C21 Visual Characterization of Tribometric Reference Surfaces Using Logistic Regression

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After attending this presentation, attendees will have learned of a visually intuitive method, based upon logistic regression, to characterize the efficacy of a tribometrist's technique in using a Tribometric Reference Surface (TRS) set. TRS's are floor surfaces with specific parameters that are utilized to, calibrate and verify a tribometer (a walkway-friction test instrument), and provide a means of comparing the test results of different tribometers on a given test surface (not a TRS).

This presentation will impact the forensic science community by giving researchers and practitioners knowledge of reliability issues in tribometric testing, and the background needed to understand the strengths and weaknesses of their technique in validating a TRS set.

Background: ASTM Committee F-13 on Pedestrian Walkway Safety and Footwear has been tasked with developing a non-proprietary Standard Test Method for the evaluation of walkway friction. As one important step, Subcommittee F13.1 on Traction is developing a Standard Test Method for measuring the slip properties of the TRS's (generically called Standard Reference Materials (SRMs) by the ASTM). Very briefly, to be considered acceptable, a tribometer must (a) rank the different TRS surfaces in the reference set in the proper, predetermined friction order (low to high) and (b) be able to discriminate (exhibit statistically-significant friction differences) between the different TRS surfaces. Importantly, the specific numeric values obtained in the testing are not in themselves considered an end result. The predetermined friction rank order of the TRS surfaces correlates with the human slip as determined by human-subject experimentation. Thus, biofidelity is inherent in the choice and ranking of the TRS set. It is noted that the official TRS set, i.e., the SRMs that are sold and certified by the ASTM, are not yet available for sale. Although the tests and analysis in this paper use similar (if not identical) TRS surfaces as will be available from ASTM International, it is important not to infer anything vis à vis the SRM set based upon these tests. Rather, the user can repeat these tests using the official SRMs, for test-process verification and quality control.

Logistic Regression: This presentation examines a process by which tribometry-instrument users can gain insight into the efficacy of their techniques using the TRS set and analyzing test results using Logistic regression.

Logistic regression is a mathematical modeling tool that allows one to determine the "best" parameters in a model that predicts a dichotomous (YES/NO) result using continuous independent, predictor variables. Here, the dichotomous variable is whether there will be a slip or not (the probability of a slip), and one (if not *the*) independent variable is the friction between the shoe (or test foot) and the surface (or test surface or the TRS) as determined by the tribometric instrument. The logistic regression parameter of interest here is the logistic slope of the curve: the larger in magnitude the slope parameter, the finer the discrimination between the slip and no-slip conditions on that TRS. Interestingly, the intercept parameter in the model is of no interest in our application. The logistic-regression equation is:

$$P(\text{slip})_i = \frac{1}{1+e^{\beta_0+\beta_1 x_i}}, \quad \textit{where}$$

P(Slip) = Probability of a slip on trial i,

β_0 is the intercept term (not used in this paper),

β_1 is the slope term

TRS Testing: The testing was conducted using a modified Slip- Test Mark II tribometer, (a portable inclinable articulated strut tribometer) and four TRS's (Official Vinyl Composition Tile (OVCT), Porcelanosa Ferroker Ceramic tile, Stone Peak Ceramic Tile, and polished black granite). The Mark II tribometer was modified such that the tribometer setting could be varied by very small angular increments (0.01° for angles up to 10°, and 0.1° above 10°). The angle of inclination was determined using a SPI-Tronic Pro 3600 Digital Protractor affixed to the inclinable carriage of the tribometer. The tribometer angle was increased until a slip was noted, the tribometer's slip angle was backed off, and sets of successive readings were taken (typically n=10 at each setting) as the tribometer's friction angle was increased, typically by 0.1° in order to generate the logistic regression values for each TRS. Here are the results, again noting that these results should not be

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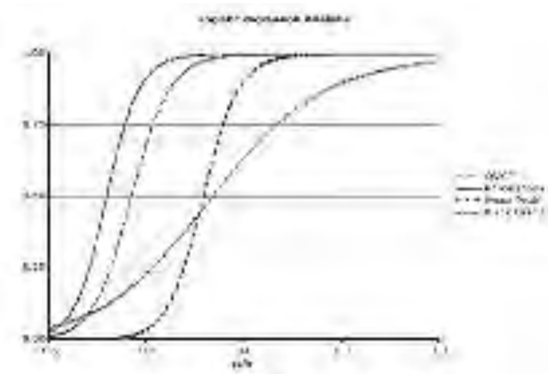
considered applicable to the ASTM-certified SRM set:

TRS surface	Number of tests	Intercept (C_0)	Friction-angle slope (C_1)	P(slip) = 0.5	r
Porcelanosa Porcelain Tile	333	50.53	-1.5380	29.4°	0.68
OVCT	456	44.59	-1.2026	34.4°	0.68
[illegible] Tile	[illegible]	[illegible]	-1.5004	[illegible]	[illegible]
Polished Black Granite	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

It was found that the two ceramic tiles and the OVCT had steep and distinctly separated logistic curves. On the other hand, the Polished Black Granite had a shallow logistics curve that crossed over all three of the other TRS curves. This is a clear indication that (a) the experimental technique used in with the Polished Black Granite was wanting or, (b) that the Granite was not the same as the granite used in the ASTM's SRM set.



Conclusion: It is concluded that, beyond the basic Analysis of Variance tools that must be utilized to ensure that the rank-order and statistically-

distinct requirements that must be met to ensure TRS-set validation, characterization of the TRS set by logistic regression is a useful technique to enable the researcher or practitioner to determine at a glance whether any problems exist in TRS set and, further, to show where those problems lie.

Tribometer, Slip and Fall, Logistic Regression, Logistic Regression

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