

# Coefficient of Friction

New Method, New Requirements - Introducing the **DCOF AcuTest<sup>SM</sup>**



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When it comes to coefficient of friction (COF), a measurement that relates to traction and tile slipperiness, confusion abounds about the many different methods for measuring it, what a COF measurement actually means, how to compare or use COF values, and whether or not there is a certain COF requirement. Research at TCNA and in Europe aimed to put these questions to rest and led to standardizing a new method for measuring COF: a method that is more accurate and repeatable and not influenced by the operator of the measurement device.

With the switch to a better method for determining COF, backed by solid data, a consensus emerged around a COF requirement for tiles that will be walked on when wet. Project specifiers can now more easily choose the right tile for the job, which should be a welcome improvement with the increasing emphasis being placed on floor safety.

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A major change is underway regarding the coefficient of friction for tile, the frequently cited and specified measurement of a tile's frictional resistance and the parameter most closely related to traction and slipperiness.

The commonly specified and often misunderstood value of 0.60 static coefficient of friction (SCOF), determined by the ASTM C1028 test method, has been superseded by a new method, new test conditions, and a new threshold value, all of which can be found in the 2012 edition of ANSI A137.1, the *American National Standard Specifications for Ceramic Tile*.

The previously mandated method determined a tile's SCOF using a 50 lb. weight, a Neolite sensor and a strain gauge. The new method, titled the **DCOF AcuTest<sup>SM</sup>**, determines dynamic coefficient of friction (DCOF) with a sophisticated instrument called the BOT-3000, a type of tribometer<sup>1</sup> specific for flooring applications.

## Previous Test Method: Pull Meter



## New Test Method: BOT-3000 (Tribometer)





The ANSI A108 Accredited Standards Committee (ASC) responsible for American National Standards for ceramic tile, comprised of representatives from all segments of the tile industry, made this important change, which is effective immediately. This article addresses the issues, methodology, terms and criteria relevant to this change.

In the context of people walking on tile floors, static friction (from which SCOF is determined) is the frictional resistance you push against when you start in motion. A slip occurs when you push off with more force than the surface can resist.

Dynamic friction (from which DCOF is determined) is the frictional resistance you push against when you are already in motion. Similar to static friction, a slip occurs when you push with more force than the surface can resist. That can happen when the angle of the force changes (i.e. the ratio of the tangential and vertical forces change) or when the floor surface becomes more slippery.

Neither SCOF nor DCOF is a property of the flooring alone, but rather a relationship between the shoe sole (or whatever is in contact with the floor) and the flooring surface. When contaminants are present,

they can alter that relationship reducing the friction between the surfaces.

The BOT-3000 is an automated portable device (similar to the GMG 100 and GMG 200 devices used in Germany) that closely correlates with the German Ramp (a laboratory-only device), which is considered by many the “gold standard” for measuring surface traction.

Unlike all other tribometer measurements, which at best only indirectly link to human ambulation and the potential for a person to slip, the German Ramp determines coefficient of friction and the potential for slip with a person walking on a ramp as the surface becomes increasingly steep. Lubricants such as soapy water and oil can be added to simulate contaminated conditions. The BOT-3000 and the GMG devices correlate more closely with the ramp than all other tribometers across a wide variety of surfaces.

The **DCOF AcuTest** method, which is now included in ANSI A137.1, determines DCOF under wet conditions using slightly soapy water, or more specifically, water with 0.05% Sodium Lauryl Sulfate (SLS) in solution. SLS is a wetting agent that allows

<sup>1</sup>A tribometer is an instrument that measures parameters in the field of tribology such as frictional forces, coefficient of friction, and the effects of lubrication.

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water to spread in a thin film, similar to that found when a slip occurs or when a floor is being cleaned. This is necessary because in actual installations residual soap can remain on the floor after cleaning and can re-emulsify when water is spilled or tracked-in creating slippery conditions. In fact many tiles when clean are hydrophobic, which means water beads on their surface, so establishing a thin film typically requires a wetting agent.

It is important to note that the results from the old SCOF method cannot be directly compared to the new DCOF method. First, the frictional resistance between two objects at rest (for example a shoe sole and a tile surface) is different and higher than that measured when motion is already taking place. Second, the new test method uses 0.05% SLS solution, which is more slippery than the de-ionized water used in ASTM C1028. Third, the new method applies less force to the test sensor than the force applied in ASTM C1028. These differences and others make it impossible to compare directly between the two methods.

While the ASTM C1028 test method has been specified for many years, contrary to popular belief, there has never been an Americans with Disabilities Act (ADA) SCOF requirement for tile surfaces. This misunderstanding stems from an outdated appendix (section A4.5) in which a 0.60 SCOF recommendation (not a requirement) was made. This document never set a requirement and didn't specify the test method for measuring SCOF. With over 10 devices available claiming to measure COF, all giving different values, it was impossible to interpret this recommendation and the recommendation was subsequently withdrawn in 2004. In fact there are no industry standards that reference 0.60 SCOF when testing per ASTM C1028, although this value is often specified for commercial projects. However, with the switch to the **DCOF AcuTest**, the 0.60 SCOF value is no longer relevant to how tiles will be measured.

There are many reasons the switch from ASTM C1028 to the **DCOF AcuTest** was made. Most important among all the relevant criteria considered was that the ASTM C1028 method is affected by a surface tension phenomenon called "stiction." Similar to how two plates of glass with water between stick to each other, stiction can affect the ASTM C1028 reading when the smooth Neolite sensor is used on smooth or polished tiles, giving a value that is artificially high in comparison to the traction the surface provides. For this reason and others, the C1028 method cautions that the SCOF value should never be used to predict slip resistance. Similarly, ANSI A137.1 cautions that DCOF alone should not be the only factor in determining the appropriateness of a tile for a particular application.

Some guidance is provided for the specifier now though, which was not in the previous version of ANSI A137.1. The 2012 version states that tiles suitable for level interior spaces expected to be walked upon when wet shall have a wet DCOF of 0.42 or greater when tested with the BOT-3000 per the procedure in the standard (i.e., per the **DCOF AcuTest**).





This value stems from extensive research at the University of Wuppertal in Germany and at TCNA. Researchers at the University of Wuppertal studied human subjects walking on force plates to find the relationship between the tangential force and the vertical force needed for reliable traction (this relationship defines the coefficient of friction). They then considered many different slippery conditions, different ways people could move on a surface, and accident statistics over many years to recommend to the national insurance body a DCOF value of 0.42 for level flooring (when measured using the German Ramp).<sup>2</sup>

In various studies at TCNA, researchers found a strong correlation between SCOF measurements using the BOT-3000 with de-ionized water and measurements made using the C1028 test method. In a further study of over 300 tile surfaces, TCNA researchers found that 0.60 SCOF measured with the BOT-3000 using de-ionized water correlated on average with 0.38 DCOF when tested with SLS solution.

Considering both the TCNA research and the years of research in Germany, the ANSI A108 Accredited Standards Committee decided to include an additional measure of safety over the current widely used SCOF value of 0.60, and revised ANSI A137.1 to include a threshold DCOF value of 0.42 (when measured per the **DCOF AcuTest** method) for level interior spaces expected to be walked upon when wet.

Remember though this does not mean all tiles with a DCOF over 0.42 are suitable for all projects, as type of use, traffic, expected contaminants, expected maintenance, expected wear and manufacturers' guidelines and recommendations are also important and must be considered by the specifier.

Section 6.2.2.1.10 of the ANSI A137.1 standard explains this in more detail and is included in its entirety below. References to Section 9.6, 9.6.1, and 9.6.2 refer to the test procedures given in those sections in the ANSI A137.1 standard.

#### Section 6.2.2.1.10 Coefficient of Friction - Reprinted from ANSI A137.1:

The coefficient of friction (COF) measurement provided in this standard is an evaluation of a tile surface under known conditions using a standardized sensor material prepared according to a specific protocol. As such it can provide a useful comparison of tile surfaces, but it does not predict the likelihood a person will or will not slip on a tile surface.

There are many factors that affect the possibility of a slip occurring on a tile surface including by way of example, but not in limitation, the following: the material of the shoe sole and the degree of its wear; the presence and nature of surface contaminants;

<sup>2</sup>The German research considered was extensive and can be found in the following publications: (1) Boenig, Stefan. Experimental Investigation to Determine the Standardized Limits of the Coefficient of Friction When Walking (Archive Number D468), University of Wuppertal Department of Safety Technology, 1996. (2) Skiba, Reinald. (1988). Sicherheitsgrenzwerte zur Vermeidung des Ausgleitens auf Fuessboeden, Zeitschrift fuer Arbeitswissenschaft (Journal of Occupational Science), 42, 47-51. (3) BGI/GUV-I 8687, 2011, "Bewertung der Rutschgefahr unter Betriebsbedingungen", German National Institute for Social Accident Insurance (DGUV). (4) Sebal, Jens. (2009). System oriented concept for testing and assessment of the slip resistance of safety, protective and occupational footwear. Berlin: Pro BUSINESS GmbH.

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the speed and length of stride at the time of a slip; the physical and mental condition of the individual at the time of a slip; whether the floor is flat or inclined, and how the tile surface is used and maintained; and the COF of the tile, how the tile is structured and how drainage takes place if liquids are involved. Because many variables affect the risk of a slip occurring, the COF shall not be the only factor in determining the appropriateness of a tile for a particular application.

Unless otherwise specified, tiles suitable for level<sup>3</sup> interior spaces expected to be walked upon when wet shall have a wet DCOF of 0.42 or greater when tested using SLS solution as per the procedure in section 9.6.1. However, tiles with a DCOF of 0.42 or greater are not necessarily suitable for all projects. The specifier shall determine tiles appropriate for specific project conditions, considering by way of example, but not in limitation, type of use, traffic, expected contaminants, expected maintenance, expected wear and manufacturers' guidelines and recommendations.<sup>4</sup>

Some specifiers find it useful to compare dry DCOF measurements to wet DCOF measurements to assess the risk of a slip when transitioning from dry to wet conditions. If dry DCOF measurements using the BOT-3000 are desired, the testing procedure found in section 9.6.2 shall be followed. Alternatively, a dry static coefficient of friction (SCOF) measurement can be made per the ASTM C1028 test method.

When wet SCOF measurements of tiles previously tested per ASTM C1028 are desired for direct comparison to historical values, the C1028 test method shall be followed. While BOT-3000 wet SCOF measurements with a Neolite sensor and distilled water generally correlate overall with ASTM C1028 measurements, results on individual tiles

may not correlate, and therefore, cannot be directly compared.

The presence on installed tiles of water (including standing water as can exist on floors which are not properly sloped for drainage or on exterior tiles immediately after a rain storm or on which snow is melting), oil, grease, and/or any other elements which reduce traction, creates slippery conditions where the risk of a slip cannot be completely eliminated. Tile installations with exposure to such elements require extra caution in product selection, use and maintenance. The risk of a slip can be diminished but not eliminated in these installations by installing tiles with a structured/textured surface, mosaic tiles or certain extruded unglazed quarry tiles. The specifier shall follow manufacturers' guidelines and recommendations for these products.

When tested using SLS solution as per the procedure in section 9.6.1, tiles with a wet DCOF of less than 0.42 (including by way of example, but not in limitation, polished tiles), shall only be installed when the surface will be kept dry when walked upon and proper safety procedures will be followed when cleaning the tiles.



<sup>3</sup>Tiles appropriate for ramp applications shall be chosen for the specific properties and use of the ramp and require a wet DCOF greater than 0.42 if the ramp will be used under wet conditions. Specifier shall determine tiles appropriate for specific project conditions, considering by way of example, but not in limitation, type of use, traffic, grade of ramp, expected contaminants, expected maintenance, expected wear, and manufacturers' guidelines and recommendations.

<sup>4</sup>The COF of installed tiles can change over time as a result of wear and surface contaminants. In addition to regular cleaning, deep cleaning and traction-enhancing maintenance may be needed periodically to maintain DCOF values.