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~~Standard Test Method for~~ Designation: D2216 – 10

Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass[1]

This standard is issued under the fixed designation D2216; 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.

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

1. Scope*

~~1.1This~~1.1 These test methods covers the laboratory determination of the water (moisture) content by mass of soil, rock, and similar materials where the reduction in mass by drying is due to loss of water except as noted in 1.4, 1.5, and 1.7. For simplicity, the word "material" ~~hereinafter also refers~~ shall refer to ~~either soil~~soil, rock or ~~rock,~~aggregate whichever is most applicable.

~~1.2Some~~1.2 Some disciplines, such as soil science, need to determine water content on the basis of volume. Such determinations are beyond the scope of this test method.

1.3 The water content of a material is defined in 3.2.1.

1.4 The term "solid material" as used in geotechnical engineering is typically assumed to mean naturally occurring mineral particles of soil and rock that are not readily soluble in water. Therefore, the water content of materials containing extraneous matter (such as ~~cement, and the like)~~ cement etc.) may require special treatment or a qualified definition of water content. In addition, some organic materials may be decomposed by oven drying at the standard drying temperature for this method (110°C). Materials containing gypsum (calcium sulfate dihydrate) or other compounds having significant amounts of hydrated ~~water)~~water may present a special problem as this material slowly dehydrates at the standard drying temperature (110°C) and at very low relative ~~humidities,~~humidity, forming a compound (such as calcium sulfate hemihydrate) ~~which~~that is not normally present in natural materials except in some desert soils. In order to reduce the degree of dehydration of gypsum in those materials containing ~~gypsum,~~gypsum or to reduce decomposition in highly/fibrous organic soils, it may be desirable to dry ~~these~~the materials at 60°C or in a desiccator at room temperature. Thus, when a drying temperature is used which is different from the standard drying temperature as defined by this test method, the resulting water content may be different from the standard water content determined at the standard drying temperature of 110°C.

NOTE~~1—Test Methods D 2974D 2974~~ 1—Test Method D2974 provides an alternate procedure for determining water content of peat materials.

1.5 ~~Materials containing water with substantial amounts of soluble solids (such as salt in the case of marine sediments) when tested by this method will give a mass of solids which includes the previously soluble solids. These materials require special treatment to remove or account for the presence of precipitated solids in the dry mass of the specimen, or a qualified definition of water content must be used. For example, see Noorany~~Materials containing water with substantial amounts of soluble solids (such as salt in the case of marine sediments) when tested by this method will give a mass of solids that includes the previously soluble dissolved solids. These materials require special treatment to remove or account for the presence of precipitated solids in the dry mass of the specimen, or a qualified definition of water content must be used. For example, see Test Method D4542 regarding information on marine sediments.

1.6 This test standard requires several hours for proper drying of the water content specimen. Test Methods D4643, D4944 and D4959 provide less time-consuming processes for determining water content. See Gilbert[2] ~~regarding information on marine soils.~~

~~1.6This test method requires several hours for proper drying of the water content specimen. Test Method D 4643D 4643 provides~~

[1] This test method is under the jurisdiction of ASTM Committee ~~D-18~~ 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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[2] ~~Noorany, I., "Phase Relations in Marine Soils", Journal of Geotechnical Engineering, ASCE, Vol. 110, No. 4, April 1984, pp. 539–543.~~

[2] Gilbert, P.A., "Computer Controlled Microwave Oven System for Rapid Water Content Determination," Tech. Report GL-88–21, Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, MS, November 1988 .

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

for drying of the test specimen in a microwave oven which is a shorter process. Also see Gilbert for details on the background of this test method. for details on the background of Test Method D4643.

1.7 This standard requires the drying of material in an oven at high temperatures. If the material being dried is contaminated with certain chemicals, health and safety hazards can exist. Therefore, this standard should not be used in determining the water content of contaminated soils unless adequate health and safety precautions are taken.

1.8 *Two test methods are provided in this standard. The methods differ in the significant digits reported and the size of the specimen (mass) required. The method to be used may be specified by the requesting authority; otherwise Method A shall be performed.*

1.7.1 *Method A*—The water content by mass is recorded to the nearest 1 %. For cases of dispute, Method A is the referee method.

1.7.2 *Method B*—The water content by mass is recorded to the nearest 0.1 %.

1.8 This standard requires the drying of material in an oven. If the material being dried is contaminated with certain chemicals, health and safety hazards can exist. Therefore, this standard should not be used in determining the water content of contaminated soils unless adequate health and safety precautions are taken.

1.9 *Units*—The values stated in SI units shall be regarded as standard excluding the Alternative Sieve Sizes listed in Table 1. No other units of measurement are included in this test method.

1.10 Refer to Practice D6026 for guidance concerning the use of significant figures that shall determine whether Method, A or B is required. This is especially important if the water content will be used to calculate other relationships such as moist mass to dry mass or vice versa, wet unit weight to dry unit weight or vice versa, and total density to dry density or vice versa. For example, if four significant digits are required in any of the above calculations, then the water content must be recorded to the nearest 0.1 %. This occurs since 1 plus the water content (not in percent) will have four significant digits regardless of what the value of the water content is; that is, 1 plus 0.1/100 = 1.001, a value with four significant digits. While, if three significant digits are acceptable, then the water content can be recorded to the nearest 1 %.

1.11 *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:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils

D4220 Practice for Preserving and Transporting Soil Samples[4] 3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[4] 4220 Practices for Preserving and Transporting Soil Samples

D4643 Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method[4] 4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

D4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[4] 4542 Test Method for Pore Water Extraction and Determination of the Soluble Salt Content of Soils by Refractometer

D6026 Guide for Using Significant Digits in Calculating and Reporting Geotechnical Test Data 4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

[3] Gilbert, P.A., "Computer Controlled Microwave Oven System for Rapid Water Content Determination", Tech. Report GL-88-21, Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, MS, November 1988.

[3] 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.

TABLE 1 Minimum Requirements for Mass of Test Specimen, and Balance Readability[A]

Maximum Particle Size (100 % Passing)		Method A Water Content Recorded to ±1 %		Method B Water Content Recorded to ±0.1 %	
SI Unit Sieve Size	Alternative Sieve Size	Specimen Mass	Balance Readability (g)	Specimen Mass (g)	Balance Readability (g)
75.0 mm	3 in	5 kg	10	50 kg	10
37.5 mm	1-½ in.	1 kg	10	10 kg	10
19.0 mm	¾ in.	250 g	1	2.5 kg	1
9.5 mm	⅜ in.	50 g	0.1	500 g	0.1
4.75 mm	No. 4	20 g	0.1	100 g	0.1
2.00 mm	No. 10	20 g	0.1	20 g	0.01

[A] If water content data is to be used to calculate other relationships, such as moist or dry mass, wet or dry unit weight or total or dry density, then specimen mass up to 200 g must be determined using a balance accurate to 0.01 g.

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
D4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
D4959 Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating
D5079 Practices for Preserving and Transporting Rock Core Samples
D6026 Practice for Using Significant Digits in Geotechnical Data
D7263 Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens
E145 Specification for Gravity-Convection ~~And~~and Forced-Ventilation Ovens

3. Terminology

~~3.1Refer to Terminology D 653D 653~~
3.1 Refer to Terminology D653 for standard definitions of terms.
~~3.2*Definitions of Terms Specific to This Standard:*~~
3.2 *Definitions:*
3.2.1 ~~*water content (of a material)*—the ratio expressed as a percent of the mass of "pore" or "free" water in a given mass of material to the mass of the solid material. A standard temperature of 110° ± 5°C is used to determine these masses.~~ water content by mass (of a material)—the ratio of the mass of water contained in the pore spaces of soil or rock material, to the solid mass of particles in that material, expressed as a percentage. A standard temperature of 110 ± 5°C is used to determine these masses.
3.3 *Definitions of Terms Specific to This Standard:*
3.3.1 *constant dry mass (of a material)*—the state that a water content specimen has attained when further heating causes, or would cause, less than 1 % or 0.1 % additional loss in mass for Method A or B respectively. The time required to obtain constant dry mass will vary depending on numerous factors. The influence of these factors generally can be established by good judgement, and experience with the materials being tested and the apparatus being used.

4. Summary of Test Method

4.1 A test specimen is dried in an oven at a temperature of ~~110°~~110 ± 5°C to a constant mass. The loss of mass due to drying is considered to be water. The water content is calculated using the mass of water and the mass of the dry specimen.

5. Significance and Use

5.1 For many materials, the water content is one of the most significant index properties used in establishing a correlation between soil behavior and its index properties.
5.2 The water content of a material is used in expressing the phase relationships of air, water, and solids in a given volume of material.
5.3 In fine-grained (cohesive) soils, the consistency of a given soil type depends on its water content. The water content of a soil, along with its liquid and plastic limits as determined by Test Method ~~D 4318~~D4318, is used to express its relative consistency or liquidity index.

NOTE 2—The quality of the result 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 ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drying Oven*—Vented, thermostatically-controlled, preferably of the forced-draft type, meeting the requirements of Specification ~~E 145~~E145and capable of maintaining a uniform temperature of 110 ± 5°C throughout the drying chamber.
6.2 *Balances*—All balances must meet the requirements of Specification ~~D 4753~~D4753 and this section. A Class GP1 balance of 0.01 g readability is required for specimens having a mass of up to 200 g (excluding mass of specimen container) and a Class GP2 balance of 0.1 g readability is required for specimens having a mass over 200 g. However, the balance used may be controlled by the number of significant digits needed (see ~~8.2.1 and 12.1.2~~1.10).
6.3 *Specimen Containers*—Suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, exposure to materials of varying pH, and cleaning. Unless a dessicator is used, containers with close-fitting lids shall be used for testing specimens having a mass of less than about 200 g; while for specimens having a mass greater than about 200 g, containers without lids may be used (see Note ~~7~~3). One uniquely numbered (identified) container or number-matched container and lid combination as required is needed for each water content determination.

NOTE~~2—The~~ 3—The purpose of close-fitting lids is to prevent loss of moisture from specimens before initial mass determination, and to prevent absorption of moisture from the atmosphere following drying and before final mass determination.

6.4 *Desiccator (Optional)*—A desiccator cabinet or large desiccator jar of suitable size containing silica gel or anhydrous calcium sulfate. It is preferable to use a desiccant ~~which~~that changes color ~~to indicate~~ when it needs ~~reconstitution. See 10.5.~~ to be reconstituted.

NOTE 34—Anhydrous calcium sulfate is sold under the trade name Drierite.

6.5 *Container Handling Apparatus*, heat resistant gloves, tongs, or suitable holder for moving and handling hot containers after drying.

6.6 *Miscellaneous*, knives, spatulas, scoops, quartering cloth, sample splitters, etc,wire saws, etc., as required.

7. Samples

7.1 Soil samples shall be preserved and transported in accordance with Practice4220Practice D4220 Section 8 Groups B, C, or D soils. Rock samples shall be preserved and transported in accordance with Practice D5079 section 7.5.2, Special Care Rock. Keep the samples that are stored prior to testing in non-corrodible airtight containers at a temperature between approximately 3 and 30°C and in an area that prevents direct contact with sunlight. Disturbed samples in jars or other containers shall be stored in such a way as to prevent or minimize moisture condensation on the insides of the containers.

7.2 The water content determination should be done as soon as practicable after sampling, especially if potentially corrodible containers (such as thin-walled steel tubes, paint cans, etc.) or plastic sample bags are used.

8. Test Specimen

8.1For8.1 For water contents being determined in conjunction with another ASTM method, the specimen mass requirement stated in that method shall be used if one is provided. If no minimum specimen mass is provided in that method then the values given below shall apply. See Howard[4]for background data for the values listed.

8.2 The minimum mass of moist material selected to be representative of the total sample shall be in accordance with the following:

Maximum particle size (100% passing)	Standard Sieve Size	Recommended minimum mass of moist test specimen for water content reported to ±0.1%	Recommended minimum mass of moist test specimen for water content reported to ±1%
2 mm or less	No. 10	20 g	20 g[A]
4.75 mm	No. 4	100 g	20 g[A]
9.5 mm	⅜ in.	500 g	50 g
19.0 mm	¾ in.	2.5 kg	250 g
37.5 mm	1½ in.	10 kg	1 kg
75.0 mm	3 in.	50 kg	5 kg

[A]To be representative not less than 20 g shall be used.

8.2.1The minimum mass used may have to be increased to obtain the needed significant digits for the mass of water when reporting water contents to the nearest 0.1% or as indicated in 12.1.2The minimum specimen mass of moist material selected to be representative of the total sample is based on visual maximum particle size in the sample and the Method (Method A or B) used to record the data. Minimum specimen mass and balance readability shall be in accordance with Table 1.

8.3Using8.3 Using a test specimen smaller than the minimum indicated in 8.2 requires discretion, though it may be adequate for the purposes of the test. Any specimen used not meeting these requirements shall be noted on the test data forms or test data sheets.

8.4When8.4 When working with a small (less than 200 g) specimen containing a relatively large gravel particle, it is appropriate not to include this particle in the test specimen. However, any discarded material shall be described and noted on the test data forms or test data sheets. form/sheet.

8.5 For those samples consisting entirely of intact rock or gravel-size aggregate, the minimum specimen mass shall be 500 g. Representative portions of the sample may be broken into smaller particles, depending on particles. The particle size is dictated by the sample's size,specimen mass, the container volume and the balance being used and to facilitate drying todetermine constant mass, see 10.4. Specimen sizesmasses as small as 200 g may be tested if water contents of only two significant digits are acceptable.

9. Test Specimen Selection

9.1 When the test specimen is a portion of a larger amount of material, the specimen must be selected to be representative of the water condition of the entire amount of material. The manner in which the test specimen is selected depends on the purpose and application of the test, type of material being tested, the water condition, and the type of sample (from another test, bag, block, and the likes.) etc.).

9.2 For disturbed samples such as trimmings, bag samples, and the like, etc; obtain the test specimen by one of the following methods (listed in order of preference):

9.2.1If9.2.1 If the material is such that it can be manipulated and handled without significant moisture loss and segregation, the material should be mixed thoroughly and then selectthoroughly. Select a representative portion using a scoop of a size that no more

[4] Annual Book of ASTM Standards, Vol 04.08.

[4] Howard, A. K., "Minimum Test Specimen Mass for Moisture Content Determination," *Geotechnical Testing Journal,* ASTM., Vol. 12, No. 1, March 1989, pp. 39-44.