Designation: ~~C1770 – 13~~ C1770 – 21

Standard Test Method for Determination of Loose and Tapped Bulk ~~Density of~~ Densities of Small Quantities of Plutonium Oxide[1]

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 (PuO_2) 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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.* Some specific hazards statements are given in Section ~~7~~7 on Hazards.

1.6 *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]

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.~~

[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.
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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.

3.1 *Definitions:*

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

3.2 ~~*Definitions:*~~*Definitions of Terms Specific to This Standard:*

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:~~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~~PuO_2 ~~oxide~~ powder poured into a graduated cylinder with a capacity of ~~10, 25, 50,~~ 10 mL, 25 mL, 50 mL, or 100 ~~cm~~$mL.^{3}$~~.~~ The cylinder size should be selected based on the amount of ~~plutonium~~PuO_2 ~~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 %.~~ 4 % (this corresponds to a change of less than one graduation on the 10 mL, 25 mL, and 50 mL graduated cylinders and two graduations on the 100 mL graduated cylinder).

5. Significance and Use

5.1 This test method is intended for determination of ~~bulk~~ loose or tapped bulk density or both for ~~plutonium~~PuO_2 ~~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 This test method can be applied to other metal powders in the nuclear industry provided that appropriate validation has been performed.

5.3 Values of loose bulk density obtained using this test method should be used with caution since they can vary considerably depending on factors such as the initial state of dispersion of the test specimen, height-to-diameter ratio of the specimen in the graduated cylinder, the dryness of the powder, and ~~other factors.~~operator-to-operator variation (for example, the speed with which the sample is poured into the cylinder).

5.4 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.

5.5 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 0.~~1 mg sensitivity.

6.2 *Graduated glass cylinder,* with a capacity of ~~10, 25, 50,~~ 10 mL, 25 mL, 50 mL, or 100 ~~cm~~$mL,^{3}$~~,~~ 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.

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

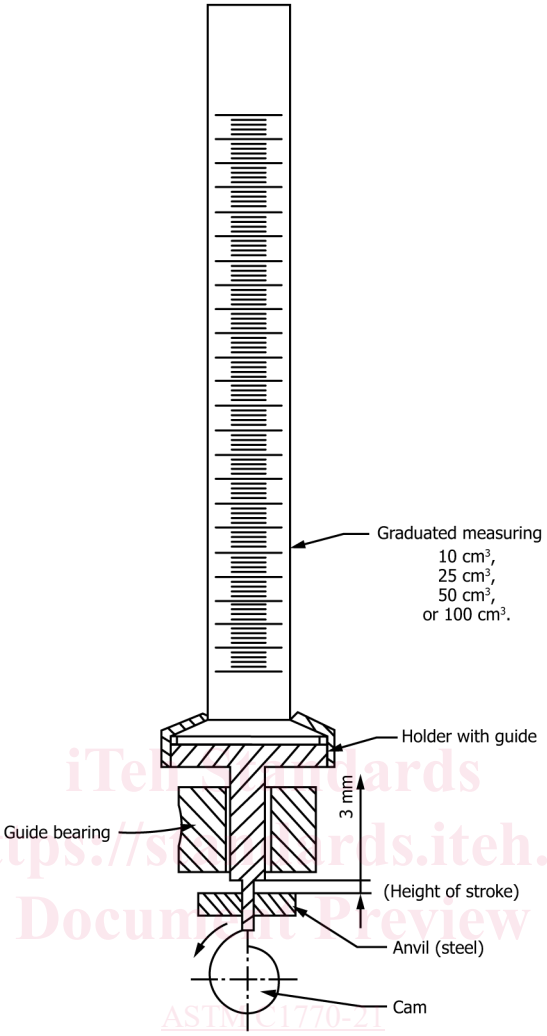

FIG. 1 Example of Tapping Apparatus
(Adapted from Test Method B527)

6.3.3 The minimum stroke or dropping height shall be ~~3 mm.~~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~~slowly 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 cm~~10^3 mL cylinder, the minimum volume is 4.0 ~~cm~~mL.)~~^{3}.)~~

NOTE 1—These volumes are necessary to determine whether the difference in tapped volumes is less than 24 % (see 7.8).

7.4.3 Avoid attempting to level the surface since ~~plutonium~~PuO_2 ~~oxide~~ powder will self-compress yielding an artificially high loose bulk density.

7.5 Record the loose bulk powder volume, V_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 cm~~cylinder graduation.[3] ~~when using a 10-cm^3 cylinder, the nearest 0.2 cm^3 when using a 25-cm^3 cylinder, or the nearest 0.5 cm^3 when using a 50-or 100-cm^3 cylinder.~~

7.6 Place the graduated cylinder containing the sample onto the balance. Determine and record the mass to the nearest ~~0.1 mg.~~ 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_T, directly to the nearest ~~0.1 cm~~cylinder graduation.[3] ~~when using a 10-cm^3 cylinder, the nearest 0.2 cm^3 when using a 25-cm^3 cylinder, or the nearest 0.5 cm^3 when using a 50-cm^3 or 100-cm^3 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_T.

7.8.5 If the difference between the two tapped volumes in 7.8.2 and 7.8.4is less than ~~2~~4 %, 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~~4 %.

7.9 *Tapping Procedure for ~~Well-Characterized~~Well-characterized Processes:*

7.9.1 Tap the cylinder for a minimum of 1000 taps.

7.9.2 Read and record the tapped bulk powder volume, V_T, directly to the nearest ~~0.1 cm~~cylinder graduation.[3] ~~when using a 10-cm^3 cylinder, the nearest 0.2 cm^3 when using a 25-cm^3 cylinder, or the nearest 0.5 cm^3 when using a 50- or 100-cm^3 cylinder.~~

8. Calculation

8.1 Calculate the loose bulk density using Eq 1:

~~$$\rho_L = (M_{(C+S)} - M_C)/V_L \quad (1)$$~~

$$\rho_L = \frac{(M_{(C+S)} - M_C)}{V_L} \quad (1)$$

Where:

~~ρ_L = loose bulk density, g/cm^3;~~
~~$M_{(C+S)}$ = mass of cylinder plus sample, g;~~
~~M_C = mass of cylinder, g; and~~
~~V_L = volume of loose bulk powder, cm$_3$.~~

ρ_L = loose bulk density, g/mL,
$M_{(C+S)}$ = mass of cylinder plus sample, g,
M_C = mass of cylinder, g, and