



Designation: D854 – 06<sup>e1</sup>

## Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer<sup>1</sup>

This standard is issued under the fixed designation D854; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

<sup>e1</sup> NOTE—The equation in Footnote B in **Table 1** was corrected editorially in April 2006.

### 1. Scope\*

1.1 These test methods cover the determination of the specific gravity of soil solids that pass the 4.75-mm (No. 4) sieve, by means of a water pycnometer. When the soil contains particles larger than the 4.75-mm sieve, Test Method **C127** shall be used for the soil solids retained on the 4.75-mm sieve and these test methods shall be used for the soil solids passing the 4.75-mm sieve.

1.1.1 Soil solids for these test methods do not include solids which can be altered by these methods, contaminated with a substance that prohibits the use of these methods, or are highly organic soil solids, such as fibrous matter which floats in water.

NOTE 1—The use of Test Method **D5550** may be used to determine the specific gravity of soil solids having solids which readily dissolve in water or float in water, or where it is impracticable to use water.

1.2 Two methods for performing the specific gravity are provided. The method to be used shall be specified by the requesting authority, except when testing the types of soils listed in **1.2.1**.

1.2.1 *Method A*—Procedure for Moist Specimens, described in **9.2**. This procedure is the preferred method. For organic soils; highly plastic, fine grained soils; tropical soils; and soils containing halloysite, Method A shall be used.

1.2.2 *Method B*—Procedure for Oven-Dry Specimens, described in **9.3**.

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

1.3.1 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 generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any consider-

ations 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 these test methods to consider significant digits used in analysis methods for engineering design.

1.4 *Units*—The values stated in SI units are to be regarded as standard. The units of measurement in the parentheses are for informational purposes only.

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.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

**C127** Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

**D653** Terminology Relating to Soil, Rock, and Contained Fluids

**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)

**D3740** Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

**D4753** Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

**D5550** Test Method for Specific Gravity of Soil Solids by Gas Pycnometer

**D6026** Practice for Using Significant Digits in Geotechnical Data

**E11** Specification for Woven Wire Test Sieve Cloth and Test Sieves

<sup>1</sup> This standard is under the jurisdiction of ASTM Committee **D18** on Soil and Rock and is the direct responsibility of Subcommittee **D18.03** on Texture, Plasticity and Density Characteristics of Soils.

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<sup>2</sup> 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.

**TABLE 1 Density of Water and Temperature Coefficient (K) for Various Temperatures<sup>A,B</sup>**

Temperature (°C)	Density (g/mL) <sup>C</sup>	Temperature Coefficient (K)	Temperature (°C)	Density (g/mL) <sup>C</sup>	Temperature Coefficient (K)	Temperature (°C)	Density (g/mL) <sup>C</sup>	Temperature Coefficient (K)	Temperature (°C)	Density (g/mL) <sup>C</sup>	Temperature Coefficient (K)
15.0	0.99910	1.00090	16.0	0.99895	1.00074	17.0	0.99878	1.00057	18.0	0.99860	1.00039
.1	0.99909	1.00088	.1	0.99893	1.00072	.1	0.99876	1.00055	.1	0.99858	1.00037
.2	0.99907	1.00087	.2	0.99891	1.00071	.2	0.99874	1.00054	.2	0.99856	1.00035
.3	0.99906	1.00085	.3	0.99890	1.00069	.3	0.99872	1.00052	.3	0.99854	1.00034
.4	0.99904	1.00084	.4	0.99888	1.00067	.4	0.99871	1.00050	.4	0.99852	1.00032
.5	0.99902	1.00082	.5	0.99886	1.00066	.5	0.99869	1.00048	.5	0.99850	1.00030
.6	0.99901	1.00080	.6	0.99885	1.00064	.6	0.99867	1.00047	.6	0.99848	1.00028
.7	0.99899	1.00079	.7	0.99883	1.00062	.7	0.99865	1.00045	.7	0.99847	1.00026
.8	0.99898	1.00077	.8	0.99881	1.00061	.8	0.99863	1.00043	.8	0.99845	1.00024
.9	0.99896	1.00076	.9	0.99879	1.00059	.9	0.99862	1.00041	.9	0.99843	1.00022
19.0	0.99841	1.00020	20.0	0.99821	1.00000	21.0	0.99799	0.99979	22.0	0.99777	0.99957
.1	0.99839	1.00018	.1	0.99819	0.99998	.1	0.99797	0.99977	.1	0.99775	0.99954
.2	0.99837	1.00016	.2	0.99816	0.99996	.2	0.99795	0.99974	.2	0.99773	0.99952
.3	0.99835	1.00014	.3	0.99814	0.99994	.3	0.99793	0.99972	.3	0.99771	0.99950
.4	0.99833	1.00012	.4	0.99812	0.99992	.4	0.99791	0.99970	.4	0.99768	0.99947
.5	0.99831	1.00010	.5	0.99810	0.99990	.5	0.99789	0.99968	.5	0.99766	0.99945
.6	0.99829	1.00008	.6	0.99808	0.99987	.6	0.99786	0.99966	.6	0.99764	0.99943
.7	0.99827	1.00006	.7	0.99806	0.99985	.7	0.99784	0.99963	.7	0.99761	0.99940
.8	0.99825	1.00004	.8	0.99804	0.99983	.8	0.99782	0.99961	.8	0.99759	0.99938
.9	0.99823	1.00002	.9	0.99802	0.99981	.9	0.99780	0.99959	.9	0.99756	0.99936
23.0	0.99754	0.99933	24.0	0.99730	0.99909	25.0	0.99705	0.99884	26.0	0.99679	0.99858
.1	0.99752	0.99931	.1	0.99727	0.99907	.1	0.99702	0.99881	.1	0.99676	0.99855
.2	0.99749	0.99929	.2	0.99725	0.99904	.2	0.99700	0.99879	.2	0.99673	0.99852
.3	0.99747	0.99926	.3	0.99723	0.99902	.3	0.99697	0.99876	.3	0.99671	0.99850
.4	0.99745	0.99924	.4	0.99720	0.99899	.4	0.99694	0.99874	.4	0.99668	0.99847
.5	0.99742	0.99921	.5	0.99717	0.99897	.5	0.99692	0.99871	.5	0.99665	0.99844
.6	0.99740	0.99919	.6	0.99715	0.99894	.6	0.99689	0.99868	.6	0.99663	0.99842
.7	0.99737	0.99917	.7	0.99712	0.99892	.7	0.99687	0.99866	.7	0.99660	0.99839
.8	0.99735	0.99914	.8	0.99710	0.99889	.8	0.99684	0.99863	.8	0.99657	0.99836
.9	0.99732	0.99912	.9	0.99707	0.99887	.9	0.99681	0.99860	.9	0.99654	0.99833
27.0	0.99652	0.99831	28.0	0.99624	0.99803	29.0	0.99595	0.99774	30.0	0.99565	0.99744
.1	0.99649	0.99828	.1	0.99621	0.99800	.1	0.99592	0.99771	.1	0.99562	0.99741
.2	0.99646	0.99825	.2	0.99618	0.99797	.2	0.99589	0.99768	.2	0.99559	0.99738
.3	0.99643	0.99822	.3	0.99615	0.99794	.3	0.99586	0.99765	.3	0.99556	0.99735
.4	0.99641	0.99820	.4	0.99612	0.99791	.4	0.99583	0.99762	.4	0.99553	0.99732
.5	0.99638	0.99817	.5	0.99609	0.99788	.5	0.99580	0.99759	.5	0.99550	0.99729
.6	0.99635	0.99814	.6	0.99606	0.99785	.6	0.99577	0.99756	.6	0.99547	0.99726
.7	0.99632	0.99811	.7	0.99604	0.99783	.7	0.99574	0.99753	.7	0.99544	0.99723
.8	0.99629	0.99808	.8	0.99601	0.99780	.8	0.99571	0.99750	.8	0.99541	0.99720
.9	0.99627	0.99806	.9	0.99598	0.99777	.9	0.99568	0.99747	.9	0.99538	0.99716

<sup>A</sup> Reference: CRC Handbook of Chemistry and Physics, David R. Lide, Editor-in-Chief, 74<sup>th</sup> Edition, 1993–1994.

<sup>B</sup>

$$\rho_w = 1.00034038 - (7.77 \times 10^{-6}) \times T - (4.95 \times 10^{-6}) \times T^2$$

where:

$\rho_w$  = Density of water in g/mL,  
 $T$  = the test temperature in °C, and  
 $K$  =  $\rho_w/0.9982063$

<sup>C</sup> mL = cm<sup>3</sup>.

### 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*—For definitions of terms used in these test methods, refer to Terminology **D653**.

### 3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *specific gravity of soil solids,  $G_s, n$* —the ratio of the mass of a unit volume of a soil solids to the mass of the same volume of gas-free distilled water at 20°C.

## 4. Significance and Use

4.1 The specific gravity of a soil solids is used in calculating the phase relationships of soils, such as void ratio and degree of saturation.

4.1.1 The specific gravity of soil solids is used to calculate the density of the soil solids. This is done by multiplying its specific gravity by the density of water (at proper temperature).

4.2 The term soil solids is typically assumed to mean naturally occurring mineral particles or soil like particles that are not readily soluble in water. Therefore, the specific gravity of soil solids containing extraneous matter, such as cement,

lime, and the like, water-soluble matter, such as sodium chloride, and soils containing matter with a specific gravity less than one, typically require special treatment (see **Note 1**) or a qualified definition of their specific gravity.

4.3 The balances, pycnometer sizes, and specimen masses are established to obtain test results with three significant digits.

**NOTE 2**—The quality of the result produced by these test methods 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/etc. Users of these test methods 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.

## 5. Apparatus

5.1 *Pycnometer*—The water pycnometer shall be either a stoppered flask, stoppered iodine flask, or volumetric flask with a minimum capacity of 250 mL. The volume of the pycnometer must be 2 to 3 times greater than the volume of the soil-water mixture used during the deairing portion of the test.

5.1.1 The stoppered flask mechanically sets the volume. The stoppered iodine flask has a flared collar that allows the stopper to be placed at an angle during thermal equilibration and prevents water from spilling down the sides of the flask when the stopper is installed. The wetting the outside of the flask is undesirable because it creates changes in the thermal equilibrium. When using a stopper flask, make sure that the stopper is properly labeled to correspond to the flask.

5.2 *Balance*—A balance meeting the requirements of Guide **D4753** for a balance of 0.01 g readability. When using the 250-mL pycnometers, the balance capacity shall be at least 500 g and when using the 500-mL pycnometers, the balance capacity shall be at least 1000 g.

5.3 *Drying Oven*—Thermostatically controlled oven, capable of maintaining a uniform temperature of  $110 \pm 5^\circ\text{C}$  throughout the drying chamber. These requirements usually require the use of a forced-draft oven.

5.4 *Thermometer*—Thermometer capable of measuring the temperature range within which the test is being performed, readable to the nearest  $0.1^\circ\text{C}$  and an immersion depth ranging between 25 to 80 mm. Full immersion thermometers shall not be used. Either a general-purpose precision mercury thermometer or a digital thermometer with a  $-1$  to  $57^\circ\text{C}$  range will meet this requirement.

5.5 *Desiccator*—A desiccator cabinet or large desiccator jar of suitable size containing silica gel or anhydrous calcium sulfate.

**NOTE 3**—It is preferable to use a desiccant that changes color to indicate when it needs reconstitution.

5.6 *Entrapped Air Removal Apparatus*—To remove entrapped air (deairing process), use one of the following:

5.6.1 *Hot Plate or Bunsen Burner*, capable of maintaining a temperature adequate to boil water.

5.6.2 *Vacuum System*, a vacuum pump or water aspirator, capable of producing a partial vacuum of 100 mm of mercury (Hg) or less absolute pressure.

**NOTE 4**—A partial vacuum of 100 mm Hg absolute pressure is approximately equivalent to a 660 mm (26 in.) Hg reading on vacuum gauge at sea level.

5.7 *Insulated Container*—A Styrofoam cooler and cover or equivalent container that can hold between three and six pycnometers plus a beaker (or bottle) of deaired water, and a thermometer. This is required to maintain a controlled temperature environment where changes will be uniform and gradual.

5.8 *Funnel*—A non-corrosive smooth surface funnel with a stem that extends past the calibration mark on the volumetric flask or stoppered seal on the stoppered flasks. The diameter of the stem of the funnel must be large enough that soil solids will easily pass through.

5.9 *Pycnometer Filling Tube with Lateral Vents (optional)*—A device to assist in adding deaired water to the pycnometer without disturbing the soil-water mixture. The device may be fabricated as follows. Plug a 6 to 10-mm ( $\frac{1}{4}$  to  $\frac{3}{8}$  in.) diameter plastic tube at one end and cut two small vents (notches) just above the plug. The vents should be perpendicular to the axis of the tube and diametrically opposed. Connect a valve to the other end of the tube and run a line to the valve from a supply of deaired water.

5.10 *Sieve*—4.75 mm (No. 4) conforming to the requirements of Specification **E11**.

5.11 *Blender (optional)*—A blender with mixing blades built into the base of the mixing container.

5.12 *Miscellaneous Equipment*, such as a computer or calculator (optional), specimen dishes, and insulated gloves.

## 6. Reagents

6.1 *Purity of Water*—Distilled water is used in this test method. This water may be purchased and is readily available at most grocery stores; hereafter, distilled water will be referred to as water.

## 7. Test Specimen

7.1 The test specimen may be moist or oven-dry soil and shall be representative of the soil solids that pass the 4.75-mm (No. 4) sieve in the total sample. **Table 2** gives guidelines on recommended dry soil mass versus soil type and pycnometer size.

7.1.1 Two important factors concerning the amount of soil solids being tested are as follows. First, the mass of the soil solids divided by its specific gravity will yield four-significant digits. Secondly, the mixture of soil solids and water is a slurry not a highly viscous fluid (thick paint) during the deairing process.

## 8. Calibration of Pycnometer

8.1 Determine the mass of the clean and dry pycnometer to the nearest 0.01 g (typically five significant digits). Repeat this

**TABLE 2 Recommended Mass for Test Specimen**

Soil Type	Specimen Dry Mass (g)	Specimen Dry Mass (g)
	When Using 250 mL Pycnometer	When Using 500 mL Pycnometer
SP, SP-SM	$60 \pm 10$	$100 \pm 10$
SP-SC, SM, SC	$45 \pm 10$	$75 \pm 10$
Silt or Clay	$35 \pm 5$	$50 \pm 10$