Designation: D7481 – 09

# Standard Test Methods for Determining Loose and Tapped Bulk Densities of Powders using a Graduated Cylinder[1]

This standard is issued under the fixed designation D7481; 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 apparatus and procedures for determining the bulk densities of free flowing and moderately cohesive powders and granular materials up to 3.5 mm in size in their loose (Method A) and tapped (Method B) states.

1.2 This test method should be performed in a laboratory under controlled conditions of temperature and humidity.

1.3 This test method is similar to those of Test Methods B212, D29, and D2854.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.4.1 The procedures used to specify how data are collected/recorded or calculated in this standard are regarded as the industry standard. In addition they are representative of the significant digits that generally should be retained. The procedures used do not consider material variations, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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]

B212 Test Method for Apparent Density of Free-Flowing Metal Powders Using the Hall Flowmeter Funnel

B527 Test Method for Determination of Tap Density of Metallic Powders and Compounds

C29/C29M Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate

D29 Test Methods for Sampling and Testing Lac Resins (Withdrawn 2005)[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2854 Test Method for Apparent Density of Activated Carbon

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4164 Test Method for Mechanically Tapped Packing Density of Formed Catalyst and Catalyst Carriers

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D6026 Practice for Using Significant Digits in Geotechnical Data

D6683 Test Method for Measuring Bulk Density Values of Powders and Other Bulk Solids as Function of Compressive Stress

## 3. Terminology

3.1 *Definitions*—For common definitions of technical terms in this standard, refer to Terminology D653.

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.24 on Characterization and Handling of Powders and Bulk Solids.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *loose bulk density, $\rho_L$, g/cm³, n—in powders*, the bulk density that results from pouring the powder into a heap or container in the absence of any applied compression, g/cm³.

3.2.2 *tapped bulk density, $\rho_T$, g/cm³, n—in powders*, the bulk density resulting from the application of compression, for example, impact or vibration, g/cm³.

## 4. Summary of Test Method

4.1 Loose bulk density (Method A) is determined by measuring the volume of a known mass of powder that has been passed through a screen or funnel into a graduated cylinder.

4.2 Tapped bulk density (Method B) is achieved by mechanically tapping a measuring cylinder containing a powder. After observing the initial volume, the cylinder is mechanically tapped, and volume readings are taken until little further volume change is observed.

## 5. Significance and Use

5.1 The data from the loose bulk density test can be used to estimate the size of bags, totes, small bins or hoppers for the storage of a fixed mass of powder in its loose condition. It can also be used to estimate the mass of powder that will fit in small size containers such as drums. It cannot be used to estimate powder quantities of large vessels such as silos.

5.2 Values of loose bulk density obtained using this test method should be used with caution, since they can vary considerably depending on the inital state of dispersion of the test specimen, height-to-diameter ratio of specimen in graduated cylinder, dryness of powder, and other factors.

5.3 The data from the tapped bulk density test can be used to estimate the needed volume of small containers holding a fixed mass of powder that has been compacted. An example would be a packing line where vibration is used to tamp powders into a small container for effective packing purposes.

5.4 Bulk density values can vary significantly if the particle size of the actual material to be handled is different than tested. A bulk solid consisting of large and small particles often has higher bulk densities than the fine particles by themselves. For powders, lower densities are possible if the fine particles are fluidized or aerated.

5.5 The results of this test method are most applicable to containers with volumes up to about one cubic meter. Another method (such as D6683) should be used when considering larger silos.

NOTE 1—The quality of the results produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors. Practice D3740 was developed for agencies engaged in the testing or inspection (or both) of soil and rock. As such it is not totally applicable to agencies performing this standard. However, users of this standard should recognize that the framework of Practice D3740 is appropriate for evaluating the quality of an agency performing this standard. Currently there is no known qualifying national authority that inspects agencies that perform this standard.

## 6. Apparatus

6.1 Balance having a minimum capacity of 400 g and meeting the requirements of Guide D4753 for a balance of 0.1 g readability.

6.2 250 mL or 100 mL standard glass graduated cylinder. See 7.3.

6.3 Two screens: 1.7 mm (No. 12 U.S. sieve), 4.00 mm (No. 5 U.S. sieve). Each screen should be full height and 200 mm diameter.

6.4 Suitable mechanical tapped density tester that provides a fixed drop of 14 ± 2 mm at a nominal rate of 300 drops per minute or a fixed drop of 3 mm ± 0.3 mm at a nominal rate of 250 drops per minute. A typical tester is shown in Fig. 1.

## 7. Preparation of Apparatus

7.1 Check that the balance is set on a sturdy table or bench, leveled and zeroed.

7.2 Make sure that the graduated cylinder is clean of any and all foreign material (including water or other liquids) prior to starting each test.

7.3 Depending on the untapped apparent volume of the test specimen and its particle size gradation, choose either a 250 mL or 100 mL standard glass graduated cylinder using the table below.

| Graduated cylinder size, mL | Untapped apparent volume of test specimen, mL | | Upper limit on particle size, mm | |
|---|---|---|---|---|
| | Min. | Max. | $d_{50}$ | Absolute max. |
| 100 | 50 | 100 | 1.3 | 2.5 |
| 250 | 125 | 250 | 1.7 | 3.5 |

## 8. Procedure

8.1 *Loose Bulk Density (Method A):*

8.1.1 Determine and record the mass of the graduated cylinder to the nearest 0.1 g.

8.1.2 Choose an appropriate dispersion method to ensure that the material hasn't agglomerated from transit. If this test is being conducted on a fine powder with particles much smaller than 1 mm, pass a sufficient quantity though a 1.00 mm (18 mesh) screen to break up agglomerates that may have formed during storage. Oversized particles should not be excluded from the test. Should any particles not pass through the screen, an alternate dispersion method is required, such as selecting a screen slightly larger than the largest particle to pass the material through, or stirring the material in a mixing bowl with a spatula. Maximum limits on particle size for this test are provided in 7.3. Avoid agglomeration and segregation of material. Describe method used on Test Data Sheet.

8.1.3 If necessary, carefully level the powder without compacting, and read the unsettled apparent volume to the nearest graduated unit. Determine and record the volume of the powder in the cylinder to the nearest graduated unit; that is, 1 mL for the 100-mL cylinder and 2 mL for the 250-mL cylinder, noting that 1 mL is equal to 1 cm³.

**FIG. 1 Typical Mechanical Tapped Density Tester**

8.1.4 An alternate method would be to fill a 250-mL or 100-mL cylinder to a measured volume line.

8.1.5 Determine and record the mass of the specimen plus graduated cylinder to the nearest 0.1 g.

8.2 *Tapped Bulk Density (Method B):*

8.2.1 Repeat steps 8.1.1 through 8.1.5.

8.2.2 Mechanically tap the cylinder containing the powder specimen by raising the cylinder and allowing it to drop under its own mass using a suitable mechanical tapped density tester that provides a fixed drop of 14 ± 2 mm at a nominal rate of 300 drops per minute. This is Method B1.

8.2.3 An alternate method (Method B2) is to use a fixed drop of 3 mm ± 0.3 mm at a nominal rate of 250 drops per minute. This may yield lower values of tapped bulk density.

8.2.4 Unless otherwise specified, tap the cylinder 500 times initially and measure the tapped volume to the nearest graduated unit. Determine and record the volume of the powder in the cylinder to the nearest graduated unit; that is, 1 mL for the 100-mL cylinder and 2 mL for the 250-mL cylinder, noting that 1 mL is equal to 1 $cm^3$ .

8.2.5 If necessary, carefully level the powder without compacting, and read the settled apparent volume to the nearest graduated unit.

8.2.6 Repeat the tapping an additional 750 times and measure the tapped volume to the nearest graduated unit.

NOTE 2—Fewer taps may be appropriate, if validated, for some powders.

8.2.7 If the difference of the two tapped volumes of 8.2.3 and 8.2.5 is less than 2 %, use the second measurement for the tapped volume. Otherwise, repeat in increments of 1250 taps, as needed, until the difference between succeeding measurements is less than 2 %.

## 9. Calculations

9.1 *Loose Bulk Density (Method A):*

9.1.1 Determine the net mass of the specimen by subtracting the mass of the graduated cylinder from that of the specimen plus graduated cylinder.

9.1.2 Divide the net mass of the specimen by the measured volume as noted on the graduated cylinder. The calculated value is the loose bulk density in g/$cm^3$. Record value to two significant digits if 100-mL cylinder is used, and three significant digits if 250-mL cylinder is used.

9.2 *Tapped Bulk Density (Method B):*

9.2.1 Divide the net mass of the specimen by the measured volume as noted on the graduated cylinder after tapping is complete. The calculated value is the tapped bulk density in g/$cm^3$. Record value to two significant digits if 100-mL cylinder is used, and three significant digits if 250-mL cylinder is used.

## 10. Test Data Sheet

10.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s), as given below, is covered in 1.4.

10.2 Record as a minimum the following general information (data):

10.2.1 Requesting agency or client and/or identifying number for job or project

10.2.2 Technician

10.2.3 Date

10.3 Record as a minimum the following test specimen data:

10.3.1 Generic name of sample

10.3.2 Chemical name of sample, if known

10.3.3 Specimen moisture (water) content, if determined. Record value to nearest 0.1 %. Indicate method used to determine moisture if not Test Method D2216.

10.3.4 Specimen temperature

10.3.5 Specimen particle size, if determined. Indicate procedure used, which may have been specified by requesting agency or client.

10.3.6 Method used to prepare test specimen in a loose state (Section 8.1.2)

10.4 Record as a minimum the following test data:

10.4.1 Volume of graduated cylinder

10.4.2 Mass of graduated cylinder empty (tare)

10.4.3 Mass of graduated cylinder filled with material

10.4.4 Volume of loose filled specimen in graduated cylinder

10.4.5 Mass of specimen plus graduated cylinder

10.4.6 Calculated net mass of specimen

10.4.7 Calculated loose bulk density

10.4.8 Fixed drop during tapped bulk density (Method B1 or B2)

10.4.9 Rate of drops per minute during tapped bulk density

10.4.10 Number of taps and corresponding values of cylinder volume

10.4.11 Calculated tapped bulk density

10.4.12 Name and model of tapped density tester used

## 11. Precision and Bias

11.1 *Precision*—Test data on precision is not presented due to the nature of the powder and other bulk solids tested by this standard. It is not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. In addition, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory variation.

11.1.1 Subcommittee D18.24 is seeking any data from users of this standard that might be used to make a limited statement on precision.

11.2 *Bias*—There is no accepted reference value for this standard, therefore, bias cannot be determined.

## 12. Keywords

12.1 loose bulk density; tapped bulk density