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coefficient of friction and the DCOF AcuTest

TCNA Technical Bulletin: Coefficient of Friction and the DCOF AcuTest

IN 2012 THE METHOD for measuring the coefficient of friction (COF) of ceramic tiles changed, as specified in the American National Standards Institute (ANSI) national standard specifications for ceramic tile, A137.1. It changed from the ASTM International test method C1028, which measures static coefficient of friction, to the test protocol provided in the A137.1–2012 standard in Section 9.6, known as the **DCOF AcuTestSM**.

What is coefficient of friction (COF)?

Coefficient of friction (COF) is the measurement of a tile's frictional resistance, closely related to traction and slipperiness. Both static and dynamic measurements can be taken. Static coefficient of friction (SCOF) is the frictional resistance one pushes against when starting in motion. Dynamic coefficient of friction (DCOF) is the frictional resistance one pushes against when already in motion. For SCOF and DCOF, a slip occurs when pushing off with more force than the surface can resist. That can happen when the angle of the force changes (e.g., pushing off harder while pressing down less) or when the floor surface becomes more slippery than anticipated.

What is the DCOF AcuTest?

The **DCOF AcuTest** is an evaluation of the COF of a tile surface under known conditions using a standardized sensor prepared according to a specific protocol. Measurements are made with the BOT-3000, an automated and portable device that measures DCOF. The ANSI standard A137.1–2012 also allows the use of other equivalent tribometers.

Wet measurements use 0.05% sodium lauryl sulfate solution to establish a thin film as would be present when a slip occurs. The precision, repeatability, and reproducibility of the **DCOF AcuTest** protocol is provided in the A137.1–2012 standard. The test was so named for easy recognition, and to distinguish it from other DCOF measurements using different instruments and/or protocols.

The **DCOF AcuTest** COF measurement is not a property of the flooring but rather a measurement of the interaction between the sensor, the lubricant, and the tile surface under controlled conditions. It is useful to allow comparison between surfaces or to evaluate how a surface has changed over time. However, while the **DCOF AcuTest** can provide a useful comparison of tile surfaces, it cannot, nor can any other device, predict the likelihood a person will or will not slip on a tile surface.

Because many variables affect the risk of a slip occurring, the **DCOF AcuTest** measurement shall not be the only factor in determining the appropriateness of a tile for a particular application.



What is the required COF for ceramic tile?

According to the ANSI A137.1–2012 standard, ceramic tiles selected for level interior spaces expected to be walked upon when wet must have a minimum wet **DCOF AcuTest** value of 0.42. Tiles with a lower value are not necessarily restricted to dry areas only, but rather are restricted to applications where they are kept dry when walked upon. In the case of residential bathrooms, the common use of bathmats can accomplish this. Similarly, in entranceways, the use of entrance mats can accomplish the same.



tile in commercial project specifications for many years.

This likely stemmed from the common misconception that the 1991 Americans with Disabilities Act (ADA) required such. In fact, the ADA did not set a requirement but rather referenced accessibility guidelines (Appendix Section A4.5) that recommended, not required, a value of 0.6 SCOF. But this section failed to specify a means of measurement. With many devices on the market for measuring COF, each producing a different value for the same tile (due to different sensors, geometry, speed of travel, etc.), the recommended 0.6 SCOF value was meaningless. Accordingly, when ADA accessibility guidelines were updated in 2004, and the guidelines for access to federal facilities covered by the Architectural Barriers Act (ABA) were updated, the 0.6 SCOF recommendations were withdrawn for both. For more information see <http://www.access-board.gov/ada-aba/final.cfm>.

When does the change take effect?

The changes to the A137.1 standard addressed herein were first passed by the accredited national consensus body responsible for ANSI A137.1 and then approved as an American National Standard by ANSI in September 2012. However, it is understood that this represents a big change and improvement to an established norm. Thus, most tile manufacturers and importers are reporting SCOF (per C1028) and **DCOF AcuTest** values during the inherent transition needed for the market to switch to the new requirements. The tile industry is targeting for this transitional period to end in December 2013.



Why the change in test methods?

While both SCOF and DCOF are relevant to human ambulation, DCOF is more widely used worldwide and arguably relates better to slips occurring while a person is in motion. Moreover, the technology on which the **DCOF AcuTest** is based was not available in the United States until recently.

The **DCOF AcuTest** in particular offers several benefits over other methods of measuring COF. First, it is a highly repeatable test method, due in part to the fact that it is an automated process with internal and external reference checks easily made. Also the process by which the sensor is prepared is highly repeatable using a

Not all products with a **DCOF AcuTest** value over 0.42 are suitable for all applications. Type of use, traffic, contaminants, maintenance, expected wear, and manufacturer's guidelines and recommendations are important and must also be considered by the specifier. Section 6.2.2.1.10 of ANSI A137.1–2012 explains this in greater detail and should be reviewed carefully by anyone involved in the specification process before picking the right tile for their next project!

What about the 0.6 ADA requirement?

Previously, there was no required COF value in the ANSI A137.1 standard for wet floors (static or dynamic), although a minimum value of 0.6 wet SCOF measured by ASTM C1028 has been commonly specified for ceramic

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device developed by the Tile Council of North America (TCNA), the drawings and specifications for which have been made freely available. The **DCOF AcuTest** also more accurately measures the COF of very smooth surfaces. And, because the BOT-3000 device making the measurements is portable, it can easily be used for taking field measurements on installed tiles. This is extremely useful since it is often necessary to measure the COF of tiles in situ, to determine if they have been affected by wear or contaminants.

Supporting research: The required **DCOF AcuTest** value, for tiles in level interior spaces expected to be walked on while wet, stems from decades of research in Europe and extensive testing at TCNA. Researchers at the University of Wuppertal in Germany (known worldwide for their traction studies) 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 COF and has been widely studied in the United States and in Europe. It is commonly found to be between 0.2 and 0.3 depending on the individual. The German researchers then considered many different slippery conditions, different ways people could move on a surface, and accident statistics over many years to recommend to the German national insurance body a minimum wet DCOF value of 0.42 for flooring.¹

In various studies at TCNA, including a study of more than three hundred tile surfaces², TCNA researchers found that 0.60 wet SCOF correlated on average with 0.38 wet DCOF.

Considering both the TCNA research and the years of research in Europe, the ANSI A108 Accredited Standards Committee decided to adopt the German recommendation and include in ANSI A137.1–2012 a required minimum threshold of 0.42 (per the **DCOF AcuTest**) for level interior spaces expected to be walked upon when wet. By requiring a value higher than 0.38, the new standard provides an additional measure of safety over the widely used ASTM C1028 wet SCOF value of 0.60.

Will floors that met the 0.6 SCOF criteria meet the new 0.42 DCOF AcuTest criteria?

Because many floors that were installed to meet or exceed 0.6 SCOF, as measured by the ASTM C1028 method, in fact greatly exceeded 0.6 SCOF, it is reasonable to expect on average those floors will also exceed the new 0.42 **DCOF AcuTest** criterion.

However, it is of utmost importance to understand there is no direct relationship between the methods; values on individual tiles cannot be correlated between the two methods. This is because the two methods measure different physical principles with different wetting agents. While a correlation on average, based on hundreds of tiles, has been established between the two methods, there are individual outliers (tiles that fall well outside the correlation) and no mathematical relationship exists to convert from one value to another on individual tiles. To know definitely if a floor meets the minimum 0.42 **DCOF AcuTest** criterion, it must be measured.

¹The 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) Sebald, Jens. (2009). System oriented concept for testing and assessment of the slip resistance of safety, protective and occupational footwear. Berlin: Pro BUSINESS GmbH.

²While the 300 surfaces chosen were selected to represent a wide spectrum of tile surfaces, no claim is made or offered that this represented the entire spectrum of available tile surfaces nor can any inference be made regarding any individual tile surface. ASTM C1028 SCOF measurements and **DCOF AcuTest** measurements cannot be directly compared or correlated on a per tile basis as different sensors, test conditions, and measurement physics are employed.



Preventing slip/fall accidents: maintenance, contaminants, and periodic assessments

The DCOF 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. With the portability and ease of the **DCOF AcuTest**, periodic evaluation of flooring surfaces is now easily accomplished.

Where floor tiles have a DCOF lower than 0.42, care must be exercised to ensure the tiles are not walked on while wet.

In addition to choosing surfaces providing sufficient traction, providing adequate lighting and designing spaces to allow for suitable drainage will reduce slip/fall accidents. Proper footwear and shoe materials can also greatly improve traction and should be considered in any campaign to reduce slips and falls.

What about ramps, exteriors, pools, etc.?

ANSI A137.1–2012 does not address areas other than interior level spaces. For other floor applications, some tile manufacturers may be able to provide guidance based on their proprietary experience. In general though, the specifier must determine which tiles are appropriate for the specific project conditions, considering by way of example, but not in limitation, type of use, traffic, grade of any ramps, expected contaminants, expected maintenance, expected wear, and manufacturers' guidelines and recommendations.



For more information, including articles and the ANSI coefficient of friction standards for tile, please visit www.TCNAtile.com



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100 Clemson Research Boulevard, Anderson, SC 29625
Phone: 864-646-8453 · Fax: 864-646-2821 · www.TCNAtile.com