



Designation: B417 – 25

Standard Test Method for Apparent Density of Non-Free-Flowing Metal Powders Using the Carney Funnel¹

This standard is issued under the fixed designation B417; 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 apparent density of non-free-flowing metal powders and powder mixtures. It is designed for those metal powders that do not freely flow through the Hall flowmeter funnel.

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 centimeter (g/cm^3) and gram (g) units is the long-standing industry practice, the values 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.

1.3 *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

- B212 Test Method for Apparent Density of Free-Flowing Metal Powders Using the Hall Flowmeter Funnel
- B215 Practices for Sampling Metal Powders
- B243 Terminology of Powder Metallurgy
- B417 Test Method for Apparent Density of Non-Free-Flowing Metal Powders Using the Carney Funnel

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 B09.02 on Base 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.

- B873 Test Method for Measuring Volume of Apparent Density Cup Used in Test Methods B212, B329, and B417
- E456 Terminology Relating to Quality and Statistics
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—Terms in Terminology B243 are applicable to this test method.

4. Summary of Test Method

4.1 A volume of powder is permitted to flow into a container of definite volume under controlled conditions. The mass of powder per unit volume is determined and reported as apparent density, Carney (AD_C).

5. Significance and Use

5.1 This test method provides a guide for evaluation of an important physical characteristic of a powder known as the apparent density. The measured apparent density bears a relationship to the mass of powder that will fill a fixed volume die cavity. The degree of correlation between the results of this test and the performance of powders during use may vary with each particular application. Note, however, that the presence of moisture, oils, stearic acid, stearates, waxes, and the temperature of the powder mass may alter the physical characteristics of the powder.

5.2 Test Method B212, using the Hall flowmeter funnel, is the preferred method for determining the apparent density of metal powders and powder mixtures. The Carney flowmeter funnel of Test Method B417 should only be used when powder will not flow through the Hall flowmeter funnel.

6. Interferences

6.1 Humidity and moisture may influence apparent density. The impact of humidity and moisture on the apparent density depends on the nature of the powder and its particle size distribution (that is, finer particles being more affected than coarse particles). The sensitivity of a given powder to humidity and moisture can be determined by measuring the apparent density of the powder in environments with different levels of moisture. If the difference of the apparent density in environments with different levels of humidity is less than 5 %, the

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

apparent density of this particular material can be estimated as insensitive to moisture within the humidity interval investigated. If the apparent density is considered sensitive to moisture (more than 5 % variation), it is recommended to measure the apparent density in environments with a controlled level of humidity (± 5 % relative humidity) and only compare results if obtained in an environment with a comparable level of humidity (± 5 % relative humidity).

6.2 Metal powders for pressing and sintering applications are usually only moderately affected by humidity and can generally be tested under ambient laboratory conditions. Mixed powders that contain lubricants and fine additives may be more susceptible to the effects of humidity but generally can be handled in a similar manner (unless it can be demonstrated that moisture may impact the apparent density). Nevertheless, the relative humidity and temperature in the laboratory when conducting the tests should be reported.

6.3 Finer powders, such as those used for binder jetting or powder-bed-fusion, can be more sensitive and should be tested for their susceptibility to the effects of moisture (see 6.1). If the apparent density is considered sensitive to moisture (more than 5 % variation), it is recommended to measure the apparent density in environments with a controlled level of humidity

(± 5 % relative humidity) and only compare results if obtained in an environment with a comparable level of humidity (± 5 % relative humidity). The relative humidity and temperature of the laboratory during the exposure should be reported.

7. Apparatus

7.1 *Powder Flowmeter*—A Carney Flowmeter (Fig. 1).

7.2 *Density Cup*—A cylindrical brass cup (Fig. 2) having a capacity of 25 cm³. The actual cup volume shall be determined according to Test Method B873. If the measured volume of the cup is outside the tolerance in Fig. 2 (25 ± 0.03 cm³), the cup shall not be used.

7.3 *Stand*—A stand (Fig. 1) to support the powder funnel concentric with the density cup so that the bottom of the powder funnel is approximately 1 in. (25 mm) above the top of the density cup when the apparatus is assembled as shown in Fig. 1.

7.4 *Workbench*—A level, vibration-free table or workbench to support the powder flowmeter stand.

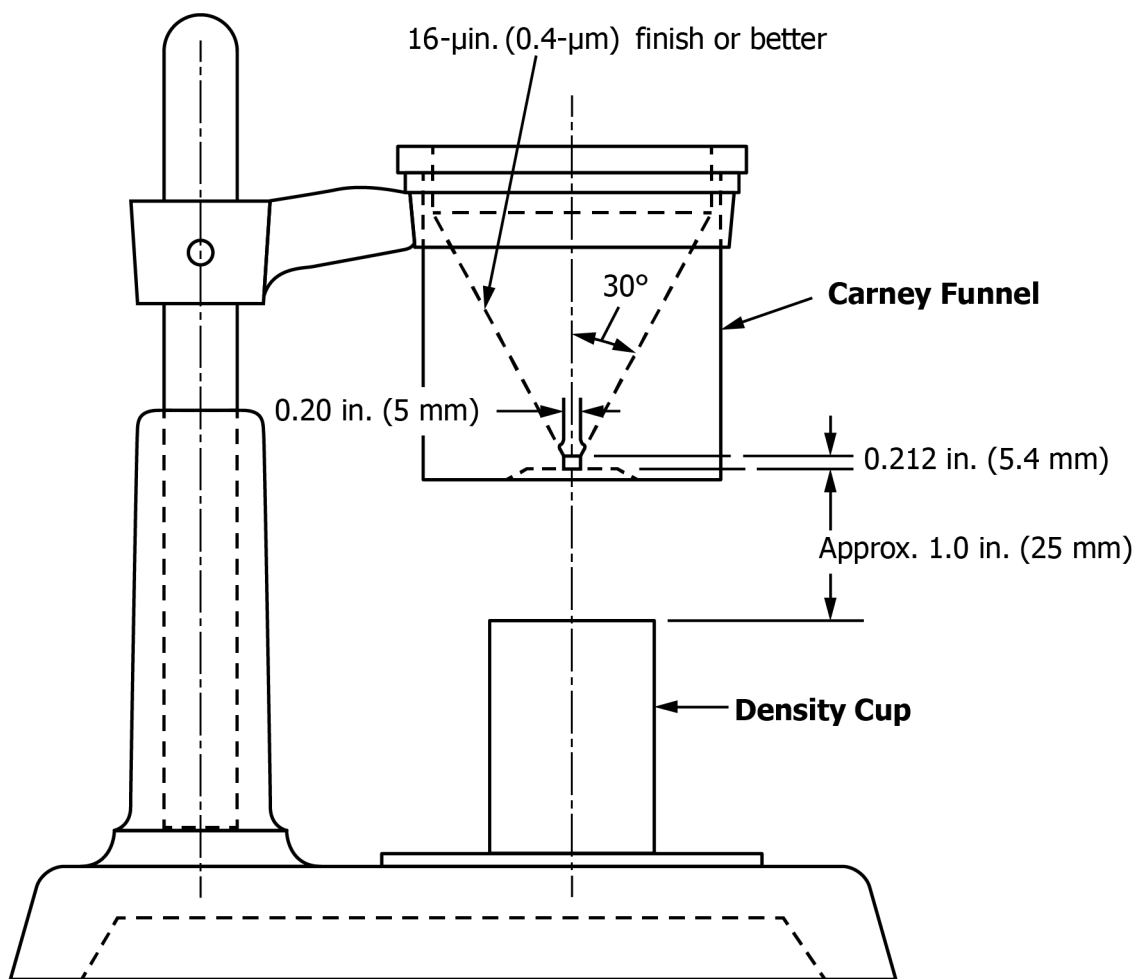


FIG. 1 Carney Flowmeter Funnel and Stand

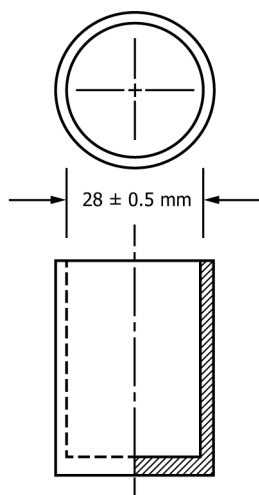


FIG. 2 Density Cup ($25 \pm 0.03 \text{ cm}^3$)

7.5 *Balance*, readable to 0.001 g, with a minimum capacity of 200 g.

7.6 *Wire*, approximately 0.10 in. (2.5 mm) in diameter by 6 in. (150 mm) in length.

7.7 *Spatula or Straight Edge*—A non-magnetic spatula or straight edge of suitable dimensions for leveling off the excess powder on top of the density cup.

8. Sampling

8.1 The test portion shall consist of a volume of approximately 30 to 40 cm^3 of metal powder obtained in accordance with Practices B215.

8.2 The test portion shall be tested as sampled. Note, however, that temperature, moisture, oils, stearic acid, stearates, waxes, and so forth may alter the characteristics of the powder.

9. Procedure

9.1 If the powder is suspected of being sensitive to moisture and humidity, record the relative humidity and temperature of the laboratory, and perform the following in an environment with a comparable level of humidity ($\pm 5\%$ relative humidity). See Section 6 – Interferences.

9.2 Weigh the empty density cup and record the mass to the nearest 0.001 g. Alternatively, place the empty density cup on the balance and tare the balance to zero.

9.3 Load the test specimen carefully into the flowmeter funnel and permit it to run into the density cup through the discharge orifice. If necessary, it may be agitated or pushed by use of the length of wire but take care to prevent the wire from entering the density cup. The density cup should not be moved during the filling operation.

9.4 When the powder completely fills and overflows the periphery of the density cup, rotate the funnel approximately 90° in a horizontal plane so that the remaining powder falls away from the cup.

9.5 Using a nonmagnetic spatula, or straight edge, with the blade held perpendicular to the top of the cup, level off the powder flush with the top of the density cup. Take care to avoid jarring the apparatus at any time.

9.6 After the leveling operation, tap the density cup lightly on the side to settle the powder to avoid spilling in transfer.

9.7 Transfer the filled density cup to the balance and weigh to determine the mass (M) of powder. Record the mass to the nearest 0.001 g.

9.8 More than one apparent density test may be run if desired. Use a fresh test portion of powder for each test. Average the apparent density values.

10. Calculation

10.1 Calculate the apparent density as follows:

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

where:

M = mass of powder in the density cup in grams, and
 V = volume of the density cup in cubic centimetres.

11. Report

11.1 Report the results as apparent density, Carney (AD_c), to the nearest 0.01 g/cm^3 .

11.2 Report the relativity humidity of the laboratory to the nearest 5 % relative humidity if applicable (see Section 6).

11.3 Report the temperature of the laboratory to the nearest 1°C if applicable (see Section 6).

12. Precision and Bias

12.1 *Precision*—The precision of this test method has not been determined by a statistically valid interlaboratory test. An interlaboratory study of the Carney AD was conducted in 1991. Each of eight laboratories tested three randomly drawn test portions from a tin powder that was 75 % minus 45 micrometres with an average apparent density of 4.19 g/cm^3 . The design of the study followed Practice E691.

12.1.1 The 95 % repeatability limit, r , as defined by Terminology E456, is 1 %. The repeatability was determined based on three individual tests in each laboratory before averaging.

12.1.2 The 95 % reproducibility, R , as defined by Terminology E456, is 4 %. The reproducibility was based on the standard deviation of the averages of three determinations in each laboratory.

12.1.3 *Measurement Uncertainty*—The precision of Test Method B417 shall be considered by those performing the test when reporting Carney apparent density test results.

12.2 *Bias*—No information can be presented on the bias of the procedures in Test Method B417 for measuring the Carney apparent density because no material having an accepted reference value is available.

13. Keywords

13.1 apparent density; carney; flowmeter funnel; metal powders

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B417 – 22) that may impact the use of this standard.

- (1) 1.1 has been modified to include powder mixtures.
- (2) An Interferences section has been added (Section 6) to provide guidance on the effects of humidity and how to handle powders that are particularly sensitive to moisture.
- (3) Footnote 3 has been deleted. Kymera International (formerly ACuPowder) is not the sole source for the Carney flowmeter funnel. It is, however, the sole source for the certified stainless steel powder used to calibrate the Carney funnel.
- (4) 9.1 has been added with instruction on testing powders under comparable humidity conditions.
- (5) Requirements for reporting relative humidity and temperature have been added to Section 11 – Report.

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