



Evaluating Bunker Sands

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The bunker sand assessment is designed to evaluate the proposed or existing sand from a performance perspective, as well as the impact on the agronomics of the putting green. The performance aspect of the sand for bunker use involves the ball impact characteristics as well as maintenance factors.

The performance of a particular bunker sand is largely the result of the sand size distribution and particle shape. Bunker properties, such as, drainage rate, crusting, and set-up are negatively affected by very fine sand, silt, and clay. A minimal amount of these particles should be part of the selection criteria. Sand shape has an affect on ball-lie, with angular sands providing better lie than round sands.

The bunker sand evaluation in the laboratory is a process that involves three distinct parts. Samples that are to be analyzed for their potential as a bunker sand are usually tested using the bunker evaluation test series (penetrometer test, crusting, setup, shape, color), infiltration rate testing, and particle size analysis. A representative sample that is approximately 1 gallon in size (10 pounds) should be submitted to the lab for bunker testing.

The bunker evaluation test series is conducted using the procedures published in *Golf Course Management* (1986, 54:64-70). The particle size and infiltration rate analyses are determined using standard operating procedures from the American Society for Testing and Materials (ASTM). The sand size distribution is based on the United States Department of Agriculture (USDA) definition of sand grain classification.

The **penetrometer test** is used to evaluate ball-lie in the sand. To the golfer, the ball-lie is probably the most important aspect of the performance of the sand. Moderate to very low tendencies to bury the ball are the more acceptable ball-lie ratings. While there are varying assessments of the results from this testing, the following ratings are typically used to when evaluating ball-lie characteristics.

Ball-lie Rating (Tendency to Bury Ball)	Penetrometer Value (kg/cm2)	Rating
High	< 1.8	Undesirable
Moderate	1.8 to 2.2	Acceptable
Slight	2.2 to 2.4	Acceptable
Very Low	> 2.4	Desirable

Color is important from the aesthetic viewpoint. Sand color is reported on wet and dry samples with the Munsell Color Chart Book. Color is typically reported with a number containing the hue, value, and chroma, with the color name following. Lighter colored sands are often preferred because they provide a nice contrast with the turf. Color is more of a personal selection, and the sand color is often dependent on local availability more than performance criteria.

Infiltration rate (saturated hydraulic conductivity) data provides an indication of how well the sand will drain after rain or irrigation. An infiltration rate of greater than 30 in/hr suggests that the sand should drain well.

Particle shape affects how the sand will pack, thus it is related to the ball-lie characteristics. Typically, sharp angular sand will provide a more desirable ball-lie than rounded sand. The **crusting** test is related to the sand's tendency to form a hard layer on top after rain or irrigation. Ideally, the sand will not crust or set-up, as this is an indication of reduced need for raking after precipitation.

Parameter		Rating
Shape	Crusting	
Rounded	Severe	Undesirable
Sub Rounded to Mixed	Slight to Moderate	Acceptable
Angular	None	Desirable

Particle size is determined using standard operating procedures from the American Society for Testing and Materials (ASTM). Particle size testing of bunker sands provides information related to properties of the bunker, as well as, the sand's effects on nearby greens.

The particle size analysis is the primary means for evaluating the potential impact of the bunker sand on the agronomics of the green. In many cases, the particle size distribution should approximate United States Golf Association (USGA) recommendations for putting green construction in order to not create a layering of the surface from the effects of explosions of bunker sand onto the putting green areas. Coarse or gravelly sands may place unwanted particles on the green and result in a surface with obstructive particles that could impair putting and mowing operations. Fine sand particle accumulations on the green's surface may cause irregularities of water movement and the overall physical characteristics of the root-zone. However, sands that have a more desirable ball lie characteristics will often have a wider particle size distribution than putting green sands.

To minimize the effect of fine sand content on the green surface from either bunker shots or wind erosion, an alternative is to use a sand that is of the same particle size as the rootzone mix or greens sand. A comparison of bunker sand size recommendations, the 2018 USGA particle size recommendations for greens mix, and the particle size of sands acceptable for "California Greens" is listed in the table below.

Our bunker sand evaluation package, includes the particle size test in conjunction with the bunker test series and infiltration rate testing. This bunker sand evaluation process should provide a good indication of how the sand will perform in the bunker and affect nearby greens.

Additional tests that can help with bunker sand evaluation include angle of repose and moisture column testing. The angle of repose test provides an approximation of how steep bunker sand walls can be built, before the sand will start to slide down steep bunker faces. The moisture column test provides information on water holding at varying sand depths, helping in the assessment of proper sand depths for bunker bases.

Table 1. Comparison of Particle Size Recommendations for Bunker and Greens Sand

Fraction Size Name	U.S. Standard Sieve Mesh	Diameter of Sieve (mm)	Bunker Sand	USGA Greensmix Sand	"California Greens" Sand
			% Retained on sieve or fraction.	% Retained on sieve or fraction.	% Retained on sieve or fraction.
Gravel	10	2.00	≤ 2%	≤ 3%	≤ 10
Very Coarse	18	1.00	≤ 15%	≤ 7%	
Coarse	35	0.50	78 – 100%	60% minimum	82 – 100%
Medium	60	0.25		≤ 20%	
Fine	100	0.15		≤ 5%	
Fine	140	0.10		≤ 5%	
Very Fine	270	0.05	≤ 5%	≤ 5%	0 – 8%
Silt		0.002	≤ 3%	≤ 5%	
Clay		< 0.002		≤ 3%	
Uniformity Coefficient (Cu)			2.0 – 5.0	1.8 – 3.5	-

While these tests are great indicators, construction and maintenance practices will have a profound affect on the actual performance. The slope of the bunker and surrounds, and the presence (or lack) of a subsurface drainage system will also have a big affect on the performance of the bunker.

Aside from playability, factors such as color and aesthetics are often weighed in the decision process. We recommend that interested parties visit a club with the sand they are considering, play into and out of it, and see how they like it.

References:

Std Test Method for Particle Size Anal. and Sand Shape Grading of Golf Course Putting Green and Sports Field Rootzone Mixes. Nov 2001. F1632-99. ASTM Vol. 15.07.

The Sand Putting Green Construction and Mangement Cooperative Extension Univ. of California Div. of Agriculture and Nat. Resources, Publication 21448.

USGA Recommendations for a Method of Putting Green Construction. 2018 revision

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