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An American National Standard

Standard Test Method for Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Rootzone Mixes[1]

This standard is issued under the fixed designation F1632; 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 covers the determination of particle size distribution of putting green and other sand-based rootzone mixes. Particles larger than 0.05 mm (retained on a No. 270 sieve) are determined by sieving. The silt and clay percentages are determined by a sedimentation process, using the pipet method. This procedure was developed for putting green rootzone mixes, those assumed to have sand contents of 80 % by weight or greater. Particle size analysis of soils may be performed by this test method or Test Method D422. This test method also describes a qualitative evaluation of sand particle shape.

1.2 *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 Document

2.1 *ASTM Standards:*[2]

D422 Test Method for Particle-Size Analysis of Soils

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

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. Apparatus

3.1 *Balance,* sensitive to 0.001 g.

3.2 *Stirring Apparatus,* may be either of the following types:

3.2.1 *For Method A—An Electric Mixer,* made for mechanical mixing of soils, or

3.2.2 *For Method B—A Horizontal Reciprocating Shaker,* with holder for 250 mL flasks or bottles.

3.3 *Sedimentation Cylinder,* a glass cylinder marked for a volume of 1000 mL. The height of the 1000 mL must be 36 ± 2 cm from the bottom on the inside.

3.4 *Thermometer,* accurate to 0.5°C.

3.5 *Pipet Rack,* a device for lowering a pipet to a precise depth in the sedimentation cylinder.

3.6 *Pipets,* Lowy or other wide tipped type, 25 mL capacity.

3.7 *Weighing Bottles or Beakers,* glass with a capacity of 100 mL.

3.8 *Sieves,* square mesh with woven wire (brass or stainless steel). The sieves shall conform to the requirements of Specification E11. A full set of sieves shall include the following:

3.8.1 *No. 10*—2 mm,

3.8.2 *No. 18*—1 mm,

3.8.3 *No. 35*—500 µm,

3.8.4 *No. 60*—250 µm,

3.8.5 *No. 100*—149 µm,

3.8.6 *No. 140*—105 µm, and

3.8.7 *No. 270*—53 µm.

3.9 *Sieve Shaker,* type that provides vertical tapping action as well as horizontal shaking.

3.10 *Desiccator.*

3.11 *Dispersing Agent,* a 5 % sodium hexametaphosphate (HMP) solution, made by dissolving 50 g of reagent or technical grade HMP in 1000 mL of distilled or demineralized water.

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

3.13 *Water*—shall be distilled or demineralized, and brought to the temperature that is expected to prevail during the sedimentation process. If air temperatures are expected to fluctuate, cylinders should be placed in a constant temperature water bath, and the distilled or demineralized water brought to the temperature of the water bath.

[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilitiesand is 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.

3.14 *Dissecting Microscope,* 25 to 50× power.

TEST METHOD 1—PROCEDURE FOR PARTICLE SIZE ANALYSIS

4. Procedure

4.1 *Dispersion of Sample:*

4.1.1 Weigh 100 ± 5 g of air-dried rootzone mix to the nearest 0.1 g and place in mixing cup (Test Method A) or flask (Test Method B). Place a duplicate sample into a drying oven set at 105 ± 5°C for correction to oven dried basis.

4.1.2 Add 100 mL of dispersing agent. Stir or swirl until the rootzone mix is thoroughly wet. Allow to stand for 4 h. If using Test Method B, place the flasks or bottles on the shaker and shake for 16 h or overnight.

4.1.3 *Test Method A*—Add about 100 mL of water to the mixing cup and place onto the mixer. Mix for 5 min on low speed.

4.2 *Determination of the Sand (2.0 to 0.05 mm) Fractions and Gravel (material >2 mm):*

4.2.1 Place a tared No. 270 sieve onto a large funnel held by a stand over a sedimentation cylinder. Pour the suspension onto the sieve. Rinse remaining sand material out of the cup or flask with water onto the sieve. Wash the collected sand and gravel with misted water to wash any remaining silt or clay particles through the sieve into the cylinder.

4.2.2 An alternative for collecting sand and gravel is to separate following the sampling for clay (4.3). In this case the suspension is poured and washed onto a No. 270 sieve after pipeting has been completed. The sample is then washed until only sand and gravel remain on the sieve. Then continue the procedure at 4.2.3. If this alternative method is used, the volume of silt plus clay suspension at pipeting time is less than 1000 ml due to the presence of sand and gravel. Thus the clay percentage as calculated in 6.1 must be corrected. Assuming a particle density of 2.65 g/cc for sand and gravel, conversion factors for various sand plus gravel weights in the cylinder are as follows:

Sand and Gravel in Cylinder, g	Conversion Factor to Correct % Clay in 6.1
68 to 92	0.97
93 to 100	0.96

4.2.3 Wash the material retained on the No. 270 sieve into a tared beaker, and place into an oven at 105 ± 5°C until dry and weigh.

4.2.4 Transfer the dried sand to a nest of sieves. Shake the sieves on a shaker for 5 min. Check thoroughness of sieving in each sieve by the hand method of sieving and continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving (see Test Method D422). Weigh gravel [material retained on No. 10 (2 mm) sieve] and each sand fraction to the nearest 0.1 g.

4.3 *Determination of Clay (<2 μm):*

4.3.1 Add distilled or demineralized water to the sedimentation cylinder to bring up to the 1000 mL volume. Cover the cylinder with waxfilm, a stopper, or watch glass. Place the cylinder into a water bath, or allow it to stand until the temperature of the suspension is the same as the water bath or the air temperature, respectively.

4.3.2 After the temperature is constant, resuspend the silt and clay by one of the two following methods: (a) stir thoroughly with a hand stirrer, using an up and down motion for at least 30 s; or (b) stopper the cylinder and shake end over end for 1 min.

4.3.3 Use Tables 1 and 2 or appropriate calculations using Stoke's Law to determine sampling depths and times for the suspension temperature.

4.3.4 Turn on the vacuum and withdraw a 25 mL sample in about 12 s. Rate of withdraw is important.

4.3.5 Discharge the sample into a tared beaker or drying dish.

4.3.6 To wash out any residual material in the pipet draw 25 mL of water into the pipet, and discharge into the same drying dish.

4.3.7 Evaporate the water and dry the clay at 105 ± 5°C.

4.3.8 Cool in a desiccator and weigh to the nearest 0.001 g.

5. Determination of Correction for Dispersing Solution

5.1 Dispense 100 mL of dispersing solution into 1 L container.

5.2 Add distilled or demineralized water to 1 L volume, stir or swirl until thoroughly mixed.

5.3 Draw 25 mL and dispense into a tared beaker or drying dish.

5.4 Draw 25 mL of water and dispense into same dish.

5.5 Evaporate in an oven at 105 ± 5°C.

5.6 Weigh the sediment in the beaker (W_D) to the nearest 0.001 g.

6. Calculation for Test Method 1

6.1 Calculate percent clay as follows:

TABLE 1 Settling Velocities and Settling Times (at 10-cm depth) for 5 g/L HMP Solutions and Particle Density of 2.65 g/cc when Sampling for Clay (<2 microns) at Various Temperatures

Temperature, °C	Settling Velocity, cm/h	Time for 10-cm Depth, h
14	1.084	9.23
15	1.112	8.99
16	1.142	8.76
17	1.172	8.53
18	1.203	8.31
19	1.233	8.11
20	1.264	7.91
21	1.295	7.72
22	1.327	7.54
23	1.358	7.36
24	1.390	7.19
25	1.423	7.03
26	1.455	6.87
27	1.488	6.72
28	1.521	6.57
29	1.555	6.43
30	1.588	6.30

TABLE 2 Sampling Depths for Clay (<2 microns) at Specified Times and Temperatures for 5.0 g/L HMP Solutions and Particle Density of 2.65 g/cc

Temperature (°C)	Sampling Depth (cm) After			
	4.5 h	5.0 h	5.5 h	6.0 h
14	4.9	5.4	6.0	6.5
15	5.0	5.6	6.1	6.7
16	5.1	5.7	6.3	6.9
17	5.3	5.9	6.4	7.0
18	5.4	6.0	6.6	7.2
19	5.6	6.2	6.8	7.4
20	5.7	6.3	7.0	7.6
21	5.8	6.5	7.1	7.8
22	6.0	6.6	7.3	8.0
23	6.1	6.8	7.5	8.2
24	6.3	7.0	7.6	8.3
25	6.4	7.1	7.8	8.5
26	6.5	7.3	8.0	8.7
27	6.7	7.4	8.2	8.9
28	6.8	7.6	8.4	9.1
29	7.0	7.8	8.6	9.3
30	7.1	7.9	8.7	9.5

$$\% \, clay = \frac{40(W_C - W_D)}{W_S} \times 100$$

where:

W_C = weight of clay in drying dish (g),
W_D = weight of sediment from dispersing solution, and
W_S = weight of rootzone sample, corrected for initial water content.

6.2 Calculate percent gravel and percent sand for each sand size fraction as follows:

$$\% \, sand \, or \, gravel = \frac{W_{SA}}{W_S} \times 100$$

where:

W_{SA} = weight of sand or gravel retained on sieve, and
W_S = corrected weight of the rootzone sample.

6.3 Calculate percent silt as follows:

$$\% \, silt = \left[\frac{W_S - W_{Ct} - W_{SSA}}{W_S} \right] \times 100$$

where:

W_S = corrected weight of the rootzone sample (g),
W_{CT} = total weight of clay (g), and
W_{SSA} = sum of sand and gravel weights (g).

TEST METHOD 2—QUALITATIVE ASSESSMENT OF PARTICLE SHAPE

7. Procedure

7.1 Place a small quantity of dried sand in a dish or on a microscope slide. Observe particle shape of several grains of sand. Repeat this two or three times.

7.2 Use Fig. 1 to describe particle angularity and sphericity.[3]

[3] From Baker, S. W., Sports Turf Research Institute, Bingley, England.

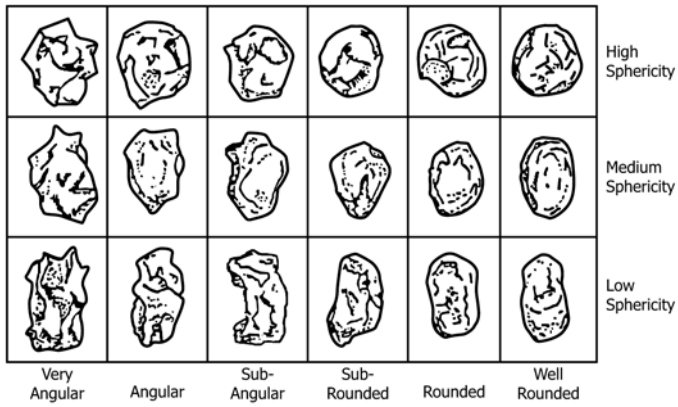

FIG. 1 Chart Showing the Angularity and Sphericity of Sand Grains

8. Report

8.1 Report the following information:

8.1.1 The particle size analysis, listing the percent gravel, sand, silt, and clay to the nearest 0.1 %. The sum of these four fractions shall equal 100,

8.1.2 The percent sand to the nearest 0.1 % retained on each sieve, expressed as the percentage of the entire sample; that is, the total sand fractions should equal the sand percentage listed in the particle size analysis,

8.1.3 The D_{85} to the nearest 0.01 mm of the root zone mix. The D_{85} is the particle diameter where 85 % of the sand particles are finer in particle size, and

8.1.4 Description of the sand particle shape.

9. Precision and Bias

9.1 *Interlaboratory Test Program*—An interlaboratory study was conducted in accordance with procedures of Practice E691. Three randomly selected test specimens for each of six rootzone mixes were sent to nine laboratories for determination of gravel, sand (total and six fractions), silt, and clay. Data on the two finest sand fractions were based on results from seven laboratories. The mixes were representative of sandy rootzones used on turfgrass areas and were mixtures of either (1) sand and peat, (2) sand and soil, or (3) sand, soil, and peat. Being typical mixes, they contained only small amounts of gravel, sands <0.15 mm, silt, and clay. Ranges of materials in each size fraction were limited due to the sizing within such rootzone mixes.

9.2 *Test Result*—The following precision information for size fraction contents and 95 % repeatability (within laboratory) and reproducibility (between laboratories) limits is in the unit of percentage, and the limits are for the comparison of two test results (within the ranges indicated), each of which is the average of three test determinations. The terms *repeatability limit* and *reproducibility limit* are used in accordance with Practice E177E11 and are indicated as *r* and *R*, respectively, in the following section.

9.3 *Precision*—In the following sections, *r* and *R* indicate the value below which the absolute difference between two individual test results obtained under repeatability (within laboratory) and reproducibility (between laboratories)

conditions, respectively, may be expected to occur with a probability of approximately 95 %. Values in parentheses following an *r* or *R* value indicate the range of *r* or *R* values for the test samples.

9.3.1 *Gravel (+No. 10)*—Test Range 0.1 to 0.8 %.

$$r = 0.6\,\%\ (0.2 \text{ to } 1.0\,\%) \quad (1)$$

$$R = 0.9\,\%\ (0.3 \text{ to } 1.3\,\%) \quad (2)$$

Test value 13.0 %.

$$r = 4.8\,\% \quad (3)$$

$$R = 9.0\,\% \quad (4)$$

9.3.2 *Very Coarse Sand (-No. 10, +No. 18)*—Test Range 0.2 to 6.1 %.

$$r = 0.8\,\%\ (0.5 \text{ to } 1.2\,\%) \quad (5)$$

$$R = 1.6\,\%\ (0.9 \text{ to } 2.2\,\%) \quad (6)$$

Test value 13.6 %.

$$r = 3.0\,\% \quad (7)$$

$$R = 4.0\,\% \quad (8)$$

9.3.3 *Coarse Sand (-No. 18, +No. 35)*—Test Range 3.2 to 26.8 %.

$$r = 1.7\,\%\ (1.3 \text{ to } 2.6\,\%) \quad (9)$$

$$R = 4.5\,\%\ (3.4 \text{ to } 5.8\,\%) \quad (10)$$

9.3.4 *Medium Sand (-No. 35, +No. 60)*—Test range 31.7 to 67.0 %.

$$r = 2.2\,\%\ (1.6 \text{ to } 3.8\,\%) \quad (11)$$

$$R = 4.8\,\%\ (3.8 \text{ to } 5.7\,\%) \quad (12)$$

9.3.5 *Fine Sand—1 (-No. 60, + No. 100)*—Test range 8.8 to 23.4 %.

$$r = 1.4\,\%\ (1.0 \text{ to } 1.8\,\%) \quad (13)$$

$$R = 2.7\,\%\ (1.7 \text{ to } 3.9\,\%) \quad (14)$$

9.3.6 *Fine Sand—2 (-No. 100, + No. 140)*—Test range 1.6 to 3.4 %.

$$r = 0.4\,\%\ (0.4 \text{ to } 0.7\,\%) \quad (15)$$

$$R = 1.0\,\%\ (0.8 \text{ to } 1.2\,\%) \quad (16)$$

9.3.7 *Very Fine Sand (-No. 140, + No. 270)*—Test range 0.6 to 2.6 %.

$$r = 0.8\,\%\ (0.5 \text{ to } 1.4\,\%) \quad (17)$$

$$R = 1.5\,\%\ (0.9 \text{ to } 2.5\,\%) \quad (18)$$

9.3.8 *Total Sand (-No. 10, +No. 270)*—Test range 87.3 to 97.9 %.

$$r = 1.6\,\%\ (1.0 \text{ to } 2.0\,\%) \quad (19)$$

$$R = 4.5\,\%\ (2.2 \text{ to } 6.0\,\%) \quad (20)$$

Test value 78.6 %.

$$r = 5.3\,\% \quad (21)$$

$$R = 12.2\,\% \quad (22)$$

9.3.9 *Silt (53 μm to 2 μm)*—Test range 1.1 to 6.1 %.

$$r = 1.6\,\%\ (0.9 \text{ to } 2.2\,\%) \quad (23)$$

$$R = 3.7\ \%\ (2.0 \text{ to } 4.3\,\%) \quad (24)$$

Test value 8.3 %.

$$R = 3.5\,\% \quad (25)$$

$$R = 6.2\,\% \quad (26)$$

9.3.10 *Clay (<2 μm)*—Test range 1.0 to 3.4 %.

$$r = 0.8\,\%\ (0.7 \text{ to } 0.9\,\%) \quad (27)$$

$$R = 1.7\,\%\ (1.4 \text{ to } 2.0\,\%) \quad (28)$$

9.4 *Bias*—The bias for these measurements is undetermined because there is no reference value for the materials (mixes) used.

10. Keywords

10.1 particle size; putting greens; sand; sand particle shape; soil; sports fields; turfgrass