



Designation: B329 – 24

Standard Test Method for Apparent Density of Metal Powders and Compounds Using the Scott Volumeter¹

This standard is issued under the fixed designation B329; 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 determination of the apparent density of metal powders and related compounds using the Scott Volumeter, also known as the Paint Pigment Volumeter.

1.2 *Units*—With the exception of the values for density and the mass used to determine density, for which the use of the gram per cubic centimetre (g/cm^3) and gram (g) units is the longstanding industry practice, the values stated in SI units are to be regarded as the standard.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

B873 Test Method for Measuring Volume of Apparent Density Cup Used in Test Methods B212, B329, and B417

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2016 Specification for Industrial Woven Wire Cloth

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology **B243**.

4. Significance and Use

4.1 This test method covers the evaluation of the apparent density physical characteristic of powders. The degree of correlation between the results of this test and the quality of powders in use will vary with each particular application and has not been fully determined.

4.2 The apparent density measured via this test method is often referred to as the “Scott Density.”

5. Apparatus

5.1 **Fig. 1** shows the Scott Volumeter consisting of the following parts:

5.1.1 *Top Funnels*—A large funnel with a No. 16 (1.18 mm) or a No. 18 (1 mm) screen per Specification **E11**, or a Light 20 \times 20 mesh (1.19 mm) or a Light 24 \times 24 mesh (0.99 mm) screen per Specification **E2016**; and a small conical funnel for directing the powder into the baffle box. Funnels and screen may be brass or stainless steel.

5.1.2 *Baffle Box*—A box with two glass sides and two wooden sides containing a series of four glass baffle plates.

The wooden baffle box may be substituted by a water-resistant material, such as stainless steel, if washing is more desirable than air cleaning.

5.1.3 *Bottom Funnel*—A small brass or stainless steel funnel directly beneath lower baffle box opening for directing the powder into the density cup.

5.1.4 *Density Cups*—A cylindrical cup having a capacity of $25.00 \text{ cm}^3 \pm 0.03 \text{ cm}^3$, with an inside diameter of $29.50 \text{ mm} \pm 2.50 \text{ mm}$; or a square cup with a capacity of $16.39 \text{ cm}^3 \pm 0.05 \text{ cm}^3$ and an inside dimension of $25.40 \text{ mm} \pm 0.02 \text{ mm}$. Density cups shall be either brass or non-magnetic stainless steel.

¹ This test method is under the jurisdiction of ASTM Committee **B09** on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee **B09.03** on Refractory Metal Powders.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

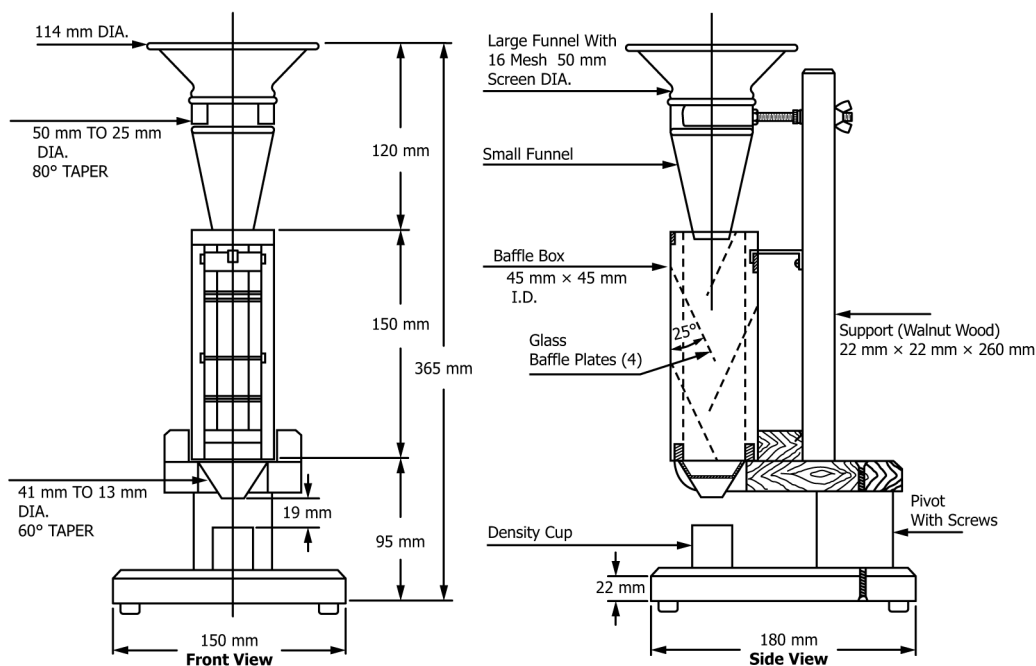


FIG. 1 Density Apparatus Assembly

5.1.5 *Stand*—A 90° pivoting wooden or stainless steel stand to support the funnels and the baffle box concentric with the density cup so that the bottom funnel lower opening is 19 mm above the top of the density cup as shown in Fig. 1 when using the square cup. Fig. 2 shows some suggested modifications for use of the cylindrical cup. Modifications A and C of Fig. 2 are

suggested when the cylindrical cup is to be used exclusively. Modification B of Fig. 2 is suggested when both cups are to be used interchangeably.

5.2 *Instrument Support*—A stand or bench surface, level and vibration free.

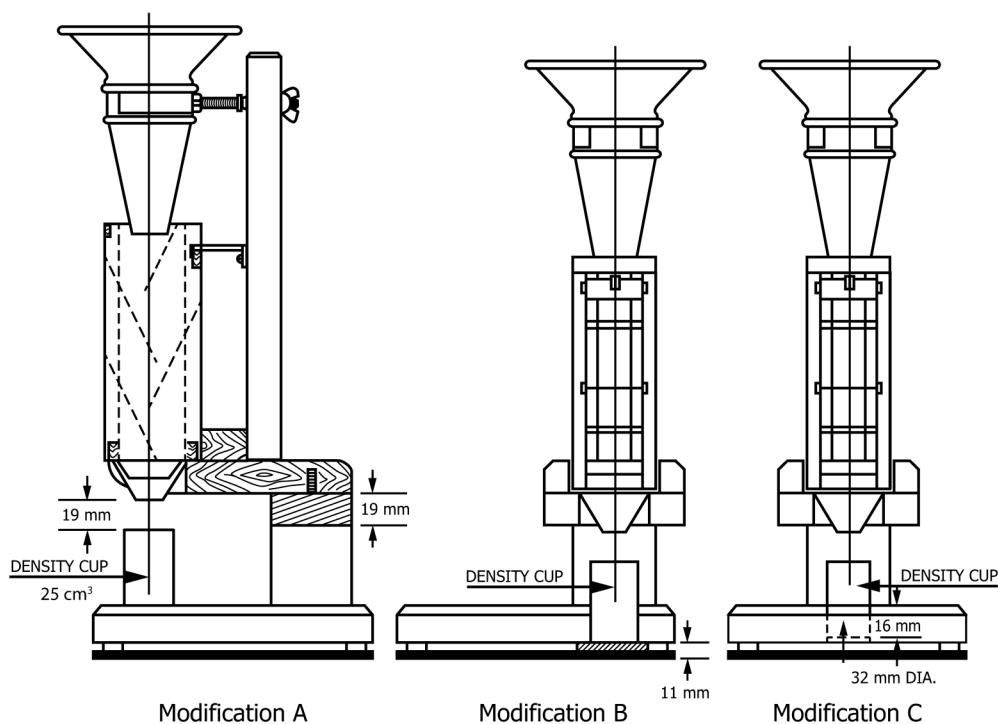


FIG. 2 Suggested Methods of Modifying the Wooden Scott Volumeter for Metric Density Cup

5.3 *Balance*—A balance, readable to 0.01 g with a capacity of at least 200 g.

5.4 *Brush*—A good quality, 25.4 mm wide brush, preferably nylon.

5.5 *Spatula*—A standard 12.7 mm wide stainless steel laboratory spatula.

6. Test Specimen

6.1 Obtain a test portion in accordance with Practices **B215**.

6.2 A minimum of 25 cm³ of powder for the square cup and 35 cm³ of powder for the cylindrical cup will be needed.

7. Calibration and Standardization

7.1 The density cups shall be calibrated in accordance with Test Method **B873**. If the density cup falls outside acceptable tolerance limits, 25.00 cm³ ± 0.03 cm³ for the cylindrical cup or 16.39 cm³ ± 0.05 cm³ for the square cup, it is not to be used.

8. Procedure

8.1 Tare or preweigh the density cup.

8.2 Pour the powder being tested carefully into the top receiving funnel and permit the powder to run into the density cup. Completely fill the density cup to overflowing or fill to overflowing and form a mound of powder above the top of the density cup. If the powder is not free-flowing, carefully brush the sample through the top receiving funnel screen without jarring the volumeter. Jarring of the volumeter could result in packing of the powder in the density cups, thus giving erroneously high values.

8.3 Remove the excess powder in the density cup by passing the edge of the spatula blade parallel to, and in contact with, the top of the cup. Move the spatula smoothly along the top surface of the cup and back again until all excess powder has been removed, special care being taken to direct the excess powder into the unfilled areas of the cup. It is important that the spatula be kept level at all times to prevent packing or pulling out of the powder. Perform the completed leveling operation to produce a uniform powder surface perfectly level with the top of the density cup.

8.4 After the leveling operation, lightly tap the side of the density cup to settle the powder to avoid spilling while transferring the cup to the balance for weighing.

8.5 Determine the mass of the powder by weighing the cup plus powder and, if preweighed and not tared, subtracting the mass of the cup; record the powder mass to the nearest 0.01 g.

9. Calculation

9.1 Calculate the apparent density as follows:

$$\text{Apparent Density, } AD_s, \text{ g/cm}^3 = M/V \quad (1)$$

where:

M = mass of powder in the density cup, g, and

V = volume of the density cup, cm³.

10. Report

10.1 Report test results as Scott Density, AD_s , in grams per cubic centimetre to the nearest 0.1 g/cm³.

10.2 Report which density cup was used in the test.

10.3 Include a reference to this test method in the report.

11. Precision and Bias

11.1 The precision of this test method is based on an interlaboratory study of Test Method B329 conducted in 2018. Each of 6 laboratories tested 5 different materials. Every “test result” represents an individual determination, and all participants reported triplicate test results. Practice **E691** was followed for the design and analysis of the data; the details are given in ASTM Research Report RR:B09-1024.³

11.1.1 *Repeatability Limit (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

11.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

11.1.1.2 Repeatability limits are listed in **Table 1**.

11.1.2 *Reproducibility Limit (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

11.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility

³ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B09-1024. Contact ASTM Customer Service at www.astm.org/contact.

TABLE 1 Scott Density (AD_s), g/cm³

Material	Average ^A \bar{x}	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Molybdenum Powder	1.52	0.03	0.06	0.07	0.16
Coarse Tungsten Carbide	4.42	0.13	0.16	0.36	0.44
Coarse Tungsten	6.77	0.10	0.37	0.29	1.03
Fine Tungsten Carbide	2.43	0.06	0.48	0.16	1.34
Fine Tungsten	1.83	0.03	0.10	0.09	0.29

^A The average of the laboratories' calculated averages.

conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

11.1.2.2 Reproducibility limits are listed in **Table 1**.

11.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice **E177**.

11.1.4 Any judgment in accordance with statements **11.1.1** and **11.1.2** would have an approximate 95 % probability of being correct.

11.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

11.3 The precision statement was determined through statistical examination of 87 results, from 6 laboratories, on 5 materials.

11.4 To judge the equivalency of two test results, it is recommended to choose the material closest in characteristics to the test material.

12. Keywords

12.1 apparent density; bulk density; Paint Pigment Volumeter; powder metallurgy; powders; refractory metals; Scott density; Scott Volumeter

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B329 – 20) that may impact the use of this standard. (Approved Oct. 1, 2024.)

(1) Incorporated the use of Specification **E2016** for the top funnel screen in **5.1.1**.

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