



Designation: D8167/D8167M – 23^{ε1}

Standard Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low- Activity Nuclear Method (Shallow Depth)¹

This standard is issued under the fixed designation D8167/D8167M; 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.

^{ε1} NOTE—Minor editorial correction was made in May 2023.

1. Scope*

1.1 This test method describes the procedures for measuring in-place bulk density of soil and soil-aggregate using nuclear equipment with radioactive sources (hereafter referred to simply as “gauges”). These gauges are distinct from those described in Test Method D6938 insofar as:

1.1.1 These gauges do not contain a system (nuclear or otherwise) for the determination of the water content of the material under measurement.

1.1.2 These gauges have photon yields sufficiently low as to require the inclusion of background radiation effects on the response during normal operation.

1.1.2.1 For the devices described in Test Method D6938, the contribution of gamma rays detected from the naturally-occurring radioisotopes in most soils (hereafter referred to as “background”) compared to the contribution of gamma rays used by the device to measure in-place bulk density is typically small enough to be negligible in terms of their effect on measurement accuracy. However, for these low-activity gauges, the gamma ray yield from the gauge is low enough that the background contribution from most soils compared to the contribution of gamma rays from the gauge is no longer negligible, and changes in this background can adversely affect the accuracy of the bulk density reading.

1.1.2.2 In order to compensate for potentially differing background contribution to low-activity gauge measurements at different test sites, a background reading must be taken in conjunction with gauge measurements obtained at a given test site. This background reading is utilized in the bulk density calculation performed by the gauge with the goal of minimizing these background effects on the density measurement accuracy.

1.2 For limitations see Section 5 on Interferences.

1.3 The bulk density of soil and soil-aggregate is measured by the attenuation of gamma radiation where the source is placed at a known depth up to 300 mm [12 in.] and the detector(s) remains on the surface (some gauges may reverse this orientation).

1.3.1 The bulk density of the test sample in mass per unit volume is calculated by comparing the detected rate of gamma radiation with previously established calibration data.

1.3.2 Neither the dry density nor the water content of the test sample is measured by this device. However, the results of this test can be used with the water content or water mass per unit volume value determined by alternative methods to determine the dry density of the test sample.

1.4 The gauge is calibrated to read the bulk density of soil or soil-aggregate.

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

1.5.1 For purposes of comparing, a measured or calculated value(s) with specified limits, the measured or calculated value(s) shall be rounded to the nearest decimal or significant digits in the specified limits.

1.5.2 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 commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.6 *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 may not be exact equivalents;

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

therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Reporting test results in units other than SI shall not be regarded as nonconformance with this standard.

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.*

NOTE 1—Nuclear density gauge manuals and reference materials, as well as the gauge displays themselves, typically refer to bulk density as “wet density” or “WD.”

NOTE 2—The term “bulk density” is used throughout this standard. This term has different definitions in Terminology D653, depending on the context of its use. For this standard, however, “bulk density” refers to, as defined in Terminology D653, “the total mass of partially saturated or saturated soil or rock per unit total volume.”

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
- D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
- D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))
- 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 Procedures)
- D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
- D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
- D4643 Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
- D4718/D4718M Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
- D4944 Test Method for Field Determination of Water (Mois-

ture) Content of Soil by the Calcium Carbide Gas Pressure Tester

- D4959 Test Method for Determination of Water Content of Soil By Direct Heating
- D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data
- D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- D7013/D7013M Guide for Calibration Facility Setup for Nuclear Surface Gauges
- D7382 Test Methods for Determination of Maximum Dry Unit Weight of Granular Soils Using a Vibrating Hammer
- D7759/D7759M Guide for Nuclear Surface Moisture and Density Gauge Calibration
- 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 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 *nuclear gauge, n*—a device containing one or more radioactive sources used to measure certain properties of soil and soil-aggregates.

3.2.2 *probe, n*—aslender, elongated device, part of the gauge, that is inserted into the soil being measured by the gauge. This device may contain either a radioactive source, a radiation detection device, or both. Probes containing only a radioactive source are commonly referred to as “source rods.”

3.2.3 *test count, n*—the measured output of a detector for a specific type of radiation for a given test.

3.2.4 *standardization count, n*—the measured output of a detector taken for the purposes of evaluating gauge stability and accounting for long-term aging of the radioactive sources. This output is frequently referred to as the “standard count” as well.

3.2.5 *background count, n*—the counts measured by the gauge to evaluate the ambient radiation in the proximity where a test measurement is to be taken rather than the radiation emitted by the gauge itself.

3.2.6 *background position, n*—the orientation of the gauge source rod when the background count is acquired.

4. Significance and Use

4.1 The test method described is useful as a rapid, nondestructive technique for in-place measurements of bulk density of soil and soil-aggregate. Test results may be used for the determination of dry density if the water content of the soil or soil-aggregate is determined by separate means, such as those methods described in Test Methods D2216, D4643, D4944, and D4959.

4.2 The test method is used for quality control and acceptance testing of compacted soil and soil-aggregate mixtures as

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.