Designation: D2937 – 24

Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method[1]

This standard is issued under the fixed designation D2937; 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 U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of in-place density of soil near the surface by the drive-cylinder method. The test method involves obtaining an intact soil sample by driving a thin-walled cylinder into the soil and conducting specific measurements and calculations for the determination of in-place density. When determination of in-place density is required at depth, Practice D1587/D1587M or D6519/D6519M may be used.

1.2 This test method is not recommended for sampling organic or friable soils which may compress during sampling. This test method may not be applicable for soft, organic, highly plastic, noncohesive, saturated or other soils which are easily deformed, compress during sampling, or which may not be retained in the drive cylinder sampler. This test may not be applicable with very hard natural soils or heavily compacted soils that may not be easily penetrated with the drive cylinder sampler. The use of this test method in soils containing an appreciable amount of particles larger than 5 mm (3⁄16 in.) may result in damage to the drive cylinder equipment. Soils containing particles larger than 5 mm (3⁄16 in.) may not yield valid results if voids are created along the wall of the cylinder during driving, or if particles are dislodged from the sample ends during trimming.

1.3 This test method is limited to the procedures necessary for obtaining specimens suitable for determining the in-place density and water content of certain soils. The procedures, precautions, and requirements necessary for selecting locations for obtaining intact samples, suitable for laboratory testing or otherwise determining engineering properties, is beyond the scope of this test method.

1.4 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.4.1 It is common practice in the engineering/construction 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. This standard has 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/ft^3 shall not be regarded as nonconformance with this standard.

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

1.5.1 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; 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 design.

1.6 *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.*

1.7 *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.*

[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.

Current edition approved July 15, 2024. Published July 2024. Originally approved in 1971. Last previous edition approved in 2017 as D2937 – 17$^{\varepsilon 2}$. DOI: 10.1520/D2937-24.

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

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/ft^3 (600 kN-m/m^3))

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D1587/D1587M Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes (Withdrawn 2024)[3]

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

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

D4643 Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating

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 Content of Soil By Direct Heating

D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data

D6519/D6519M Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this standard, refer to Terminology D653.

4. Significance and Use

4.1 This test method can be used to determine the in-place density of soils which do not contain significant amounts of particles larger than 5 mm (3⁄16 in.), and which can be retained in the drive cylinder. This test method may also be used to determine the in-place density of compacted soils used in construction of structural fill, highway embankments, or earth dams. When the in-place density is to be used as a basis for acceptance, the drive cylinder volumes must be as large as practical and greater than 850 cm^3 (0.030 ft^3).

4.2 The general principles of this test method have been successfully used to obtain samples of various field compacted fine-grained soils having a maximum particle size of 5 mm (3⁄16 in.) for purposes other than density determinations, such as testing for engineering properties.

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 facility used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some, but not all, of those factors.

5. Apparatus

5.1 *Drive Cylinders,* of approximately 100 to 150 mm (4.00 to 6.00 in.) diameter. Larger sizes may be used if desired or required. Typical details of drive cylinders with outside diameters of 100 mm (4.00 in.) are shown in Fig. 1 (see also Table 1). Drive cylinders of other diameters require proportional changes in the drive-cylinder tube and drive-head dimensions. The volume of the cylinders with the dimensions shown in Fig. 1 is approximately 940 cm^3 (0.033 ft^3). The apparatus shown in Fig. 1 is of a design suitable for use at or near the surface.

5.1.1 When the in-place density is to be used as a basis for acceptance of compacted fill, the drive cylinders should be as large as practical to reduce the effects of errors and shall be equal to or greater than 850 cm^3 (0.030 ft^3).

5.1.2 The number of drive cylinders required depends on the number of samples to be taken and the anticipated rapidity by which the cylinders can be returned to service after processing.

5.1.3 The cylinders shown in Fig. 1 meet the clearance ratio, wall thickness and area-ratio requirements as set forth by Hvorslev[4] for drive cylinder samplers, and shall not exceed 10 to 15 %, as defined by the following:

$$A_r = \left[(Dw^2 - De^2)/De^2\right] \times 100 \quad (1)$$

where:

A_r = area ratio, %,
Dw = maximum external diameter of the drive cylinder, and
De = effective (minimum) internal diameter of the drive sampler at the cutting edge after swaging.

5.1.4 Except for very short drive cylinder samplers with no clearance, the inside clearance ratio of the drive cylinders shall be from 0.5 to 3.0 %, with increasing ratios as the plasticity increases in the soil being sampled. Inside clearance ratio is defined by the following:

$$C_r = \frac{Di - De}{De} \times 100 \quad (2)$$

where:

C_r = inside clearance ratio, %
De = effective (minimum) internal diameter of the sampler at the cutting edge after swaging, and
Di = internal diameter of the sampler.

5.1.5 Drive cylinders of other diameters shall conform to these requirements.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Hvorslev, M. J., "Surface Exploration and Sampling of Soils for Engineering Purposes," Engineering Foundation, 345 E. 47th St., New York, NY 10017.