



Standard Test Methods for Saturated Hydraulic Conductivity, Water Retention, Porosity, and Bulk Density of Putting Green and Sports Turf Root Zones¹

This standard is issued under the fixed designation F1815; 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 These test methods cover the measurements of saturated hydraulic conductivity, water retention, porosity (including distribution of capillary and air-filled porosity at a known soil suction), and bulk density on sand-based root zone mixes to be used for construction and topdressing of golf course putting greens including United States Golf Association (USGA) recommended greens, golf course tees, sand-based sports fields, or other highly trafficked turfgrass areas. These test methods are designed for sand-based mixes and are not intended for use with fine or medium textured soils, for example, sandy loams and loams.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns 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 its use.*

2. Referenced Documents

2.1 ASTM Standards:²

- D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
- D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- D2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
- D4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

¹ These test methods are under the jurisdiction of ASTM Committee F08 on Sports Equipment and Facilities and are the direct responsibility of Subcommittee F08.64 on Natural Playing Surfaces.

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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.

- D4959 Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating
- D5550 Test Method for Specific Gravity of Soil Solids by Gas Pycnometer
- E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
- F1647 Test Methods for Organic Matter Content of Putting Green and Sports Turf Root Zone Mixes

3. Summary of Test Method

3.1 *Test Method A*—Saturated hydraulic conductivity is determined on compacted, saturated mix or sand soil cores. Water flow through the core is maintained at a constant hydraulic head until a steady flow rate is achieved, at which time aliquots of the outflow are collected.

3.2 *Test Method B*—Water retention is obtained at a soil suction as defined by the design architect or engineer in the specifications. In lieu of a specification, or if testing for USGA greens, the water retention shall be determined at a soil suction of 30 cm. The water shall be extracted from a prepared core by means of a tension table or other water extraction apparatus. When equilibrium is achieved, the weight is recorded. The core is oven dried at 105°C until a constant weight is obtained. Water retention is calculated on an oven dried basis. Bulk density is calculated from the mix or sand dry weight and volume.

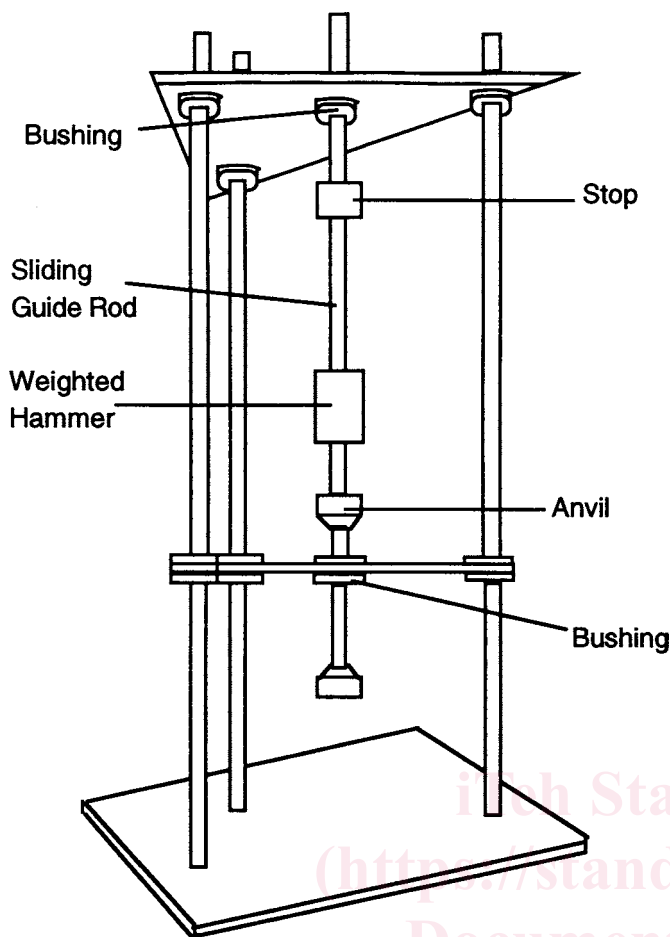
3.3 *Test Method C*—Total porosity is calculated from the bulk density and particle density.

3.4 *Test Method D*—Capillary porosity is calculated from the bulk density and water retention information. Air-filled or aeration porosity is calculated from the difference of total and capillary porosity.

4. Apparatus

4.1 *Cylinders*, made of metal, PVC, or similar rigid materials shall have an inside diameter of 51 or 76 + 2 mm (2 or 3 + 0.08 in.), and a height of 76 + 2 mm (3 + 0.08 in.).

4.2 *Compactor*, shall be such as to exert a total potential energy of 3.03 J/cm² (14.3 ft-lb/in.²) across the cross-sectional area of the core. Fig. 1 shows an example of such a device where a weighted hammer is dropped 15 times from a height of



NOTE 1—It has been found that 15 drops of the hammer from a height of 305 mm (12 in.) (as measured from the bottom of the weight to the top of the anvil) will produce a degree of compaction comparable to a severely compacted putting green, provided the soil contains moisture approximating field capacity.

FIG. 1 A Suggested Impact-Type Compactor to Produce a Total Dynamic Energy of 3.03 J/cm² Across the Surface Cross-Sectional Area of the Core

305 + 2 mm (12 + 0.08 in.). A51 mm (2 in.) diameter core will require 15 drops of a 1.36 kg (3 lb) hammer from a height of 305 mm (12 in.). A76 mm core will require 15 drops of a 3.02 kg (6.7 lb) hammer from a height of 305 mm (12 in.). The drops shall be completed within 1 min. The compactor shall rest on a rigid foundation such as a cube of concrete with a mass of not less than 40 kg (90 lb). Secure the base of the compactor to the foundation. The diameter of the compaction foot should be sufficient to prevent binding with the inside wall of the cylinder, but no more than 2 mm smaller in diameter than the inside diameter of the cylinder. The clearance between bushings and the guide rod should be sufficient to prevent binding, but should be no greater than 2 mm.

4.3 *Permeameter*, capable of maintaining a constant head of water for several hours.

4.4 *Tension or Porous Plate Apparatus*, capable of extracting water out of the cores at a soil suction of up to 4 kPa (40 cm suction). Fig. 2 shows an example of a tension table.

4.5 *Oven*, capable of maintaining a constant temperature of 105 ± 5°C.

4.6 *Balance*—A balance sensitive to 0.1 g.

4.7 *Thermometer*, accurate to 0.5°C.

4.8 *Sieves*, No. 5 (4 mm).

5. Preparation of Samples

5.1 Premixed Samples:

5.1.1 The cylinders should be prepared by attaching a double layer of cheesecloth or other suitable cloth material, including brass, stainless steel, or fiberglass, onto the bottom of each cylinder. The cheesecloth or other material should be trimmed to a consistent size prior to or after placement on the cylinder. Weigh and record the weight of each cylinder.

5.1.2 Screen the root zone mixture through a No. 5 (4 mm) sieve to remove peat clods and other debris. Peat clods should be broken up and returned to the sample.

5.1.3 In mixes containing peat or other organic amendments, determine percent organic matter using one of the methods in Test Methods F1647 to quantify organic matter content on a weight basis. This value and the method used should be reported so that field checks of mixes can be made to assure that the mix corresponds to that developed in the laboratory.

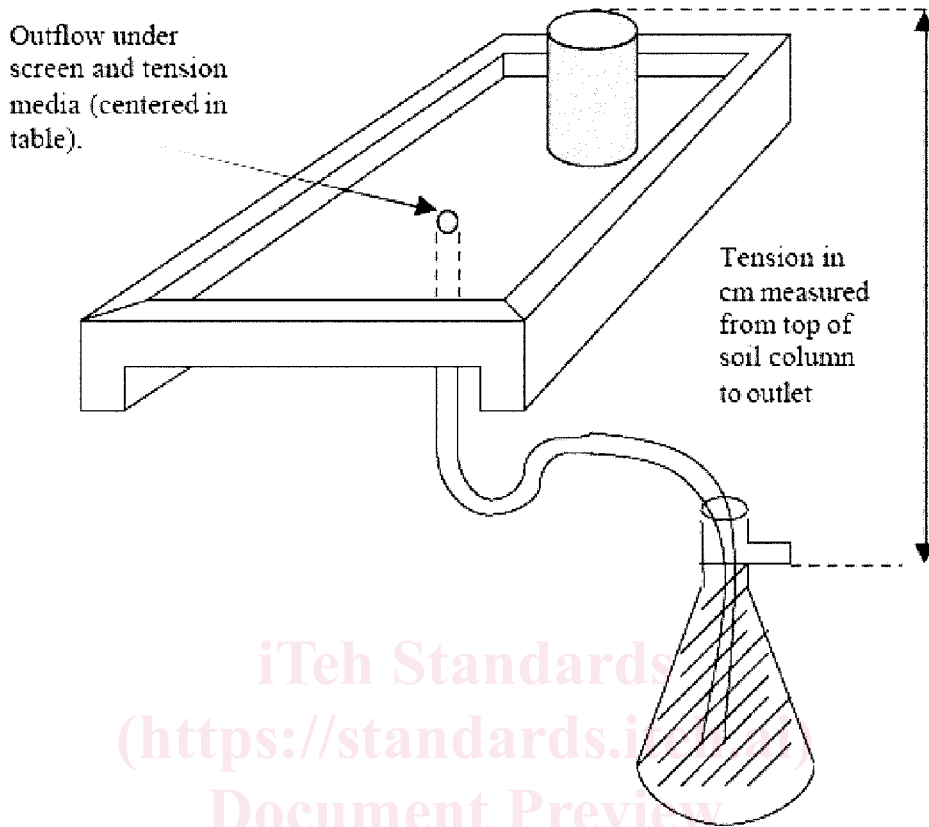
5.1.4 The gravimetric water content of the sample shall be determined by a referenced (Test Methods D2216, D4643, D4959) or other appropriate method. The water content of the sample shall be adjusted to 8 + 0.5 % by adding water to the sample by misting if the antecedent water content is below 8 %, or by air drying the sample if the antecedent water content is above 8 %. Water content is expressed on a dry weight basis ((wt. water/wt. dry soil) × 100).

5.1.5 Place moistened root zone mix into the cylinder, tapping gently on a firm surface as mix is added. Add sufficient quantities of mix to fill the cylinder. The intent here is to have the surface of the compacted mix or sand within 10 mm from the top, but not above the lip of a 76 mm height cylinder. If the level of the compacted mix is above 76 mm or below 66 mm, remove the mix and repack the cores. To ensure a sufficient height (66 to 76 mm) of the compacted mix or sand, a cylinder longer than 76 mm can be used or a second cylinder of the same diameter and 2 cm or greater in height can be secured to a 76 mm test cylinder prior to filling and compaction of the sample. This cylinder is removed after compaction.

5.1.6 Place the cylinder in a pan of water and allow it to saturate from the bottom up for at least 30 min, until the mix in the core is visibly saturated. The level of the water in the pan shall be within 2 mm below the top of the cores. Be careful not to splash any water onto the mix or sand surface.

5.1.7 Place the cylinders on a tension table or other water extracting device, set to remove water at the desired soil suction (see Fig. 2 for proper measurement). Samples evaluated for USGA greens should have water extracted at a soil suction of -3 kPa (30 cm). Leave sample cores on the tension table for at least 16 h. Cover the tension table and cylinders with a plastic sheet or similar cover to minimize evaporation from the surface of the cores and the tension table.

Tension Table



Cross Section of Tension Table

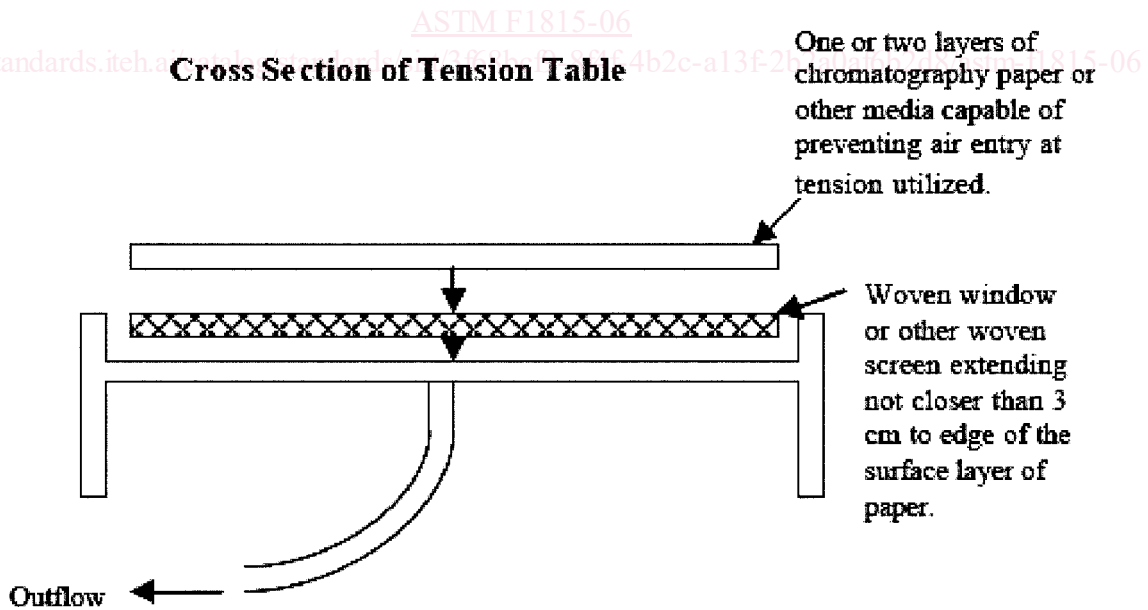


FIG. 2 Suggested Tension Apparatus Capable of Extracting Water out of the Mix or Sand Cores

5.1.8 Place the cylinder onto the base of the compactor, and drop the weight 15 times from a height of 305 + 2 mm (12+ 0.08 in.).

5.1.9 Remove the upper cylinder, if one is used. If the level of the mix is above the top of the lower cylinder, remove the mix, repack the cylinder with new mix, resaturate the sample,