

Standard Test Method for Determination of Loose and Tapped Bulk Density of Plutonium Oxide¹

This standard is issued under the fixed designation C1770; 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 loose and tapped bulk density of plutonium oxide powder.

1.2 This test method is applicable when limited quantities of powder are available for performance of the measurements. Alternative test methods, such as Test Methods B527 or D7481, may be used when sufficient quantities are available.

1.3 This test method contains notes that are explanatory and are not part of the mandatory requirements of the method.

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

1.5 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. Some specific hazards statements are given in Section 7 on Hazards.

2. Referenced Documents

2.1 ASTM Standards:²

B527 Test Method for Tap Density of Metal Powders and Compounds

- C859 Terminology Relating to Nuclear Materials
- D3766 Terminology Relating to Catalysts and Catalysis
- D6393 Test Method for Bulk Solids Characterization by Carr Indices
- D7481 Test Methods for Determining Loose and Tapped Bulk Densities of Powders using a Graduated Cylinder
- E135 Terminology Relating to Analytical Chemistry for Metals, Ores, and Related Materials

E1272 Specification for Laboratory Glass Graduated Cylinders

3. Terminology

3.1 For definitions of terms used in this test method but not defined herein, refer to Terminologies C859 and E135.

3.2 Definitions:

3.2.1 *bulk density*, n—ratio of the mass of a collection of discrete pieces of solid material to the sum of the volumes of: the solids in each piece, the voids within the pieces, and the voids among the pieces of the particular collection. **D3766**

3.2.2 *loose bulk density, n*—bulk density that results from pouring the powder into a heap or container in the absence of any applied compression. **D7481**

3.2.3 *tapped bulk density*, *n*—bulk density resulting from the application of compression, for example, impact or vibration. **D7481**

4. Summary of Test Method

4.1 Loose bulk density is determined by measuring the volume of a known mass of plutonium oxide powder poured into a graduated cylinder with a capacity of 10, 25, 50, or 100 cm³. The cylinder size should be selected based on the amount of plutonium oxide powder available for the test.

4.2 The cylinder is then mechanically tapped at a dropping height of 3 mm for 2 min at 250 taps per minute, and the resulting volume is then measured. This process is repeated for cycles of 2 min until the difference in tapped volumes is less than 2 %.

5. Significance and Use

5.1 This test method is intended for determination of bulk loose or tapped density or both for plutonium oxide or similar metallic powders or compounds in the nuclear industry. It is intended for use when the quantity of available material for performing the measurements is limited because of reasons such as nuclear safety or laboratory scale limits on nuclear inventory.

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 initial state of dispersion of the

¹ This test method is under the jurisdiction of ASTM Committee C26 on Nuclear Fuel Cycle and is the direct responsibility of Subcommittee C26.05 on Methods of Test.

Current edition approved Jan. 1, 2013. Published February 2013. DOI: 10.1520/ C1770-13

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.

test specimen, height-to-diameter ratio of the specimen in the graduated cylinder, the dryness of the 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.

5.4 This test method may be useful for the determination of the Carr Compressibility Index as described in Test Method D6393.

6. Apparatus

6.1 Balance, analytical, 0.1-mg sensitivity.

6.2 *Graduated glass cylinder*, with a capacity of 10, 25, 50, or 100 cm³, Class A, meeting the requirements of Specification E1272.

6.3 *Tapping Apparatus*, with the following features (see Fig. 1).

6.3.1 The apparatus permits the tapping of the graduated cylinder against a firm base.



FIG. 1 Example of Tapping Apparatus (Adapted from Test Method B527)

6.3.2 The apparatus shall be capable of a tapping rate of 250 + 15 taps per minute.

6.3.3 The minimum stroke or dropping height shall be 3 mm.

6.3.4 The apparatus shall have an adjustable counter that can be pre-set to deliver between 1 and 9999 taps.

7. Procedure

7.1 Ensure that the balance is set on a sturdy surface, leveled, and zeroed.

7.2 Ensure that the graduated glass cylinder is dry and clean of any and all foreign material before starting each test.

7.3 Determine and record the mass of the graduated cylinder to the nearest 0.1 mg.

7.4 Transfer the powder to the graduated cylinder as follows:

7.4.1 Using a powder funnel, quantitatively pour the sample into the graduated cylinder.

7.4.2 Ensure that the volume of the loose bulk powder is at least 40 % of the volume of the cylinder (for example, when using a 10-cm³ cylinder, the minimum volume is 4.0 cm^3 .)

Note 1—These volumes are necessary to determine whether the difference in tapped volumes is less than 2 % (see 7.8).

7.4.3 Avoid attempting to level the surface since plutonium oxide powder will self-compress yielding an artificially high loose bulk density.

7.5 Record the loose bulk powder volume, $V_{\rm L}$. If the surface is level, read the volume directly. If the surface is not level, determine the volume by calculating the mean value between the highest and the lowest reading of the surface. Record the volume to the nearest 0.1 cm³ when using a 10-cm³ cylinder, the nearest 0.2 cm³ when using a 25-cm³ cylinder, or the nearest 0.5 cm³ when using a 50-or 100-cm³ cylinder.

7.6 Place the graduated cylinder containing the sample onto the balance. Determine and record the mass to the nearest 0.1 mg.

7.7 Load the graduated cylinder containing the sample into the tapping apparatus. Tap the cylinder as described in either 7.8 or 7.9:

7.8 *Tapping procedure for processes not well characterized:* 7.8.1 Tap the cylinder for 2 min at 250 taps per minute for a total of 500 taps.

7.8.2 Read and record the tapped bulk powder volume, $V_{\rm T}$, directly to the nearest 0.1 cm³ when using a 10-cm³ cylinder, the nearest 0.2 cm³ when using a 25-cm³ cylinder, or the nearest 0.5 cm³ when using a 50-cm³ or 100-cm³ cylinder.

7.8.3 Tap the cylinder for an additional 2 min at 250 taps per minute.

7.8.4 Read and record the volume, $V_{\rm T}$.

7.8.5 If the difference between the two tapped volumes in 7.8.2 and 7.8.4 less than 2 %, use the smaller of the two measurements in 7.8.2 and 7.8.4 for the tapped volume. Otherwise, repeat 7.8.3 and 7.8.4 until the difference between succeeding measurements is less than 2 %.

7.9 Tapping Procedure for Well-Characterized Processes:

(1)

7.9.1 Tap the cylinder for a minimum of 1000 taps.

7.9.2 Read and record the tapped bulk powder volume, $V_{\rm T}$, directly to the nearest 0.1 cm³ when using a 10-cm³ cylinder, the nearest 0.2 cm³ when using a 25-cm³ cylinder, or the nearest 0.5 cm³ when using a 50- or 100-cm³ cylinder.

 $\rho_L = (M_{(C+S)} - M_C)/V_L$

8. Calculation

8.1 Calculate the loose bulk density using Eq 1:

Where:

 ρ_L = loose bulk density, g/cm³; $M_{(C+S)}$ = mass of cylinder plus sample, g; M_C = mass of cylinder, g; and V_L = volume of loose bulk powder, cm₃.

8.2 Calculate the tapped bulk density using Eq 2:

$$\rho_T = \left(M_{(C+S)} - M_C \right) / V_T \tag{2}$$

Where:

 $\begin{array}{lll} \rho_T &= \text{tapped bulk density, g/cm}^3; \\ M_{(C+S)} &= \text{mass of cylinder plus sample, g}; \\ M_C &= \text{mass of cylinder, g; and} \\ V_T &= \text{volume of tapped bulk powder, cm}_3. \end{array}$

Note 2—The difference between $M_{\rm (C+S)}$ and $M_{\rm C}$ is the mass of the powder sample.

9. Test Data Sheet

9.1 *General Information*—Record as a minimum the following:

9.1.1 Requesting agency or client,

9.1.2 Analyst, and

9.1.3 Date.

9.2 *Test Specimen Information*—Record as a minimum the following:

9.2.1 Unique sample identification and

9.2.2 Sample description.

9.3 Test Results-Record as a minimum the following:

- 9.3.1 Volume of graduated cylinder;
- 9.3.2 Mass of empty graduated glass cylinder, M_C;
- 9.3.3 Mass of cylinder plus sample, $M_{(C+S)}$;
- 9.3.4 Volume of loose bulk powder, $V_{\rm L}$;
- 9.3.5 Calculated loose bulk density, $\rho_{\rm L}$;

9.3.6 Number of taps and corresponding values of tapped bulk powder volume, $V_{\rm T}$, for each cycle of tapping performed;

9.3.7 Calculated tapped bulk density, ρ_T ; and

9.3.8 Identification for tapping apparatus used.

10. Precision and Bias

10.1 Precision and bias data were not available at the time of publication of this test method. An interlaboratory study will be conducted within five years of the publication of this standard, following which a revised version of this standard will be published containing precision and bias data. Those interested in participating in the study should contact the committee having jurisdiction for this standard.

11. Keywords

11.1 apparent density; nuclear materials; packed density; powder metallurgy

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