



## Engineering Sciences Section - 2015

### D16 Can Barefoot Slip Resistance Be Quantified Using the ASTM F2508 Standard for Tribometric Testing?

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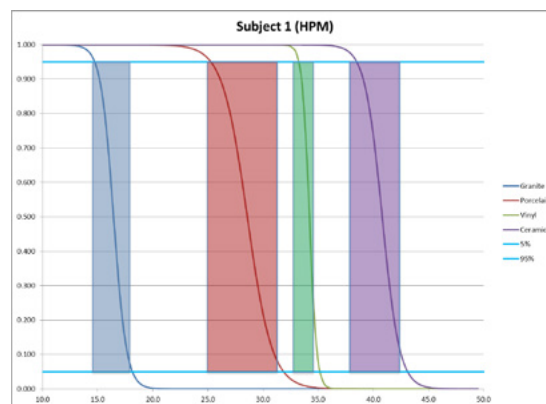
After attending this presentation, attendees will better understand the latest developments in barefoot walkway-safety tribometry.

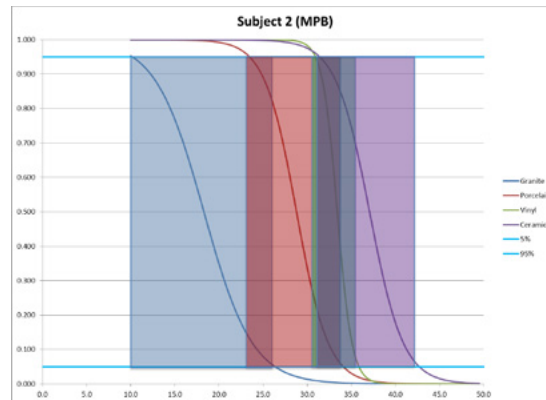
This presentation will impact the forensic science community by providing practitioners with an understanding of the problems and progress in barefoot tribometry and apprising researchers with an understanding of the state of barefoot tribometry.

**Background:** Walkway tribometers have been used to characterize slip resistance of walkway surfaces. Such tribometers typically use a Neolite® or leather “test foot” to assess slip resistance. This study explored barefoot slip resistance; while a leather or Neolite® Test Liner (NTL) test foot may resemble the outsole or heel of a shoe, it is a poor model for the human heel. In this experiment, a custom step meter was used to explore the behavior of the bare foot during slip, using the American Society for Testing and Materials (ASTM) F2508 *Standard Practice for Validation and Calibration of Walkway Tribometers Using Reference Surfaces* methodology.<sup>1,2</sup>

The step meter is a device which can control the motion of the lower leg of an individual and allow the *in vivo* heel to be “dropped” onto a test surface in a repeatable manner. The test surface is inclined incrementally until slip occurs, similar to a “ramp test.” Previous studies have shown the step meter results to agree with those of validated tribometer tests.<sup>3,4</sup> For this study, a more sophisticated statistical analysis than contained in F2508 is utilized: the logistic regression is used to find the point at which  $p(\text{slip})=p(\text{no slip})=0.5$ .<sup>5</sup> A concurrent study validated the step meter fitted with an NTL test foot using the ASTM F2508 protocol.<sup>6</sup> This study explores the behavior of the *in vivo* bare heel of two test subjects on the four reference surfaces used in the F2508 standard.

**Experiment:** There were two test subjects for this study. The testing procedure was as follows: prior to testing, the subject’s foot was allowed to hydrate for five minutes by submersion in a water bath. The subject’s right leg was then fixed in the step meter. The step meter allows the subject’s heel to be dropped vertically onto the test surface in a repeatable manner. The four reference surfaces described in ASTM F2508 were used in this study: granite (RS-A), porcelain (RS-B), vinyl (RS-C), and ceramic (RS-D). Surfaces were successively installed in the modified step meter and wetted with distilled water. For each surface, the instrument’s test-surface inclination angle was incrementally increased. At each angle, the heel was dropped onto the surface ten times and the number of slips occurring was recorded. A logistic regression was performed on the data to determine the  $p(\text{slip})=0.5$  point and that value was recorded as the tribometer threshold for slip for that surface. The 5th and 95th percentile values were used as the lower and upper boundaries of the confidence interval for this measure.





**Results:** Graphs of the results of the logistic regression are shown above. For one subject, the combination of the modified step meter and the bare foot as test foot satisfied the F2508 standard. The results from the second subject, while similar to those of the first subject, did not statistically differentiate between the test surfaces.

**Discussion:** As the tribometer used in this study has been validated with a standard NTL Test Foot, one is left to speculate on the differences between the bare heels of the two test subjects evaluated.<sup>6</sup> Why would one test foot “pass” F2508 and another not? It is suspected that there are differences between feet in a number of areas. Levels of hydration of the foot may have been different between the two subjects; no attempt was made to evaluate this hydration. There may be subject-to-subject differences in the skin ridges (heel “fingerprints”) that would affect slip resistance on a wetted surface; subject-to-subject differences may mean that some people have “slipperier feet” than others. While the reference surfaces were prepared as per F2508 (cleaning), no standard cleaning of the subjects’ feet was performed; it is possible that perspiration or other materials or factors “contaminated” the human test foot.

**Further Research:** The engineering solution to the problems discussed above would be to “standardize” the human foot for tribometric testing; however, if the objective is to assess the slip resistance of the barefoot pedestrian with any degree of biofidelity, such a test (or test protocol) *must* allow for subject-to-subject variations in the human heel. Such variation must be quantified to allow the application of tribometric walkway safety testing to the problem of barefoot walkway slip resistance.

## References:

1. Besser M, Medoff H, and Marpet M. “Biofidelity-based Comparison of Barefoot Slip Resistance (Laboratory) against an *in vivo* tribometer and a standard Tribometer,” in *Proceedings of the 2010 International Conference on Fall Prevention and Protection (NIOSH sponsored–2010)*
2. ASTM, F2508 Standard Practice for Validation and Calibration of Walkway Tribometers Using Reference Surfaces, *ASTM International*, West Conshohocken, PA.
3. Medoff H, Brungraber R, Hilferty C, Patel J, Mehta K. 2002. Variable inclinable stepmeter: using test subjects to evaluate walkway surface/footwear combinations. In: Marpet MI, Sapienza MA, editors. *Metrology of pedestrian locomotion and slip resistance*, ASTM STP 1424. West Conshohocken, PA: ASTM:51-72.
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5. Medoff H, Besser M, Marpet M. “Visual Characterization of Tribometric Reference Surfaces Using Logistic Regression” in *Proceedings of the American Academy of Forensic Sciences, 62<sup>nd</sup> Annual Scientific Meeting*, Seattle, WA. 2010.
6. Medoff H, Connolly C, Besser M, Marpet M. “Test Program to Verify Utility of Step Meter using NTL as a Test Foot as per ASTM F-2508 Protocol” in *Proceedings of the American Academy of Forensic Sciences, 67<sup>th</sup> Annual Scientific Meeting*, Seattle, WA. 2014.

## Barefoot, Tribometry, ASTM F2508