ANSI A137.1 American National Standard Specifications for Ceramic Tile—2012

Section 6.2.2.1.10 Coefficient of Friction Specification

Section 9.6 Procedure for Dynamic Coefficient of Friction (DCOF) Testing

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Secretariat
Tile Council of North America, Incorporated

Abstract
This publication presents an excerpt from a voluntary standard specification for ceramic tile.

American National Standard

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Foreword

This voluntary standard lists and defines various types, sizes, physical properties and grading procedures for ceramic tile. It is intended as a guide to aid the general public, manufacturers, distributors, specifiers, architects, tile contractors, and other businesses and professionals in the tile industry.

While the existence of the standard does not in any respect preclude anyone, including those who have accepted it, from manufacturing, marketing, purchasing or using products, processes or procedures not conforming to this standard, producers of ceramic tile made in conformance with this standard are encouraged individually to indicate such conformance in advertising, promotion, and on tags and labels.

These standards were processed and approved for submittal to ANSI by the Accredited Standards Committee (ASC) on Ceramic Tile A108. Committee approval of a standard does not necessarily imply that all committee members voted for its approval. The A108 Committee had the following members at the time it approved these standards:

Committee Members

Organization Represented	Name of Representative
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ARCOM, Inc.	Eugene “Buz” Groshong
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Atlas Minerals and Chemicals	Steve Abernathy
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Bostik, Inc.	Scott Banda
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Dal-Tile International	James Neel
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Fortifiber Building Systems Group	Roger Barker
Glass Tile Consultants	Scott Fleming
Great Lakes Ceramic Tile Council	Gerald Chioini
Gypsum Association	Robert Wessel
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Materials and Methods Standards Association	Jim Whitfield
Metropolitan Ceramics/Ironrock, Inc.	Roy Gorton, Jr.
Michael Byrne Associates	Michael Byrne
National Association of Home Builders	Gary Ehrlich

Committee Members continued

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UL Environment	Josh Jacobs
United Brotherhood of Carpenters	Greg Hefele
United States Gypsum Corporation	Steve Rausch
US TAG to ISO TC-189 WG3	Greg Schad
Wood Construction and Engineering Consultant	Frank Woeste

6.2.2.1.10 Coefficient of Friction: 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; 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[1] 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[2], and manufacturers' guidelines and recommendations.

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.

[1]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.

[2]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.

9.6 Procedure for Dynamic Coefficient of Friction (DCOF) Testing:

9.6.1 Wet Dynamic Coefficient of Friction

9.6.1.1 Apparatus

9.6.1.1.1 *BOT 3000*[1] automated testing device capable of testing static and dynamic coefficient of friction with the test travel distance set to 10 inches (254 mm). If the tile size is less than 10 x 10 inches (254 x 254 mm) and greater than 4 x 4 inches (101.6 x 101.6 mm), run the test with the longest possible travel distance that fits on the tile. For mosaic tiles, bond enough pieces of the specimen to a solid surface to provide a 10 x 10 inch (254 x 254 mm) or larger specimen and test with 10 inch (254 mm) travel distance.[2] Verify the strain gauge daily using the verification mass provided by the manufacturer. The upper measurement limit for the BOT 3000 is 1.00. If while testing, the BOT 3000 measures a value of 1.00, report the value as ≥1.00.

9.6.1.1.2 *SBR sensors*[3], with a new sensor rubber thickness of 4.0 mm ±0.2 (0.16 inch ± 0.01) and a Shore A hardness of 95±3. Discontinue use when sensor thickness is less than 2.5 mm (0.10 inch).

9.6.1.1.3 *Sanding Device*[4], machined fixture with an inner radius of 68 mm (2.68 inch) as shown in Figure 2 and 3. The sanding device shall contain a steel spring that is 2-3/16 inches (55.6 mm) long, has an outer diameter of ¾ inch (19.1 mm), and a wire diameter of 0.062 inches (1.57 mm) with a spring constant, k, of 7.5 lbf/inch ± 0.5 lbf/inch (1.31 N/mm ± 0.09 N/mm).[5]

9.6.1.1.4 *BOT 3000 Standard Tiles*[6], quantity three. Standard tiles were manufactured under controlled conditions and are available from the Tile Council of North America.

9.6.1.2 Reagents and Materials

9.6.1.2.1 *0.05% Sodium-Lauryl Sulfate (SLS)*, commercially available at higher concentrations than required for this testing. Dilute with distilled or de-ionized water to reach 0.05% SLS solution. For example, if SLS solution is purchased at 29% concentration mix 6.54 mL of 29% SLS solution with 1 gallon of distilled water to obtain 0.05% SLS solution.

9.6.1.2.2 *Renovator #120*[7], diluted per manufacturer's instructions sufficient to fully remove surface contaminants.

9.6.1.2.3 *Cloth or paper towel*, that does not leave lint or residue after use.

9.6.1.2.4 *Soft bristle scrubbing pad.*

9.6.1.2.5 *Sand Paper,* waterproof, 400 grit, super fine, silicon carbide.

9.6.1.2.6 *Spray Adhesive*[8], multipurpose spray adhesive.

9.6.1.2.7 *Paint Brush.*

[1]The BOT 3000 or an equivalent has been found satisfactory. The BOT 3000 is manufactured by Regan Scientific Instruments, Inc., 901 S. Kimball Ave. Southlake, TX 76092, and has been extensively studied by the committee.

[2]Bond mosaic tiles in sheet form without grouting. For loose mosaics, bond with the joints not exceeding 1/8 inch (3.18 mm) and do not grout.

[3]The SBR sensor or equivalent has been found satisfactory. The SBR sensors are available from Regan Scientific Instruments, Inc., 901 S. Kimball Ave. Southlake, TX 76092. The SBR rubber shall conform to the following specifications: 4.0 ± 0.2 mm thickness, 1.23 ± 0.2 g/cm^3 density, 95 ± 3 Shore A hardness, >10 MPa tensile strength, >250% flexibility, and <250 mm^3 wear-ability.

[4]The sanding device or the equivalent has been found satisfactory. The sole source of supply of the sanding device known to the committee at this time is Tile Council of North America, 100 Clemson Research Blvd. Anderson, SC 29625. If you are aware of alternative suppliers, please provide this information to ANSI Headquarters.

[5]A Hillman #155 spring or equivalent has been found satisfactory. A Hillman #155 spring can be purchased through a supplier of The Hillman Group products. A supplier can be found by contacting The Hillman Group, 10590 Hamilton Ave., Cincinnati, OH 45231.

[6]The BOT 3000 Standard Tile or the equivalent has been found satisfactory. The sole source of supply of the standard tile known to the committee at this time is Tile Council of North America, 100 Clemson Research Blvd. Anderson, SC 29625. If you are aware of alternative suppliers, please provide this information to ANSI Headquarters.

[7]Renovator #120 or equivalent has been found satisfactory. Renovator #120 is available from Hillyard, 302 North 4th St., PO Box 909, St. Joseph, MO 64501.

[8]3M Super 77 Multipurpose Adhesive or equivalent has been found satisfactory. 3M Super 77 Multipurpose adhesive can be purchased through a supplier of 3M adhesive products.

9.6.1.3 Sensor Resurfacing Procedure

9.6.1.3.1 Cut sand paper into strips 1.5 inch (38.1 mm) thick by 9 inch (228.6 mm) long.

9.6.1.3.2 Using the multipurpose spray adhesive, lightly spray the back of the sandpaper. Be sure that the adhesive does not contaminate the front of the sandpaper.

9.6.1.3.3 Attach the paper to the sanding device (9.6.1.1.3) with the edge of the paper flush with the back of the sanding device.

9.6.1.3.4 Allow to dry according to manufacturer's instructions or until the paper is firmly secured in place.

9.6.1.3.5 Insert sensor into the sanding device.

9.6.1.3.6 Wet the sand paper if desired to create less wear and debris on the sand paper.

9.6.1.3.7 While pressing down on the sensor (holding the edges of the sensor), turn the sensor holder until the full SBR rubber area is over sand paper and let go. The sensor should be firmly pressing against the sandpaper.

9.6.1.3.8 Sand the sensor by rotating it back and forth over the sandpaper.

9.6.1.3.9 Periodically remove the sensor to view the rubber surface. Brush sandpaper and sensor with a dry paint brush to remove excess material.

9.6.1.3.10 Once the sensor no longer has a wear line down the center it is ready for use (Figures 5 and 6.)

9.6.1.4 Sensor Verification

9.6.1.4.1 The standard tile shall be cleaned prior to testing:

9.6.1.4.1.1 Using Renovator #120, diluted per manufacturer's instructions sufficient to fully remove surface contaminants, and warm tap water clean the tile and scrub using a soft bristle scrubbing pad to remove any dust or debris that have collected on the surface. Rinse thoroughly to remove all the detergent.

9.6.1.4.1.2 Allow to air dry or dry with a cloth or paper towel that does not leave residue or a hair dryer.

9.6.1.4.2 Place three standard tiles on a solid surface in a row with the edges butted together.

9.6.1.4.3 Wet the path that the sensor will follow with 0.05% SLS water.

9.6.1.4.4 Make one dynamic measurement on the center tile.

9.6.1.4.5 If the value is between 0.28 and 0.31, proceed with testing. If the value falls above or below that range repeat Sections 9.6.1.3.5-9.6.1.3.10. If after multiple attempts of resurfacing the sensor, the average does not fall within the stated range, a new sensor should be used or the standard tile should be re-cleaned or replaced.

9.6.1.4.6 Repeat Sections 9.6.1.3.5-9.6.1.3.10 after sensor verification before proceeding to Section 9.6.1.5.

9.6.1.5 Test Procedure - Dynamic COF with 0.05% SLS Water

9.6.1.5.1 All test specimens shall be cleaned prior to testing:

9.6.1.5.1.1 Using Renovator #120, diluted per manufacturer's instructions sufficient to fully remove surface contaminants, and warm tap water clean the tile and scrub using a soft bristle scrubbing pad to remove any dust or debris that have collected on the surface. Rinse thoroughly to remove all the detergent.

9.6.1.5.1.2 Allow to air dry or dry with a cloth or paper towel that does not leave residue or a hair dryer.

9.6.1.5.2 Place three specimens on a solid surface in a row.

9.6.1.5.3 Wet the path that the sensor will follow with 0.05% SLS water.

9.6.1.5.4 Make a total of four dynamic measurements on the center tile. Make one measurement then turn the BOT 3000 180° and make the second measurement. Then turn the tile 90° and make the final two measurements in the same fashion as above. If wheel slippage occurs, values shall be considered invalid and the wheels shall be cleaned and dried thoroughly before additional measurements are made.

9.6.1.5.5 Record all four dynamic measurements then take an average.

9.6.1.5.6 Repeat Sections 9.6.1.5.1-9.6.1.5.5 on two additional pieces of tile repeating Section 9.6.1.3.5-9.6.1.3.10 before each tile. For textured tile, the three pieces of tile shall be representative of the different texture variations. If the tile is known to have more than three texture variations, test a representative tile of each texture.

9.6.1.5.7 After testing all tiles, resurface the SBR sensor (Sections 9.6.1.3.5-9.6.1.3.10) then recheck and record the sensor verification (Sections 9.6.1.4.2-9.6.1.4.5). If the value falls outside a range of 0.27 to 0.32, determine the source of error, take corrective action, and repeat the entire testing procedure.

9.6.2 Dry Dynamic Coefficient of Friction (DCOF) – If Desired

9.6.2.1 Repeat Section 9.6.1 except sand the sensor and run the test and sensor verification in the dry condition. For sensor verification, use 0.67 to 0.73 as the verification value.

9.6.3 Report

9.6.3.1 Report the following information:

9.6.3.1.1 Type of tile or surface, including unique identifying name or number.

9.6.3.1.2 Temperature and relative humidity during testing.

9.6.3.1.3 Calibration due date of BOT 3000 device.

9.6.3.1.4 Sensor material.

9.6.3.1.5 SLS water concentration (wet DCOF testing only).

9.6.3.1.6 Statement of sensor verification including actual dynamic coefficient of friction values measured on the standard tile before and after testing test specimens.

9.6.3.1.7 Individual and average wet dynamic coefficient of friction for each tile.

9.6.3.1.8 Individual and average dry dynamic coefficient of friction for each tile (if desired).

9.6.4 Discussion of Wet DCOF Method Precision

9.6.4.1 Precision: The precision of this test method is based on an interlaboratory study conducted in May 2011. Each of six laboratories tested seven different materials. Every "test result" was calculated using the average of four individual wet dynamic coefficient of friction measurements. The laboratories obtained three replicate test results for each material.

9.6.4.1.1 Repeatability: Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "r" value for that material; "r" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day.

9.6.4.1.1.1 "Sr" represents the repeatability standard deviation.

9.6.4.1.2 Reproducibility: Two test results shall be judged not equivalent if they differ by more than the "R" value for that material; "R" is the interval representing the difference between two test results for the same material, obtained by different operators using different equipment.

9.6.4.1.2.1 SR" represents the reproducibility standard deviation.

9.6.4.1.3 Any judgment in accordance with these two statements would have an approximate 95% probability of being correct.

9.6.4.2 The precision statement was determined through statistical examination of 126 results, from six laboratories, representing six different BOT 3000 devices, on seven materials. Descriptions of the seven surfaces tested are as follows:

Surface 1: Polished porcelain

Surface 2: Glazed porcelain, lightly textured

Surface 3: Glazed porcelain, heavily textured

Surface 4: Standard tile, glazed ceramic, smooth

Surface 5: Unglazed mosaics

Surface 6: Unglazed porcelain, textured

Surface 7: Glazed porcelain, smooth

Table 16: Dynamic Coefficient of Friction with 0.05% SLS Water

Surface	Average, x	Standard Deviation, Sx	Repeatability Standard Deviation, Sr	Reproducibility Standard Deviation, SR	Repeatability, r	Reproducibility, R
1	0.36	0.02	0.02	0.02	0.05	0.05
2	0.44	0.02	0.01	0.02	0.03	0.05
3	0.43	0.02	0.02	0.02	0.06	0.06
4	0.27	0.01	0.01	0.01	0.03	0.03
5	0.63	0.02	0.01	0.03	0.04	0.07
6	0.65	0.03	0.01	0.03	0.03	0.08
7	0.24	0.01	0.01	0.01	0.02	0.02

Figure 1: BOT3000

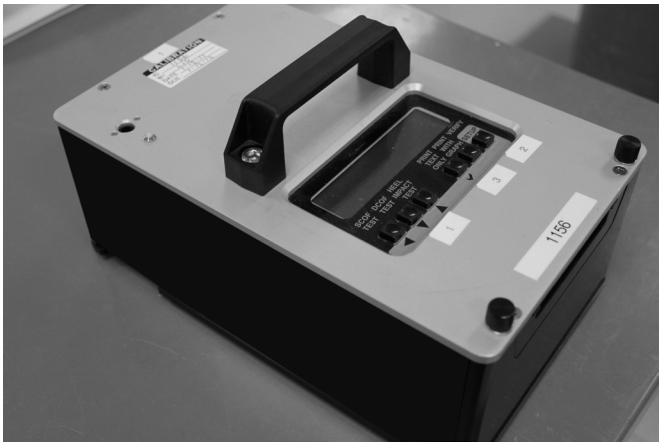

Figure 2: Diagram of Sanding Device

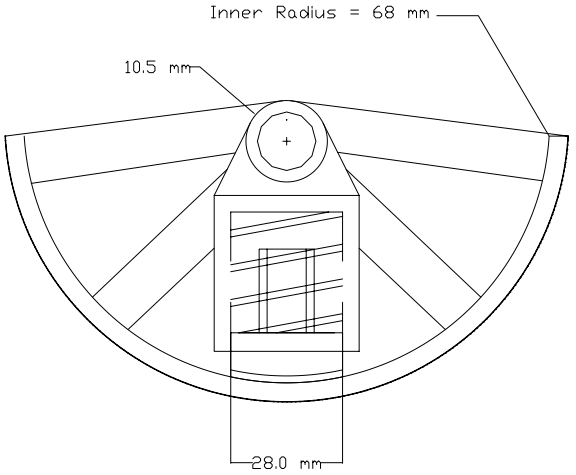

Figure 3: Photo of Sanding Device

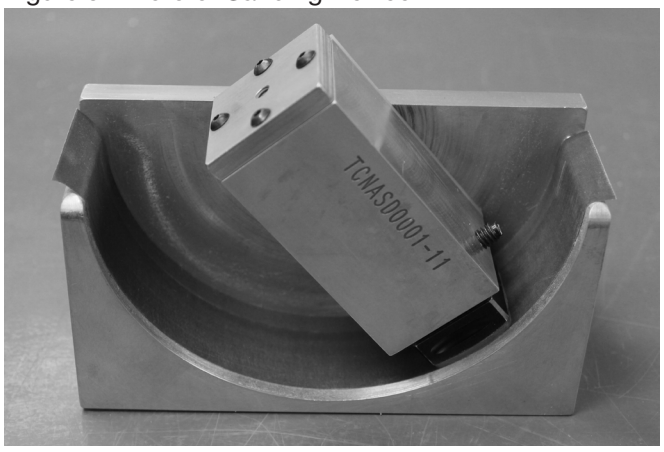

Figure 4: SBR Sensor

Figure 5: SBR Sensor With Wear Line

Figure 6: SBR Sensor Without Wear Line (Note: There may be a “sanding line” that remains after sanding is completed, as seen below.)