



Designation: F3400 – 19

Standard Test Method for *In-situ* Testing of Functional Properties of Equine Surfaces: Artificial Surfaces¹

This standard is issued under the fixed designation F3400; 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 specification for the measurement of the functional properties of equine surfaces; cushioning, impact, firmness, responsiveness and uniformity. This test method specifies test procedures that are appropriate for field testing of equine surfaces. This test method defines the functional properties of equine surfaces. This test method does not specify safety criteria. The extent to which functional properties contribute to individual injury risk is not known.

1.2 Where appropriate values are stated in SI units.

1.3 *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.*

1.4 *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. Terminology

2.1 *Definitions:*

2.1.1 *consistency, n*—how much the surface changes with time and use.

2.1.2 *corner, n*—identifiable area that is being used by horses to turn from a long to a short side or vice-versa.

2.1.3 *cushioning, n*—how much a surface is supportive compared to how much it gives when riding on it.

2.1.4 *grip, n*—how much the horse's foot slides during landing, turning and pushing off.

2.1.5 *impact firmness, n*—the shock experienced by the horse and rider when the hoof contacts the surface.

2.1.6 *quarter line, n*—a line located at either $\frac{1}{4}$ or $\frac{3}{4}$ width of the surface parallel to the long side.

2.1.7 *responsiveness, n*—how active or springy the surface feels to the rider.

2.1.8 *track, n*—a regularly used area of the surface that is usually 1 to 1.5 m away from and parallel to the perimeter of the surface.

2.1.9 *uniformity, n*—how regular the surface feels when the horse moves across it.

3. Summary of Test Method

3.1 This procedure specifies the measurement of the functional properties of equine surfaces that include racing surfaces using a machine designed to replicate the vertical loading of a horse's limb while simultaneously sliding across the track surface. This is accomplished by a falling mass along angled rails on the machine. A second axis perpendicular to the surface allows for sliding motion upon impact. Measurements of multiple functional properties of the surface is accomplished by the machine's three-axis load cell that measures forces, the three-axis accelerometer that measures decelerations, and string potentiometer that measures deformation and recovery properties. The data is stored and can be easily downloaded to a computer for analysis. The machine is able to collect functional property data while replicating the speed and impact of a realistic horse-hoof-surface collision.

4. Significance and Use

4.1 This test method specifies test procedures that can easily be used for field testing of equine surfaces. It is a test method that can be consistently applied to any equine surface and can quantitatively measure functional properties and track surface performance changes over time.

5. Interferences

5.1 To remove unwanted signal noise, appropriate filtering may be applied to the sampled signals. This must be specified in the report. And is shown in the [Table 1](#).

6. Apparatus

6.1 Field testing of equine surfaces *in-situ* must include the following; measurement of the surface cushion moisture

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TABLE 1 Filters Used with OBST Data

Sensor	Filter
Tri-axial load cell	4th order bi-directional Butterworth with 400 Hz cut off (1)
Tri-axial accelerometer	4th order bi-directional Butterworth with 400 Hz cut off (1)
Linear potentiometer or equivalent	4th order bi-directional Butterworth with 100 Hz cut off (2)
String potentiometer or equivalent	4th order bi-directional Butterworth with 100 Hz cut off (2)

content, temperature and depth, air analysis (for surfaces containing binders) and measurement of the functional properties of the surface.

6.2 The requirements of the equipment design for testing the functional properties of equine surfaces are listed in Table 2. Meaningful between surface comparisons of functional properties are essential.

6.3 The design of equipment (Orono Biomechanical Surface Tester (OBST)) and instrumentation currently used to measure the functional properties of equine surfaces *in-situ* is summarized below with assembly drawing given in Fig. 1. Further information about the OBST can be found at the designer's website (10). The tester is a two-axis gravity driven impact type of apparatus, which drops a hoof shaped projectile (with size 2 steel shoe) at an angle to the soil surface with a landing speed of approximately 3.8 m/s. The device is supported by a frame that is mounted to a vehicle of sufficient weight to secure it to the ground during testing. In principle, the two non-orthogonal axes of motion drive the hoof into the ground, which produces a simultaneous downward motion and a forward slide of the shoe. This mimics the motion of the forelimb of a horse during the early loading phase. Force is generated by accelerating a 33 kg mass down a long set of rails that are angled at 12° from a 840 mm vertical height. A second set of shorter linear bearings that are vertically aligned accommodate a pre-loaded spring and damper system to which the hoof is attached. This moves down as a part of the mass attached to the slide and when the hoof contacts the ground the second preloaded axis is compressed and the difference in angle between the angled rails and vertically aligned bearings forces the hoof to slide forward. Load from the spring-mass-damper system is recorded directly above the hoof using a dynamic load cell (a). Acceleration is recorded from a tri-axial accelerometer attached to a stiff mass above the hoof (b). Deformation and recovery response is measured from a linear potentiometer that is attached to the upper and lower aspects of

the linear bearing arrangement (c). Landing speed is measured using a string potentiometer attached to the falling mass of the system (d).

6.4 Instrumentation used with the OBST to measure the functional properties of equine surfaces is listed in Table 3. Signals from the OBST instrumentation are collected at 5000 Hz synchronously with a 16 bit A/D converter and a digital I/O interface. A user guide for the OBST can be found in Supplemental Information (see Certification Procedure).

6.5 A time domain reflectometry (TDR) soil moisture meter with two 7.5 cm rods is required to obtain *in-situ* moisture measurement from surfaces that do not contain wax, other moisture replacement products or rubber particles. For all surfaces that a TDR cannot be used, sealable bags approximately 125 by 150 mm and a sealable container are required.

6.6 For surfaces that contain a binder a temperature probe is required to obtain temperature measurements from the surface.

6.7 Needle probe and narrow hand trowel to measure surface cushion depth and inspect the sub-surface (where necessary).

6.8 For surfaces that contain a binder, a MiniRAE 3000² and 1 L cover bell to measure Total Volatile Organic Compounds (TVOC) are required.

7. Sampling, Test Specimens, and Test Units

7.1 For surfaces that contain a binder the temperature probe should be used. For each of the locations identified for mechanical testing take an average of 3 readings from the probe and record the location (grid reference) and average temperature measurement or include the temperature measurement in the functional properties file metadata.

7.2 Use SI units when it is applicable.

7.3 For surfaces that do contain wax, other products that are used to substitute moisture or rubber particles, 100 g samples should be collected from each location. Place each sample in a sealed bag and clearly identify the grid reference on the bag. Put all of the samples in a sealable container, label with arena identifiers and date and seal the container.

7.4 Agreed remedial work, maintenance, and, if needed, required alterations in preparation. This should be in consultation with footing experts/on-site maintenance team and laboratories analyzing material samples.

8. Calibration and Standardization

8.1 Raw signals must be converted from voltages into SI units for each sensor using current calibration information.

9. Procedure

9.1 Record the size of the arena plus any notable features (for example, entrance, equipment store, vehicle access point)

TABLE 2 Equipment Design Requirements

Design Requirement	Current Range Measured in Horses
Quantification of vertical force reduction	7 to 14 kN (3, 4)
Quantification of vertical impact acceleration	0 to 350 g (5, 6)
Quantification of surface frequency response	time of propulsive phase $\approx$ 0.1 s (7)
Quantification of horizontal sliding/shear resistance	20 to 120 mm (8, 9)

² The sole source of supply of the apparatus known to the committee at this time is RAE Systems, <https://www.raesystems.com>. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.