



# Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method<sup>1</sup>

This standard is issued under the fixed designation D 1556; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope\*

1.1 This test method may be used to determine the in-place density and unit weight of soils using a sand cone apparatus.

1.2 This test method is applicable for soils without appreciable amounts of rock or coarse materials in excess of 1½ in. (38 mm) in diameter.

1.3 This test method may also be used for the determination of the in-place density and unit weight of intact or *in situ* soils, provided the natural void or pore openings in the soil are small enough to prevent the sand used in the test from entering the voids. The soil or other material being tested should have sufficient cohesion or particle attraction to maintain stable sides on a small hole or excavation, and be firm enough to withstand the minor pressures exerted in digging the hole and placing the apparatus over it, without deforming or sloughing.

1.4 This test method is not suitable for organic, saturated, or highly plastic soils that would deform or compress during the excavation of the test hole. This test method may not be suitable for soils consisting of unbound granular materials that will not maintain stable sides in the test hole, soils containing appreciable amounts of coarse material larger than 1½ in. (38 mm), and granular soils having high void ratios.

1.5 When materials to be tested contain appreciable amounts of particles larger than 1½ in. (38 mm), or when test hole volumes larger than 0.1 ft<sup>3</sup> (2830 cm<sup>3</sup>) are required, Test Method D 4914 or D 5030 are applicable.

1.6 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and a unit of force (lbf). This implicitly combines two separate systems of units, that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. This test method has been written using the gravitational system of units when dealing with the inch-pound system. In this system the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording

pounds of mass (lbm), or the recording of density in lbm/ft<sup>3</sup> should not be regarded as nonconformance with this test method.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026 unless superseded by this standard.

1.7.1 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 variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; it is common practice to increase or reduce significant digits or reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analytical methods for engineering design.

1.8 *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:<sup>2</sup>

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft<sup>3</sup> (600 kN-m/m<sup>3</sup>))

D 1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft<sup>3</sup> (2,700 kN-m/m<sup>3</sup>))

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

- as Used in Engineering Design and Construction
- D 4253** Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
  - D 4254** Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
  - D 4643** Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
  - D 4718** Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
  - D 4753** Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
  - D 4914** Test Methods for Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit
  - D 4944** Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
  - D 4959** Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating
  - D 5030** Test Method for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit
  - D 6026** Practice for Using Significant Digits in Geotechnical Data

### 3. Terminology

3.1 *Definitions:* For definitions of terms in this standard, refer to Terminology **D 653**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *compacted lift, n*—a layer of compacted soil.

### 4. Summary of Test Method

4.1 A test hole is hand excavated in the soil to be tested and all the material from the hole is saved in a container. The hole is filled with free flowing sand of a known density, and the volume is determined. The in-place wet density of the soil is determined by dividing the wet mass of the removed material by the volume of the hole. The water content of the material from the hole is determined and the dry mass of the material and the in-place dry density are calculated using the wet mass of the soil, the water content, and the volume of the hole.

### 5. Significance and Use

5.1 This test method is used to determine the density and water content of compacted soils placed during the construction of earth embankments, road fill, and structural backfill. It often is used as a basis of acceptance for soils compacted to a specified density or percentage of a maximum density determined by a test method, such as Test Methods **D 698** or **D 1557**.

5.1.1 Test Methods **D 698** and **D 1557** require that mass measurements of laboratory compacted test specimens be determined to the nearest 1 g so that computed water contents and densities can be reported to three and four significant digits, respectively. This standard is a field procedure requiring mass measurements to the nearest 5 g. As such water content calculations should only be reported to two significant digits and density to three significant digits.

5.2 This test method can be used to determine the in-place density of natural soil deposits, aggregates, soil mixtures, or other similar material.

5.3 The use of this test method is generally limited to soil in an unsaturated condition. This test method is not recommended for soils that are soft or friable (crumble easily) or in a moisture condition such that water seeps into the hand excavated hole. The precision of the test may be affected for soils that deform easily or that may undergo a volume change in the excavated hole from vibration, or from standing or walking near the hole during the test (see **Note 1**).

**NOTE 1**—When testing in soft conditions or in soils near saturation, volume changes may occur in the excavated hole as a result of surface loading, personnel performing the test, and the like. This can sometimes be avoided by the use of a platform that is supported some distance from the hole. As it is not always possible to detect when a volume change has taken place, test results should always be compared to the theoretical saturation density, or the zero air voids line on the dry density versus water content plot. Any in-place density test on compacted soils that calculates to be more than 95 % saturation is suspect and an error has probably occurred, or the volume of the hole has changed during testing.

**NOTE 2**—Notwithstanding the statements on precision and bias contained in this test method, the precision of this test method 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 **D 3740** are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice **D 3740** does not in itself ensure reliable testing. Reliable testing depends on many factors; Practice **D 3740** provides a means of evaluating some of those factors.

### 6. Apparatus

6.1 *Sand-Cone Density Apparatus*, consisting of sand container, sand cone, and base plate.

6.1.1 *Sand Container*, an attachable jar or other sand container having a volume capacity in excess of that required to fill the test hole and sand cone during the test.

6.1.2 *Sand Cone*, a detachable appliance consisting of a cylindrical valve with an orifice approximately ½ in. (13 mm) in diameter, attached to a metal funnel and sand container on one end, and a large metal funnel (sand-cone) on the other end. The valve will have stops to prevent rotating past the completely open or completely closed positions. The appliance will be constructed of metal sufficiently rigid to prevent distortion or volume changes in the cone. The walls of the cone will form an angle of approximately 60° with the base to allow uniform filling with sand.

6.1.3 *Base Plate*, a metal base plate or template with a flanged center hole cast or machined to receive the large funnel (cone) of the appliance described in 6.1.2. The base plate may be round or square and will be a minimum of 3 in. (75 mm) larger than the funnel (sand-cone). The plate will be flat on the bottom and have sufficient thickness or stiffness to be rigid. Plates with raised edges, ridges, ribs, or other stiffeners of approximately ⅜ to ½ in. (10 to 13 mm) high may be used.

6.1.4 The mass of the sand required to fill the sand cone and base plate will be determined in accordance with the instructions in **Annex A1** prior to use.

6.1.5 The details for the apparatus shown in **Fig. 1** represents the minimum acceptable dimensions suitable for testing soils having maximum particle sizes of approximately 1½ in.

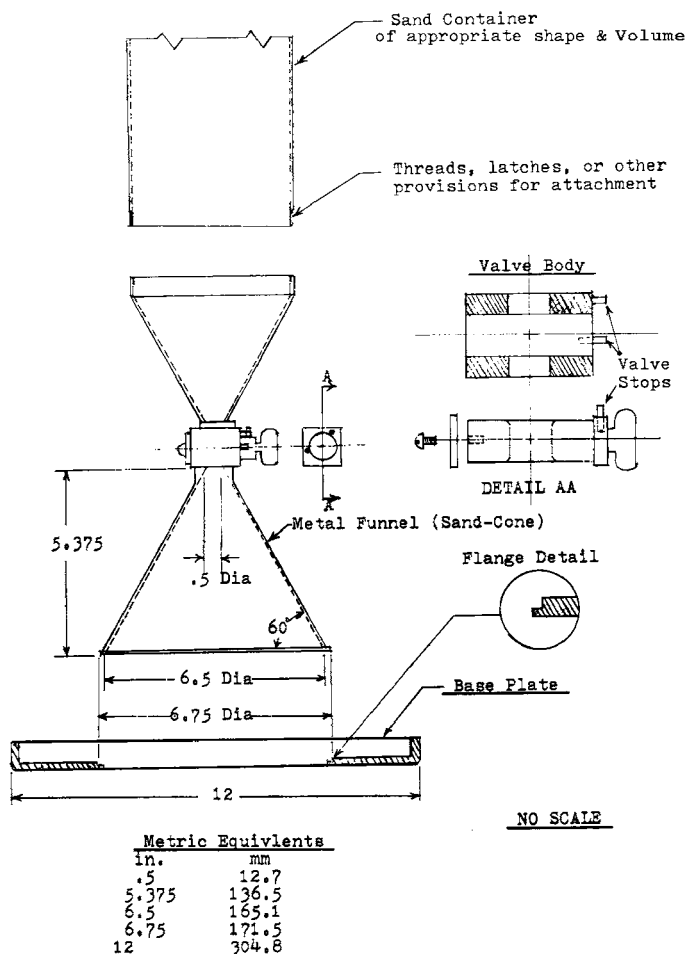


FIG. 1 Density Apparatus

(38 mm) and test hole volumes of approximately 0.1 ft<sup>3</sup> (2830 cm<sup>3</sup>). When the material being tested contains a small amount of oversize and isolated larger particles are encountered, the test should be moved to a new location. Larger apparatus and test hole volumes are needed when particles larger than 1½ in. (38 mm) are prevalent. The apparatus described here represents a design that has proven satisfactory. Larger apparatus, or other designs of similar proportions may be used as long as the basic principles of the sand volume determination are observed. When test hole volumes larger than 0.1 ft<sup>3</sup> (5660 cm<sup>3</sup>) are required Test Method D 4914 should be utilized.

6.2 *Sand*—Sand must be clean, dry, uniform in density and grading, uncemented, durable, and free-flowing. Any gradation may be used that has a uniformity coefficient ( $C_u = D_{60}/D_{10}$ ) less than 2.0, a maximum particle size smaller than 2.0 mm (No. 10 sieve), and less than 3 % by weight passing 250 μm (No. 60 sieve). Uniformly graded sand is needed to prevent segregation during handling, storage, and use. Sand free of fines and fine sand particles is required to prevent significant bulk-density changes with normal daily changes in atmospheric humidity. Sand comprised of durable, natural sub-rounded, or rounded particles is desirable. Crushed sand or sand having angular particles may not be free-flowing, a condition that can cause bridging resulting in inaccurate density determinations (see Note 3). In selecting a sand from a

potential source, a gradation and bulk-density determinations in accordance with the procedure in Annex A2 should be made on each container or bag of sand. To be an acceptable sand, the bulk-density variation between any one determination shall not be greater than 1 % of the average. Before using sand in density determinations, it shall be dried, then allowed to reach an air-dried state in the general location where it is to be used (see Note 4). Sand shall not be re-used without removing any contaminating soil, checking the gradation, drying and re-determining the bulk-density (see Note 5). Bulk-density tests of the sand will be made at time intervals not exceeding 14 days, always after any significant changes in atmospheric humidity, before reusing, and before use of a new batch from a previously approved supplier (see Note 6).

NOTE 3—Some manufactured (crushed) sands such as blasting sand have been successfully used with good reproducibility. The reproducibility of test results using angular sand should be checked under laboratory controlled testing situations before selecting an angular sand for use.

NOTE 4—Many organizations have found it beneficial to store sands in moisture resistant containers. Sand should be stored in dry areas protected from weather. The use of a lighted bulb or other heat source in, or adjacent to the storage containers has also been found to be beneficial in areas of high humidity.

NOTE 5—As a general rule, reclaiming sand after testing is not desirable.

NOTE 6—Most sands have a tendency to absorb moisture from the atmosphere. A very small amount of absorbed moisture can make a substantial change in bulk-density. In areas of high humidity, or where the humidity changes frequently, the bulk-density may need to be determined more often than the 14 day maximum interval indicated. The need for more frequent checks can be determined by comparing the results of different bulk-density tests on the same sand made in the same conditions of use over a period of time.

6.3 *Balances or Scales*—Meeting Specification D 4753, with 5.0 g readability, or better, to determine the mass of sand and excavated soils. A balance or scale having a minimum capacity of 20 kg (44 lbf) and 5 g (0.01 lbf) readability is suitable for determining the mass of the sand and the excavated soil when apparatus with the dimensions shown in Fig. 1 is used.

6.4 *Drying Equipment*—Equipment corresponding to the method used for determining water content as specified in Test Methods D 2216, D 4643, D 4959, or D 4944.

6.5 *Miscellaneous Equipment*—Knife, small pick, chisel, small trowel, screwdriver, or spoons for digging test holes, large nails or spikes for securing the base plate; buckets with lids, plastic-lined cloth sacks, or other suitable containers for retaining the density samples, moisture sample, and density sand respectively; small paint brush, calculator, notebook or test forms, etc.

## 7. Procedure

7.1 Select a location/elevation that is representative of the area to be tested, and determine the density of the soil in-place as follows:

7.1.1 Inspect the cone apparatus for damage, free rotation of the valve, and properly matched baseplate. Fill the cone container with conditioned sand for which the bulk-density has been determined in accordance with Annex A2, and determine the total mass.



7.1.2 Prepare the surface of the location to be tested so that it is a level plane. The base plate may be used as a tool for striking off the surface to a smooth level plane.

7.1.3 Seat the base plate on the plane surface, making sure there is contact with the ground surface around the edge of the flanged center hole. Mark the outline of the base plate to check for movement during the test, and if needed, secure the plate against movement using nails pushed into the soil adjacent to the edge of the plate, or by other means, without disturbing the soil to be tested.

7.1.4 In soils where leveling is not successful, or surface voids remain, the volume horizontally bounded by the funnel, plate and ground surface must be determined by a preliminary test. Fill the space with sand from the apparatus, determine the mass of sand used to fill the space, refill the apparatus, and determine a new initial mass of apparatus and sand before proceeding with the test. After this measurement is completed, carefully brush the sand from the prepared surface (see **Note 7**).

**NOTE 7**—A second calibrated apparatus may be taken to the field when this condition is anticipated (instead of refilling and making a second determination). The procedure in 7.1.4 may be used for each test when the best possible accuracy is desired, however, it is usually not needed for most production testing where a relatively smooth surface is obtainable.

7.1.5 The test hole volume will depend on the anticipated maximum particle size in the soil to be tested and the depth of the compacted layer. Test hole volumes are to be as large as practical to minimize the errors and shall not be less than the volumes indicated in **Table 1**. A hole depth should be selected that will provide a representative sample of the soil. For construction control, the depth of the hole should approximate the thickness of one, or more, compacted lift(s). The procedure for calibrating the sand must reflect this hole depth. See **Annex A2**.

7.1.6 Dig the test hole through the center hole in the base plate, being careful to avoid disturbing or deforming the soil that will bound the hole. The sides of the hole should slope slightly inward and the bottom should be reasonably flat or concave. The hole should be kept as free as possible of pockets, overhangs, and sharp obtrusions since these affect the accuracy of the test. Soils that are essentially granular require extreme care and may require digging a conical-shaped test hole. Place all excavated soil, and any soil loosened during digging, in a moisture tight container that is marked to identify the test number. Take care to avoid losing any materials. Protect this material from any loss of moisture until the mass has been determined and a specimen has been obtained for a water content determination.

7.1.7 Clean the flange of the base plate hole, invert the sand-cone apparatus and seat the sand-cone funnel into the

flanged hole at the same position as marked during calibration (see **Annex A1**). Eliminate or minimize vibrations in the test area due to personnel or equipment. Open the valve and allow the sand to fill the hole, funnel, and base plate. Take care to avoid jarring or vibrating the apparatus while the sand is running. When the sand stops flowing, close the valve.

7.1.8 Determine the mass of the apparatus with the remaining sand, record, and calculate the mass of sand used.

7.1.9 Determine and record the mass of the moist material that was removed from the test hole. When oversized material corrections are required, determine the mass of the oversized material on the appropriate sieve and record, taking care to avoid moisture losses. When required, make appropriate corrections for the oversized material using **Practice D 4718**.

7.1.10 Mix the material thoroughly, and either obtain a representative specimen for water content determination, or use the entire sample.

7.1.11 Determine the water content in accordance with **Test Method D 2216**, **D 4643**, **D 4944**, or **D 4959**. Correlations to **Test Method D 2216** will be performed when required by other test methods.

7.2 Water content specimens must be large enough and selected in such a way that they represent all the material obtained from the test hole. The minimum mass of the water content specimens is that required to provide water content values accurate to 1.0 %.

## 8. Calculation

8.1 Calculations shown are for mass in grams and volumes in cubic centimetres. Other units are permissible provided the appropriate conversion factors are used to maintain consistency of units throughout the calculations. See **1.6** for additional comments on the usage of inch-pound units.

8.2 Calculate the volume of the test hole as follows:

$$V = (M_1 - M_2)/\rho_1 \quad (1)$$

where:

$V$  = volume of the test hole, cm<sup>3</sup>,

$M_1$  = mass of the sand used to fill the test hole, funnel and base plate, g (from **7.1.8**),

$M_2$  = mass of the sand used to fill the funnel and base plate (from **Annex A1.2.2.6**), g, and

$\rho_1$  = bulk density of the sand (from **A2.3.5**), g/cm<sup>3</sup>.

8.3 Calculate the dry mass of material removed from the test hole as follows:

$$M_4 = 100 M_3/(w + 100) \quad (2)$$

where:

$w$  = water content of the material removed from test hole, %, (from **7.1.11**),

$M_3$  = moist mass of the material from test hole, g, (from **7.1.9**), and

$M_4$  = dry mass of material from test hole, g, or multiply by 0.002205 for lb.

8.4 Calculate the in-place wet and dry density of the material tested as follows:

$$\rho_m = M_3/V \quad (3)$$

**TABLE 1 Minimum Test Hole Volumes Based on Maximum Size of Included Particle**

Maximum Particle Size		Minimum Test Hole Volumes	
in.	(mm)	cm <sup>3</sup>	ft <sup>3</sup>
½	(12.7)	1415	0.05
1	(25.4)	2125	0.075
1½	(38)	2830	0.1

$$\rho_d = M_4/V$$

where:

- $V$  = volume of the test hole,  $\text{cm}^3$  (from 8.2),  
 $M_3$  = moist mass of the material from the test hole, g, (from 7.1.9),  
 $M_4$  = dry mass of the material from the test hole, g, (from 8.3),  
 $\rho_m$  = wet density of the tested material  $\text{g/cm}^3$  or its wet unit weight,  $\gamma_m$  in  $\text{lb/ft}^3$  where  $\gamma_m = \rho_m \times 62.43$ , and  
 $\rho_d$  = dry density of the tested material,  $\text{g/cm}^3$  or its dry unit weight,  $\gamma_d$  in  $\text{lb/ft}^3$  where  $\gamma_d = \rho_d \times 62.43$ .

8.5 It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory densities determined in accordance with Test Method D 698, D 1557, D 4253, or D 4254. This relation can be determined by dividing the in-place density by the laboratory density and multiplying by 100. Calculations for determining relative density are provided in Test Method D 4254. Corrections for oversize material, if required, should be performed in accordance with Practice D 4718.

## 9. Report

9.1 Report, as a minimum, the following information:

- 9.1.1 Test location, elevation, thickness of layer tested, or other pertinent data to locate or identify the test.  
 9.1.2 Test hole volume,  $\text{cm}^3$  or  $\text{ft}^3$ .  
 9.1.3 In-place wet density,  $\text{g/cm}^3$  or  $\text{lb/ft}^3$ .  
 9.1.4 In-place dry density,  $\rho_d$ ,  $\text{g/cm}^3$ .  
 9.1.5 In-place dry unit weight,  $\text{kN/m}^3$  ( $\rho_d \times 9.807$ ), or  $\text{lb/ft}^3$  ( $\rho_d \times 62.43$ ), expressed to the nearest 0.1  $\text{KN/m}^3$ , or 1.0  $\text{lb/ft}^3$ .  
 9.1.6 In-place water content of the soil expressed as a percentage of dry mass, and the test method used.  
 9.1.7 Test apparatus identity and calibrated volume.  
 9.1.8 Bulk density of the sand used,  $\text{g/cm}^3$ , or  $\text{lb/ft}^3$ .

- 9.1.9 Visual description of the soil or material designation.  
 9.1.10 Mass and percentage of oversized particles and the size sieve used, if performed.  
 9.1.11 Comments on the test, as applicable.  
 9.1.12 If the in-place dry density or unit weight is expressed as a percentage of another value, include the following:  
 9.1.12.1 The laboratory test method used.  
 9.1.12.2 The comparative dry density or unit weight value and water content used.  
 9.1.12.3 Correction for oversized material and details, if applicable.  
 9.1.12.4 The comparative percentage of the in-place material to the comparison value.  
 9.1.13 If the in-place density, unit weight, or water content are to be used for acceptance, include the acceptance criteria applicable to the test.

## 10. Precision and Bias

10.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

10.1.1 Subcommittee D18.08 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

10.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

## 11. Keywords

11.1 acceptance tests; compaction tests; degree of compaction; density tests; earthfill; embankments; field control density; field tests; in-place density; in-place dry density; *in situ* density; relative density; sand cone; soil compaction; soil tests; unit weight.

## ANNEXES

### (Mandatory Information)

#### A1. CALIBRATION OF SAND CONE APPARATUS

##### A1.1 Scope

A1.1.1 This annex describes the procedure for determining the mass of sand contained in the funnel and base plate of the sand-cone apparatus.

A1.1.2 The mass of sand contained in the apparatus and base plate is dependent on the bulk-density of the sand. Consequently, this procedure must be performed for each apparatus whenever there are changes in the sand bulk-densities.

##### A1.2 Calibration Procedure

A1.2.1 Calibration of the apparatus can be accomplished by either of two methods:

A1.2.1.1 *Method A*—By determining the mass of calibrated sand that can be contained in each funnel and base plate set, or

A1.2.1.2 *Method B*—By determining the volume of sand needed to fill each funnel and base plate set and applying this volume constant whenever new sand bulk-densities are calculated.

A1.2.1.3 Since the mass of sand contained in the apparatus funnel and base plate is dependent on the bulk density of the sand, if Method A is used, it must be repeated whenever the bulk-density of the sand changes.

A1.2.2 All determinations of mass are to be made to the nearest 5 g.

A1.2.3 *Method A*:

A1.2.3.1 Fill the apparatus with sand that is dried and conditioned to the same state anticipated during use in testing.

A1.2.3.2 Determine the mass of the apparatus filled with sand, g.

A1.2.3.3 Place the base plate on a clean, level, plane surface. Invert the container/apparatus and seat the funnel in the flanged center hole in the base plate. Mark and identify the apparatus and base plate so that the same apparatus and plate can be matched and reseated in the same position during testing.

A1.2.3.4 Open the valve fully until the sand flow stops, making sure the apparatus, base plate, or plane surface are not jarred or vibrated before the valve is closed.

A1.2.3.5 Close the valve sharply, remove the apparatus and determine the mass of the apparatus and remaining sand. Calculate the mass of sand used to fill the funnel and base plate as the difference between the initial and final mass.

A1.2.3.6 Repeat the procedure a minimum of three times. The maximum variation between any one determination and the average will not exceed 1 %. Use the average of the three determinations for this value in the test calculations.

**A1.2.4 Method B (Optional):**

A1.2.4.1 When large numbers of tests and batches of sand are anticipated, it may be advantageous to determine the volume of each apparatus and base plate. Baring damage to the

apparatus or mismatching of the base plates, this volume will remain constant, and will eliminate the need to repeat Method A when the sand bulk-density changes (see **Note A1.1**). If this alternative is chosen, the calculations in the field test must be altered to determine the total volume of the sand in the field test hole and apparatus. The volume of the apparatus is then subtracted to determine the volume of the test hole.

A1.2.4.2 Determine the mass of sand required to fill the apparatus funnel and base plate in accordance with **A1.2.3**, following steps **A1.2.3.1-A1.2.3.6** for each batch of sand.

A1.2.4.3 Calculate the volume of the funnel and base plate by dividing the bulk-density of the sand (as determined in **Annex A2**) by the mass of sand found in **A1.2.3.6**. Perform a minimum of three determinations and calculate an average value. The maximum volume variation between any one determination and the average will not exceed 1 %. Use the average of the values when performing test calculations.

**NOTE A1.1**—The sand-cone apparatus should be routinely inspected for damage that may affect the volume of the cone. Dings, out-of-round, or other damage will affect the volume and will necessitate a redetermination of the volume (if repairable).

## A2. CALIBRATION OF DENSITY SAND

### A2.1 Scope

A2.1.1 This annex is used for determining the bulk-density (calibration) of the sand for use in this test method.

A2.1.2 The calibration determines an average density of the sand for use in calculating the volume of the test hole.

### A2.2 Equipment Required

A2.2.1 *Container*—Select a container of known volume that is approximately the same size and allows the sand to fall approximately the same distance as the hole excavated during a field test. The 1/30-ft<sup>3</sup> (944-cm<sup>3</sup>) and 1/13.33-ft<sup>3</sup> (2124-cm<sup>3</sup>) molds specified in Test Methods **D 698**, or the 0.1-ft<sup>3</sup> (2830-cm<sup>3</sup>) mold specified in Test Method **D 4253** are recommended. Alternatively, cast duplicates of actual test holes may be used. This is accomplished by forming plaster of paris negatives in actual test holes over a range of test volumes, and using these as forms for portland cement concrete castings. These should be cast against a flat plane surface, and after the removal of the negative, sealed water tight and the volume determined in accordance with the procedure in Test Method **D 4253** (10.2.2).

A2.2.1.1 Determine the container volume to 1 % using water in accordance with the procedures described in Test Method **D 4253**.

A2.2.2 *Sand-Cone Apparatus*—Use a sand cone apparatus of the same size and design as will be used during field testing.

A2.2.2.1 Flow characteristics through different valve assemblies have been shown to cause different bulk-density values. Bulk-density determinations will be required for each apparatus set unless other assemblies are determined to provide the same results.

A2.2.3 *Balance or Scale*—A balance or scale having a sufficient capacity to determine the mass of the calibration container filled with sand. For 0.500 ft<sup>3</sup> (14 200 cm<sup>3</sup>) contain-

ers, a balance having a minimum capacity of 50 lb (20 kg) and meeting the requirements of Specification **D 4753** for 0.01-lb (5-g) readability is required.

A2.2.4 *Metal Straightedge*, about 2 in. (50 cm) wide, at least 1/8 in. (3 mm) thick, and length approximately 1.5 times the diameter of the calibration container.

### A2.3 Bulk-Density Determination

A2.3.1 Fill the assembled apparatus with sand. The sand is to be dried and conditioned to the same state anticipated during use.

A2.3.2 Determine and record the mass of the calibration container when empty.

A2.3.3 *Method A (Preferred):*

A2.3.3.1 When the calibration container has the same diameter as the flanged center hole in the base plate, invert and center the sand filled apparatus and base plate on the calibration container.

A2.3.3.2 Fully open the valve and allow the sand to fill the container. When the sand flow stops, close the valve.

A2.3.3.3 Determine the mass of the apparatus and remaining sand. Calculate the net mass of sand in the calibration container by subtracting the mass of sand contained in the cone and base plate (as determined in **Annex A1**) and record.

A2.3.4 *Method B (Alternative):*

A2.3.4.1 Invert and support the apparatus over the calibration container so that the sand falls approximately the same distance and location as in a field test, and fully open the valve.

A2.3.4.2 Fill the container until it just overflows and close the valve. Using a minimum number of strokes and taking care not to jar or densify the sand, carefully strike off excess sand to a smooth level surface. Any vibration or jarring during the

bulk-density determination will result in settling and densifying the sand, leading to erroneous results.

A2.3.4.3 Clean any sand from the outside of the calibration container. Determine the mass of the container and sand. Record the net mass of the sand by subtracting the mass of the empty container.

A2.3.5 Perform at least three bulk-density determinations and calculate the average. The maximum variation between any one determination and the average will not exceed 1 %. Repeated determinations not meeting these requirements indicates nonuniform sand density, and the sand source should be re-evaluated for suitability. The average value obtained is to be used in the test calculations.

## A2.4 Calculation

A2.4.1 Calculate the bulk-density of the sand as follows:

$$\rho_1 = M_5/V_1 \quad (\text{A2.1})$$

where:

$\rho_1$  = bulk-density of the sand, g/cm<sup>3</sup>, (multiply by 9.807 for KN/m<sup>3</sup>, or 62.43 for lb/ft<sup>3</sup>),

$M_5$  = mass of the sand to fill the calibration container, g, (from A2.3.4.3), and

$V_1$  = volume of the calibration container, cm<sup>3</sup> (from A2.2.1.1).

## SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1556 – 00) that may impact the use of this standard. (Approved Sept. 15, 2007.)

(1) Revised Section 1 to include requirements of significant digits.

(2) Revised Section 3 to include definition for compacted lift.

(3) Revised Section 5 to include guidelines for significant digits for water content and density.

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