# A NEW APPROACH FOR REFERENCE MATERIALS FOR SLIP RESISTANCE TESTING

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## 1. INTRODUCTION

For many methods, implemented for slip resistance testing of floorings and shoes, the use of reference or calibration materials is required or recommended to create a basis for reliable assessment and comparability of the acquired results. This applies not only for the established methods in Europe, summarized in CEN/TS 16165 for slip resistance measurement on pedestrian surfaces (including the ramp method, the measurement of the dynamic coefficient of friction and the pendulum test). It also concerns the DIN EN ISO 13287 on slip resistance of footwear as personal protective equipment, as well as its international counterparts like e.g. ASTM F2913 on Footwear and test surfaces and the ASTM F2508 – 16, which describes the standard practice for validation, calibration, and certification of walkway tribometers.

A well-known, general problem is the durability and availability of these materials. This leads to elaborate trial-and-error procedures to select, choose and specify new references, especially if the materials are mainly based upon commercially available products, which have no certain long term availability and furthermore in many cases fail to perform after long-term use. This situation motivated the FGK Forschungsinstitut für Anorganische Werkstoffe –Glas/Keramik - GmbH and the PFI Prüf- und Forschungsinstitut Pirmasens e.V. from Germany to join forces in a national cooperative project to develop robust, reproducible and controllable reference systems, based upon surface topography characterisation as an objective tool to specify slip resistance settings [1] as initially developed within the European SlipSTD Project [2, 3], with improved durability and control tools for surfaces and shoes. One of the aims is also to look at reference systems which help to evaluate application areas for slip measurement methods.

## 2. THE IMPACT OF TOPOGRAPHY BASED SURFACE GROUPING

The use of optical topography measurements to assess the actual slip risk of hard floor surfaces has and is being upgraded to support these issues, based upon a reliable, reproducible and valid measurement of topographical key parameters. These parameters are Pk, specifying the core roughness of a surface, and Pp, the height of the profile above the mean line. These lead to a differentiation of the ceramic surfaces in surface groups with different slip resistance behavior, and, in this case very relevant, different suitability of the test methods (figure 1).

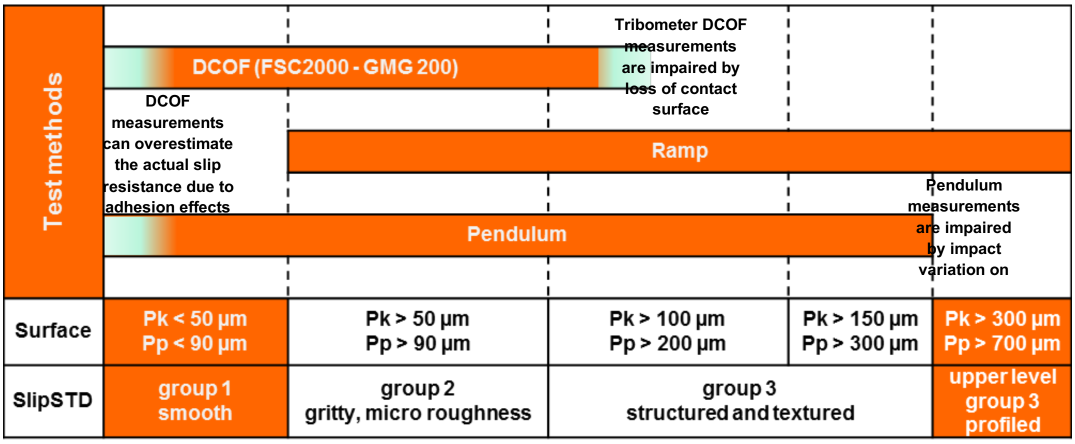


***Figure 1.*** *Suitability of different slip test methods dependent on the surface characteristics according to the SlipSTD Research [2, 3].*

This is an important aspect to include in the investigation of the current reference systems for the different methods (figure 2). Regarding the transferability of these reference materials between different methods, critical differences can be observed. An important observation is that at the moment for tribometer as well as for pendulum measurements reference materials are used, whose surfaces without exception are within group 1, which incorporates, as mentioned in figure 1, the risk of misinterpretation of the actual slip resistance. On the other hand it implies that these methods are not reliable to classify the reference materials from the ramp. Nevertheless these methods are used in practice on surfaces from group 2 or even group 3, where, like in the case for the ramp references, there is the risk of underestimating the slip resistance.

| Reference materials for: | surface parameters | | DIN CEN/TS 16165 – 06/2012 | | | | | | | SlipSTD PAS surface group |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pk | Pp | Ramp | R-Class | Standard Requirements | DCOF | Standard Requirements | PVT | Standard Requirements | |
| DIN CEN/TS 16165 (Ramp Oil/Shoe) | | | | | | | | | | |
| ST-I new | 11 µm | 80 µm | 9.8° | R9 | 8.7 ° ± 3,0° | 0,53 | | 35 | | 1 |
| ST-II new | 75 µm | 120 µm | 20.0° | R11 | 17.3° ± 3,0° | 0.58 | | 29 | | 2 |
| ST-III new | not relevant | | 28.4° | R12 | 27.3° ± 3,0° | - | | - | | 3 |
| DIN CEN/TS 16165 (DCOF GMG 2000) | | | | | | | | | | |
| UGL Tile | 17 µm | 47 µm | - | - | - | 0.50 | 0,45 ± 0,04 | 30 | | 1 |
| HPL tile | 22 µm | 75 µm | - | - | - | 0.24 | 0,28 ± 0,03 | 13 | | 1 |
| Floatglas | 1 µm | 1 µm | - | - | - | 0.11 | 0,12 ± 0,03 | 9 | | 1 |
| DIN CEN/TS 16165 (PVT Pendulum) | | | | | | | | | | |
| Eurotile 2 | 9 µm | 20 µm | 8.5° | - | 29 - 39 | 0.53 | | 35 | 29 - 39 | 1 |
| Verification foil | 4 µm | 7 µm | - | - | 58 - 64 | - | | 62 | 58 - 64 | 1 |

***Figure 2.*** *Performance of the reference materials measured (where possible) using the range of test methods included in the CEN/TS 16516. Too small samples (pendulum and DCOF measurements) cannot be measured on the ramp, like too structured surfaces (STIII for ramp) are not suited for pendulum and DCOF measurements.*

Given that the aim of reference surfaces is that they represent the surface or surface groups also measured in practice, this might even imply that methods could be disqualified for a certain surface range, dependent on their results on corresponding reference surfaces.

## 3. SURFACE CHARACTERIZATION OF REFERENCE MATERIALS

The study of on how actual surface characteristics can help to evaluate differences in the interpretation of the slip risk and its durability is the topic of a separate publication at Qualicer 2018 [4]. From this investigation another parameter was derived, which supports the understanding of the correlation of surface characteristics and slip resistance: the parameter Psk, specifying the peak/valley distribution about the mean line [4].

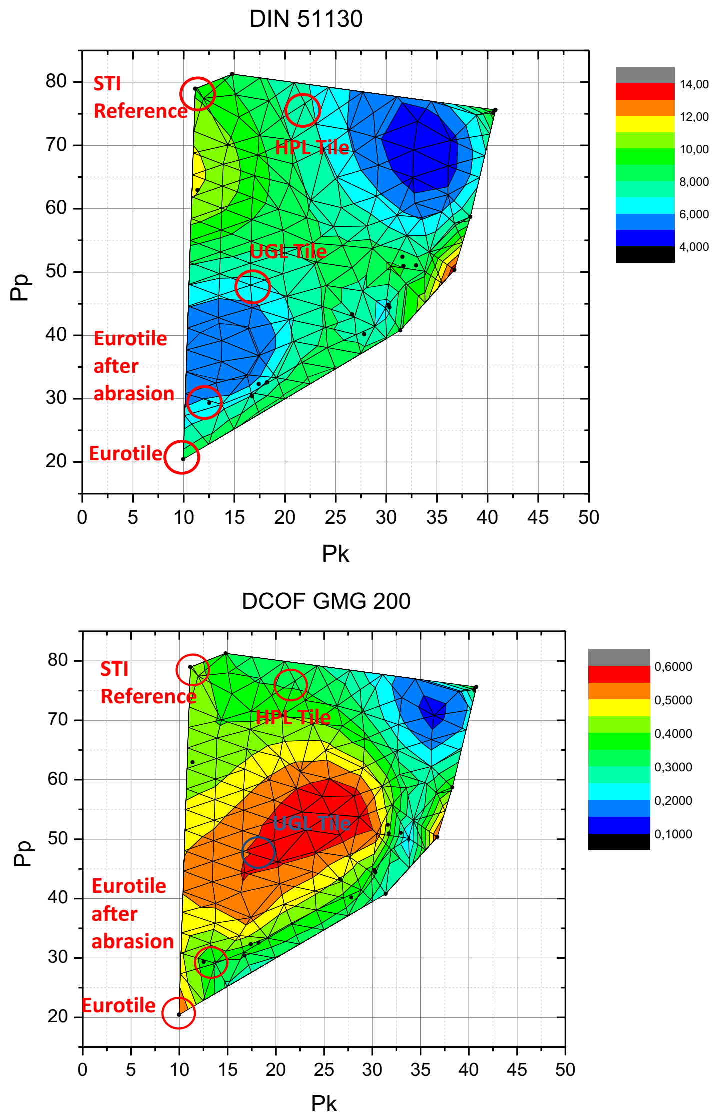


***Figure 3.*** *Slip resistance results of group 1 tiles (here about 25 tiles surfaces including abrasion stages) on the ramp method and with the DCOF tribometer measurements as a function of the surface parameters Pk and Pp (in µm). The location of the reference tiles is indicated.*

The new graphic presentation of the slip resistance results as a function of the surface parameters Pk and Pp, discussed in the mentioned publication and illustrated in figure 3 for group 1 tiles, can now be used to evaluate the slip resistance reached and possible effects of wear for the reference systems. As example the possibility to test wear on the so called Eurotile II is displayed: although its surface shows an increase in Pk (from 9 to 12 µm) and Pp (from 20 to 29 µm) after abrasion (removal of surface matrix, increasing protrusion height), the slip resistance decreases from 8.5° to 6° according to the ramp method: this indicates loss of contact surface, as can be explained due to the moderate Psk value. This indicates that the small increase of the peaks in a regular peak/valley profile disconnects the shoe partially from the core roughness, this decreasing the friction [4]. When looking at the DCOF measurements, the value of 0.53 decreases to about 0.35 (actually measured 0.37). Looking at figure 2 and figure 3 there is a large difference in the evaluation between ramp and DCOF: by virtually increasing Pk and Pp the slip resistance reduces before picking up again when a certain profile height value is reached (the blue area), the DCOF value even before that reaches a stable high value about 0.5 to 0.6 (for the UGL tile a DCOF of 0.5 is measured, where the value of the ramp measurement is estimated as about 6° (just R9, here no actual measurements could yet be performed).

## 4. OUTLOOK

As these graphs are based on multiple tile surfaces, evaluations of new surfaces, initially only characterized by topographic measurements before actual measurement of slip resistance, these evaluations have shown a highly predictive potential. It thus helps to design surfaces with a targeted slip resistance value, to establish its shift in slip resistance upon wear, as well as the difference in results on the surface from different methods. This support for slip resistant surface design is being are combined with using durable materials, providing targeted, controllable and durable slip resistance settings for a surface range, relevant to the bandwidth of surfaces from practice. This is the range that thus might in fact even be used to specify the applicability of measurement methods on the different surfaces, or even to disqualify methods for a certain surface range. (figure 1). This implication is under ongoing investigation and discussion.

The preparation of first prototypes of reference systems on this basis, their performance and their potential are under ongoing investigation during the preparation of this publication. The results will be presented and discussed in the final poster at Qualicer 2018.

## 5. ACKNOWLEDGEMENTS

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