C44 Effect of Surface Tension on the Ability of a Selection of Tribometers to Rank and Differentiate Standard Reference Surfaces

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After attending this presentation, attendees will understand: (1) the significance of surface tension on the slip measuring process; (2) the importance of quantifying and standardizing measurement variables under wet conditions; and, (3) the effect of surface tension on machine bias.

This presentation will impact the forensic science community by demonstrating the effect of surface tension on wet slip resistance measurements and machine bias.

Method: ASTM F2508 was used to measure the effect of variations stemming from the use of surfactants on test results using the same reference materials with a Slip-Test Mark II portable inclinable articulated strut tribometer (PIAST).

Slip resistance and coefficient of friction measurements have been made since the time of Leonardo Da Vinci. In more recent history, efforts to make such measurements meaningful in the context of human ambulation have resulted in a series of test surfaces being subjected to human ambulation studies. The results of those ambulation studies using a select population of young adults produced a suite of walkway surfaces that when wet, ranged in slip resistance from very low (granite) to high (unglazed tile). ASTM F2508 correlated the human-ambulation-study results to tribometer measurements. Slip resistance measurements under water-wet conditions sometimes produce readings that are higher than when that same surface is tested under dry conditions. These results were often considered to be as anomalous, but recently, both normative analysis and carefully controlled tests demonstrated this to be the case. Certain European slip resistance test methods, e.g., DIN-Ramp studies, routinely use surfactants to minimize the effects of surface tension, a factor in the wet-test/dry-test anomaly.

To determine the effect of slip resistance on ranking and discriminating the reference surfaces (Surface), the ASTM F2508-11 specified adjunct tiles from ASTM International: ADJF2508-T4 (Granite), ADJF2508-T2 (Glazed tile), ADJF2508-T1 (Vinyl Composition Tile (VCT)), and ADJF2508-T3 (Unglazed tile) were obtained for this study. These four SURFACEs were tested.

Two Surfactants, sodium lauryl sulfate (SLS) and nonionic surfactant were used to reduce the surface tension of water. Tests were conducted using distilled water and the two surfactants were each tested at two concentrations: 0.05% SLS ((SLS-Low) this is the concentration mandated in ASTM F2508 for cleaning the reference surfaces), 0.10% SLS ((SLS-High) this is the concentration mandated in the DIN Ramp protocol), 0.05% Triton X-100 ((Triton-Low) this is the concentration mandated in ASTM F2508 for testing the granite reference surface), and 0.10% Triton X-100 (Triton-High). Distilled water (Water) was also used, for a total of five Surfactant conditions.

Forty tests for each Surface/Surfactant Condition set were conducted: five replications in each of eight directions 45° apart (Direction). A total of 800 tests were conducted (5 replications x 8 Directions x 4 Surfaces x 5 Surfactants). The tests results were analyzed using a screening ANOVA, with Surface, Surfactant, and Direction as the factors. Direction was found to be not-at-all significant (p-value >40%); Surface and Surfactant were both highly significant (p-values of 0.00% and 0.02% respectively).

The results were aggregated over the not-significant factors, giving the following results, where the first number is the mean value and the second is the standard deviation:

	Granite	**Glazed tile**	**VCT**	**Glazed tile**
Water	0.146/0.01	0.185/0.021	0.406/0.055	?1.08/0
SLS-low	0.106/0.008	0.185/0.025	0.327/0.029	?1.08/0
SLS-High	0.103/0.009	0.169/0.029	0.264/0.015	?1.08/0
Triton Low	0.121/0.009	0.171/0.028	0.297/0.014	?1.08/0
Triton-High	0.122/0.012	0.172/0.026	0.282/0.019	?1.08/0

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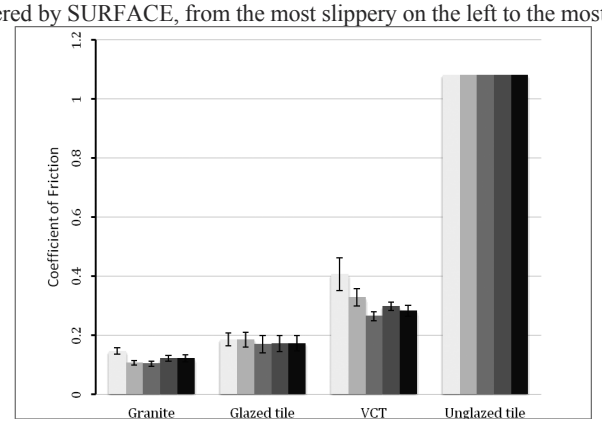
The bar graph below is clustered by SURFACE, from the most slippery on the left to the most tractive on the right:



The individual bars in each cluster, from left to right (light to dark) are Water, SLS-Low, SLS-High, Triton-Low, and Triton-High. The error bars at the top of the bars are ±one standard deviation. The zero-length error bars for the unglazed tile are a result of the PIAST having reached its maximum reading (1.08); thus there was zero variation. (The results on Unglazed Tile are not to be used.)

The conclusion from the testing is that it matters less what surfactant one uses, but one should use a surfactant, especially in Granite and VCT. Worth noting is that the subset of the results for a given Surfactant: 160 tests, defines the F2508-11 validation sequence.

Surface Tension, Slip Resistance, Reference Surfaces

