Standard Method for Conducting an Interlaboratory Study (ILS) to Establish Repeatability and Reproducibility of a Walkway Tribometer Measuring Wet Dynamic Coefficient of Friction (DCOF) for a Common Hard-Surface Walkways

Section 1: Scope/Purpose/Application/Exceptions

1.1 Scope

This method specifies the procedure for conducting an inter-laboratory study (ILS) for a walkway tribometer used to measure the wet dynamic coefficient of friction (DCOF) of common hard-surface walkways.

1.2. Purpose

This test method evaluates the validity, repeatability and reproducibility of instruments and methods employed to evaluate the wet DCOF of common hard-surface walkway surfaces across a typical traction range.

1.3 Application

This ILS applies to any tribometer (test instrument) which purports to measure the wet DCOF of common hard-surface walkways as prescribed in the NFSI B101.3 (most current version) Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values)

Note: The ILS for evaluating test methods used to evaluate walkway traction does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the Operator to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. No express or implied representation or warranty is made regarding the accuracy or significance of any test results, for which instrument performance is evaluated by this ILS methodology set forth herein, in terms of slip resistance.

Section 2: Reference to other Standards and Publications

NFSI B101.1 (most current version) – Test Method for Measuring the Wet DCOF of Common Hard-Surface Floor Materials.

NFSI B101.3 (most current version) Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values)

ASTM D297-93(2006) Standard Test Method for Rubber Products – Chemical Analysis

ASTM D2240-05 Standard Test Method for Rubber Property – Durometer Hardness

ASTME691-92 Standard Practice for Conducting and Interlaboratory Study to Determine the Precision of a Test Method

ASTM F1646-03 Standard Terminology Relating to Safety and Traction of Footwear

ASTM F-2508-13 Standard Practice for Validation, Calibration, and Certification of Walkway Tribometers Using Reference Surfaces

Section 3: Definitions

3.1 Analysis of Variance (ANOVA). A statistical technique that separates systematic variation that is attributable to the operator and/or testing instrument from random variation.

3.2 Friction. Resistance to the relative motion of two solid objects in contact. This force is parallel to the plane of contact and is perpendicular to the normal force.

3.3 High Traction. The physical property of a floor or walkway that is designed to mitigate slipping by pedestrians wearing ordinary footwear during normal human ambulation by providing a reasonably sufficient level of available contact friction (Traction).

3.4 Interlaboratory Study (ILS). A controlled study designed to evaluate the consistency of two or more laboratories purporting to measure the same object or phenomenon.

3.5 Laboratory. A combination of instrument, method and person (Operator) or persons used to evaluate the wet DCOF of a flooring material.

3.6 Low Traction. The physical property of a floor or walkway that provides a comparatively low level of available friction, thus increase the risk of slipping during normal human ambulation.

3.7 Moderate Traction. The physical property of a floor or walkway that provides a moderate level of available friction, thus creating a moderate risk of slipping during normal human ambulation.

3.8 Normally Trained Operator. A tribometer operator who has received normal (sufficient) training on the operation of the walkway tribometer under review, but who does not possess expert-level knowledge on tribology and/or the specific tribometer being evaluated by the ILS.

3.9 P-Value. A statistical term that, for the purpose of this standard, quantifies the likelihood that variability in DCOF readings can be attributed to the use of different examples of the same tribometer instruments and/or different normally trained operators. For this ILS, a p-value < 0.1. constitutes an unacceptable degree of Operator and/or instrument-related variation.

3.10 Qualified Individual. A qualified individual is a particular person who having complied with the specific requirements or precedent conditions via education, training, experience, or other

requisites of a position that s/he holds or seeks, and who can perform the essential functions of the position.

3.11 Validation Surfaces – two (2) engineered hard surface materials whose wet dynamic coefficient of friction (DCOF) values have been tested and verified by the National Floor Safety Institute (NFSI). When tested in accordance with NFSI B101.3 (most current version) one surface will possess a wet DCOF value between 0.13 – 0.18 (Low Traction) the other surface will possess a wet DCOF value between 0.70 – 0.75 (High Traction). See Attachment 4.

3.12 Repeatability. Or, test-re-test reliability, is the variation in measurements taken by a single person or instrument on the same item and under the same conditions. Repeatability conditions include the same measurement procedure, the same observer, the same measuring instrument, used under the same conditions, the same location and repetition over a short period of time.

3.13 Reproducibility. Refers to the ability of a test or experiment to be accurately reproduced, or replicated, by independent parties evaluating the same material(s) under the same conditions.

3.14 Slip Resistance. The property of a floor or walkway surface that acts in sufficient opposition to those forces and movements exerted by a pedestrian under normal conditions of human ambulation (see Traction).

3.15 Dynamic Coefficient of Friction (DCOF). The ratio of the horizontal component of force applied to a body required to overcome resistance to movement when the body is already in motion divided by the vertical component of the weight of the body or force applied to the surface where movement occurs.

3.16 Dynamic Friction. The resistance opposing the force required to perpetuate the movement of one surface over another.

3.17 Traction. The friction between the sole material of a shoe and the fixed surface it moves upon.

3.18 Walkway Tribometer. An instrument or device specifically designed to measure the available level of traction upon a flooring material or walkway surface.

Section 4: Procedure for the Inter-laboratory Study of a Walkway Tribometer Method

This method for conducting an inter-laboratory study (ILS) may be utilized to evaluate the performance of any tribometer designed to measure the wet dynamic coefficient of friction (DCOF) of a floor or walkway surface under the conditions specified herein.

4.1 Laboratory. A laboratory shall be defined as the combination of one instrument and one Operator. ILS participants shall create six (6) unique laboratories by combining three (3) different measurement instruments and two (2) normally trained operators. For the purpose of this ILS, data shall be collected from each instrument/Operator combination.

4.1.1 Validation Surfaces. Two validation surfaces shall be provided by the NFSI. One surface is designated as "low traction" and the second surface is designated as "high traction." All testing shall be conducted in conformance with NFSI B101.3 (most current version) Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values). See Attachment 4.

4.2 Data Collection. Each tribometer seeking ILS validation shall collect data from each laboratory according to the following guidelines.

4.2.1 Designate a Qualified Individual. A qualified individual is a supplier neutral, third-party observer who is a licensed Professional Engineer (PE) and has knowledge in the area of Tribology and or techniques of measurement for quality assurance - ideally as a quality engineer (CQE), reliability engineer (CRE) or quality auditor (CQA) from the American Society for Quality (ASQ). Qualified Individuals must be approved by the NFSI and shall be required to sign an affidavit as an attest to their neutrality.

4.2.2 Generate and Record Data. Data shall be generated, recorded, and submitted to NFSI to the following guidelines:

4.2.2.1 Each of the six laboratories shall test each validation surface four times, once in the N-S direction, once in the S-N direction, once in the E-W direction and once in the W-E direction and record the results in Attachment 3. This process will be repeated for all three (3) tribometers for a total of forty-eight (48) observations. Testing shall comply with the measurement techniques set forth in the tribometer supplier's operating manual.

4.2.2.2 The neutral third-party observer shall confirm that each laboratory is conducting measurements in accordance with the methodologies set forth in the walkway tribometer supplier's operating manual and in compliance with NFSI B101.3 (most current version) Standard.

4.2.2.3 The neutral third-party observer shall record all data on standard data collection forms provided by the NFSI. (Data Collection Sheet in Attachment 3.)

4.2.2.4 The NFSI recognizes that mistakes can be made in measuring walkway traction. As such, the Operator may elect to exclude an observation prior to receiving visual or other sensory feedback about the measurement. Once the value from the observation is known to the Operator, the value may not be excluded from the data set. It is the responsibility of the third-party observer to decide when an observation may or may not be excluded.

4.2.2.5 The neutral third-party observer shall sign each data collection sheet as an attest to the data collection process, and forward the data sheets to the NFSI at the following address:

NFSI
P.O. Box 92607
Southlake, TX 74892
Attn: Laura Cooper

Section 5: Method for Analyzing the Data Collected During a Walkway Tribometer Inter-laboratory Study

Upon receipt of data collection forms signed by the neutral third-party observer, NFSI's designated analyst(s) shall evaluate the submitted data and render an official statement about the instrument/method's performance on the ILS.

5.1 Data Editing. For each data set of (48) observations from each of the six (6) laboratories employed to test each of the two (2) surfaces provided by the NFSI, the two (2) highest readings and the two (2) lowest readings shall be excluded from the data set, leaving a net total 40 observations.

5.2 Data Analysis. To qualify for NFSI recognition (Approval) as a walkway tribometer, the instrument and method shall perform satisfactorily both on the Pass/Fail Evaluation and the Analysis of Variance (ANOVA) Evaluation.

5.2.1 Pass/Fail Evaluation. The NFSI has set-forth a methodology by which the walkway tribometer's performance in testing standard materials is evaluated using a Pass/Fail test.

5.2.1.1 Pass/Fail Criteria. Pass/fail criteria have been set forth by the NFSI that are approximately +/- 10% of the known value for the tested material. For example, if the wet DCOF for a material is known to be 0.48, any reading that is between 0.53 and 0.44 shall be designated a "Pass." Any reading that falls outside of these bounds shall be designated a "Fail."

5.2.1.2 Required Confidence Level. The NFSI requires that the pass/fail test shall allow for a five percent (5%) likelihood of a false reading and be statistically accurate at the 95% confidence level.

5.2.1.3 Pass/Fail Judgment for a Material. A laboratory shall be deemed to "Pass" in its ability to test a particular flooring material if all forty (40) observations of the wet DCOF for that validation surface fall within the Pass/Fail criteria bounds set forth by the NFSI. The presence of any outlying observations in the edited data shall constitute a "Fail" for the laboratory/material combination.

5.2.1.4 Pass/Fail Judgment for a Laboratory. A laboratory shall be deemed to "Pass" if all forty (40) observations of the wet DCOF for each of the two (2) validation surfaces fall within "Pass" category of the Pass/Fail criteria bounds set forth by the NFSI. The presence of any outlying

observations in the edited data set shall constitute a "Fail" for the laboratory for the Pass/Fail evaluation.

5.2.1.5 Pass/Fail Judgment for a Walkway Tribometer Methodology. A walkway tribometer method shall be deemed to "Pass" if all observations made by each of the six (6) laboratories on each of the two (2) standard designated validation surfaces fall within the pass/fail criteria set forth by the NFSI. The presence of any outlying observations in the edited data set shall constitute a "Fail" for the tribometer methodology for the Pass/Fail evaluation.

5.2.2 Analysis of Variance (ANOVA) Evaluation.

5.2.2.1 Methodology. NFSI shall employ a three-factor ANOVA process to evaluate the performance of each walkway tribometer instrument and method combination in testing materials with high and low traction. The analysis shall be conducted according to standard and customary statistical techniques. The following table summarizes the experimental design employed for the ANOVA.

		Instrument 1	Instrument 2	Instrument 3
Operator 1	NFSI Low Traction Material	40 Observations	40 Observations	40 Observations
	NFSI High Traction Material	40 Observations	40 Observations	40 Observations
Operator 2	NFSI Low Traction Material	40 Observations	40 Observations	40 Observations
	NFSI High Traction Material	40 Observations	40 Observations	40 Observations

5.2.2.2 Evaluation. The walkway tribometer method shall pass the ANOVA evaluation if the p-value is greater than 0.10, meaning that the likelihood of instrument and/or Operator interference is less than 10% when testing high.

5.3 Overall Pass/Fail Criteria. The instrument/method shall be deemed to have passed the NFSI inter- laboratory study for a walkway tribometer only if it successfully succeeds in both the Pass/Fail and ANOVA evaluations.

5.4 Waiting Period for Reassessment. In the event that an instrument/method is unsuccessful in its attempt to achieve ILS validation from the NFSI, the supplier may attempt validation after a mandatory waiting period of ninety (90) days. There is no limit to the number of times ILS validation may be attempted.

Section 6: Report Generated Following Data Analysis for a Walkway Tribometer Inter-laboratory Study

For each instrument/method's submission, a confidential report shall be submitted to the sponsoring organization. The report shall serve to state whether or not the instrument/method passed or failed the NFSI ILS for a Walkway Tribometer. The report shall contain the following details and analysis.

1. A clear statement of overall Pass/Fail status.
    a. If the instrument method/passed, a certificate of confirmation shall accompany the report.
    b. If the instrument/method failed, a concise statement of weaknesses shall be provided to enable the supplier to modify the instrument and/or method.
2. Details about the Pass/Fail evaluation data for each instrument/Operator/material combination.
3. Details about the ANOVA evaluation to test for instrument/method and or Operator bias in the measurement.

Section 7: Term of Validation

7.1 Standard Term of Certification. If successfully validated by the NFSI inter-laboratory study method, the instrument/method's certification of ILS validation shall be valid for a period of five (05) years, after which to retain its certificate of validation, the instrument must be revalidated according to the then current methodology set forth by the NFSI.

7.2. Provision for Design Change. Any change in the design of a walkway tribometer instrument and/or method that materially alters the core method for measuring the wet DCOF of a walkway material invalidates the certification of ILS validation and the new instrument/method shall require revalidation.

Attachment 1 – Logic for Pass/Fail Analysis for Establishing Repeatability of a Walkway Tribometer

The NFSI opted to use a pass/fail test to establish repeatability of a walkway tribometer. To pass, each laboratory must produce 48 reading that fall within the range specified by the NFSI for a given Surface. The logic for requiring 48 observations that fall within the specified range is based upon the following standard equation for determining the sample size of a pass/fail test.

$$n = \frac{\ln\left(1 - \frac{c\%}{100\%}\right)}{\ln\left(1 - p\right)}$$

Where:
n = The required number of observations without a "failure," which is an observation that falls outside of the specified parameters
ln = log normal
c% = The required confidence level, in our case 95%
p = Specified p-value – in our case, 0.05

For the pass/fail portion of the ILS for walkway tribometers, the equation is as follows:

$$n = \frac{\ln\left(1 - \frac{95\%}{100\%}\right)}{\ln\left(1 - 0.05\right)} = 58.40$$

The resultant value of 58.40 was rounded to 48 – a slightly more conservative requirement than that produced by the standard equation. To circumvent complications associated with data editing, it was decided to require a total number of 64 observations per laboratory per Surface type. The highest two and lowest two readings are automatically excluded by the data analyst. If the remaining 48 observations fall within the parameters set forth by NFSI for the pass/fail test, the specified laboratory passes for the specified Surface. If all laboratory/Surface combinations pass, the walkway tribometer passes the pass/fail portion of the ILS to establish repeatability.

Attachment 2 – Analysis of Variance (ANOVA) to Establish Reproducibility for a Walkway Tribometer

Overview

Analysis of Variance, or ANOVA, is a statistical technique employed to differentiate and analyze the significance of systematic variation relative to random variation observed in a sample data set. For the purposes of validating a walkway tribometer under the NFSI Interlaboratory Study (ILS) method, our objective is to differentiate variation specifically related to different tribometer instruments provided by a single supplier and/or different tribometer operators associated with each laboratory. The ANOVA is employed to establish the reproducibility of a walkway tribometer.

Significance to Walkway Tribometer Measurement

A valid walkway tribometer must produce repeatable and accurate results with no significant interference induced by the Operator or serial number on an instrument provided by a particular supplier. If an unacceptable level of Operator or instrument interference exists, it could result in false positive (measurements identify a problem when one does not actually exist) or false negative (measurements fail to identify a problem when one does actually exist) readings in the field.

Method

For the walkway tribometer ILS study, the ANOVA will compare the variation within the following "treatment" groups to the total amount of variation observed for all observations.

- Operator to Operator Variation
- Instrument to Instrument Variation
- Combined Operator/Instrument to Operator/Instrument Variation

ANOVA employs the Fisher Test, more commonly called the F-Test, which is based upon the Fisher Distribution first developed in the 1920s by Sir Ronald A. Fisher. The F-Test is the ratio of systematic variation to total variation. The result is reported as the p-value, which denotes the probability that the group responsible for systematic variation is the same as the larger sample population. As with most statistical techniques, the p-value penalized when the study includes a small number of observations. A larger sample size affords more "degrees of freedom" to the analysis. For the purpose of the walkway tribometer ILS, a p-value < 0.10 on any of the three treatment groups shall be deemed significant, causing the instrument seeking validation to fail.

Attachment 3 –Data Collection Sheet

Device 1.	**Surface 1.**	**Surface 1.**	**Surface 1.**	**Surface 1.**	**Surface 2.**	**Surface 2.**	**Surface 2.**	**Surface 2.**
Operator 1.								
Operator 2.								

Device 2.	**Surface 1.**	**Surface 1.**	**Surface 1.**	**Surface 1.**	**Surface 2.**	**Surface 2.**	**Surface 2.**	**Surface 2.**
Operator 1.								
Operator 2.								

Device 3.	**Surface 1.**	**Surface 1.**	**Surface 1.**	**Surface 1.**	**Surface 2.**	**Surface 2.**	**Surface 2.**	**Surface 2.**
Operator 1.								
Operator 2.								

NOTE: two 2 operators using 3 tribometers = 6 labs. Each lab will collect 48 total data points.

Validation surface sample measurements are to be taken in four different directions:
N-S (↓), E-W (←), S-N (↑), W-E (→).

Attachment 4 – Reference Surface Material Specifications

High- Traction Surface

        Material: 12" X 12" X 3/8" clear tempered glass with beveled edge
        Pattern: 1/8" X 1/8" X 80 microns checkerboard
        Pattern Material: kiln fired ceramic ink (white) applied at 720 DPI print resolution
        thickness.
        Source: M3 Glass, Inc. Irving, TX or equivalent

Low-Traction Surface

        Material: 12" X 12 X ¼" Arctic White King Starboard plastic sheet with beveled edge
        Source: Boat Outfitters Inc. Ocoee, FL SKU #13770-42002-1-CP or equivalent