



Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)¹

This standard is issued under the fixed designation D 2922; 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

1.1 These test methods cover the determination of the total or wet density of soil and soil-rock mixtures by the attenuation of gamma radiation where the source and detector(s) remain on the surface (Backscatter Method) or the source or detector is placed at a known depth up to 300 mm (12 in.) while the detector(s) or source remains on the surface (Direct Transmission Method).

1.2 The density in mass per unit volume of the material under test is determined by comparing the detected rate of gamma radiation with previously established calibration data.

1.3 The values tested in SI units are to be regarded as the standard. The inch-pound equivalents may be approximate.

1.4 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and a unit of force (lbf). This implicitly combines two separate systems of units; that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. These test methods have been written using the gravitational system of units when dealing with the inch-pound system. In this system the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft³ should not be regarded as nonconformance with these test methods.

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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific Hazard statements, see Section 6.

¹ These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

Current edition approved Nov. 1, 2005. Published November 2005. Originally approved in 1971. Last previous edition approved in 2004 as D 2922 – 04^{ε1}.

2. Referenced Documents

2.1 ASTM Standards:²

- D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
- D 1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))
- D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D 3017 Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)
- D 4253 Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
- D 4643 Test Method for Determination of Water Content by the Microwave Oven Heating
- D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
- D 4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method
- D 4959 Test Method for Determination of Water (Moisture) Content by Direct Heating

3. Significance and Use

3.1 The test methods described are useful as rapid, nondestructive techniques for the in-place determination of density of soil and rock.

3.2 The test methods are suitable for quality control and acceptance testing for construction and for research and development applications.

3.3 The nondestructive nature of the tests allow repetitive measurements to be made at a single test location.

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.

4. Interferences

4.1 The chemical composition of the sample may affect the measurement, and adjustments may be necessary.

4.2 The test methods exhibit spatial bias in that the instrument is more sensitive to the density of the material in close proximity to the surface (Backscatter Method only).

NOTE 1—The nuclear gauge density measurements are somewhat biased to the surface layers of the soil being tested. This bias has largely been corrected out of the direct transmission method and any remaining bias is insignificant. The backscatter method is still more sensitive to the material within the first several inches from the surface.

4.3 Oversize rocks or large voids in the source-detector path may cause higher or lower density determination. Where lack of uniformity in the soil due to layering, rock or voids is suspected, the test volume site should be dug up and visually examined to determine if the test material is representative of the full material in general and if rock correction (see 9.6) is required.

4.4 The sample volume is approximately 0.0028 m³ (0.10 ft³) for the Backscatter Method and 0.0057 m³ (0.20 ft³) for the Direct Transmission Method when the test depth is 15 cm (6 in.). The actual sample volume is indeterminate and varies with the apparatus and the density of the material. In general, the higher the density the smaller the volume.

5. Apparatus

5.1 *Nuclear Gauge*—An electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

5.1.1 A sealed source of high energy gamma radiation such as cesium or radium.

5.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

5.2 *Reference Standard*—A block of material used for checking instrument operation and to establish conditions for a reproducible reference count rate.

5.3 *Site Preparation Device*—A plate, straightedge, or other suitable leveling tool which may be used for planning the test site to the required smoothness, and in the Direct Transmission Method, guiding the drive pin to prepare a perpendicular hole.

5.4 *Drive Pin*—A pin of slightly larger diameter than the rod in the Direct Transmission Instrument, used to prepare a hole in the material under test for inserting the rod.

5.5 *Drive Pin Extractor*—A tool that may be used to remove the drive pin in a vertical direction so that the pin will not distort the hole in the extraction process.

5.5.1 A slide hammer, with a drive pin attached, may also be used both to prepare a hole in the material to be tested and to extract the pin without distortion to the hole.

6. Hazards

6.1 This equipment utilizes radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become familiar with applicable safety procedures and government regulations.

6.2 Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation

of film badge data, and so forth, are a recommended part of the operation and storage of this instrument.

7. Calibration

7.1 Calibration of the instrument will be in accordance with **Annex A1**.

8. Standardization and Reference Check

8.1 Nuclear gages are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and material density. To offset this aging, the gage may be calibrated as the ratio of the measured count rate to a count rate made on a reference standard or to an air-gap count (for the backscatter air-gap technique, see 9.5.1.3). The reference count rate should be of the same order of magnitude as the measured count rate over the useful density range of the instrument.

8.2 Standardization of the gage shall be performed at the start of each day's work, and a record of these data shall be retained for a sufficient time to ensure compliance with subsections 8.2.3 and 8.2.3.1. Perform the standardization with the gage located at least 8 m (25 ft) away from other sources of radioactive material, and clear of large masses or other items which may affect the reference count rate.

8.2.1 If recommended by the instrument manufacturer to provide more stable and consistent results: (1) turn on the gauge prior to use to allow it to stabilize, (2) leave the power on during the use of the gage for that day.

8.2.2 Using the reference standard, take at least four repetitive readings at the normal measurement period and determine the mean. If available on the gage, one measurement period of four or more times the normal period is acceptable. This constitutes one standardization check.

8.2.3 If the value obtained above is within the limits stated below, the gage is considered to be in satisfactory condition, and the value may be used to determine the count ratios for the day of use. If the value is outside these limits, allow additional time for the gage to stabilize, make sure the area is clear of sources of interference, and then conduct another standardization check. If the second standardization check is within the limits, the gage may be used, but if it also fails the test, the gage shall be adjusted or repaired as recommended by the manufacturer. The limits are as follows:

$$|N_s - N_o| \leq 1.96 \sqrt{\frac{N_o}{F}} \quad (1)$$

where:

N_s = value of current standardization count,

N_o = average of the past four values of N_s taken for prior usage, and

F = value of prescale. [The prescale value (F) is a divisor which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0.] Some instruments may have provisions to compute and display these values.

8.2.3.1 If the instrument standardization has not been checked within the previous three months, perform at least four new standardization checks, and use the mean as the value for N_o .