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An American National Standard

Standard Practice for Validation, Calibration, and Certification of Walkway Tribometers Using Reference Surfaces[1]

This standard is issued under the fixed designation F2508; 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.

ε[1] NOTE—Editorially corrected footnote 4 in August 2017.

1. Scope

1.1 This practice is intended to establish the procedures for validation, calibration, and certification of walkway tribometers.

1.2 This practice provides a walkway tribometer supplier with a procedure and suite of reference surfaces to validate his walkway tribometer by properly ranking and differentiating the surfaces.

1.3 This practice provides the user of a walkway tribometer with a procedure and suite of reference surfaces to test calibration of his instrument.

1.4 This practice provides a procedure through which an entity may certify a walkway tribometer model, signifying that the walkway tribometer model has a completed and documented validation and interlaboratory study.

1.5 This practice describes the necessary materials, specifications, and the cleaning process for reference materials, as well as the requirements for the validation of a supplier's walkway tribometer and calibration of a user's walkway tribometer.

1.6 This practice applies to walkway tribometers without reference to the nature of the scale of the readings produced by them. The scale used in the reports of validation and calibration must be the same, and are to be those of the instrument or defined for the instrument.

1.7 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only and are not considered standard.

1.8 *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.*

1.9 *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]

D1349 Practice for Rubber—Standard Conditions for Testing

D3244 Practice for Utilization of Test Data to Determine Conformance with Specifications

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F1646 Terminology Relating to Walkway Safety and Footwear

3. Terminology

3.1 For terms used in this practice not identified herein, refer to Terminology F1646.

3.2 *Definitions:*

3.2.1 *paired t-test, n*—a test of statistical significance based on the use of student's *t*-distribution and used to compare two sample means (see Annex A2).

3.2.2 *supplier, n*—any individual, agent, company, manufacturer, or organization responsible for the walkway tribometer prior to receipt by the user. **D3244**

3.2.3 *test foot, n*—shoe bottom material or surrogate mounted on the walkway tribometer that comes into contact with the surface being tested.

3.2.4 *walkway tribometer, n*—any apparatus used to measure the frictional forces acting at an interface between a walkway surface and shoe material.

[1] This practice is under the jurisdiction of ASTM Committee F13 on Pedestrian/Walkway Safety and Footwear and is the direct responsibility of Subcommittee F13.10 on Traction.

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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.

3.2.4.1 *Discussion*—A judgement of the adequacy of these frictional forces acting on a walkway surface/shoe surface interface is the basis for an assessment of slip properties relative to human locomotion.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *calibration, n*—the set of operations that establishes, under specified conditions, the relationship between the values obtained by a walkway tribometer and the corresponding supplier reference values.

3.3.2 *certification test method, n*—a specific test method that is used for all walkway tribometer operational tasks in this practice performed as part of a certification.

3.3.3 *laboratory, n*—a combination of one individual, uniquely identifiable walkway tribometer, one individual, uniquely identifiable test foot, and one operator, none of which (or whom) may be reused for the same purpose in the interlaboratory study being conducted.

3.3.4 *reference surfaces (RS's), n*—specified materials, identified in Section 7, that have an experimentally demonstrated slip properties for a select population of pedestrians and serve as references for walkway tribometer measurements.

3.3.5 *validation, n*—the set of operations that establishes, under specified conditions, the proper ranking and differentiation of reference surfaces by a walkway tribometer.

4. Summary of Practice

4.1 This practice establishes a procedure to: *(1)* validate walkway tribometer models against a human gait-based reference system, *(2)* calibrate each individual walkway tribometers of a validated model against published suppliers' reference values (as defined in 9.1, Eq 4), and *(3)* certify that the tribometer model has completed a documented validation and interlaboratory study.

4.2 This practice provides for validation and calibration of walkway tribometers as a means of verifying their relationship to reference surfaces and verifying a particular device continues to produce consistent results. Certification, if conducted, formally documents the methods, data, and results of a validation and interlaboratory study.

4.3 The method of ranking walkway surface slip properties using a limited population of ambulating human subjects is supported by a peer-reviewed study.[3]

4.4 Validation consists of a series of 24 tests on each reference surface from this practice. A walkway tribometer model is considered valid if it ranks the four reference surfaces from this practice in the proper order with statistically significant differentiation between results obtained for each surface. Validation is intended to be accomplished for each walkway tribometer model when it is initially introduced and is to be accomplished by or on behalf of the supplier and made available to each user.

4.5 Calibration for a specific walkway tribometer requires a series of 16 tests on each of the reference surfaces from this practice. A specific walkway tribometer is considered within calibration if the bias of the mean test values for each surface falls within the 95 % confidence interval for the walkway tribometer model as established by the validation tests (as defined in 9.1, Eq 4).

5. Significance and Use

5.1 To be meaningful, walkway tribometer results must correlate the slip characteristics of a surface or contaminant, or both, to the actual propensity for human slips. To achieve this goal, walkway tribometer models must be validated against a standard with relevance to human ambulation.

5.2 This practice prescribes a series of reference surfaces with known relative slip potential ranging from very high to low (as defined by laboratory conditions only) upon which walkway tribometer models can be validated. The relative slip potential of each reference surface was established from human subject walking trials.[3]

5.3 The following should be considered in applying the validation and calibration obtained by this practice:

5.3.1 The scientific study upon which the validation process is based was conducted with a select population of young adults (mean age 26 years) who were free from gait deviations while walking in a straight path on a level surface with a mean walking velocity of 2.18 m/s. This walking velocity is faster than the average walking velocity for the general population which includes a much wider age range with greater variability; thus, the study sample population of pedestrians and conditions is not representative of the larger general population of pedestrians.

5.3.2 All subjects walked in Oxford-style shoes whose soles were constructed of smooth styrene butadiene rubber (SBR) with 75A Shore hardness. The shoe style and sole material is not representative of all combinations available in the marketplace.

5.3.3 The reference surfaces defined in this practice are not representative of all walkway surfaces. The outcome of the validation practice reflects performance on the type of reference surfaces and surface conditions defined in this practice only. Validation and calibration of a walkway tribometer as defined by this practice does not imply validation and calibration under all combinations of test foot materials and walkway surfaces.

5.3.4 The validation and calibration procedure defined by this practice is not intended to establish a "safe threshold" value for any walkway surface.

6. Apparatus

6.1 The walkway tribometer shall be free of defects and operational throughout its range. Refer to the walkway tribometer instruction manual to ensure proper operation and instrument condition before the validation and calibration process.

6.2 *Test Foot Designation and Condition:*

[3] Powers, C. M., Blanchette, M. G., Brault, J. R., Flynn, J., and Siegmund, G. P., "Validation of Walkway Tribometers: Establishing a Reference Standard," *Journal of Forensic Sciences*, Vol. 55, No. 2, March 2010, pp. 366–370.

6.2.1 The supplier must provide test foot material, dimension, storage, and service life specifications. The specifications shall be sufficient to permit procurement of an exemplar test foot.

6.2.2 A uniquely numbered test foot, meeting the supplier's material and dimensional specifications shall be provided with the walkway tribometer being tested.

6.2.2.1 The calibration results shall apply only to the walkway tribometer/test foot combination tested.

6.2.3 Prepare the test foot as prescribed by the walkway tribometer supplier or by a fully documented procedure included in the validation or calibration report.

7. Reference Surfaces (RS's)[4]

7.1 *Reference Surfaces:*

7.1.1 *RS A*—Polished black granite whose surface beneath the test foot is covered with a continuous film of 0.04 % by volume solution of Triton X-100[5] (nonionic surfactant) in distilled water (that is, 200 µL of Triton X-100 per 500 mL of distilled water).

7.1.2 *RS B*—Porcelain whose surface beneath the test foot is covered with a continuous film of distilled water.

7.1.3 *RS C*—Vinyl composition tile whose surface beneath the test foot is covered with a continuous film of distilled water.

7.1.4 *RS D*—Ceramic whose surface beneath the test foot is covered with a continuous film of distilled water.

7.2 Each RS shall be permanently marked to designate its reference class (that is, "A", "B", "C", "D").

7.3 Reference surfaces shall be stored in a manner that prevents deformation and contamination.

7.4 Reference surfaces should not be used for validation or calibration testing after 5 years from date of purchase.

8. Procedure

8.1 *Environment*—The validation and calibration test shall be performed at a humidity level of 50 ± 5 % and a temperature range of 23 ± 2°C (73.4 ± 3.6°F) (derived from Practice D1349).

8.2 *Reference Surface Preparation*—The reference surface shall be free from visible dents, cracks, voids, or other significant blemishes.

8.2.1 *Cleaning:*

8.2.1.1 No surface treatment except as specified in this section is permitted.

8.2.1.2 Prepare a 0.05 % by volume solution of liquid sodium lauryl sulfate in distilled water (that is, 250 µL of sodium lauryl sulfate per 500 mL of distilled water).

8.2.1.3 Dip a clean soft-bristled nylon brush in the cleaning solution and gently scrub in a circular pattern the entire reference surface for a minimum of 10 s. Reapply the cleaning solution and repeat the minimum 10-s scrubbing two times.

8.2.1.4 Rinse the surface thoroughly with distilled water, ensuring that no visible suds or soap residues remain.

8.2.1.5 Prepare an ethanol solution containing equal parts denatured ethanol in distilled water.

8.2.1.6 Dip a clean soft-bristled nylon brush, different from that used in 8.2.1.3, in the ethanol solution and gently scrub the reference surface for 10 s.

8.2.1.7 Dry the reference surface with dry and oil-free compressed air or air dry if compressed air is not available. Any visible contamination remaining after this step will disqualify the reference surface for use.

8.2.1.8 Ensure that handling of the reference surface does not introduce contaminants to the surfaces, including exposing the surfaces to contact of human skin.

8.2.1.9 The cleaning procedure should be performed before each testing session.

8.3 *Reference Surface Mounting*—Mount the reference surface onto a flat and rigid substrate that prevents movement of the reference surface parallel to the test plane of the walkway tribometer during testing. Select a substrate that will not deform during wet testing.

8.4 *Walkway Tribometer Validation Testing*—Using the walkway tribometer being validated and the test foot prepared in 6.2.3, perform 24 tests in accordance with a uniquely identifiable version of the walkway tribometer supplier's operating instructions or any other formal procedure in the test area of each of the four reference surfaces that have been prepared in accordance with 8.2. Of the 24 tests, perform 6 in each of 4 orthogonal directions, that is, at 0, 90, 180, and 270° relative to an arbitrarily defined direction on the reference surface. Record the results of all tests as specified in Section 10.

9. Analysis of Results and Walkway Tribometer Validation

9.1 For the 24 tests on each reference surface, calculate the mean $(\bar{X})$, standard deviation (*SD*), standard error (*SE*) of the mean, and 95th percentile confidence interval (*CI*) for the walkway tribometer test results for each reference surface using Eq 1 through Eq 4, respectively:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n}(x_i) \tag{1}$$

where:

n = number of measurements (24), and
x_i = test result

$$SD = \sqrt{\frac{1}{n-1}\cdot\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{2}$$

$$SE = \frac{SD}{\sqrt{n}} \tag{3}$$

$$95\text{th percentile } CI = \bar{X} \pm (1.96 \times SE) = \bar{X} - (1.96 \times SE) \text{ to } \bar{X} + (1.96 \times SE) \tag{4}$$

[4] Available from ASTM International Headquarters. Order Adjunct No. ADJF2508CS. Original adjunct produced in 2011.

[5] The sole source of supply of the apparatus known to the committee at this time is Gallade Chemical, Santa Ana, CA. 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.