Designation: D5080 – 20

# Standard Test Method for Rapid Determination of Percent Compaction[1]

This standard is issued under the fixed designation D5080; 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.

## 1. Scope*

1.1 This test method describes the procedure for rapidly determining the percent compaction and the variation from optimum water content of an in-place soil for use in controlling construction of compacted earth. These values are obtained by developing a three-point compaction curve at the same water content as the in-place soil without knowing the value of the water content. The soil used for the compaction curve is normally the same soil removed from the in-place density test. For the remainder of this designation, this test method will be referred to as the *rapid method*.

1.2 This test method is normally performed for soils containing more than 15 % fines (minus 75-µm (No. 200) sieve size).

1.3 When gravel-size particles are present in the soil being tested, this test method is limited to a comparison of the minus 4.75-mm (No. 4) sieve-size fraction of the in-place density material to a laboratory compaction test of minus 4.75-mm (No. 4) sieve-size material (Method A of Test Methods D698). Subject to the limitations of Practice D4718/D4718M, this test method is also applicable to comparisons of other sieve-size fractions (for example, Method C of Test Methods D698) or other compactive efforts (for example, Test Methods D1557) if new water content adjustment values are determined (see 6.1 and Appendix X2).

1.4 *Units*—The values stated in SI units are to be regarded as standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.4.1 The use of balances or scales recording pounds of mass (lbm), or the recording of density in pounds of mass per cubic foot (lbm/ft$^3$) should not be regarded as nonconformance with this test method.

1.4.2 The sieve designations are identified using the "standard" system in accordance with Specification E11, such as 25-mm and 75-µm, followed by the "alternative" system of 1-in. and No. 200, respectively, in parentheses.

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 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 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; 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 analytical 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* See Section 9.

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.*

## 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$^3$))

[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**

D1556/D1556M Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$))
D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4718/D4718M Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
D6026 Practice for Using Significant Digits in Geotechnical Data
D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

## 3. Terminology

3.1 *Definitions*—For definitions of common technical terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *added water, z*—amount of water, expressed as a percentage of the wet soil mass, which is added to wet soil before compacting a specimen in the rapid method; if the water content of the wet soil is decreased, the amount of "added water" is a negative number (for example, −2.0 %).

3.2.2 *C value*—ratio, expressed as a percentage, of in-place wet density at field water content to the wet density of a laboratory compacted specimen prepared at field water content; the *C* value is a comparison of compactive effort of field compaction equipment to standard laboratory compactive effort.

3.2.3 *compaction curve at field water content*—plot showing the relationship between wet density at field water content (converted wet density) and the percent of "added water."

3.2.4 *converted wet density, $\rho wet_c$*—wet density of a compacted specimen after being converted (by correcting for the amount of "added water") to the wet density at field water content.

3.2.5 *D value*—ratio, expressed as a percentage, of in-place wet density at field water content to laboratory maximum wet density as determined from a compaction curve developed at field water content as determined by the rapid method; the *D* value is the rapid method equivalent of percent compaction.

3.2.6 *field water content, $w_f$*—water content of the minus 4.75-mm (No. 4) fraction of in-place soil.

3.2.7 *field wet density, $\rho wet_f$*—wet density as determined from an in-place density test.

3.2.8 *maximum wet density at field water content, ρm*—wet density defined by the peak of the laboratory compaction curve at field water content.

3.2.9 $w_f - w_o$—expression for the difference between the in-place water content and the optimum water content as determined by the rapid method.

## 4. Summary of Test Method

4.1 A representative sample of soil is obtained in conjunction with performing Test Method D1556/D1556M, D2167, D6938, or D2937. Soil specimens are compacted in accordance with Method A of Test Methods D698. At least three specimens are compacted, the first at field (in-place) water content, and each of the remaining at different water contents. A parabolic curve is assumed as defined by the three compaction points, and the peak point of the curve is determined mathematically. The ratio of in-place wet density at field water content to laboratory maximum wet density is determined. An approximation of the difference between optimum water content and field water content is determined. After the actual field water content is determined by ovendrying in accordance with Test Methods D2216 (usually the next day), the dry densities, unit weights, and optimum water content are calculated.

## 5. Significance and Use

5.1 The rapid method is performed to quickly evaluate percent compaction and variation from optimum water content of soils used in construction without knowing the value of field water content at the time of the test.

5.1.1 Test results are usually determined within 1 to 2 h from the start of the test.

5.1.2 The value of percent compaction obtained using the rapid method will be the same as the percent compaction calculated using dry density values.

5.1.3 The value of the difference between field water content and optimum water content will be approximate, but will be within ±0.1 to 0.2 percentage point of the difference calculated once the field water content is known.

5.2 Test results may be used to determine if the compacted material meets density and water content control values that are specified as a percentage of a standard maximum density and optimum water content such as determined in Method A of Test Methods D698. A three-point compaction curve is used in place of the four- or five-point curve required in Test Methods D698.

5.3 This test method is based on the assumption that a three-point compaction curve is a parabola at the section of the curve close to optimum water content so that the peak point of the curve can be determined mathematically. This assumption results in the major difference between this test method and obtaining the maximum density and optimum water content from a full five-point compaction curve.

5.4 Once the field ovendry water content has been determined in accordance with Test Methods D2216, the values of dry density, dry unit weight, and optimum water content can be calculated (see Note 1).

5.5 This test method can also be used for foundation or borrow area material to compare in-place dry density and unit weight and water content to laboratory maximum dry density and unit weight and optimum water content.

5.6 This test method has the advantage that the maximum density value can be obtained on the same soil excavated during the in-place density test.

NOTE 1—Since there is no need to immediately determine the water contents of material from the in-place density test or the laboratory compaction points, use of rapid water content determinations such as microwave, direct heat, nuclear, etc., is not needed. However, if desired, the percent compaction and variation from optimum water content may be determined using dry density values based on rapid water content test methods. Using three compaction points and determining the maximum density mathematically would still apply. However, the rapid water content methods may give results that differ from the accepted oven-dried water content values and will lengthen the time of performing this test method.

NOTE 2—The quality of the results produced by this test method 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. Users of these test methods are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable testing depends on many factors; Practice D3740 provides a means of evaluating some of those factors.

## 6. Interferences

6.1 The water content adjustment values were determined based on average density and optimum water content values of a large number of soil samples containing only minus 4.75-mm (No. 4) sieve-size particles. The soil being tested should be compared with the information in Appendix X2. For soils having properties significantly different, the water content adjustment values may not be applicable. If this is the case, new adjustment values must be determined for the specific soil (see Appendix X2).

6.2 For samples significantly dry or wet of their optimum water content (+6.0 %, −4.0 %), the values $w_f - w_o$ are less accurate.

## 7. Apparatus

7.1 Equipment for determining the in-place density as required by this test method.

7.2 Equipment for preparing laboratory compaction specimens as required for Method A of Test Methods D698.

7.3 Equipment for determining water content as required by this test method.

7.4 *Graduated Cylinder,* 100-mL capacity, graduated to 1 mL.

7.5 *Electric Fan,* or other drying device.

7.6 *Sieve,* a 4.75-mm (No. 4) sieve conforming to the requirements of Specification E11.

7.7 *Miscellaneous Equipment*—Brushes, knife, mixing pans, scoop, etc., for mixing or trimming soil specimens; bucket with lid or other suitable container for retaining the test sample.

## 8. Reagents and Water

8.1 Tapwater that is free of acids, alkalies, and oils and is generally suitable for drinking should be used for wetting the soil prior to compaction.

## 9. Hazards

9.1 *Safety Hazards*—While there are no safety hazards specific to this test method, there are safety precautions in the referenced test designations that are applicable.

9.2 *Technical Hazards*—The test specimens should be prepared and compacted as quickly as possible to minimize moisture loss. If the test is not performed immediately, store the sample in a moisture-proof container to prevent the loss of moisture. A determination of the water content before and after storage is recommended.

## 10. Standardization/Calibration

10.1 Verify equipment for determining the in-place density is standardized/calibrated according to the test method being used. Actual requirements will vary by test method.

10.1.1 If in-place density is to be determined in accordance with Test Method D1556/D1556M, verify that the sand cone density apparatus and density sand have both been calibrated for the batch of sand to be used for this test method.

10.1.2 If in-place density is to be determined in accordance with Test Method D2167, verify the rubber balloon apparatus has been calibrated to verify the accuracy of the volume indicator. In general, calibration should be performed annually, as a minimum, and whenever damage, repair, or change of the membrane has occurred.

10.1.3 If in-place density is to be determined in accordance with Test Method D2937, verify the measurements of the drive cylinder tube to be used for this test method have been determined. In general, determination of tube measurements are required before first use and when damage is suspected or repairs have been conducted.

10.2 Verify equipment for preparing laboratory compacted specimens, including balances, molds, and rammers is standardized in accordance with Test Methods D698. In general, standardization is required before initial use, after repairs, and at intervals not exceeding 1,000 test specimens, or annually, whichever occurs first.

## 11. Procedure

11.1 The procedure for performing this test method is divided into four sections as follows:

11.1.1 Obtain in-place density,

11.1.2 Compact specimens and obtain compaction curve,

11.1.3 Determine maximum point from compaction curve, $D$ value, and $w_f - w_o$, and

11.1.4 Complete test for record.

NOTE 3—Since the calculations are an integral part of the procedure, the calculations are included in the sections on procedure.

### OBTAIN IN-PLACE DENSITY

11.2 Perform the test for determining in-place wet density in accordance with Test Method D1556/D1556M, D2167, D6938,