Designation: D4944 – 18

Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester[1]

This standard is issued under the fixed designation D4944; 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 outlines procedures for determining the water (moisture) content of soil by chemical reaction using calcium carbide as a reagent to react with the available water in the soil producing a gas. A measurement is made of the gas pressure produced when a specified mass of wet or moist soil is placed in a testing device with an appropriate volume of reagent and mixed.

1.2 This test method is not intended as a replacement for Test Method D2216; but as a supplement when rapid results are required, when testing is done in field locations, or where an oven is not practical for use. Test Method D2216 is to be used as the test method to compare for accuracy checks and correction.

1.3 This test method is applicable for most soils. Calcium carbide, used as a reagent, reacts with water as it is mixed with the soil by shaking and agitating with the aid of steel balls in the apparatus. To produce accurate results, the reagent must react with all the water which is not chemically hydrated with soil minerals or compounds in the soil. Some highly plastic clay soils or other soils not friable enough to break up may not produce representative results because some of the water may be trapped inside soil clods or clumps which cannot come in contact with the reagent. There may be some soils containing certain compounds or chemicals that will react unpredictably with the reagent and give erroneous results. Any such problem will become evident as calibration or check tests with Test Method D2216 are made. Some soils containing compounds or minerals that dehydrate with heat (such as gypsum) which are to have special temperature control with Test Method D2216 may not be affected (dehydrated) in this test method.

1.4 This test method is limited to using calcium carbide moisture test equipment made for 20 g, or larger, soil specimens and to testing soil which contains particles no larger than the 4.75 mm (No. 4) Standard sieve size.

1.5 The values stated in SI units are to be regarded as standard. The inch-pound units given in parentheses are mathematical conversions, which are provided for information purposes only and are not considered standard.

1.5.1 Cited sieve sizes are the standard sieve sizes given in Table 1 of Specification E11.

1.6 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026 unless superseded by this standard.

1.6.1 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 of 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.

1.7 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific hazards statements, see Section 7.

1.8 *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]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

[1] 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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[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

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
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
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of terms used in this test method can be found in Terminology D653.

4. Summary of Test Method

4.1 A measured volume of calcium carbide, in excess of that needed to react with the water, is placed in the testing apparatus along with two steel balls and a representative specimen of soil having all particles smaller than the 4.75 mm (No. 4) sieve size and having a mass equal to that specified by the manufacturer of the instrument or equipment. The apparatus is shaken vigorously in a rotating motion so the calcium carbide reagent can contact all the available water in the soil. Acetylene gas is produced proportionally to the amount of available water present. The apparent water content is read from a pressure gauge on the apparatus calibrated to read in percent water content for the mass of soil specified.

4.2 A calibration curve is developed for each instrument and each soil type by plotting the pressure gauge reading and the water content determined from Test Method D2216 using representative specimens of the soil. The calibration curve is used to determine a corrected water content value for subsequent tests on the same type of soil.

5. Significance and Use

5.1 The water content of soil is used throughout geotechnical engineering practice, both in the laboratory and in the field. Results are sometimes needed within a short time period and in locations where it is not practical to install an oven or to transport samples to an oven. This test method is used for these occasions.

5.2 The results of this test have been used for field control of compacted embankments or other earth structures such as in the determination of water content for control of soil moisture and dry density within a specified range.

5.3 This test method requires specimens consisting of soil having all particles smaller than the 4.75 mm (No. 4) sieve size.

5.4 This test method may not be as accurate as other accepted methods such as Test Method D2216. Inaccuracies may result because specimens are too small to properly represent the total soil, from clumps of soil not breaking up to expose all the available water to the reagent and from other inherent procedural, equipment or process inaccuracies. Therefore, other methods may be more appropriate when highly accurate results are required, or when the use of test results is sensitive to minor variations in the values obtained.

NOTE 1—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. 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 *Calcium Carbide Pressure Tester Set Including:*

6.1.1 Testing chamber with attached pressure gauge.

NOTE 2—The testing chamber with pressure gauge and the balances are calibrated as a set (see Section 8).

6.1.2 A set of tared manual balances or portable electronic balance meeting the requirements of a GP2 of Specification D4753.

6.1.3 Carrying case.

6.1.4 Typical apparatus configurations are shown in Fig. 1. The typical pressure chamber is constructed of a die-cast aluminum that is approximately 20 cm (8 in.) deep and 15 cm (6 in.) in diameter at its widest dimension. It has a removable cap on one end and an integrated pressure gauge on the other end.

NOTE 3—Testers that use a smaller mass are available, but cannot be used with this standard given the inaccuracies outlined in 5.4.

6.2 *Small Scoop,* for measuring reagent.

6.3 *Two Steel Balls,* (manufacturer supplied). The two solid steel balls are included and matched to the specific gauge. They are approximately 30 mm (1.2 in.) in diameter and weigh approximately 130 grams (4.6 oz).

6.4 *Brush and Cloth,* for cleaning and other incidental items.

6.5 *Sieve,* 4.75 mm (No. 4), conforming to the requirements of Specification E11.

6.6 *Calcium Carbide Reagent,* finely pulverized, of a grade that will readily combine with the available sample moisture and is capable of producing acetylene gas in the amount of at least 0.14 cubic meters/kg (2.25 cu ft/lb). It is recommended to purchase calcium carbide manufactured expressly for use in moisture testing equipment and in small containers with air tight replaceable lids, to store it in a dry place, to keep the lid on the container at all times except when measuring out a portion for use in a test, and to use a complete container before opening a new one. Calcium carbide quality will deteriorate with time after it becomes exposed to the atmosphere or a source of moisture. Periodic purchase of a new supply is recommended.

FIG. 1 Typical Calcium Carbide Gas Pressure Test Apparatus for Water Content of Soil
FIG. 1a (left) Apparatus Set with Manual Tared Balance FIG. 1b (right) Apparatus Set with Portable Electronic Balance

6.7 *Miscellaneous Clothing or Safety Equipment,* such as goggles to protect the operator (see 7.2).

6.8 *Equipment,* as listed in Test Method D2216, for performing comparison tests to make calibration curves.

7. Safety Hazards

7.1 When combined with water, the calcium carbide reagent produces a highly flammable or explosive acetylene gas. Testing should not be carried out in confined spaces or in the vicinity of an open flame, embers or other source of heat that can cause combustion. Care should be exercised when releasing the gas from the apparatus to direct it away from the body. Lighted cigarettes, hot objects or open flames are dangerous in the area of testing.

7.2 As an added precaution, the operator should use a dust mask, clothing with long sleeves, gloves and goggles to keep the reagent from irritating the eyes, respiratory system, or hands and arms.

7.3 Attempts to test excessively wet soils or improper use of the equipment, such as adding water to the testing chamber, could cause pressures to exceed the safe level for the apparatus. This may cause damage to the equipment and an unsafe condition for the operator.

7.4 Care should be taken not to dispose or place a significant amount of the calcium carbide reagent where it may contact water because it will produce an explosive gas.

7.5 Calcium carbide is classified as a hazardous material and the user should conform to appropriate regulations regarding the use, storage, handling and transportation of calcium carbide.

8. Calibration

8.1 The manufacturer-supplied equipment set, including the testing chamber with attached gauge and the balance scales, are calibrated as a unit and paired together for the testing procedure.

8.2 Calibration curves must be developed for each equipment set using the general soil types to be tested and the expected water content range of the soil. As new materials are introduced, further calibration is needed to extend the curve data for the specific instrument. If tests are made over a long period of time on the same soil, a new calibration curve should be made periodically, not exceeding 12 months. Before a new batch of reagent is used for testing, two checkpoints at least 3 dial readings apart shall be compared to the existing curve. If variation is exceeded by more than 1.0 % of moisture, a new calibration curve shall be established.

8.3 Calibration curves are produced by selecting several samples representing the range of soil materials to be tested and having a relatively wide range of water content. Each sample is carefully divided into two specimens by quartering procedures or use of a sample splitter. Taking care to not lose any moisture, one specimen is tested in accordance with the procedure of this test method (see 10.1 – 10.6) without using a calibration curve, and the other specimen is tested in accordance with Test Method D2216.

8.4 The results of the oven dry water content determined by Test Method D2216 from all the selected samples are plotted versus the gauge reading from the calcium carbide tester for the corresponding test specimen pair. A best fit curve is plotted through the points to form a calibration curve for each soil type. Comparisons should be relatively consistent. A wide scatter in data indicates that either this test method or Test Method D2216 is not applicable to the soil or conditions. Fig. 2 shows a typical calibration curve.

8.5 Calibration kits are available from manufacturers for testing gasket leakage and for calibrating the gauge. Periodic checks for gasket leakage are recommended. The gasket should be changed when leakage is suspected. Gauge calibration problems can usually be detected as the instrument calibration curves are made. When the gauge needs adjusting, any good quality calibrating gauge can be used.