will be accurate to within the claimed 0.25 % if the following conditions are met in their entirety:

9.1.1 All measuring devices (calipers, scales, and balances) have accuracy, at the time of use, equal to the resolution of the device. Such accuracy can be verified by measurement of standards before and after any series of density determinations, plus a program of regular calibration of standards.

9.1.2 The machined specimens have right angles accurate to ±1°.

9.1.3 The machined specimens have plane surfaces flat to within 0.05 % of the dimension perpendicular to the plane. If the specimen is a rectangular parallelepiped, nonparallel opposite sides will cause a systematic error if a standard micrometer having flat anvil faces is used. (If a round anvil micrometer is used, disregard the following.) The systematic error will be greater than the accuracy of the measurement if the measurements of a given dimension are uniformly increasing or decreasing along the specimen, and if tan θ > (0.001) (mean dimension being measured)/(micrometer anvil diameter), where θ is the angle by which the sides deviate from parallelism (θ = 0° for parallel sides). If tan θ is greater than the specified tolerance, the specimen should be discarded.

9.2 If specimens having volumes close to the minimum (500 mm^3) are used, extra care should be taken to ensure that the specified accuracies are achieved.

9.3 Surface roughness may cause systematic errors in dimension measurements since micrometer calipers generally read surface peaks. In order to ensure that the accuracy standards for dimension measurements are met, the maximum peak-to-valley distance shall be less than 0.05 % of the dimension being measured.

9.4 The buoyant effect of the air will cause a systematic error. For typical carbon and graphite, the densities will be low by approximately 0.05 %. This systematic error has been taken into account in the overall bias (0.25 %) of the test method.

9.5 Errors can be introduced by deformation of specimens from application of force during dimensional measurement. Care must be taken not to exert force on a specimen during measurement, particularly when measuring a low modulus material.

9.6 Contamination of specimens during handling can cause the apparent mass to deviate from the true mass. The cautions in Sections 5 and 6 concerning specimen handling and cleanliness must be observed.

10. Keywords

10.1 bulk; carbon density; graphite; gravimetric; physical