Designation: D2937 – 10

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 by the drive-cylinder method. The test method involves obtaining a relatively intact soil sample by driving a thin-walled cylinder and the subsequent activities for the determination of in-place density. When sampling or in-place density is required at depth, Test Method D1587 should be used.

1.2 This test method is not appropriate for sampling organic soils which can compress upon sampling, very hard natural soils and heavily compacted soils which cannot be easily penetrated by the drive sampler, soils of low plasticity which will not be readily retained in the cylinder, or soils which contain appreciable amounts of gravel (particles coarser than 4.75 mm (3⁄16 in.)). The presence of particles coarser than 4.75 mm (3⁄16 in.) may introduce significant errors in density measurements by causing voids along the wall of the cylinder during driving, and when coarse materials have to be dislodged by the trimming of the sample obtained by the cylinder.

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 and precautions necessary for selecting locations and obtaining intact samples suitable for laboratory testing or otherwise determining engineering properties is beyond the scope of this test method.

1.4 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.

1.4.1 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. As stated, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. 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 engineering 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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))

[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**

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
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 Procedure)
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 (Moisture) Content of Soil 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 (Moisture) Content of Soil By Direct Heating
D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

3.1 *Definitions*—All definitions are in accordance with 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 coarser than 4.75 mm (3⁄16 in.), and which can be readily 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 not less than 850 cm^3 (0.030 ft^3).

4.2 This test method is not recommended for use in organic or friable soils. This test method may not be applicable for soft, highly plastic, noncohesive, saturated or other soils which are easily deformed, compress during sampling, or which may not be retained in the drive cylinder. The use of this test method in soils containing particles coarser than 4.75 mm (3⁄16 in.) may result in damage to the drive cylinder equipment. Soils containing particles coarser than 4.75 mm (3⁄16 in.) may not yield valid results if voids are created along the wall of cylinder during driving, or if particles are dislodged from the sample ends during trimming.

4.3 The general principles of this test method have been successfully used to obtain samples of some field compacted fine-grained soils having a maximum particle size of 4.75 mm (3⁄16 in.) for purposes other than density determinations, such as the testing for engineering properties.

NOTE 1—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies which meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing depends on many factors; Practice D3740 provides a means of evaluating some of those factors.

5. Apparatus

5.1 *Drive Cylinders,* of approximately 102 to 152 mm (4.00 to 6.00 in.) diameter or larger. Typical details of drive cylinders with outside diameters of 102 mm (4.00 in.) are shown in Fig. 1 (see also Table 1). Drive cylinders of other diameters will 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 cylinders shall be as large as practical to minimize the effects of errors and shall in no case be smaller than 850 cm^3 (0.030 ft^3).

5.1.2 The number of 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 weighing, cleaning, etc.

5.1.3 The cylinders shown in Fig. 1 meet the clearance ratio, wall thickness and area-ratio requirements as set forth by Hvorslev[3] for drive samplers, and should preferably not exceed 10 to 15 %, as defined by the following:

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

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 samplers with no clearance, the inside clearance ratio of the cylinders should 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 Cylinders of other diameters should conform to these requirements.

5.2 *Drive Head*—The typical details of the drive heads and appurtenances are shown in Fig. 1. The drive head has a sliding weight for driving the cylinder.

5.3 *Straightedge*—steel, approximately 3 mm (⅛ in.) by 38 mm (1½ in.) by 305 mm (12.0 in.) with one edge sharpened at

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

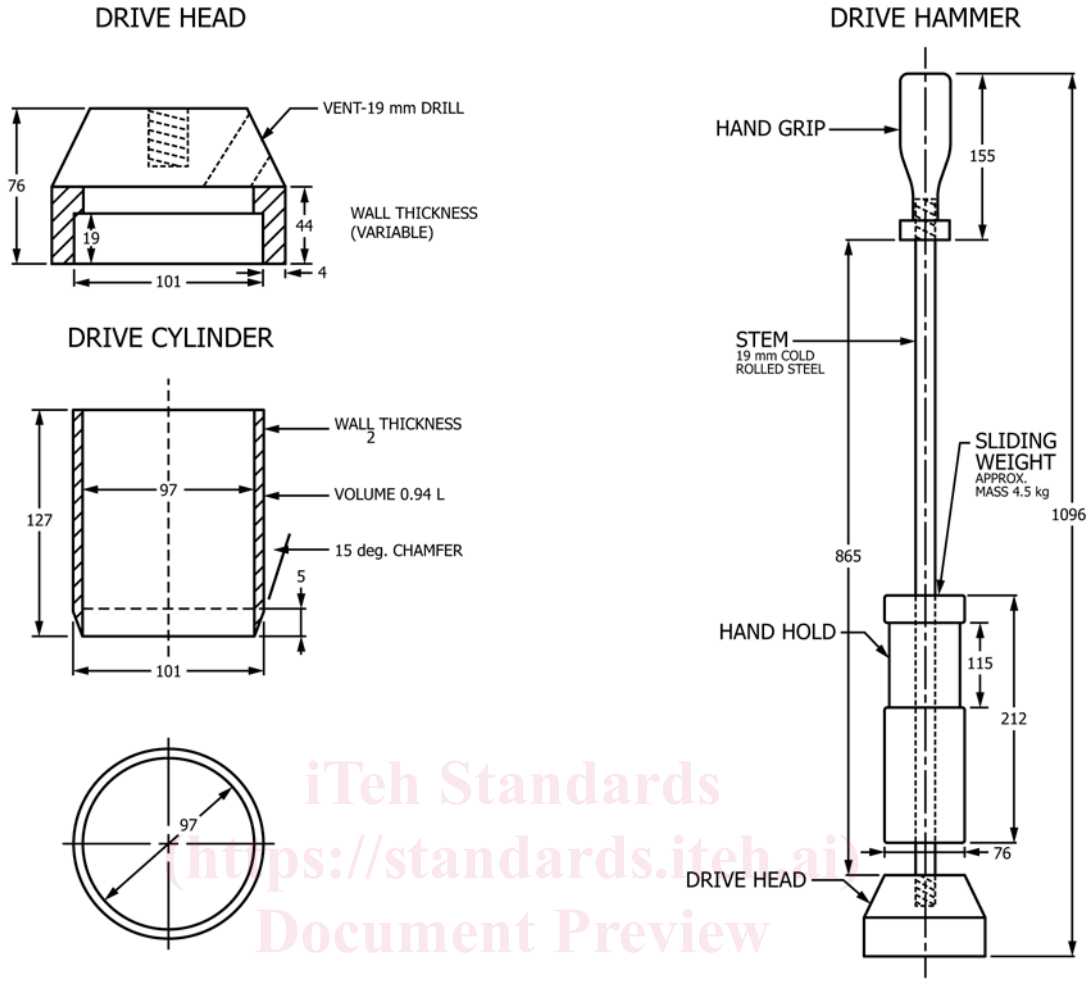

FIG. 1 Typical Design for a Surface Soil Sampler

TABLE 1 Dimensional Equivalent for Fig. 1

mm	in.	mm	in.
2	5/64	103	4 1/16
4	5/32	115	4½
5	3/16	127	5.00
19	¾	155	6.00
44	1¾	212	8.00
76	3.0	865	36.00
98	3⅞	1096	45.00
102	4.00		

approximately a 45° angle for trimming the ends of the sample flush with the cylinder.

5.4 *Shovel*—Any one of several types of shovels or spades is satisfactory in shallow sampling for digging the cylinders out after they have been driven into the soil.

5.5 *Balances*—A balance having a minimum capacity of 10 kg (22 lbs) and meeting the requirements of Specification D4753 for a balance of 1 g (0.002 lbs) readability is required for the cylinders shown in Fig. 1. Larger cylinders will require a balance of 25 kg (55 lbs) capacity with readability of 1 gm (0.002 lbs).

5.6 *Drying Equipment*—Equipment or ovens, or both, to determine water (moisture) content in compliance with Test Methods D2216, D4643, D4944, or D4959.

5.7 *Miscellaneous Equipment*—Brushes, sledgehammers, plastic bags, metal cans with lids, or other suitable containers