National Floor Safety Institute

B101.4 Standard Test Method for Measuring the Wet Barefoot Condition of Walking and Bathing Surfaces

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Suggestions for improvement of this standard should be sent to the Standards Developer: National Floor Safety Institute, 1845 Precinct Line Road, Suite 212, Hurst, TX 76054

This standard was processed and approved for submittal by the NFSI B101 Main Standards Committee on Safety Requirements for Slip, Trip and Fall Prevention. Approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard procedure, the B101 Main Standards Committee had the following members:

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In Memory of
America’s Favorite TV Dad
Mr. Robert “Bob” Lane Saget

B101.4 Standard Test Method for Measuring the Wet Barefoot Condition of Surfaces

Section 1: Scope/Purpose/Application/Exceptions

1.1 Scope

This test method specifies the procedure and devices for both laboratory and field testing to measure the wet Dynamic Coefficient of Friction (DCOF) for hard surfaces that are intended to be used under wet barefoot conditions where individuals stand, step, bathe, shuffle or walk including all types of indoor and outdoor improved surfaces in public or private areas.

1.2 Purpose

This test method provides a measurement procedure setting forth wet DCOF ranges in the wet barefoot condition by individuals who stand, step, bathe, shuffle, or walk, which facilitate remediation of walkway surfaces when warranted.

1.3 Application

The test measurement procedure specified in this standard for surfaces intended to be used wet in a walking barefoot condition shall be conducted using the Dynamic Coefficient of Friction (DCOF) method only.

This test method applies to all types of commercial and residential hard surfaces intended to be used wet in the barefoot condition in a standing posture to any extent, where individuals stand, step, bathe, shuffle or walk including all types of indoor and outdoor improved surfaces in public or private areas. This test method includes, but is not limited to the following locations:

- Bathroom/locker room shower surfaces/tiles/pans/enclosures.
- Bathroom/tub/hot tub/jacuzzi/spa/sauna/steam room surfaces/enclosures.
- Physical therapy areas and apparatus involving water, such as but not limited to whirlpool/hydrotherapy baths or water massage.
- Bathroom/locker room floor tiles and floor surfaces.
- Commercial facilities, residential homes, multi-dwelling units, hotels, and water parks.
- Splash parks and water spray/fountain areas intended for human use.
- Water slide standing entry launch pools and user access areas.
- Private or public pool decks, patios, diving boards, and pool entry stairs/ramps/ladders.
- Cruise ship swimming pool decks, entries, copings and stairs.
- Marine vessel standing surfaces/decks intended to be used in wet barefoot conditions.
- Public/private/commercial/residential/lake, pond, beach and waterfront piers and docks.
- Normally submerged surfaces of wading pools, pool steps, skimmer gutters and wave

pools that are able to be tested with an approved tribometer.
- Private or public saunas, spas, and steam rooms.
- Private or public recreation center shower rooms.
- Swimming pool, spa, and sauna decks.

This test method does not apply to the following:

- Unimproved land, natural walkways, natural ponds, rivers, grass, beach, and the like.
- Water slide chutes.
- Personal water rafts.
- Inflatable water plays structures and toys.
- Surfboards, waveboards, water skis, and the like.
- Marine vessel/cruise ship surfaces/decks that are not intended to be used under wet barefoot conditions.
- Personal watercraft seated foot placement areas.
- Surfaces not intended to be used under wet barefoot conditions.
- Soft surfaces such as fibrous materials (carpeting, carpet matting, etc.).

This test method includes all types of hard surfaces and materials used in the environments listed above upon which persons are intended to stand, step, bath, shuffle, or walk, including but not limited to: hard-surface materials such as a bathtub or shower enclosures, ceramic/porcelain tile, brushed/polished/painted/coated/finished concrete, textured/polished stone, acrylic, vinyl tile, wood, coated/painted metal, or synthetic laminates; impact absorbent materials such as foam-based/rubber-based tiles and sheets and coatings; composite surface materials; and such materials with coatings, polishes, appliques or other traction-enhancing treatment(s) are applied.

> *Note: This test method does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. No express or implied representation or warranty is made regarding the accuracy or significance of any test results in terms of preventing slips or falls in all cases for all people with all types of water-based contaminants. No surface material is completely slip-proof under all wet barefoot conditions with all types of contaminants. Judgment is required on a case-by-case basis to determine the intended use of the surface.*

1.4 Exceptions

This test method is not intended for dry surface testing and does not propose to be an accurate measurement method for determining dry surface traction. Dry surface test data should not be compared to wet surface data. No inferences should be implied or concluded regarding dry vs. wet COF test results from this test method.

This test method does not address wet surface testing with ordinary footwear, which is

addressed in NFSI B101.3 (most current version). Scientific testing has shown that the traction provided by a wet surface may be higher for barefoot skin of all ages than for ordinary footwear when tested in the same manner, due to the pliability and characteristics of human tissue. This standard prescribes a test method that will ensure reasonably safe use of a wet surface specifically when barefoot. As such, **the performance values in this standard do not apply to ordinary footwear use**. For surfaces intended to be used with both bare feet and ordinary footwear, compliance with slip resistance standards for footwear use will also be required. Use the appropriate standard for the incident being investigated. It is recommended to test both the SCOF and DCOF of the subject surface.

This standard does not address the wet barefoot use of ambulation aids, such as canes, crutches, walkers, rollators, prosthetics, or similar walking assisting devices.

Section 2: Reference to Other Standards and Publications

AS 4586:2013 Standard for Slip Resistance Classification of New Pedestrian Surface Materials (Appendix C)

AS 4563:2013 Slip Resistance Measurement of Existing Pedestrian Surfaces

AS/NZS 4586:2004 Standard for Slip Resistance Classification of New Pedestrian Surface Materials (Revised as AS 4586:2013)

ASME A112.19.1-2018/CSA B45.2-18, Enamelled Cast Iron and Enameled Steel Plumbing Fixtures

ASTM F-462 Standard Consumer Safety Specification for Slip-Resistant Bathing Facilities (Withdrawn 2016)

German Institute for Standardization (DIN) Method DIN 51097, Determination of anti-slip properties: Wet-loaded barefoot area; Walking method: Ramp test

ISO 5725-5/Cor1:2005 Accuracy (Trueness and Precision) Of Measurement Methods and Results - Part 5: Alternative Methods for The Determination of The Precision of a Standard Measurement Method – Corrigendum

NFSI B101.3 (most current version) Test Method for Measuring Wet DCOF of Common Hard Surface Floor Materials

NFSI: Inter-Laboratory Study (ILS) for Tribometers Designed to Measure the Wet Dynamic Coefficient of Friction (DCOF) of Common Hard Surfaced Walkways

SA HB 198:2014 Guide to Specification and Testing of Slip Resistance of Pedestrian Surfaces

Section 3: Definitions

3.1 Directional Bias - a characteristic of a material whose coefficient of friction measurement may differ depending on the direction in which the material surface is being tested.

3.2 Dynamic Coefficient of Friction (DCOF) - the ratio of the horizontal component of force applied to a body required to overcome resistance to movement when the body is already in motion divided by the vertical component of the weight of the body or force applied to the surface where movement occurs.

3.3 Eligible Variable-Traction Surface - to be classified as an "eligible variable-traction surface" for the purpose of this standard test method, a surface shall have adhesive traction-enhancing stickers, appliques, strips, or other traction-enhancing materials grooves/molding/texture, or other surface modification intended to improve traction, such that there is no 7.6 cm x 7.6 cm (3.0 in. x 3.0 in.) square area within the intended stepping/standing/walking surface that is completely void of such surface modification. The traction-enhancing surface modification is not required within 5.1 cm (2.0 in.) of a drain or the edge of the intended stepping/standing/walking surface (Ref. ASME A112.19.1-2018/CSA B45.2-18 Figure 8).

3.4 Friction - resistance to the relative motion of two solid objects in contact. On a level surface, this force is parallel to the plane of contact and is perpendicular to the normal force.

3.5 Grain - a characteristic of many natural materials surfaces, such as wood, which may exhibit directional bias as it relates to slip resistance.

3.6 Incline - a walkway with a slope greater than 1:20 and less than 1:12 (rise: run).

3.7 SBR - Styrene Butadiene Rubber.

3.8 Slip Resistant (Wet Barefoot Surface) - a walking or bathing surface which when tested per this method is High-Traction when utilized under wet barefoot conditions (See Table 1).

3.8 SLS - Sodium Lauryl Sulfate.

3.10 Surfactant Solution - a solution consisting of SLS and distilled or de-ionized water which when combined has a final dilution level of 0.1% SLS solution. The solution is employed to reduce the water surface tension when testing on wet hard-surface walkway.

3.11 Test Area - the physical space required for the testing apparatus to perform its primary function.

3.12 Tile Joint - the space between two (2) or more pieces of tile. This space may be filled, par or unfilled.

3.13 Traction - the friction between the sensor material and the surface it moves upon.

3.14 Tribometer - an instrument or device specifically designed to measure the available level of traction upon a walkway surface.

3.14.1 Approved Tribometer - a device that is in compliance with the following criteria:

3.14.1.1 The tribometer should demonstrate reliability and reproducibility in measuring the Dynamic Coefficient of Friction per the Inter-Laboratory Study (ILS) for Tribometers Designed to Measure the Wet Dynamic Coefficient of Friction (DCOF) of Common Hard Surface Walkways.

3.14.1.2 The tribometer manufacturer shall be capable of providing calibration, repair, and maintenance, and a reference check surface method for field performance verification, and other services necessary to ensure device reliability.

3.14.1.3 The tribometer shall be capable of providing a digital display of results for DCOF to the hundredths (two positions right of the decimal point) using a scale of 0.00 to 1.00 or greater.

3.15 Wet Barefoot Surface - a surface intended to be used in a wet barefoot walking, bathing, shuffling, or standing condition, where individuals are expected to stand, shuffle, or take one or more steps in any one direction before pausing, such as bathing facilities (bathtubs and showers), swimming pool or spa decks, water park surfaces, restroom/bathroom/locker room floors, boat decks, piers, and sauna floors.

Section 4: Test Procedure

4.1 Test Requirements

This test procedure should be conducted using an Approved Tribometer designed to measure the wet Dynamic Coefficient of Friction (DCOF) of the surface under anticipated use, depending on the classification of surface. Testing of wet barefoot surfaces shall be conducted using the wet DCOF method as specified in Section 4.3 below.

4.2 Testing Device

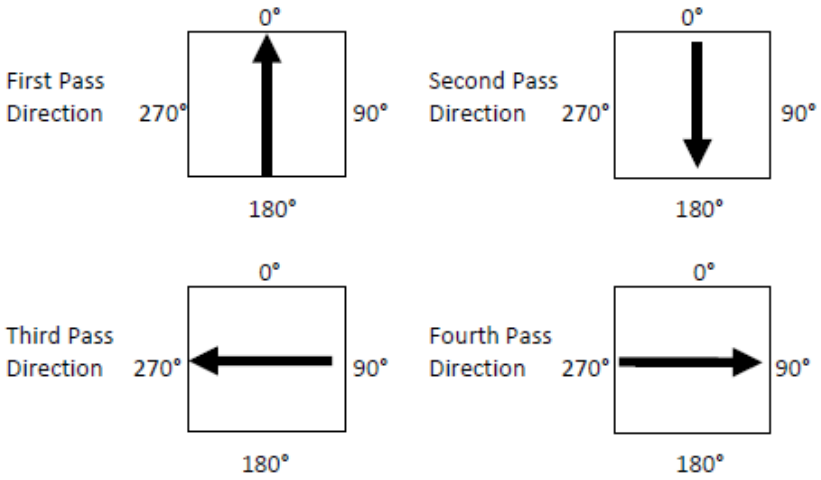
Testing shall be performed using an Approved Tribometer fitted with an SBR test sensor material that complies with the standard set forth herein. **The performance requirements for wet barefoot surfaces in this standard are based on Approved Tribometer test results only.** The tribometer manufacturer's operating, calibration and validation directives shall be followed.

4.3 Wet Dynamic Coefficient of Friction (Wet DCOF) Test Procedure

4.3.1 Walkways Including Swimming Pool, Spa, and Boat Decks

Perform test method on each site as outlined in NFSI B101.3 (most current version). Test each site in (4) directions. Test a minimum of (3) sites per zone. Interpret test result data per table 1 in section 5 of this standard. If test area does not permit (4) directions, test the maximum allowed by the size constraints, (3) or (2) directions, and note exception.

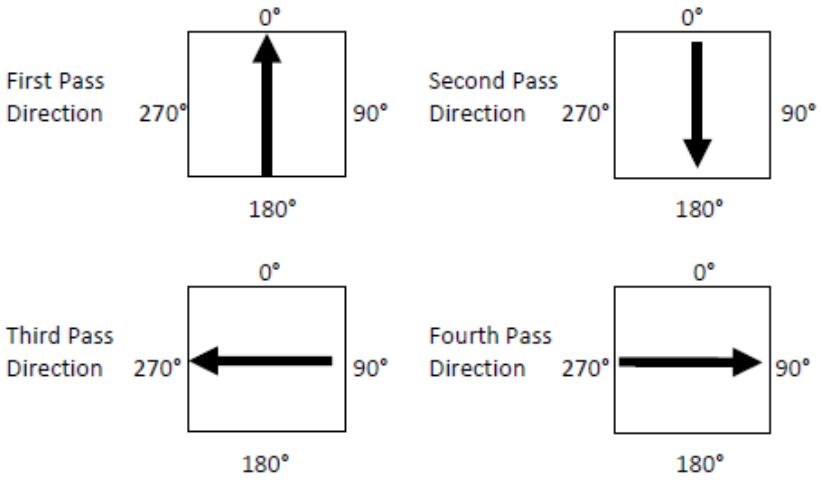
Label pass direction diagrams as example. Should not matter if one rotates 90 degrees each time as long as the data presentation follows suit.



4.3.2 Bathtubs, and Shower Enclosures

Perform test method on each site as outlined in NFSI B101.3 (most current version). Test each site in (4) directions when test area permits. If the test area size and or configuration does not allow for (4) directions, test a minimum of (2) directions and note exception. Test a minimum of (3) sites per zone. Interpret test result data per table 1 in section 5 of this standard.

Label pass direction diagrams as example. Should not matter if one rotates 90 degrees each time as long as the data presentation follows suit.



4.4 Testing of Variable-Traction Surfaces or Materials

For surfaces that qualify as an 'eligible variable-traction surface' as per Section 3, the DCOF testing (depending on the surface classification) shall be conducted entirely on the enhanced/modified traction surface. If the enhanced/modified area is too small and cannot be configured for testing of that surface alone, then the test results must include the DCOF contribution from any non-enhanced/non-modified surface that was within that tested area.

For surfaces that have enhanced/modified traction in some areas but do not qualify as an eligible variable-traction surface' per Section 3, the testing shall be conducted on the non-enhanced/non-modified traction surface only. If the non-enhanced/non-modified area is too small and cannot be configured for testing of that surface alone, then the test results are not adequate. Interpret test result data per table 1 in section 5 of this standard.

4.5 Testing of Curved or Small Surface Areas

For surfaces that cannot be tested using the procedures above due to the surface curvature or limited surface area such as: pool ladder steps, tub enclosures without a flat section large enough for testing, curved spas surfaces (See Image 1. Below), the test examiner may request from the manufacturer, or prepare, flat sample boards of the material for testing, provided that the surface roughness and surface finish of the material is unchanged. This option would not be feasible for a surface currently in-use in the field with a surface roughness or finish that has been modified by weather, wear, chemicals, or other factors. Interpret test result data per table 1 in section 5 of this standard.

Image 1.

Section 5: Calculations/Data Interpretation

Final test results shall be recorded as Wet DCOF values on a linear scale from 0.00 to 1.00. Calculate and record the average for the four directional tests (unless space confinements allow for less directions as mentioned in Section 4.3.2) for each of the three test surfaces in accordance with the testing device manufacturer's instructions.

The potential slip risks for wet barefoot surfaces shall be interpreted according to the performance requirements listed in Table 1.

Table 1: Performance Standard for wet Barefoot Walking and bathing Surfaces

Wet DCOF	Traction Rating for Wet Barefoot Use	Recommended Action
≥ 0.60 (level)	High Traction. Low probability of wet barefoot slipping	Monitor and test DCOF regularly and maintain cleanliness.
0.40 to 0.59 (level)	Moderate Traction. Elevated probability of wet barefoot slipping	Monitor and test DCOF regularly and maintain cleanliness. Consider using traction enhancing products and practices where applicable for intended use.
< 0. 39 (level)	Low Traction. High probability of wet barefoot slipping	Seek professional intervention. Replace surface or treat with traction enhancing product(s).

NOTE: The categories in Table 1 is not indicative of all possible conditions. These ranges were established by way of a human ambulation reference surface study performed in 2021 by the NFSI. Supporting research from epidemiological studies conducted in Canada, Australia, Japan, and Europe, comparing wet barefoot traction to DCOF test values on the same surfaces, using the NFSI B101.3 test method were also considered.

Section 6: Test Report

The Test Report shall include as a minimum:

6.1 types of surface material(s) tested
6.2 location(s) of test areas and sites
6.3 description of areas tested
6.4 condition of test area (e.g., oily, sticky, textured, contaminated, damaged, etc.)
6.5 name and identifying number (e.g., serial number) of tribometer used for testing
6.6 test method used (DCOF)
6.7 average and individual values for each area tested
6.8 traction rating of surface for wet barefoot use (results from Table 1 and/or 2)
6.9 Signature of auditor/technician

Section 7: Safety & Environmental Information

7.1 Potential Hazards in Test Area Vicinity

Never leave a test area unattended. People may trip over objects left in the test area. Wipe the residual solution left on the test surface after each test with a clean cloth or towel and then a dry cloth or towel to ensure a thorough removal of the SLS solution. It is recommended to place a hazard warning such as a safety cone or sign to identify your work area and to alert personnel or the public to your presence.

7.2 Testing Environment

The tribometer manufacturer's instructions or procedures regarding temperature and humidity requirements for the proper operation and storage of the device shall be followed. Conduct DCOF wet testing in the environmental conditions that are regarded as typical for the test area.

Appendix A

Note: This appendix provides supporting reference background information and known published scientific literature relevant to this standard. The documents and standards herein while in the broad subject area of slips, trips, and falls, are not in the exact context or scope of the B101 standards series but do suggest authoritative citations for this field of injury prevention.

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