



Designation: D5220/D5220M – 21

Standard Test Method for Water Mass per Unit Volume of Soil and Rock In-Place by the Neutron Depth Probe Method¹

This standard is issued under the fixed designation D5220/D5220M; 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 covers the measurement of the water mass per unit volume of soil and rock by thermalization or slowing of fast neutrons, where the neutron source and the thermal neutron detector are placed at the desired depth in the bored hole lined by an access tube.

1.1.1 For limitations see Section 6 on Interferences.

1.2 The water mass per unit volume, expressed as mass per unit volume of the material under test, is determined by comparing the thermal neutron count rate with previously established calibration data (see [Annex A1](#)).

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined. Within the text of this standard, SI units appear first followed by the inch-pound (or other non-SI) units in brackets.

1.3.1 Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice [D6026](#).

1.4.1 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 should generally 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; and 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 analysis methods for engineering design.

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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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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific hazards are given in Section 8.

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

- [D653 Terminology Relating to Soil, Rock, and Contained Fluids](#)
- [D1452 Practice for Soil Exploration and Sampling by Auger Borings](#)
- [D1586 Test Method for Standard Penetration Test \(SPT\) and Split-Barrel Sampling of Soils](#)
- [D1587 Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes](#)
- [D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration](#)
- [D2216 Test Methods for Laboratory Determination of Water \(Moisture\) Content of Soil and Rock by Mass](#)
- [D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method](#)
- [D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction](#)
- [D4428/D4428M Test Methods for Crosshole Seismic Testing](#)
- [D5195 Test Method for Density of Soil and Rock In-Place at Depths Below Surface by Nuclear Methods](#)
- [D6026 Practice for Using Significant Digits in Geotechnical Data](#)

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

D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

D7263 Test Methods for Laboratory Determination of Density and Unit Weight of Soil Specimens

3. Terminology

3.1 *Definitions*—For definitions of common technical terms in this standard, refer to Terminology **D653**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *neutron probe*—a cylindrical device containing a fast neutron source and a thermal neutron detector.

4. Summary of Test Method

4.1 This test method uses thermalization of neutron radiation to determine the in-place water mass per unit volume of soil and rock at various depths by placing a probe containing a neutron source and a thermal neutron detector at desired depths in a bored hole lined by an access tube as opposed to surface measurements in accordance with Test Method **D6938**.

4.2 Neutrons emitted by the source are thermalized (slowed) by collisions with materials of low atomic numbers. Hydrogenous materials, such as water and other compounds containing hydrogen, are most effective in thermalizing neutrons. In this apparatus the neutrons thermalized by the material under test are detected by the thermal neutron detector.

4.3 In the absence of interference elements as discussed in Section 6, the number of thermalized neutrons is a function of the hydrogen content of the material under test and the water content is proportional to the hydrogen content.

4.4 By the use of a calibration process the water mass per unit volume is determined by correlating the count rate to known water mass per unit volume values.

5. Significance and Use

5.1 This test method is useful as a rapid, nondestructive technique for the measurement of the in-place water mass per unit volume of soil and rock at desired depths below the surface.

5.2 This test method is useful for informational and research purposes. The information acquired from this test method is best used for quality control and acceptance testing when correlated to actual water mass per unit volume using procedures and methods described in **A1.2.3**.

5.3 The non-destructive nature of this test method allows repetitive measurements to be made at a single test location for statistical analysis and to monitor changes over time.

5.4 The fundamental assumptions inherent in this test method are that the material under test is homogeneous and hydrogen present is in the form of water as defined by Test Method **D2216**.

NOTE 1—The quality of the result produced by this standard 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/sampling/inspection, and the like. Users of this

standard are cautioned that compliance with Practice **D3740** does not in itself assure reliable results. Reliable results depend on many factors; Practice **D3740** provides a means of evaluating some of those factors.

6. Interferences

6.1 The sample heterogeneity, density, and chemical composition of the material under test will affect the measurements. The apparatus must be calibrated to the material under test or adjustments made in accordance with **Annex A2**.

6.1.1 Hydrogen, in forms other than water, as defined by Test Method **D6938** and carbon, present in organic soils, will cause measurements in excess of the true water value. Some elements such as boron, chlorine, and minute quantities of cadmium, if present in the material under test, will cause measurements lower than the true water value.

6.2 This test method exhibits spatial bias in that it is more sensitive to water contained in the material closest to the access tube. The measurement is not necessarily an average water content of the total sample involved.

6.2.1 Voids around the access tube can affect the measurement (see **10.1.2**).

6.3 The actual sample volume that the instrument measures is indeterminate and varies with the apparatus and the water content of the material. In general, the greater the water content of the material, the smaller the volume involved in the measurement. For example, the sample volume is approximately 0.048 m³ [1.7 ft³] for a soil with a water content of 200 kg/m³ [12.5 lbm/ft³].

7. Apparatus (See Fig. 1)

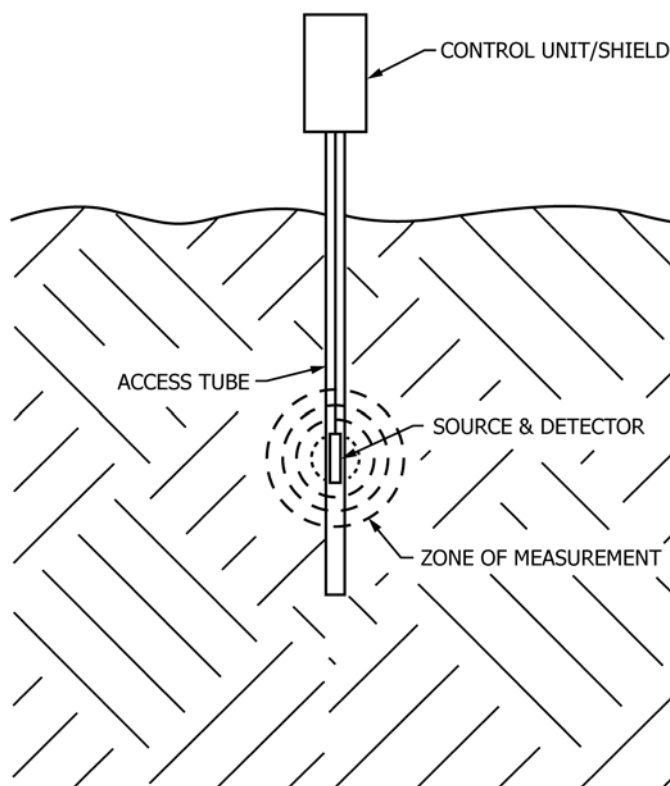


FIG. 1 Schematic Diagram; Water Content by Neutron Depth Probe Method