



Standard Test Method for Tap Density of Metal Powders and Compounds¹

This standard is issued under the fixed designation B527; 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 specifies a method for the determination of tap density (packed density) of metal powders and compounds, that is, the density of a powder that has been tapped, to settle contents, in a container under specified conditions.

1.2 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 long-standing industry practice, the values in SI units are to be regarded as 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[B215 Practices for Sampling Metal Powders](#)

[B243 Terminology of Powder Metallurgy](#)

[E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods](#)

[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 of Terms Specific to This Standard:* Terms used in this test method are defined in [B243](#).

4. Significance and Use

4.1 This test method covers the evaluation of the tap density physical characteristic of metal powders and related com-

¹ This specification 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 service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

pounds. The degree of correlation between the results of this test method and the quality of powders in use will vary with each particular application and has not been fully determined.

5. Apparatus

5.1 *Balance*, of appropriate capacity to satisfy the requirements shown in [Table 1](#) and accuracy of ± 0.05 g.

5.2 *Graduated Glass Cylinder*, calibrated to contain 100 cm^3 at 20 °C, the height of the graduated portion being approximately 175 mm. The graduations shall be at 1 cm^3 intervals, thus allowing a measuring accuracy of ± 0.5 cm^3 . For apparent densities over 4 g/cm^3 , do not use the 100 cm^3 cylinder, see section [5.2.1.1](#).

5.2.1 Alternatively, the following may be used:

5.2.1.1 *Graduated Glass Cylinder*, calibrated to contain 25 cm^3 at 20 °C, the height of the graduated portion being approximately 135 mm. The graduations shall be at 0.2 cm^3 intervals, thus allowing a measuring accuracy of ± 0.1 cm^3 .

5.2.1.2 A 25 cm^3 cylinder shall be used for powders of apparent density higher than 4 g/cm^3 , in particular for refractory metal powders.

5.3 *Tapping Apparatus*, which permits the tapping of the graduated cylinder against a firm base. The tapping shall be such that a densification of the powder can take place without any loosening of its surface layers. The stroke shall be 3 mm and the tapping frequency shall be between 100 and 300 taps/min. An example of a tapping apparatus is shown in [Fig. 1](#).

6. Test Specimen

6.1 For the quantities of powder required for each test, see [Table 1](#). Obtain test portions according to Practices [B215](#).

6.2 In general, the powder should be tested in the as-received condition. In certain instances the powder may be dried. However, if the powder is susceptible to oxidation, the drying shall take place in a vacuum or in inert gas. If the powder contains volatile substances, it shall not be dried.

6.3 The test shall be carried out on three test portions, if possible.

7. Procedure

7.1 Clean the inside wall of the graduated cylinder (see [5.2](#)) with a suitable clean brush or, if necessary, by rinsing with a

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

TABLE 1 Capacity and Accuracy of the Test Portion Mass and Graduated Cylinder

Apparent Density g/cm ³	Mass of Test Portion g	Cylinder Capacity cm ³	Cylinder Accuracy cm ³
<1	50 ± 0.2	100	0.5
1-4	100 ± 0.5	100	0.5
>4	100 ± 0.5	25	0.2

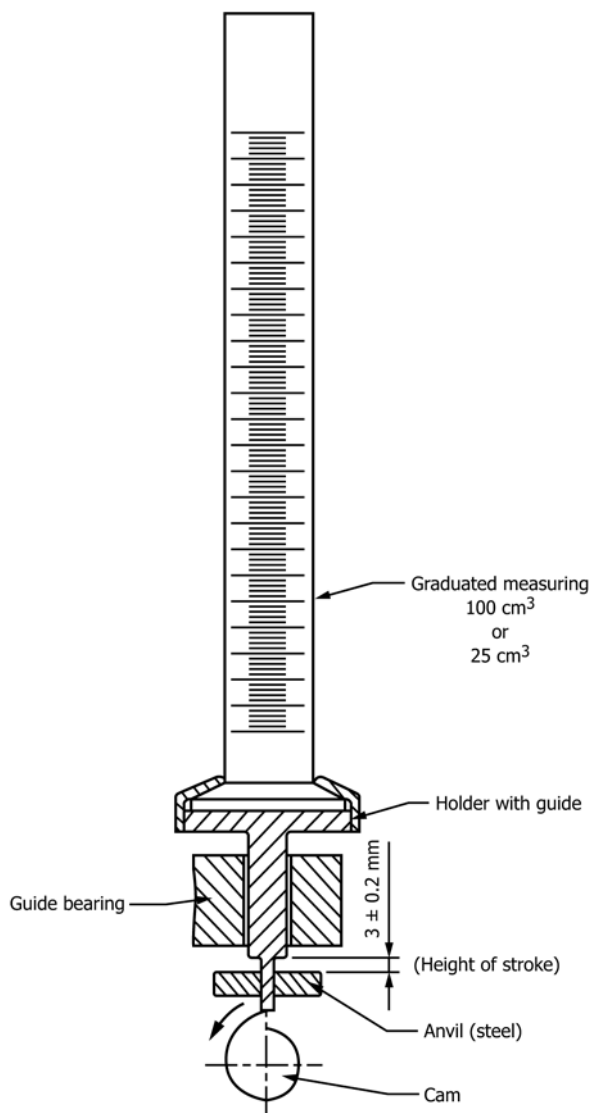


FIG. 1 Example of Tapping Apparatus

solvent, such as acetone. If a solvent is used, thoroughly dry the cylinder before reuse.

7.2 Weigh, to the nearest 0.1 g, the mass of the test portion as indicated in [Table 1](#), using a balance (see [5.1](#)).

7.3 Pour the test portion into the graduated cylinder. Take care that a level surface of the powder is formed. Place the cylinder in the tapping apparatus (see [5.3](#)). Tap the cylinder until no further decrease in the volume of the powder takes place (see [Note 1](#)).

NOTE 1—In practice, the minimum number of taps, *N*, such that no

further change in volume takes place would be determined. For all further tests on the same type of powder, the cylinder would be subjected to *2N* taps, except where general experience and acceptance have established a specific number of taps (no less than *N* taps) as being satisfactory. For fine refractory metal powders, 3000 taps has been found to be satisfactory for all sizes.

7.4 If the tapped surface is level, read the volume directly. If the tapped surface is not level, determine the tap volume by calculating the mean value between the highest and the lowest reading of the tapped surface. Read the final volume to the nearest 0.5 cm³ when using a 100 cm³ cylinder and to the nearest 0.2 cm³ when using a 25 cm³ cylinder.

8. Calculation

8.1 The tap density is given in the following equation

$$TD = \frac{M}{V} \quad (1)$$

where:

- TD* = tap density, g/cm³,
- M* = mass of powder, g, and
- V* = volume of tapped powder, cm³.

9. Report

9.1 Report the following information:

- 9.1.1 Reference to this test method,
- 9.1.2 All details necessary for identification of the test sample,
- 9.1.3 The drying procedure, if the powder has been dried,
- 9.1.4 Cylinder capacity, mass of test portion and method used,
- 9.1.5 All results obtained. Report tap density to the nearest 0.1 g/cm³ for powders with apparent densities up to and including 4 g/cm³. For powders with apparent densities higher than 4 g/cm³, report to the nearest 0.2 g/cm³;
- 9.1.6 All operations not specified in this test method or regarded as optional, and
- 9.1.7 Details of any occurrence that may have affected the result.

10. Precision and Bias

10.1 *Precision*—The precision of this test method is based on an intralaboratory study of Test Method B527, conducted in 2011–2012. A single laboratory with two operators analyzed three different powders for tap density. Either 10 or 20 replicates were reported for each material in this study. Except for testing in just one lab, Practice [E691](#) was followed for the study design; the details are given in ASTM Research Report No. RR:B09-1020.³ The precision statement was determined through statistical examination of 50 results, from a single laboratory, testing three materials. The materials were designated in the study as:

1. Cermet (TiC based), apparent density 1.02 g/cm³
2. Iron (Ancorsteel 1000), apparent density 2.92 g/cm³
3. Tungsten carbide (WC), apparent density 6.91 g/cm³

³ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B09-1020. Contact ASTM Customer Service at service@astm.org.

10.1.1 *Test Results*—The precision information presented herein has been calculated for the comparison of three materials, each of which is the mathematical average of ten or twenty individual test determinations.

10.1.1.1 *95 % Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the *r* value for that material; *r* is the interval representing the critical difference between two test results for the same material, using the same mass and appropriate volumetric cylinder capacity according to **Table 1**. Repeatability limits are listed in **Table 2**. The within-laboratory repeatability limit, *r*, as defined by Terminology **E456**, is

dependent on the apparent density of the tested material (see **Table 2**). At the 95 % confidence level, duplicate tap density results from the same laboratory should not be considered to be different unless they differ by more than *r*.

10.1.1.2 *Reproducibility Limit (R)*—The reproducibility limit of this test method is being determined and will be available in December, 2019. Reproducibility results cannot be determined from a single laboratory study.

10.2 *Bias*—No information can be presented on the bias of the procedure in Test Method B527 for measuring tap density because no material having an accepted reference value is available.

10.3 The above terms (“repeatability limit” and “reliability limit”) are used as specified in Practice **E177**.

10.4 Any judgment in accordance with statement **10.1.1** would normally have an approximate 95 % probability of being correct, however because of the limited number of participants in this study, consider the precision noted as an estimate.

TABLE 2 Tap Density (g/cm³)

Material (100 gm per run)	Cylinder Capacity cm ³	Average ^A \bar{x}	Repeatability Standard Deviation s_r	Repeatability Limit r
Cermet – 20 replicates	100	1.6	0.02	0.06
Iron – 20 replicates	100	3.7	0.10	0.29
Tungsten Carbide (WC) – 10 replicates	25	8.2	0.07	0.20

^AThe average of the laboratories' calculated averages.

11. Keywords

11.1 apparent density; bulk density; density; density ratio; metal powders; packed density; powder metallurgy; tap density

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B527 – 14) that may impact the use of this standard. (Approved April 1, 2015.)

(1) Removed "Determination of" from the title.

Committee B09 has identified the location of selected changes to this standard since the last issue (B527 – 06) that may impact the use of this standard. (Approved April 1, 2014.)

(1) Changed “metallic” to “metal” in the title.

(2) Section **3** on Terminology was added and subsequent sections were renumbered.

(3) Units statement added to the Scope, Section **1**, indicating that the standard uses SI, and removed inch-pound units.

(4) Minor editorial changes were made throughout.

(5) Clarifications in some sections regarding accuracy.

(6) In **5.2.1.2**, delete phrase allowing the use of 25 cm³ cylinder for lower density powders. A larger volume cylinder must be used for powders with density less than 4 g/cm³.

(7) Replacement of **Table 1**. Mass of sample used and capacity of the graduated cylinder was modified to be consistent with other international standards following the analysis of published data.

(8) Addition of data in Section **10**.

(9) Changes made to acronyms to conform with newly accepted B09 Policy Guide, e.g., P_t for tap density is now *TD*.

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