

SLIP RESISTANCE—ADVANCEMENTS IN PRODUCT USE CATEGORIES FOR HARD SURFACE FLOORING AND ADOPTION OF STANDARDS INTO NORTH AMERICAN BUILDING CODES

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I. SUMMARY

The standardization of slip resistance in North America has been ongoing for decades. However, to this point, North American standards have not specified “product use categories” to guide consumers, designers, or specifiers towards appropriate product use specification based on slip resistance. In comparison, the German criteria BGR-181 provides extensive detail with R values (derived from the German Standard DIN 51130, which provides a five-level classification from R9 to R13) for many different work environments. Since the German criteria are neither referenceable by North American building code organizations nor widely understood throughout the North American market, the ANSI Accredited Standards Committee A108 developed new provisions for ANSI A326.3, *American National Standard Test Method for Measuring Dynamic Coefficient of Friction of Hard Surface Flooring Materials*, including a five-category classification system to communicate areas of use for flooring products.

ANSI A326.3 has already been adopted into North American building codes and is widely specified by design professionals for applications where hard surface flooring is expected to be walked upon when wet. The addition of “product use categories” will allow manufacturers to directly inform specifiers, designers, suppliers, and consumers where to best and more safely use their tile products. That is expected to revolutionize the safer use of tile and distinguish tile products from all other flooring products that are not so labeled.

The following is an outline of topics which are addressed in this paper:

- The evolution of the North American standard A326.3 relating to slip resistance;
- Criteria, product use categories, and “possible areas of use” included in ANSI A326.3;
- The adoption of ANSI A326.3 by the specification community and building code organizations.

II. INTRODUCTION

Dynamic Coefficient of Friction, or DCOF,¹ is often mistakenly portrayed as the sole indicator of a surface’s slipperiness. While DCOF can be helpful in assessing slipperiness, the measurement of DCOF by traditional means does not consider many aspects relating to traction and the DCOF value does not indicate where a product should be used, which is fundamentally important to tile purchasers. To provide a better assessment of traction and better communicate product use, the most recent version of ANSI A326.3, *American National Standard Test Method for Measuring Dynamic Coefficient of Friction of Hard Surface Flooring Materials*,² includes a mandatory requirement that hard surface flooring products be classified into one or more of five new “product use classifications” listed in Table One of the standard.

This unique system is unlike any other in the North American marketplace and allows manufacturers to define internal product selection criteria to classify products based on multiple traction-related parameters. As a result, manufacturers are not restricted to a single measurement criterion, nor are they required to use a specific tribometer device (many of which can produce misleading values on three-dimensionally patterned/profiled surfaces).³ Rather, new language in the standard requires that manufacturers consider a variety of different factors in determining their own internal product selection criteria.⁴

Including product use classifications in A326.3 allows for more effective communication on where products can be appropriately used, based on traction characteristics, in a way that has never before been standardized in North America. Most importantly, better specification of tile flooring is anticipated, potentially resulting in a reduction of slip and fall injuries on such flooring.

¹ DCOF as defined in ANSI A326.3 *Definition of Terms* is the ratio of the force necessary to keep a surface already in motion sliding over another surface divided by the weight (or normal force) of the sliding object. Different contaminants such as dirt, water, soap, oil, or grease can change this value.

² ANSI A326.3 was initially published in 2017, based substantially on criteria previously standardized and published in ANSI A137.1, including a test method for measuring wet or dry dynamic coefficient of friction (DCOF) of hard surface flooring materials in the laboratory or field. In 2021, it was updated to provide five product use categories for hard surface flooring products.

³ Refer to Section IV of this paper for further discussion on how patterning/profiling can affect tribometer measurements.

⁴ Refer to ANSI A326.3 Section 3.4 and Section V of this paper for more information on manufacturer declarations.

III. EFFECT OF VARIOUS PARAMETERS ON TRACTION AND TRIBOMETRY

There are several physical aspects of ceramic tile surfaces which affect traction, such as surface asperities/texture and directional patterning/profiling. Other traction-related factors, aside from the flooring itself, include type of contamination on the surface, various human factors (e.g., speed and length of stride, physical and mental condition of the individual), footwear or lack thereof, and other properties inherent to the installed flooring system (e.g., grout joints, drainage). Addressing the complexity of the issue, the introduction of A326.3 states:

There are many factors that affect the possibility of a slip occurring on a 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; how the hard surface flooring material is used and maintained; and the DCOF of the material, how the flooring surface is structured, and how drainage takes place if liquids are involved.

While many of the above factors play a significant part in traction experienced when walking, several also impact DCOF measurements using tribometers. For example, surface structure/texture, which can improve traction, can also cause misleading DCOF measurements. Tribometers can ride along the “peaks” of the texture, measuring only certain high points rather than making constant surface contact across the distance of the measurement. Similarly, grout joints and tile edges may affect DCOF results on mosaics such that the results may not be representative of the traction experienced on the tile. Combined with the fact that there are many different tribometer devices available that differently measure DCOF, there is a need for a standardized system that allows manufacturers to assess their products based on multiple traction-related factors, not just DCOF.

IV. PRODUCT USE CATEGORIES

To enable manufacturers to better communicate the relative traction of their flooring products, ANSI ASC A108⁵ developed and incorporated five product use categories into A326.3. This is similar in concept to the “R” values in the German work premises rule BGR/GUV-R 181 that utilizes DIN 51130⁶ “R” values to specify flooring for work premises and areas contained in BGR-181⁷ (see Table 1). The “R” values are derived from the angles at which harnessed, human operators, wearing standardized footwear, “slip” on an increasingly inclined, oil-slicked ramp. Unlike the German system, the new A326.3 system allows for criteria to be considered that do not rely on a single test method, which is beneficial for surfaces that may generate misleading DCOF test results.

Acceptance Angle	Assessment Group (R Group)	Examples of work premises and areas (as described in BGR-181)
>35°	R13	Sausage kitchens, vegetable processing, delicacies, or mayonnaise manufacture
>27° to 35°	R12	Commercial kitchens serving over 100 meals per day, manufacture of fats or oils, sculleries, etc.
>19° to 27°	R11	Commercial kitchens serving up to 100 meals per day, machining areas, vehicle repair areas, etc.
>10° to 19°	R10	Garages, damp storage areas, coffee kitchens, sanitary areas, etc.
>6° to 10°	R9	Foyers (indoor), customer and eating areas, corridors, stairways, etc.
<6°	-	Areas without slippery substances

Table 1 DIN 51130 acceptance angles, assessment groups, and examples of work areas and premises

⁵ ANSI Accredited Standards Committee A108 develops standards which define the installation of ceramic, glass, and stone tiles and panels as well as the test methods, physical properties, and sustainability of ceramic, glass, stone, and other hard surface tile and panels, and installation materials. Refer to <https://www.tcnatile.com/ansi-updates-to-standards-a108-committee-info/2-main-content/209-ansi-accredited-standards-committee-asc-a108.html> for further information.

⁶ DIN 51130, *Testing of floor coverings; determination of the anti-slip properties; workrooms and fields of activities with slip danger; walking method; ramp test* German National Standard.

⁷ BGR-181 (Rules on Occupational Safety and Health), *Floors in working rooms and working areas subject to a risk of slipping*. October 1993.

For four of the five A326.3 categories, manufacturers can employ a variety of differing criteria, including the physical parameters of the flooring, their experience with similar surfaces, and various test methods (e.g., ANSI A326.3 DCOF testing, DIN 51130 ramp testing, BS 7976 pendulum testing), to better understand product traction and develop classifications. Specifically, Section 3.4 of ANSI A326.3 states the following regarding manufacturer-declared product use classifications:

Manufacturer shall declare product use classification based on manufacturing parameters, internal quality control criteria, their experience with similar surfaces, and the criteria in this standard for all surfaces classified under Sections 4.1.3, 4.1.4, and 4.1.5, mosaic surfaces, and flooring where surface structure (e.g. three-dimensionally patterned or profiled surfaces) results in misleading DCOF measurements due to test device constraints. Optionally, surfaces classified under Section 4.1.2 shall also be permitted to be manufacturer-declared. Hard surface flooring manufacturer shall define internal product selection criteria (for example, but not in limitation, DCOF limit values established using this test method or other test methods, internal reference standards and practices, and/or the presence of abrasive grain and/or surface structure) for each product where the manufacturer-declared product use classification is not based on DCOF criteria developed per this standard. Regardless of declared product use classification, specifier shall determine materials 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.

Descriptions for each of the five product use categories defined in Sections 4.1.1 through 4.1.5 of A326.3, as well as the "possible areas of use" for each section, are excerpted below.⁸ The italicized informative notes provide information relevant to each of the classifications they correspond to, but do not constitute normative language of the standard:⁹

⁸ In each provided excerpt for the product use classifications, text contained in brackets is added for clarity.

⁹ "Normative language" describes requirements of the standard; "informative language" (i.e., "informative notes") does not define or describe requirements of the standard.

a) INTERIOR, DRY

Product shall be kept dry, level, and free of contaminants when in use.

INFORMATIVE NOTE:

Possible Areas of Use: Subject to determination by specifier and the criteria in this standard [A326.3], may include, but are not limited to, indoor shopping malls (excepting food courts), hotel lobbies, office buildings, showrooms, home interiors without water sources and other level areas where surface will be kept dry and contaminant free when walked upon and proper safety procedures will be followed when cleaning the hard surface flooring materials. Walk-off mats may be necessary for use in entrance areas of the possible areas of use where water or other contaminants would otherwise be occasionally or consistently transported onto the flooring surface. Hard surface flooring not intended to be walked upon when wet shall have a dry DCOF value of 0.42 or greater when tested per Section 10.0 of this standard [A326.3].*

b) INTERIOR, WET

Product shall have a minimum measured wet DCOF value of 0.42*¹⁰ or greater when tested per this standard [A326.3] or be manufacturer-declared for this category based on manufacturing parameters, internal quality control criteria, and manufacturer experience with similar surfaces (see Section 3.4 [of A326.3]). Attributes to consider for products manufacturer-declared for this category include, but are not limited to, product size, texture, structure, and drainage.

INFORMATIVE NOTE:

Possible Areas of Use: Subject to determination by specifier and the criteria in this standard [A326.3], may include, but are not limited to, entry foyers, public restrooms (without showers), grocery stores, "front of the house" in fine and casual dining restaurants with a closed kitchen, home interiors including bathrooms and kitchens, and other areas where floors may be walked upon when wet if level, clean, maintained, and free of standing water or other contaminants.

¹⁰ * Each instance of the 0.42, 0.50, or 0.55 threshold limit values provided in this report applies to the BOT 3000E device; devices being used as equivalent may have different threshold limit values, which shall be independently correlated to those values determined with the BOT 3000E, and independently-derived precision statements which shall be provided by the device manufacturer.

c) INTERIOR, WET PLUS

Product shall be manufacturer-declared for this category based on manufacturing parameters, internal quality control criteria, and manufacturer experience with similar surfaces. Attributes to consider include, but are not limited to, product size, texture, structure, and drainage. Products meeting Interior, Wet Plus criteria may require frequent maintenance to keep clean.

INFORMATIVE NOTE:

Possible Areas of Use: Subject to determination by specifier and the criteria in this standard [A326.3], may include, but are not limited to, public showers, interior pool decks, locker rooms, covered exterior areas, steam rooms, "front of the house" applications in restaurants with an open kitchen, and in "front of the house" applications in quick service, fast-casual, and self-service restaurants, food areas in gas stations, and other similar areas where floors may be walked upon when wet if clean, maintained, and free of standing water or other contaminants.

INFORMATIVE NOTE:

In the absence of superseding manufacturer-declared product use classification, excepting where measured DCOF is lower due to the impact of structure on the DCOF measurement, it is generally accepted that hard surface flooring in this category should have at least a minimum wet DCOF value of 0.50, with factors other than wet DCOF also taken into consideration. Such factors include, but are not limited to, expected contaminants, drainage, surface structure, effect of structure on the DCOF measurement, number of grout joints (see Informative Note in Section 9.1.7), traction-enhancing features, and intended use, in addition to the other criteria in this standard. As the suitability of the installed hard surface flooring depends significantly on such factors, a single normative DCOF limit value is not provided.*

INFORMATIVE NOTE:

Interior, Wet Plus products for applications intended to be walked upon with footwear can, but are not required to, have physical surface characteristics different from products in the same category intended to be walked upon barefoot. Such characteristics can include, but are not limited to, more aggressive surface structure and traction enhancing features for use with footwear, and potentially less texture and lower wet DCOF in barefoot applications.

d) EXTERIOR, WET

Product shall be manufacturer-declared for this category based on manufacturing parameters, internal quality control criteria, and manufacturer experience with similar surfaces. Attributes to consider include, but are not limited to, product size, texture, structure, and additionally in wet applications, drainage. Products meeting Exterior, Wet criteria may require frequent maintenance to keep clean.

INFORMATIVE NOTE:

Possible Areas of Use: Subject to determination by specifier and the criteria in this standard [A326.3], may include, but are not limited to, level outdoor living spaces including pool decks, walkways, patios, and sidewalks, where such floors may be walked upon when wet (excluding ice or snow) if level, clean, maintained, and free of standing water or other contaminants.

INFORMATIVE NOTE:

In the absence of superseding manufacturer-declared product use classification, excepting where measured DCOF is lower due to the impact of structure on the DCOF measurement, it is generally accepted that hard surface flooring in this category should have at least a minimum wet DCOF value of 0.55, with factors other than wet DCOF also taken into consideration. Such factors include, but are not limited to, expected contaminants, drainage, surface structure, effect of structure on the DCOF measurement, number of grout joints (see Informative Note in Section 9.1.7), traction-enhancing features, and intended use, in addition to the other criteria in this standard. As the suitability of the installed hard surface flooring depends significantly on such factors, a single normative DCOF limit value is not provided.*

Note: Exterior, Wet labeling does not refer to frost resistance. For ceramic tile, refer to ANSI A137.1 for frost resistance criteria.

e) OILS/GREASES

Product shall be manufacturer-declared for this category where oil, grease, and/or fats may be present, based on manufacturing parameters, internal quality control criteria, and manufacturer experience with similar surfaces. Attributes to consider include, but are not limited to, product size, texture, structure, and drainage. Products meeting Oils/Greases criteria may require frequent maintenance to keep clean.

INFORMATIVE NOTE:

Possible Areas of Use: Subject to determination by specifier and the criteria in this standard [A326.3], may include, but are not limited to, level areas regularly exposed to automotive fluids, "back of the house" fast food or family style restaurants, food preparation areas with grills or deep-fry equipment, and any area where oil, grease, and/or fats may be present so long as such floors are level, regularly cleaned, maintained, and free of standing water and contaminant build-up.

INFORMATIVE NOTE:

In the absence of superseding manufacturer-declared product use classification, excepting where measured DCOF is lower due to the impact of structure on the DCOF measurement, it is generally accepted that hard surface flooring in this category should have at least a minimum wet DCOF value of 0.55, with factors other than wet DCOF also taken into consideration. Such factors include, but are not limited to, expected contaminants, drainage, surface structure, effect of structure on the DCOF measurement, number of grout joints (see Informative Note in Section 9.1.7), traction-enhancing features, and intended use, in addition to the other criteria in this standard. As the suitability of the installed hard surface flooring depends significantly on such factors, a single normative DCOF limit value is not provided.*

V. POTENTIAL IMPACTS OF THE A326.3 CLASSIFICATION SYSTEM**a) IMPACT ON SPECIFIERS, DESIGN PROFESSIONALS, AND ARCHITECTS**

Prior to requiring product use classification, sometimes products suitable for certain projects were excluded due to misleadingly low DCOF test results on highly textured surfaces. For example, a surface with profiled surface ridges, a rough finish, and a high measured acceptance angle (or "R" value) per DIN 51130 might also have a "low" measured DCOF due to how a device testfoot moves across the peaks of the surface profiling; as a result, especially in the US, that surface would most likely not be considered for a given application despite being appropriate. In other instances, products inappropriate for various wet applications are often specified when DCOF values are not understood. In both cases, requiring product use specification directly impacts specifiers, designers, architects, etc. who can use the new product use classification to specify tile products with more confidence for a variety of applications.

b) IMPACT ON PEDESTRIANS

Pedestrians benefit from the A326.3 product use classification system through better specifications and, by extension, a resulting reduction in slip and fall injuries caused by improperly and/or poorly specified flooring. Additionally, based on the language in A326.3 Section 3.4 (previously shown in Section IV) and Section 3.1, the standard spells out that the product use classification should be considered by the specifier while also considering expected traffic, contaminants, use, wear and maintenance, along with any additional manufacturer guidelines and recommendations. This attention to the many parameters that can cause a slip, along with better understanding by those responsible for maintaining the flooring, can lead to a dramatic reduction in slip/fall events.

c) IMPACT ON EXPORTERS TO THE UNITED STATES

With ANSI A326.3 already referenced in ANSI A137.1, *American National Standard Specifications for Ceramic Tile*, imported products will need to be classified per A326.3 to satisfy commercial procurement and installation criteria. Meeting the criteria of the standard should incur no, or minimal, costs for manufacturers and exporters of ceramic tile to the US, as manufacturers already know where their products can be utilized safely and there is no requirement for box labeling. As such, the standard imparts no additional manufacturing costs and the product use criteria can be communicated through digital product literature, technical specifications, or any other form of readily-available communication.

d) IMPACT ON THE MARKETPLACE

According to North American tile producers, product use classifications for tile will become widely available for ceramic tile products in 2022. As ANSI A326.3 is a voluntary hard surface flooring standard not limited in scope to ceramic tile, other flooring industries could use and benefit from the standard. This would lead to a reduction in those slip events which commonly occur due to lack of clarity on where manufacturers recommend their products be used.

As an example, a 2019 Clemson University report showed that 82% of plastic-based material (PBM) flooring products had measured wet DCOF values of less than 0.42.^{11,12} Additionally, 27% of the measured products exhibited “directionality” when wet, which is defined as a DCOF measurement along one edge differing from a measurement taken on a perpendicular edge by at least 0.05. Directionality can be caused by texture, roughness, and patterning on a flooring surface, and affect traction experienced when turning a corner. All of the evaluated products were advertised or claimed as waterproof or water resistant or depicted being used in areas where flooring gets wet. The report suggests that, at a minimum, a dry-use only warning should be indicated for the products that exhibited wet directionality or measured below 0.42 wet DCOF. If the A326.3 classification were applied to those products based on the information presented in the report, they would be classified as “Interior, Dry,” requiring that they only be walked upon when dry and level. If classified as such, use of those products in wet areas, where they presented a real slip risk, could be avoided.

¹¹ Sanders, John, and Grant Davidson. *Wet Slip Resistance of Plastic Based Material Flooring (PBM Flooring)*. Clemson University, December 2019.

¹² For the study, a total of 22 different PBM products were tested using the ANSI A326.3 wet DCOF test method.

VI. ADOPTION OF A326.3 BY THE SPECIFICATION COMMUNITY AND BUILDING CODE ORGANIZATIONS

a) NORTH AMERICAN INDUSTRY AND SPECIFICATION COMMUNITY

A large variety of stakeholders from different sectors of the hard surface flooring industry participated in both the initial development and revisions of ANSI A326.3. Accordingly, the method is widely used and specified in North American flooring industries including ceramic tile, stone, concrete, and several others. Specifically, all United States-based ceramic tile manufacturers utilize the A326.3 test method to evaluate their products and are in the process of rolling out product use classifications for each of their products based on the newly published revisions to A326.3.

b) INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)

In 2021, the IAPMO Uniform Swimming Pool, Spa, & Hot Tube Code (USPSHTC)¹³ was updated to establish measurable criteria for suitably slip resistant surfaces around pools, spas, and hot tubs. The code for slip-resistant walkway surfaces includes the following provisions:

- A required wet dynamic coefficient of friction (DCOF) value of no less than 0.42, for level walkway surfaces intended to be walked upon when wet, as determined in accordance with the current ANSI A326.3 standardized test method.
- A corrected minimum DCOF requirement for inclined/sloped walkways, which require greater available friction to prevent slipping.
- Guidance for testing on three-dimensionally patterned or profiled walkways.
- An appendix providing additional information regarding the determination of DCOF values for hard surface walkways intended to be slip-resistant.

For three-dimensional or textured surfaces, the code notes that testing shall be conducted on a nominally flat section of such walkways. Where that is not possible, the code states that the specifier must provide documentation substantiating their product choice, similar to what is required for manufacturer declarations per the A326.3 system. As a result, it is expected that the code will help in the improved specification of flooring products.

¹³ Per IAPMO, the USPSHTC “establishes minimum requirements and standards for the protection of the public health, safety and welfare.” Refer to <https://codes.iapmo.org/home.aspx?code=USPSHTC&code=USPSHTC> for more information.

c) INTERNATIONAL CODE COUNCIL (ICC)

In 2021 the ICC International Swimming Pool and Spa Code (ISPSC)¹⁴ committee voted unanimously to accept language proposed by the Tile Council of North America (TCNA) and the Pool and Hot Tub Alliance (PHTA) requiring testing per A326.3 or AS 4586¹⁵ for products deemed to be “slip resistant.” With no public comments submitted in opposition to the language, it will appear in the next revision of the ISPSC occurring in 2024.

VII. CONCLUSION

The addition of five new “product use” classification categories in ANSI A326.3 is expected to revolutionize the specification and use of ceramic tile in the US and distinguish it from other hard surface flooring that is not similarly classified. With the standard not limited to ceramic tile, it can be utilized by a variety of hard surface flooring industries to improve manufacturer communication and transparency regarding where their products can safely be used. By extension, specifiers, designers, suppliers, and consumers will be better informed on how to more safely and appropriately use hard surface flooring.

Importantly, the system provides a tool for manufacturers to clearly communicate the relative traction of their flooring, without restriction to a single measurement criterion or device. With A326.3 already referenced in North American building codes and widely specified by design professionals for areas where flooring is expected to be walked upon when wet, wide use of the product use classification system is anticipated in the US. As a result, it is expected that pedestrians, the primary beneficiary of better specified flooring, will experience fewer slip events.

¹⁴ Per ICC, the ISPSC establishes “minimum regulations for public and residential pools, spas, and hot tubs using prescriptive and performance-related provisions.” Refer to <https://codes.iccsafe.org/content/ISPSC2021P1> for more information.

¹⁵ AS 4586 is an Australian standard titled *Slip resistance classification of new pedestrian surface materials*. It provides a classification rating system ranging from P0 up to P5 (see Table 2 of AS 4586), each of which correspond to a defined measurement range using a pendulum tester.

VII. REFERENCES

- [1] ANSI A137.1 *American National Standard Specifications for Ceramic Tile*.
- [2] ANSI A326.3 *American National Standard Test Method for Measuring Dynamic Coefficient of Friction of Hard Surface Flooring Materials*.
- [3] AS 4586 *Slip resistance classification of new pedestrian surface materials*.
- [4] DIN 51130 *Testing of floor coverings; determination of the anti-slip properties; workrooms and fields of activities with slip danger; walking method; ramp test* German National Standard.
- [5] BGR 181 *Fußböden in Arbeitsräumen und Arbeitsbereichen mit Rutschgefahr* [Floors in working rooms and work areas subject to a risk of slipping].
- [6] IAPMO 2021 *Uniform Swimming Pool, Spa, and Hot Tub Code*.
- [7] Davidson, G., & Astrachan, E. (February 13-14, 2020). Existing and Developing Requirements in the United States for Communicating Traction and Areas of Use for Flooring. In Fundación Gómez Pardo (Ed.), *Proceedings "Slips, Trips & Falls. Conference Madrid 2020"* (pp. 63-70).
- [8] Sanders, John, and Grant Davidson. *Wet Slip Resistance of Plastic Based Material Flooring (PBM Flooring)*. Clemson University, December 2019.