



Designation: D425 – 17

Standard Test Method for Centrifuge Moisture Equivalent of Soils¹

This standard is issued under the fixed designation D425; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This test method covers the determination of the moisture equivalent of soil in the laboratory by means of a centrifuge technique.

1.2 This test method is limited to specimens of coarse-grained sandy soils having a maximum particle size of less than 2.00 mm and with fines of low plasticity. Soils having a unified soil classification, based upon procedures outlined in Practice D2488 such as SP, SW, SC-SM, or SM are considered acceptable for the test method.

1.2.1 For soils that are predominantly fine-grained, coarse-grained soils with medium to high plasticity, intact specimens or soils being tested at a specific density or unit weight refer to Test Methods D6836.

1.3 This test method is intended to be performed in a constant temperature environment. Variations in temperature exceeding the range outlined in 8.7 may influence the test data.

1.4 *Units*—The values stated in SI units are to be regarded as the standard except for sieve designations, which also include the “alternative” system in accordance with E11.

1.5 All recorded and calculated values shall conform to the guide for significant digits and rounding established in Practice D6026.

1.6 The procedures used to specify how data are collected/recorded and 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 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 commensurate with these considerations. It is beyond the scope of these test methods to consider significant digits used in analysis methods for engineering design.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

¹ This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

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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

- 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
- D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- 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
- D6836 Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, or Centrifuge
- E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 Definitions:

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *capillary fringe zone*—the zone above the free water elevation in which water is held by capillary action.

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.

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

3.2.2 *centrifuge moisture equivalent*—the water content of a soil after it has been saturated with water and then subjected for one hour to a centrifugal force equal to 1000 times that of gravity.

3.2.3 *specific retention*—the ratio of the volume of water that cannot be drained from a saturated soil under the action of force of gravity to the total volume of voids.

3.2.4 *water-holding capacity*—the smallest value to which the water content of soil or rock can be reduced by gravity drainage.

4. Summary of Test Method

4.1 The centrifuge moisture equivalent of soils is determined by initially air-drying the soil sample. Two 5-g test specimens are selected from the sample and thoroughly soaked in distilled or deionized water. The specimens are centrifuged for 1 h at a force equal to 1000 times that of gravity at a constant temperature of $20 \pm 1^\circ\text{C}$. The moisture content is determined after centrifuging in accordance with Test Methods [D2216](#). The average of the two water contents is the moisture equivalent of the soil.

5. Significance and Use

5.1 All water contained in a saturated soil cannot be removed by gravity drainage alone. The amount of water retained after gravity drainage is usually expressed as the water holding capacity or specific retention of the soil. These values may be influenced by elapsed time, the particle-size distribution and the plasticity of the soil. In most cases, as the plasticity increases so does the moisture equivalent value.

5.2 The centrifuge moisture equivalent is determined by applying a centrifugal force great enough to reduce the capillary fringe zone sufficiently so that it can be ignored without introducing error. The centrifugal force is maintained sufficiently low as not to withdraw a large proportion of the water that is held securely above the capillary fringe (see [Note 1](#)).

5.3 It has been determined that for at least medium-textured soils (sandy to silty particle-size distribution) the centrifuge moisture equivalent approximates the water holding capacity and when combined with the bulk density can be used to calculate an approximate specific retention and specific yield. These properties when combined with porosity can be used to estimate aquifer storage coefficient.

NOTE 1—If a soil will hold water 100 mm by capillarity acting against gravity, the soil will theoretically be able to hold the water only 0.1 mm against a centrifugal force that is 1000 times greater than the force of gravity.

NOTE 2—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 [D3740](#) are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice [D3740](#) does not in itself assure reliable testing. Reliable testing depends on many factors; Practice [D3740](#) provides a means of evaluating some of these factors.

6. Apparatus

6.1 *Centrifuge*—A centrifuge capable of generating a force equal to 1000 times the force of gravity on the center of gravity of the soil specimen for a period of 1 h. The centrifuge chamber shall be capable of maintaining a controlled temperature of $20 \pm 1^\circ\text{C}$. In place of a temperature controlled chamber, the entire centrifuge may be operated in a controlled environment capable of meeting the temperature requirement of $20 \pm 1^\circ\text{C}$.

6.1.1 The revolutions per minute, N , required to provide a centrifugal force of 1000 times gravity is determined from the equation:

$$N = \sqrt{\frac{RCF}{0.000001111 \, rm}} \quad (1)$$

where:

N = revolutions per minute,

RCF = relative centrifugal force (1000),

r = radius of rotation to center of gravity of the test specimen, mm, and

m = mass of the body, taken as unity.

For most standard centrifuges, N will equal approximately 2300 rpm.

6.2 *Gooch Crucible*—Two procelain Gooch crucibles having a capacity of approximately 25 mL, and a diameter at the bottom of the crucible of about 20 mm ([Fig. 1](#)). The crucible shall have a perforated bottom and be compatible for use with the centrifuge being used.

6.3 *Babcock Trunnion Cups*—At least two centrifuge cups with caps and with a crucible holder for supporting the Gooch crucible above the bottom of the cup ([Fig. 1](#)). The holder shall have sufficient clearance to fit fully within the cup and support the cup in such a manner that the water removed during the centrifuging operation does not come in contact with the crucible and soil. Cups and crucible holders shall be balanced in pairs opposite each other in the centrifuge.

6.4 *Filter Paper*—A circular piece of filter paper of sufficient size to cover the inside bottom of the Gooch crucible (see [Note 3](#)).

NOTE 3—A medium speed, high wet strength (hardened) filter paper is recommended.

6.5 *Balance*—A balance having a readability of 0.01 g, and accurate to ± 0.03 g, conforming to Specification [D4753](#).

6.6 *Humidifier*—A cabinet or large jar with water in the lower half of the container. A shelf positioned above the level of the water should be covered with moisture resistant fabric on which to store the crucibles and soil specimens.

6.7 *Oven*—A thermostatically controlled drying oven, preferably of the forced-draft type, capable of maintaining a uniform temperature of $110 \pm 5^\circ\text{C}$ throughout.

6.8 *Water Content Containers*—Suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, and cleaning. Containers shall have close-fitting lids to prevent loss of moisture from the soil prior to the initial weighing and to prevent absorption of moisture from the atmosphere following oven drying and before final

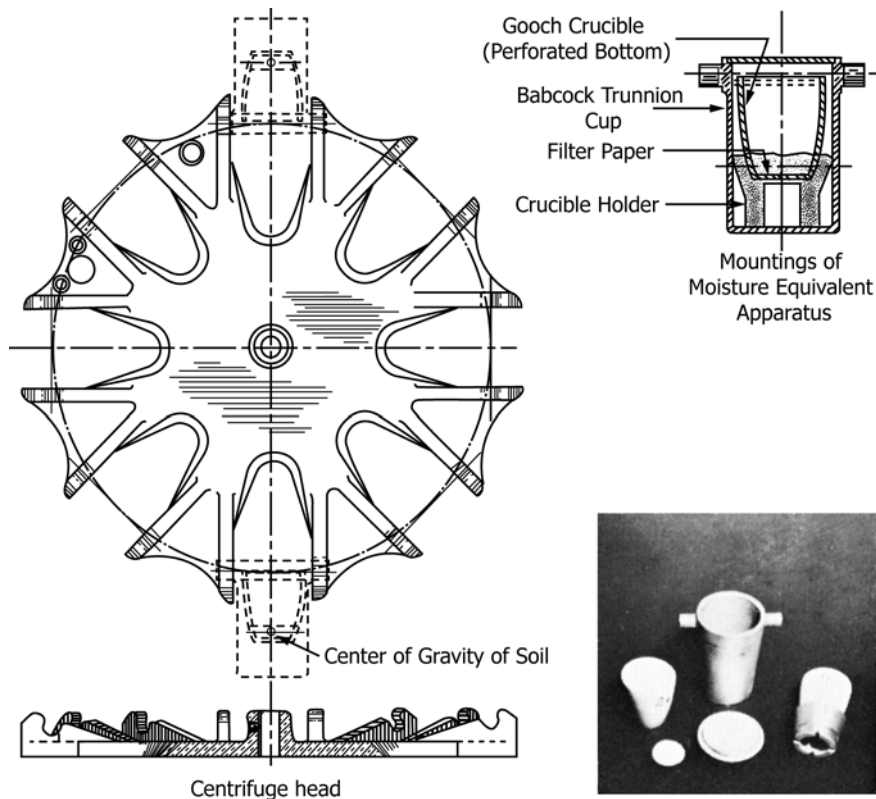


FIG. 1 Crucible, Trunnion Cup, and Cup Holder

weighing. One container is needed for each water content determination. Containers should be 50-100 mL capacity (see Note 4).

NOTE 4—It is recommended that the containers be numbered in pairs to coincide with the crucible numbers.

6.9 *Mortar and Pestle*—A mortar and rubber-tipped pestle suitable for breaking up the soil aggregations.

6.10 *Sieve*—2.00-mm (No. 10) mesh sieve conforming to Specification E11.

6.11 A pan or container used to collect the sample once passed through the 2.00-mm (No. 10) sieve.

7. Samples and Specimens

7.1 Air dry the as-received soil sample. Break up the aggregations thoroughly using the mortar and pestle. Dry sieve the sample through the 2.00-mm (No. 10) sieve.

7.2 Thoroughly mix the sample and split by use of a sample splitter or quartering method to obtain about 50 g of air-dried soil.

7.3 Obtain two 5-g specimens of material for testing. The crucibles shall be paired in such a way that the masses of the crucibles and contents meet the requirements of the manufacturer of the centrifuge.

8. Procedure

8.1 Place a disk of wet filter paper on the bottom of the two crucibles. The filter paper shall cover the entire bottom of the crucible but not rest on the crucible's wall.

8.2 Loosely and evenly place the two soil specimens into the paired crucibles.

8.3 Place the crucibles in a pan of distilled or demineralized water to a depth at least 5 mm above the height of the soil in the crucible. Allow the soil to absorb water until fully saturated.

NOTE 5—Eight hours or overnight is normally sufficient time for the soil to become saturated and is indicated by the presence of free water covering the surface of the soil.

8.4 Place the crucible and specimen in the humidifier to drain for at least 12 h to obtain uniform distribution of water throughout the soil mass.

8.5 Pour or siphon off any water remaining above the surface of the specimens.

8.6 Place the paired crucibles into the centrifuge cups fitted as described in 6.2 and position opposite each other in the centrifuge.

8.7 Maintain the centrifuge environment at a temperature $20 \pm 1^\circ\text{C}$ and adjust the centrifuge to the required speed within 5 min by five incremental and equal steps.

8.8 Maintain the centrifuge speed and temperature for 60 min. The speed of the centrifuge shall exert a centrifugal force 1000 times greater than that of gravity upon the center of gravity of each of the test specimens.

8.9 Following the 60 min centrifuging period, allow the centrifuge to come to rest with as little braking as possible, but not to exceed a 5-min time interval.

8.10 Immediately after centrifuging, transfer the soil from the two crucibles to water content containers as quickly as possible to minimize moisture loss. It is not necessary to remove all of the soil from the crucibles.

8.10.1 Determine the water content of each specimen in accordance with Test Methods **D2216**.

8.11 If water is observed on the top of the soil after centrifuging, the soil is said to have water-logged. The centrifuge moisture equivalent is not considered to be valid for this material and the report should be so noted.

8.12 A sample data sheet is shown in **Fig. 2**.

9. Calculation

9.1 Calculate the centrifuge moisture equivalent as the average of the water contents of the two specimens as determined by Test Methods **D2216**.

10. Report: Test Data Sheet(s)/Form(s)

10.1 The methodology used to specify how data are recorded on the test data sheet(s)/forms(s), as given below, is covered in **1.6**.

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

(1) Laboratory Sample No.								
(2) Container No.								
(3) Weight of container + wet sample (W_{CWS}), g								
(4) Weight of container + dry sample (W_{CS}), g								
(5) Weight of moisture (W_W), g (3 – 4)								
(6) Weight of container (W_C), g								
(7) Weight of dry sample, (W_S), g (4 – 6)								
(8) Moisture Equivalent (w_{cme}), % ($5 \div 7$) \times 100								
(9) Average Moisture Equivalent (w_{cme}), %								
Date and Name: Analyzed _____ Computed _____ Checked _____								
Remarks: _____								

(1) Laboratory Sample No.								
(2) Container No.								
(3) Weight of container + wet sample (W_{CWS}), g								
(4) Weight of container + dry sample (W_{CS}), g								
(5) Weight of moisture (W_W), g (3 – 4)								
(6) Weight of container (W_C), g								
(7) Weight of dry sample, (W_S), g (4 – 6)								
(8) Moisture Equivalent (w_{cme}), % ($5 \div 7$) \times 100								
(9) Average Moisture Equivalent (w_{cme}), %								
Date and Name: Analyzed _____ Computed _____ Checked _____								
Remarks: _____								

FIG. 2 Centrifuge Moisture Equivalent Sample Data Sheet

10.2.1 Name of the person performing the test.

10.2.2 Identification of sample including project number, project name, boring number, sample number, and depth if appropriate.

10.2.3 Description of the soil including the Unified Soil Classification following Practice **D2487** or **D2488**.

10.2.4 The average centrifuge moisture equivalent of the specimen to the nearest 1 %.

10.2.5 If one or both of the specimens were water-logged, the report shall state that the centrifuge moisture equivalent was not valid for the soil tested.

11. Precision and Bias

11.1 *Precision*—Information on the precision of this test method is being gathered.³

12. Keywords

12.1 centrifuge moisture equivalent; specific retention; specific yield, storage capacity; water holding capacity

³ For a discussion of variables which affect the results of this test, see Johnson, A. I., Prill, R. C., and Morris, D. A., "Specific Yield-Column Drainage and Centrifuge Moisture Content," U.S. Geological Survey Water Supply Paper 1662-A, 1963.

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1988 (Reapproved 2008)) that may impact the use of this standard. (January 15, 2017)

(1) Section 1. Scope: Revised section by adding reference to D6026, updating reference to alternative test methods. Added subsection on how data are collected.

(2) Section 2. Referenced Documents: Added pertinent standards to the list and removed discontinued standards.

(3) Section 3. Terminology: Updated reference to D653.

(4) Section 4. Summary of Test Method: Clarified wording.

(5) Section 5. Significance and Use: Clarified wording; added Note 1 on how the test works; and Note 2 on the reference to D3740.

(6) Section 6. Apparatus: Clarified wording.

(7) Section 7. Revised section to conform to D18 SPM

(8) Section 8. Procedure revised much of the text and added subsections to more easily differentiate the necessary steps.

(9) Section 10. Report: Revised to bring into conformance with D18 SPM.

(10) Added summary of changes.

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