NATIONAL FLOOR SAFETY INSTITUTE

April 19, 2018

Office of the Secretary
Consumer Product Safety Commission
Washington, DC 20207

Petition to Mandate the Use of the ANSI/NFSIB101.5 Standard Guide for Uniform Labeling Method for Identifying the Wet Dynamic Coefficient of Friction (Traction) of Floor Coverings, Floor Coverings with Coatings, and Treated Floor Coverings

Scope

This petition requests that the Consumer Product Safety Commission (CPSC) mandate manufacturers of floorcoverings and coatings to uniformly label their products' slip-resistance per the American National Standards Institute (ANSI) B101.5-2014 "Standard Guide for Uniform Labeling Method for Identifying the Wet Dynamic Coefficient of Friction (Traction) of Floor Coverings, Floor Coverings with Coatings, and Treated Floor Coverings." (attached) and that flooring retailers provide point of purchase information (ie; placards, signs, etc.) communicating the use of the label as a part of the product selection process.

Requirements for Petitions

1. Indicate the product (or products) regulated under the Consumer Product Safety Act or other statute the Commission administers for which a rule is sought.

We request that the manufacturers of hard surface, resilient flooring materials and topical floor coatings (finishes/polishes) be mandated to label their products DCOF to provide point-of-sale information about the product's degree of slip-resistance in accordance with the labeling set out in ANSI/NFSI B101.5 standard (attached). According to the National Floor Safety Institute (NFSI), 55% of all same-level slips and falls, occur as the result of a hazardous (slippery) walkway. Given such, it is estimated that more than half of all same level falls take place in the home which most are the result of a slip and fall.

Currently, manufacturers of floor coverings are not compelled to provide the consumer any information as to the slip resistance of their products which has directly contributed to consumers being harmed by selecting flooring materials that did not have an adequate level of slip resistance. Floor covering manufacturers who do not routinely test and label their products slip resistance (Coefficient of Friction (COF)) include:

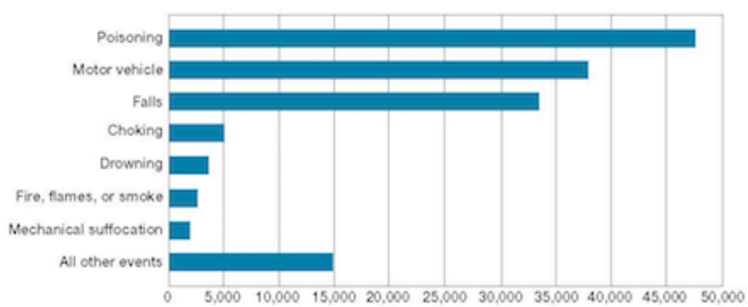
- Ceramic and Porcelain Tile
- Natural Stone (marble, granite, etc.)
- Resilient Flooring (vinyl)
- Synthetic Laminate Materials
- Finished and Engineered Wood (bamboo, cork, etc.)
- Floor Finishes, Polishes, Paints and Coatings
- Polished Concrete

In the absence of readily accessible slip resistance (traction) safety information provided via a single and nationally adopted industry consensus test method and an associated uniform product label, the consumer is at risk of selecting an inappropriately slippery floor and often falsely assume that all floors are safe for use simply because they are available for sale. Different types of floor coverings have wide-ranging differences in slip resistance, many of which may be inappropriate for specific use. This is true both for residential and commercial applications. However, the consumer, specifically the elderly, may only find out that they made the wrong choice after they have fallen and injured themselves. The failure by the floor covering industry to inform the consumer as to their products safety (traction) is one of the leading factors as to why so many Americans especially those of our nation's elderly population slip and fall.

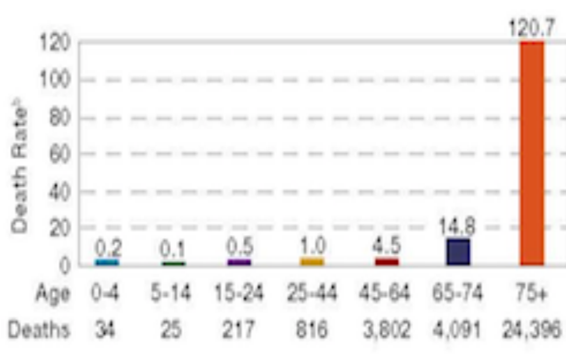
2. Set forth facts, which establish the claim that the issuance of the rule is necessary (for example, such facts may include personal experience: medical, engineering or injury data, or a research study).

Although all floor covering consumers would benefit from the proposed uniform labeling system, the primary focus of our petition is aimed at protecting those most vulnerable from the risk of a slip and fall event that being our nation's elderly population.

According to the U.S. Census Bureau approximately ten thousand (10,000) baby-boomers are retiring each day and according to the Harvard University Health Letter [1.] the baby-boomer generation will have an average life expectancy of 81.6 years of which many may live to age 90. According to the National Safety Council's Injury Facts (2014 edition) of the 38,300,000 individuals who sought medical attention due to an unintentional injury, 1,930,000 took place in the home. Sixty-three thousand (63,000) Americans died in their home as a result of an unintentional injury. Of the estimated $793.8 billion cost for unintentional injuries (2012) $220.3 billion was spent on injuries which occurred in the home.



There has been a 38% increase in accidental falls for those age 65+. In 2005, 16,400 seniors lost their life as a result of an accidental fall that number has risen to 23,100 in 2014 and 28, 487 in 2017.



In 2005, 20,200 Americans lost their life as a result of an accidental fall, many of which were same-level slips and falls. That number rose to 27,800 in 2014 and 33,000 in 2017. Over the past decade fall related fatalities have risen by nearly 52% and are likely to continue to rise.

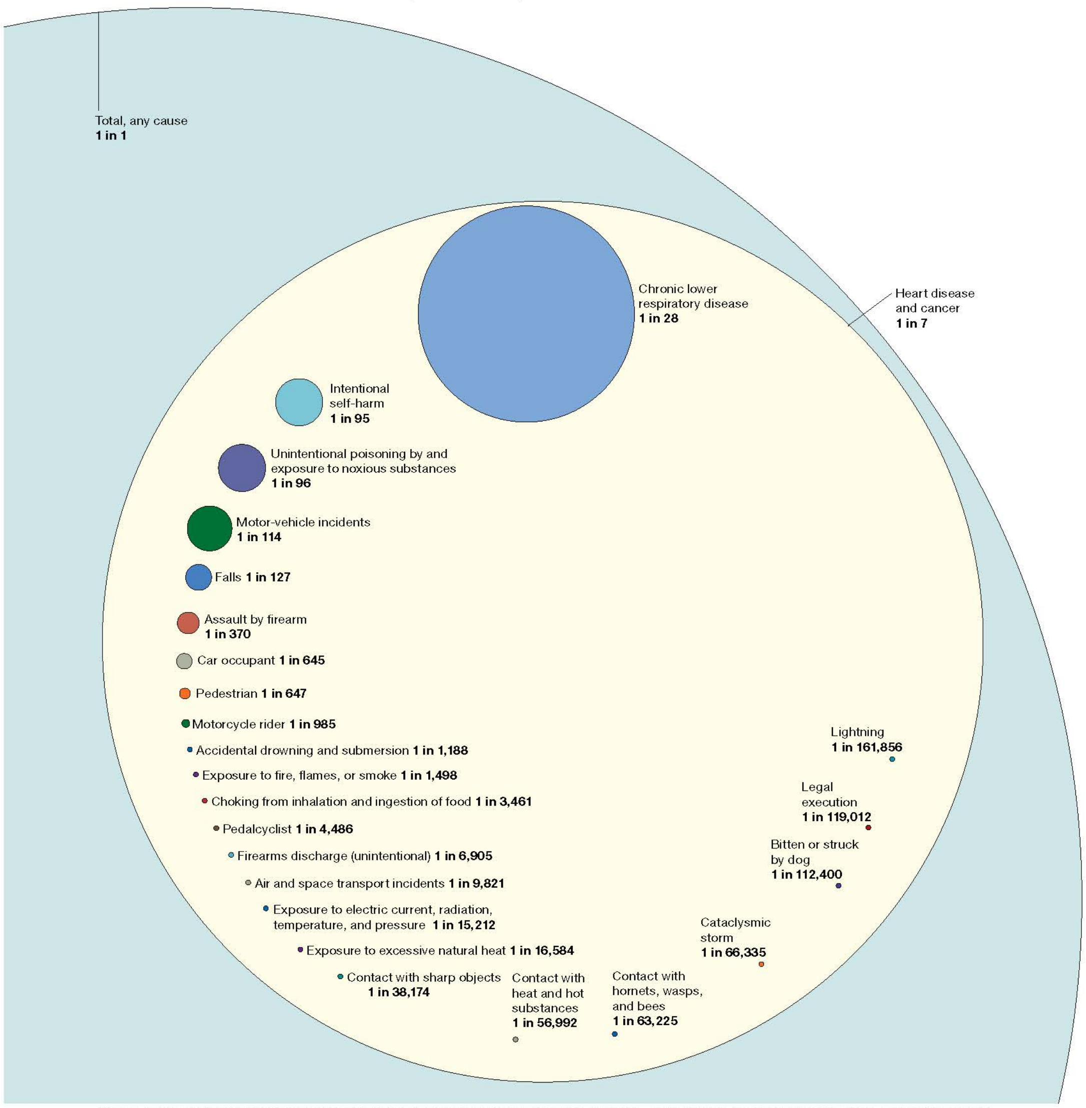
The lifetime risk of accidental death as a result of a fall is nearly equal to that of automobile accidents!

(2017 NSC Accident Facts)

ALL INJURIES

The Odds of Dying From... (cont.)

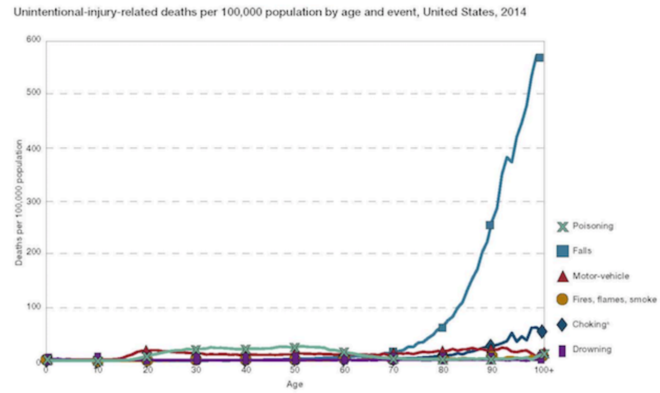
Lifetime odds of death for selected causes, United States, 2014[a]



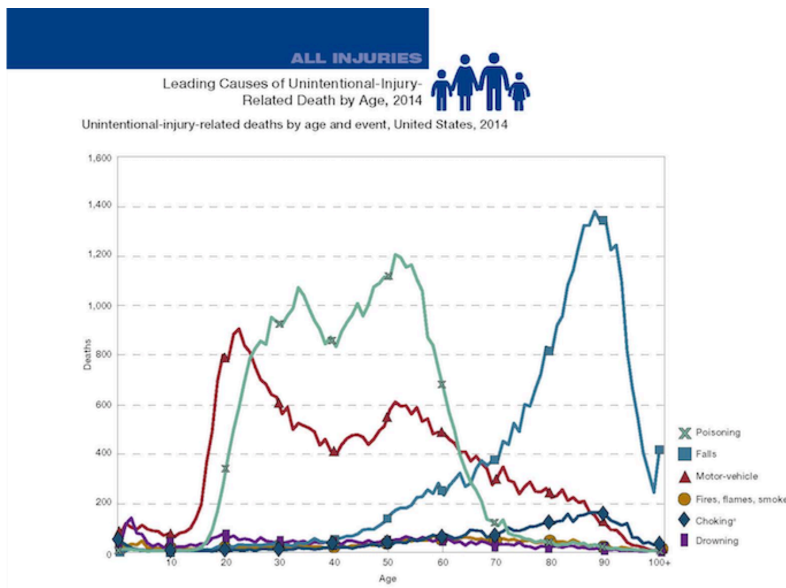
Source: National Safety Council estimates based on data from National Center for Health Statistics—Mortality Data for 2014 as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Population and life expectancy data are from the U.S. Census Bureau. For mortality figures, estimated one-year and lifetime odds, and external cause classification codes based on the 10th Revision of "The International Classification of Diseases" (ICD) for the causes illustrated, see table on pages 41–42.

[a]Latest official figures.

INJURY FACTS® 2017 EDITION NATIONAL SAFETY COUNCIL® 43



Accidental falls disproportionally affects the elderly more than any other demographic age group of our society. According to the National safety Council (NSC), "Falls were the third leading cause of unintentional-injury related death in the United States in 2010, the leading cause of unintentional-injury-related death for people age 70 or older and the second leading cause for ages 64-69 for each year of age; deaths resulting from falls peaked at 1,178 for individuals age 87."

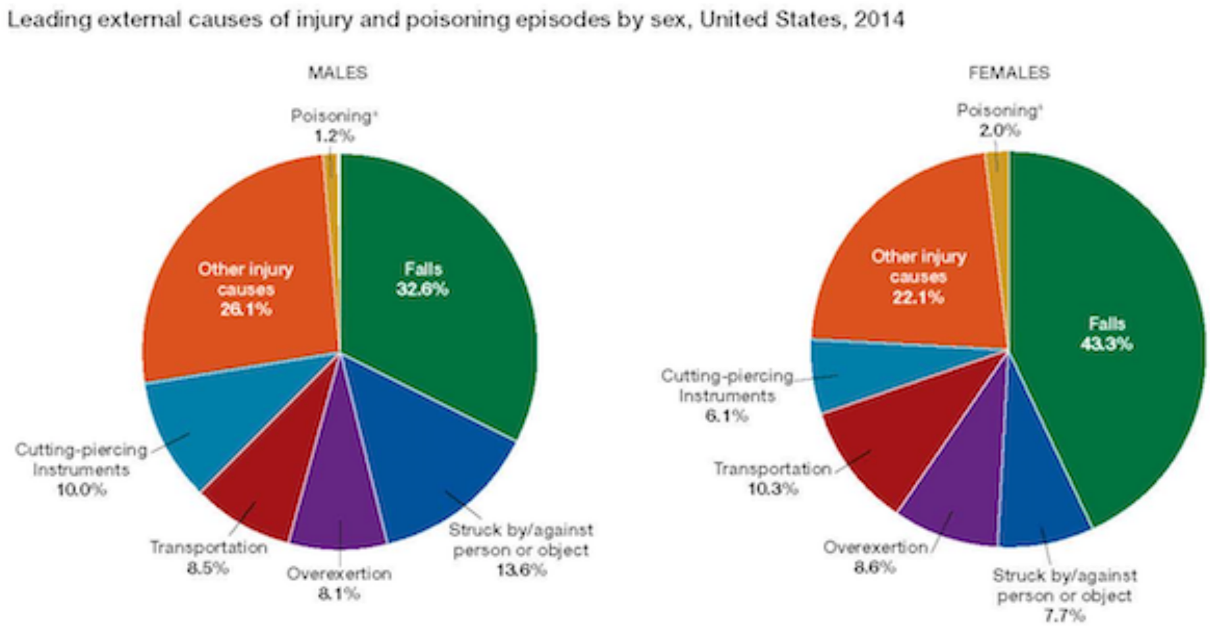


Between the years 2004 and 2012 the economic impact of nonfatal unintentional injuries rose by 38% from $574.8 billion in 2004 to $793.8 Billion in 2012.

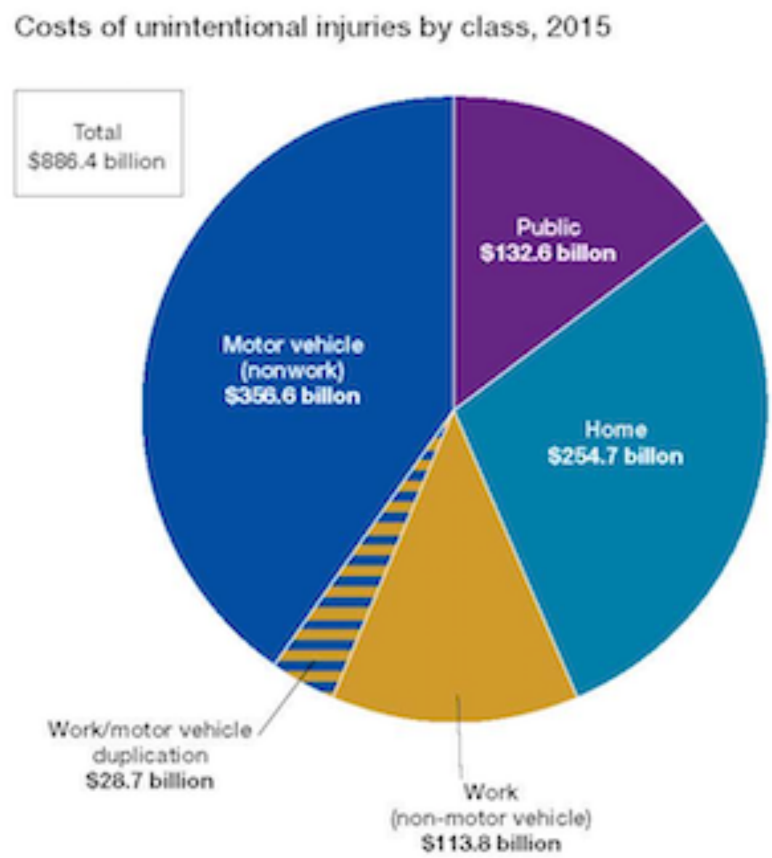
According to the National Health Interview Survey, 2011, 42.9% of females and 27.7% of males will fall and seek medical attention. Of the 37,872,000 injury episodes, 12,343,000 occurred in the home and 6,941,000 occurred outside of the home. The study revealed, "Falls and motor vehicle incidents were the leading causes of injury-related emergency department visits, accounting for 26% and 11% of the total, respectively. In total, about 10.5 million visits to emergency departments in 2010 were due to unintentional falls and nearly 4.5 million were due to motor vehicle incidents." Of the 29,310,000 unintentional injuries as identified via the E-code system, 10,512,000 were the result of a fall (E880.0-E886.9, E888).

In 2011, falls represented the leading cause of non-fatal injuries, which required emergency room treatment for all age groups.

1.- Harvard Health Publications, Harvard Medical School: "Average Life Expectancy: Measuring yours."



Sadly, since submitting our 2015 petition the slip and fall crisis has worsened. 2017 NSC data reveals an increase in fall fatalities. According to the CDC, "In 2015, the direct medical costs of older adult falls, adjusted for inflation, were $34 billion. With the population aging, both the number of falls and the costs to treat fall injuries are likely to increase."



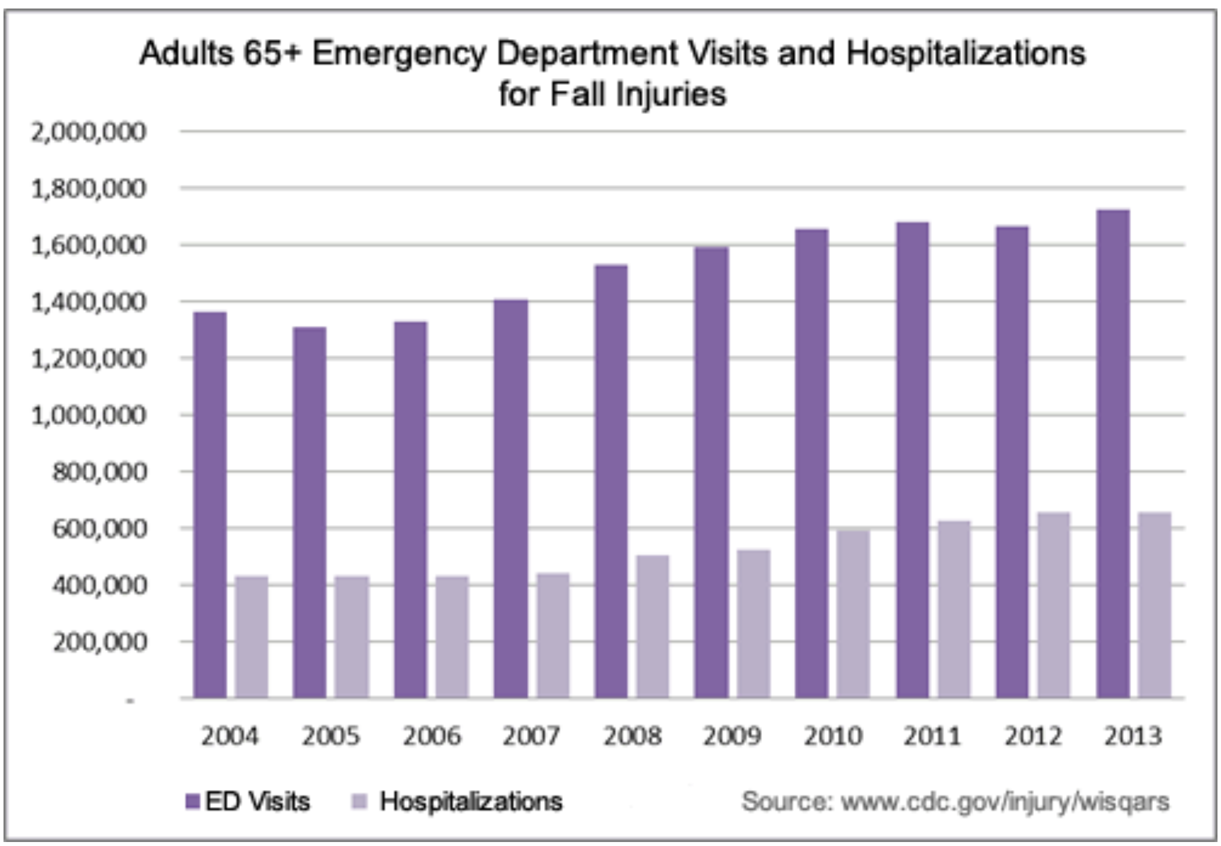
How Big Is the Problem?

- One in three adults aged 65 and older falls each year.[2] Of those who fall, 20% to 30% suffer moderate to severe injuries that make it hard for them to get around or live independently, and increase their risk of early death.[3]
- Older adults are hospitalized for fall-related injuries five times more often than they are for injuries from other causes.[4]
- Annually, emergency departments treat about 2.5 million nonfatal fall injuries among older adults; more than 30%, or about 734,000 of these patients have to be hospitalized.[5]

How Are Costs Calculated?

The costs of fall-related injuries are often shown in terms of direct costs.

- Direct costs are what patients and insurance companies pay for treating fall-related injuries. These costs include fees for hospital and nursing home care, doctors and other professional services, rehabilitation, community-based services, use of medical equipment, prescription drugs, changes made to the home, and insurance processing.
- Direct costs do not account for the long-term effects of these injuries such as disability, dependence on others, lost time from work and household duties, and reduced quality of life.



How Costly Are Fall-Related Injuries Among Older Adults?

- In 2013, the total direct medical costs of fall injuries for people 65 and older, adjusted for inflation, was $34 billion.[1]
- Among community-dwelling older adults, fall-related injury is one of the 20 most expensive medical conditions.[7]
- In 2002, about 22% of community-dwelling seniors reported having fallen in the previous year. Medicare costs per fall averaged between $14,306 and $21,270 (in 2013 dollars).[8]
- Among community-dwelling seniors treated for fall injuries, 65% of direct medical costs were for inpatient hospitalizations; 10% each for medical office visits and home health care, 8% for hospital outpatient visits, 7% for emergency room visits, and 1% each for prescription drugs and dental visits. About 78% of these costs were reimbursed by Medicare.[9]

How Do These Costs Break Down? Age and Sex.

- The costs of fall injuries increase rapidly with age.[1]
- Costs of both fatal and nonfatal falls are higher for women than for men.[1]
- Medical costs for women, who comprised about 60% of older adults, are two to three times higher than the costs for men.[1]

Type of Injury and Treatment Setting

- Approximately three-fourths of fall deaths, and three-fourths of total costs, are due to traumatic brain injuries (TBI) and injuries to the lower extremities.[1]
- Injuries to internal organs are responsible for about 28% of fall deaths and account for about 29% of costs.[6]
- Fractures are both the most common and most costly nonfatal injuries. Just over one-third of nonfatal injuries are fractures, but these account for about 61% of total nonfatal costs.[1]
- Hospitalizations account for nearly two-thirds of the costs of nonfatal fall injuries and emergency department treatment accounts for about 20%.[1]
- On average, the hospitalization cost for a fall injury is over $35,000.[10]
- Hip fractures are the most serious and costly fall-related fracture. Hospitalization costs account for about 44% of the direct medical costs for hip fractures.[10]

Nursing home residents fall frequently. About 1,800 older adults living in nursing homes die each year from fall-related injuries and those who survive frequently sustain injuries that result in permanent disability and reduced quality of life.[1]

- More than 1.4 million people 65 and older live in nursing homes.[2] If current rates continue, by 2030 this number will rise to about 3 million.[3]
- About 5% of adults 65 and older live in nursing homes, but nursing home residents account for about 20% of deaths from falls in this age group.[4]
- Each year, a typical nursing home with 100 beds reports 100 to 200 falls. Many falls go unreported.[4]
- Between half and three-quarters of nursing home residents fall each year.[5] That is twice the rate of falls among older adults living in the community.
- Patients often fall more than once. The average is 2.6 falls per person per year.[6]
- About 35% of fall injuries occur among residents who cannot walk.[7]

Leading Causes of Nonfatal Unintentional Injuries

Falls are the leading cause of nonfatal unintentional injuries that are treated in hospital emergency departments, according to data from the All Injury Program, a cooperative program involving the National Center for Injury Prevention and Control, the Centers for Disease Control and Prevention, and the Consumer Product Safety Commission. Nearly 9.2 million people were treated in an emergency department for fall-related injuries in 2014. Falls were the leading cause of nonfatal injuries for all age groups except for the 10- to 14 and 15- to 24-year-old age groups, for which struck by or against an object or person was the leading cause. Struck by or against, overexertion, and motor vehicle crashes involving vehicle occupants also were leading causes for most age groups (please see color key at the bottom of the opposite page).

Leading causes of nonfatal unintentional injuries treated in hospital emergency departments by age group, United States, 2014[a]

Rank	All ages	Age group: Younger than 1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65 or older
1	Falls 9,163,980	Falls 129,404	Falls 818,850	Falls 622,225	Struck by/ against 535,500	Struck by/ against 865,847	Falls 764,225	Falls 726,920	Falls 943,379	Falls 1,001,304	Falls 2,791,459
2	Struck by/ against 4,083,298	Struck by/ against 28,577	Struck by/ against 317,648	Struck by/ against 386,752	Falls 533,032	Falls 832,979	Overexertion 596,781	Overexertion 506,447	Overexertion 444,754	Overexertion 276,676	Stuck by/ against 281,308
3	Overexertion 3,132,271	Other bite/ sting[b] 12,042	Other bite/ sting[b] 165,536	Other bite/ sting[b] 117,961	Overexertion 282,976	Overexertion 636,085	Struck by/ against 589,679	Struck by/ against 418,522	Struck by/ against 395,394	Struck by/ against 264,024	Overexertion 222,387
4	Motor vehicle occupant 2,412,109	Foreign body 10,891	Foreign body 122,229	Cut/pierce 100,315	Cut/pierce 111,781	Motor vehicle occupant 594,353	Motor vehicle occupant 513,641	Motor vehicle occupant 370,982	Other specified[c] 394,517	Motor vehicle occupant 243,750	Motor vehicle occupant 191,849
5	Cut/pierce 1,959,505	Inhalation/ suffocation 10,441	Overexertion 78,491	Overexertion 83,021	Pedalcyclist 84,383	Cut/pierce 408,048	Cut/pierce 390,725	Other specified[c] 306,042	Motor vehicle occupant 342,581	Other specified[c] 213,974	Cut/pierce 147,739
6	Other specified[c] 1,751,918	Other specified[c] 9,266	Cut/pierce 78,428	Pedalcyclist 70,964	Unknown/ unspecified 72,270	Other specified[c] 291,986	Other specified[c] 338,244	Cut/pierce 296,099	Poisoning 273,232	Cut/pierce 185,389	Poisoning 119,150
7	Poisoning 1,231,033	Fire/burn 8,087	Other specified[c] 63,396	Foreign body 61,112	Motor vehicle occupant 69,008	Other bite/ sting[b] 185,547	Poisoning 220,487	Poisoning 209,879	Cut/pierce 265,317	Poisoning 181,339	Other bite/ sting[b] 103,084
8	Other bite/ sting[b] 1,216,927	Cut/pierce 5,507	Fire/burn 48,389	Motor vehicle occupant 56,511	Other bite/ sting[b] 68,770	Poisoning 175,948	Other bite/ sting[b] 181,712	Other bite/ sting[b] 138,422	Other bite/ sting[b] 141,378	Other bite/ sting[b] 102,454	Other specified[c] 92,209
9	Unknown/ unspecified 722,811	Unknown/ unspecified 5,445	Unknown/ unspecified 38,409	Dog bite 43,369	Other transport[d] 37,456	Unknown/ unspecified 132,016	Unknown/ unspecified 112,258	Unknown/ unspecified 91,609	Unknown/ unspecified 97,250	Unknown/ unspecified 68,220	Other transport[d] 80,011
10	Foreign body 531,277	Overexertion 4,623	Dog bite 33,771	Other transport[d] 33,210	Dog bite 31,790	Other transport[d] 91,805	Other transport[d] 76,068	Other transport[d] 65,952	Other transport[d] 67,338	Other transport[d] 49,252	Unknown/ unspecified 75,150
All causes of nonfatal unintentional injury											
Number	28,728,927	234,572	1,880,144	1,668,218	1,925,790	4,646,758	4,158,992	3,425,716	3,667,832	2,806,269	4,314,635[e]
Per 100,000 population	9,010.0	5,941.0	11,803.6	8,129.9	9,316.2	10,565.7	9,557.3	8,455.8	8,439.8	7,002.1	9,330.3[e]

Source: NEISS All Injury Program, Office of Statistics and Programming, National Center for Injury Prevention and Control, the Centers for Disease Control and Prevention, and Consumer Product Safety Commission.

[a]See color key on opposite page.

[b]Other than dog bite.

[c]Injury associated with any other specified cause that does not fit another category. Includes electric current, explosions, fireworks, radiation, animal scratch, etc. Excludes all causes listed in the table and bb/pellet gunshot, drowning and near drowning, firearm gunshot, suffocation, machinery, natural and environmental conditions, pedestrians, and motorcyclists.

[d]Includes occupant of any transport vehicle other than a motor vehicle or motorcycle (e.g., airplane, space vehicle, railcar, boat, all-terrain vehicle, animal and animal-drawn conveyances, battery-powered carts, ski lifts, and other cable cars not on rails).

[e]Includes 4,475 cases with age unknown.

How Serious Are These Falls?

- About 1,800 people living in nursing homes die from falls each year.[1]
- About 10% to 20% of nursing home falls cause serious injuries; 2% to 6% cause fractures.[1]
- Falls result in disability, functional decline and reduced quality of life. Fear of falling can cause further loss of function, depression, feelings of helplessness, and social isolation.[5]

Why Do Falls Occur More Often in Nursing Homes?

Falling can be a sign of other health problems. People in nursing homes are generally frailer than older adults living in the community. They are usually older, have more chronic conditions, and have more difficulty walking. They also tend to have thought or memory problems, have difficulty with activities of daily living, and to need help getting around or taking care of themselves.[8] All of these factors are linked to falling.[9]

What Are the Most Common Causes of Nursing Home Falls?

- Muscle weakness and walking or gait problems are the most common causes of falls among nursing home residents. These problems account for about 24% of the falls in nursing homes.[5]
- Environmental hazards in nursing homes cause 16% to 27% of falls among residents.[1,5]
- Such hazards include wet floors, poor lighting, incorrect bed height, and improperly fitted or maintained wheelchairs.[5, 10]

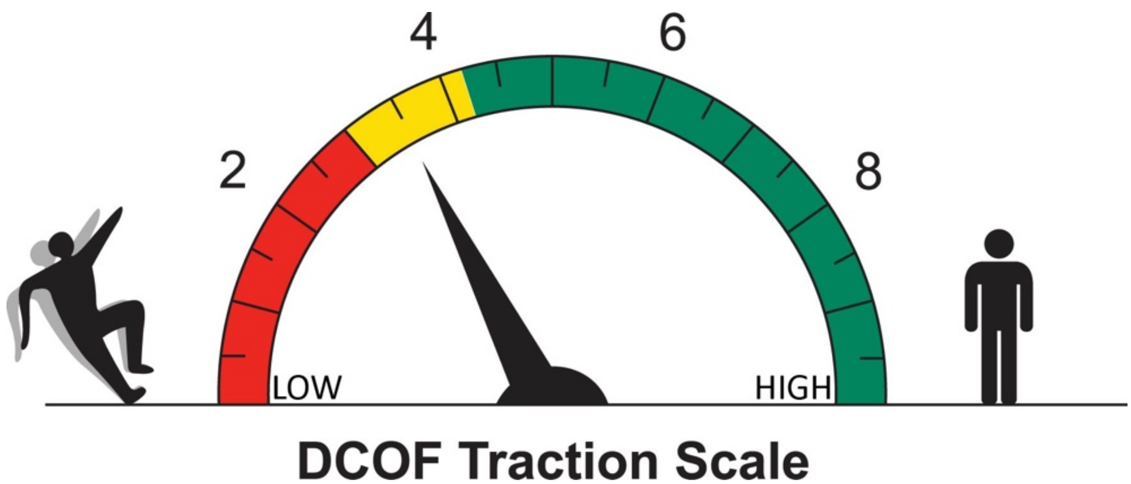
The National Council on Aging (NCOA) Falls Free 2015 National Falls Prevention Action Plan (NFPA) addresses the immediate need to reduce elder falls and outlines specific goals and strategies. The NFPA Home Safety Goal A. states that "All older adults will have knowledge of and access to effective home safety measures (including information, assessments, and home modifications) that reduce home hazards, improve independent functioning, and lower the risk of falls." Evidence based data had demonstrated that the elderly are disproportionally at a heightened risk of a same level slip and fall event.

The NFPA strategy to accomplish Goal A. is to "Raise awareness and disseminate information about home safety practices and options for caregivers and older adults to reduce falls." The action plan further seeks to: "Develop and promote standards related to product safety, service quality, skill level of home modification providers, and expected outcomes to assist consumers in making informed decisions about home safety." The National Floor Safety Institute was a participant at the 2015 Whitehouse Conference on Aging, which established the plan whereby our proposed mandatory labeling requirement, is in direct support of the NFPA goals and strategies.

3. Contain an explicit request to initiate Commission rulemaking and set forth a brief description of the substance of the proposed rule thereof, which it is claimed should be issued by the Commission. (A general request for regulatory action which does not reasonably specify the type of action requested shall not be sufficient.)

We ask the Commission to mandate the use of the ANSI/NFSI B101.5-2014 labeling standard which would require the identification via a easy to understand product label (below) of the flooring materials Traction as tested per the ANSI/NFSI B101.3-2012 standard (attached). The label would provide a graphic of a gas gauge like traction scale with an arrow pointing to the products level of traction (modified DCOF). When measured per the ANSI/NFSI B101.3-2012 standard the DCOF is that of a fractional value and not a whole number which may be confusing to the consumer and the scale represents as a whole number. In an effort to reduce confusion, the ANSI/NFSI B101.5-2014 standard has been developed to present the products level of traction in whole numbers on a scale of 0-10. This label has been thoroughly examined and is by way of an independent third-party study (attached) and is in compliance with the ANSI Z535.3 standard for product safety labeling criteria.

The labels purpose is to provide easy to understand information as it relates to product slip risk potential so consumers can make a more informed choice when selecting floors and or floor coatings.



Furthermore, this petition is in compliance with the second and fourth goals of the CPSC 2016-2020 Strategic plan which calls for preventing hazardous products from reaching consumers and strategic Objectives

- 2.1 - Improve identification and assessment of hazards to consumers
- 2.1.2 - Improve quality and specificity of hazard information
- 2.1.3 - Improve agency capacity to identify and assess chronic hazards
- 2.3 - Increase capability to identify and stop imported hazardous consumer products
- 4.2.2 - Expand communications with targeted audiences

This petition calls for the mandated use of two American National Standards Institute (ANSI) voluntary consensus standards ANSI/NFSI B101-3-2012 and ANSI/NFSI B101.5-2014 which we are requesting the commission mandate their use. Section 7.b.1 of the Consumer Product Safety Act which states that: *"The Commission shall rely upon voluntary consumer product safety standards rather than promulgate a consumer product safety standard prescribing requirements described in subsection (a) whenever compliance with such voluntary standards would eliminate or adequately reduce the risk of injury addressed and it is likely that there will be substantial compliance with such voluntary standards."*.

4. To address the issue of whether a regulation is necessary, a request, at a minimum, must provide information that could support a claim that the regulation is needed to reduce or eliminate a risk of injury. Although you provide information indicating that injuries result from slipping on flooring materials, you do not put forth any information showing a connection between the point-of-sale labeling requirement that you advocate and a reduction in slip, trip, and fall injuries. Indeed, rather than claiming that slip-resistance labeling would reduce or eliminate the risk of injury, your request states only that mandating a floor slip-

resistance labeling requirement "will serve as the first tangible step in advancing an elder fall prevention strategy and national agenda.

The NFSI B101 committee intentionally created the ANSI/NFSI B101.5 standard for the intended purpose of informing the public as to the slip risk associated with flooring materials and coatings whereby they could then make a more informed buying decision. We believe that if the consumer is informed as to the traction of a specific product that they would avoid selecting high risk (low-traction) products which would reduce the corresponding slip risk. Research contained below has demonstrated a direct link between traction levels and the risk of a slip and fall event. Unfortunately, today's consumer is provided no information relating to the safety of flooring products which we contend is an underlying cause of many slip and fall injuries.

The proposed request is similar to that of the governments mandatory labeling of food products whereby important nutritional information is provided in a uniformly standardized label, which the consumer can use to make informed food-purchasing decisions. Certain food contents, like that of a particular low traction floor can be detrimental to public health whereby the use of a mandatory product label can assist the consumer in making a more informed decision. Those at risk, specifically the elderly, will then have the benefit of selecting flooring which offer higher slip resistance and in-turn reduce the risk of an accidental slip and fall event. Furthermore, flooring manufacturers along with their retail and distribution base can assist in providing point of purchase information explaining the purpose of the label and encourage consumers to use the label as a part of the overall buying decision.

The economic impact to the manufacturing industry will be minimal since most flooring manufacturers already test the coefficient of friction of their products as a part of their quality control process but do not do such via a uniform test method. Not all slip resistance test methods are the same nor do all slip resistance test devices produce identical results. It is for this reason that we stress the adoption of a single, uniform test method that being the ANSI/NFSI B101.3-2012 standard which applies to all types of hard surface flooring materials and coatings and limits the use of test instruments (tribometers) to those which have undergone an independent scientific Interlaboratory Laboratory Study (ILS) as required per the ANSI/NFSI B101.3-2012 standard.

Today's floor covering consumer has little to no information as it relates to the slip resistance and therefore the slip related risk of the flooring materials they select for use in their homes and businesses. Consumers assume that all floor coverings are safe only to realize after a serious and debilitating fall that the flooring material they selected was more slippery then they thought. Most slips and falls are preventable and if the consumer is aware of the slip risk associated with various types of flooring materials they will be empowered to make more informed choices. Mandating the use of a uniform product label is the first step in reducing the growing epidemic of falls particularly to our most vulnerable citizens, the elderly. In the interest of public safety, we therefore urge the CPSC to require manufacturers of commercial and residential floor coverings and coatings to test their products per the ANSI/NFSI B101.3-2012 standard and label their products per the wet DCOF label as defined in the ANSI/NFSI B101.5-2014 standard.

Revisions From Our 2015 Petition

While most of those who expressed support of our 2015 petition via the public commenting period were directly and materially affected by the consequences of same level slips and falls such as medical, safety, and consumer groups, the majority in opposition were concentrated in a single industry that being flooring manufacturers, flooring suppliers and their related trade association members.

In response to public comments stating possible confusion which may stem from the two various COF test methods (ie: SCOF and DCOF) identified in the ANSI/NFSI B1201.5 standard we are now only requesting compliance with the ANSI/NFSI B101.3 wet DCOF standard and its associated label as described in the ANSI/NFSI B101.5 standard. The ANSI/NFSI B101.3 wet DCOF standard applies to all types of hard-surface floors and coatings and therefore would be the most suitable test method for determining pedestrian safety. Furthermore, the ceramic tile industry employs the use of a wet DCOF quality control test method for uninstalled production material and therefore have the capability to comply with our petition immediately.

Based on their review of our 2015 petition, the Commission concluded that: “the agency lacks sufficient information to demonstrate that the proposed action to mandate a floor covering label would assist consumers in assessing the comparative safety of floor covering products, or lead to a reduced number of slip and fall incidents” and denied the petition.

On May 25, 2017 representatives from the NFSI met with CPSC staff to better understand their objections. These objections centered around three primary concerns as voiced in their January 19, 2017 response. In was stated that in order to issue a final rule under Section 27(e) of the CPSA that the Commission would need to demonstrate that the information proposed to be provided to consumers affords “performance or technical data” and that the information is “related to performance and safety as may be required to carry out the purposes of this Act.”

As it relates to “Performance and Safety” CPSC staff concluded that:

1. That there is a perceived lack of consistency and accuracy among various COF test methods and test instruments (tribometers).

2. That there was inconclusive research in support of our petition, specifically research that would correlate flooring COF data and its impact on slip and fall injuries.

3. That the proposed product label would provide limited effectiveness.

Concern #1. Lack of Consistency and accuracy among various test methods and lack of consistency of test instruments

Although the general contention by CPSC staff is true, that not all walkway slip resistance test instruments (tribometers) produce accurate and reproducible data, such variations in both the testing methodology and associated tribometers have been adequately addressed. Our proposal specifies a single and scientifically accurate test method that being the ANSI/NFSI B101.3-2012. A nearly identical test method has been in use in Europe for over three decades and has proven to be a reliable, accurate, and reproducible. In fact, the ceramic tile industries ANSI A137.1-2017 standard employs a similar wet DCOF test method. To eliminate CPSC staffs concern, our petition restricts the testing methodology to the ANSI/NFSI B101.3-2012 method which mandates a select category of tribometers as to reduce lack of consistency between the various devices.

Although the general contention by CPSC staff that not all walkway slip resistance test instruments (tribometers) produce accurate and reproducible data is true, such variations in tribometers has been adequately addressed. NFSI Approved tribometers are those which have undergone a comprehensive, scientifically designed and engineered Inter-Laboratory Study (ILS) (enclosed) when successfully completed by a tribometer manufacturer demonstrates both a high degree of accuracy and reproducibility.

Furthermore, in 2003, CPSC staff conducted a comprehensive independent evaluation on the then NFSI's Universal Walkway Tester (UWT-3000) tribometer (enclosed) which they confirmed demonstrated a high level of accuracy and reproducibility as it relates to the measurement of walkway slip resistance. The UWT-3000 was the first NFSI Approved device which was widely distributed and renamed as the BOT-3000 and is now known as the TracScan.

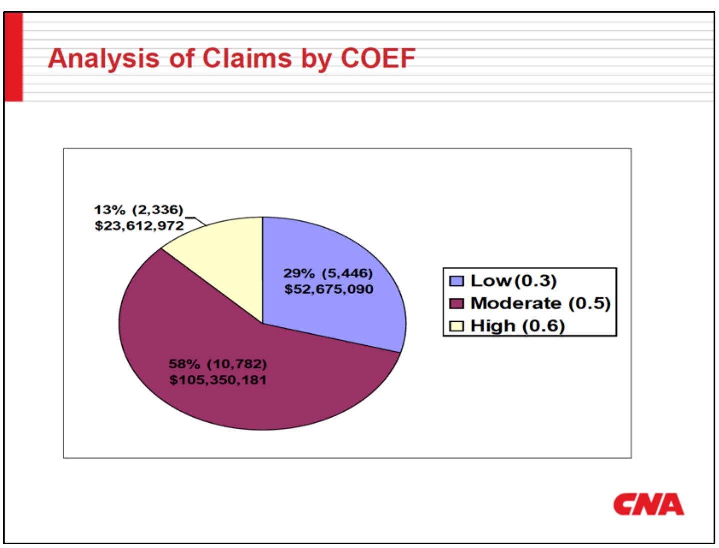
Our proposal specifies a single and scientifically accurate test method that being the ANSI/NFSI B101.3-2012 test method. This test method is based on a test method that has been in use in Europe for over three decades and is both reliable, accurate, and reproducible. To eliminate CPSC staffs concern, our petition restricts the testing methodology to the ANSI/NFSI B101.3-2012 test method which mandates the use of NFSI Approved tribometers discussed above.

Concern #2. Insufficient evidence to support the assertion that a high COF value leads to a decreased hazard of slips and falls.

In response to CPSC's staffs concern that there is a lack of scientific evidence linking COF to injury claims, the NFSI commissioned a comprehensive research report (enclosed) produced by one of the world's leading researchers, Dr. Wen-Ruey Chang P.E. of Chang WR Falls Prevention LLC. Dr. Chang's report definitively conjoins the measurement of wet DCOF to that of injury claims and concludes that higher traction surfaces significantly reduce the risk of same level slips and falls than that of low traction surfaces.

Additionally in 2007, the CNA Insurance company published a study entitled "Slips and Falls Study: Objective Auditing Techniques to Control Slips and Falls in Restaurants" (enclosed) which they correlated the relationship between a floors COF and the associated rate of slip and fall injury claims. One of the conclusions recommended that consumers "Know what the "out-of-the-box" slip resistance is on the floor materials in your facility." In 2015, CNA released a second study entitled "Measuring the Risk of Slips and Falls: An Injury Reduction Study Using Tribometry" (enclosed). The study sought to correlate the wet COF of walkways to that of same-store claims data and revealed a direct correlation between wet COF and slip and fall claims.

The study concluded that floors whose wet COF was ranked in the "High-Traction" range represented only 13% of injury claims while floors whose wet COF were either Moderate to Low-Traction represented 87% of slip and fall related injury claims.



The evidence is clear. The wet coefficient of friction of floor surfaces can be relied upon as an excellent predictive model for identifying and preventing slip and fall events and related injuries. Furthermore, the study revealed that low traction floors present a higher rate of slip and fall injuries than that of higher traction floors.

2017 CNA Insurance Company Study Revealed That 50% of Floors Fall below the Minimum Safety Threshold

A two-year CNA Insurance company study (enclosed) revealed that 50% of the surveyed sites failed to produce a Dynamic Coefficient of Friction (DCOF) level above the American National Standards Institute (ANSI) minimum threshold for safety. The study indicates that most business owners either do not know what the traction level is of the products they purchase or simply overlook the effects of flooring selection and ongoing maintenance as it relates to safety. The study also associated a high-frequency trend of Traumatic Brain Injuries (TBI) with that of slip and fall claims.

The CNA data revealed that slip and fall claims overtime occur with more frequency than severity and continue to pose challenges for businesses. The same could also be true for residential users. These findings underscore the need for attention to floor safety and regular surface resistance testing to avoid fall accidents and related injuries. According to CNA's frequency data, retail trade and real estate businesses present the greatest potential for slip and fall accidents, with 40% of harmful events occurring on walking/working surfaces, mainly entryway floors. The study found that paid loss for a GL non-TBI claim is $30,150 and a TBI claim is $269,643. Paid loss for a WC non-TBI claim is S26,158 and a TBI claim is $259,158.

CNA identified four principles of floor safety which their number one recommendation was to: "Choose flooring that is slip resistant; consider its properties and the space and environment. The key here is material selection. Do you know how your specifiers selecting and qualifying flooring material? This is the "Design" phase."

Sadly, both commercial and residential flooring consumers have no clear way to accurately identify the slip resistance of the floors they purchase which in-turn they frequently and mistakenly select lower traction materials.

In support of the CNA study and Dr. Chang's report, we are also including as an addendum to this petition, thirty-one (31) additional references to international scientific research which validates the use of wet DCOF testing as defined within the ANSI/NFSI B101.3-2012 standard as a means of accurately measuring, predicting and preventing pedestrian slip and fall events.

Concern #3. Limited effectiveness of the proposed label

In response to CPSC staffs concern as it relates to the effectiveness of the product label we are enclosing a copy of the 2008 independent research performed by Applied Safety and Ergonomics, Inc. The study was commissioned as a part of the development of the ANSI/NFSI B101.5-2014 standard and was ultimately used as a guide in developing the final label design. The study concluded that 88% of the individuals who participated in the research study were able to correctly report the meaning of the symbol (label) and that based on the studies recommended language which was incorporated in the final publication of the ANSI/NFSI B101.5-2014 standard that the traction label is in compliance with the ANSI Z535.3 "Criteria for Safety Symbols" standard. In short, the label as defined in the ANSI/NFSI B101.5-2014standard would serve as a highly effective means of product labeling.

Independent Third-Party Testing

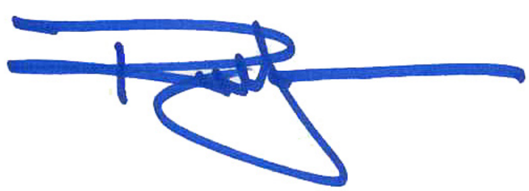
In 2018 Underwriter Laboratories (UL) joined the NFSI Board of Directors and will soon be testing flooring materials per the ANSI/NFSI B101.3 standard. Flooring manufacturers will now have a third testing option and can comply with the proposed mandatory testing requirement by: (a.) testing their products in their own laboratory per the ANSI/NFSI B101.3 standard, (b.) submit their products to the NFSI for testing or (c.) submit their products to UL for testing. Since many floor coverings and coatings manufactures already use UL as their testing organization it is likely that they will continue to do so once required to comply with our petition.

Conclusion

Same-level slips and falls has risen to crisis level which demands immediate action. The growing problem associated with same-level slips and falls is serious, real and expected to get worse as our population ages. Technology exists and is widely used that can accurately measure the wet DCOF of walkways both in the laboratory as well as in-situ. Research has proven that the higher the COF the lower the risk of slipping. Since 2009 a series of nationally adopted voluntary standards consensus standards have been published via the ANSI consensus process and have proven to provide reliable and valuable information as it relates to (a.) DCOF testing methodology, (b,) accurate and reproducible tribometry, and (c.) correlation of COF test results with that of anticipated slip and fall incidents. Sadly, the manufacturers of floor coverings and coatings have consciously chosen not to adopt these standards which in-turn is jeopardizing the public's safety.

Since our 2015 petition not a single flooring manufacturer tests or labels their products per the ANSI/NFSI B101.3 walkway safety standard or the B101.5 product labeling standard. The floor covering industry continues to ignore the safety and well-being of the American public and in-turn is intentionally exposing our nations at-risk population to the unnecessary risk of a slip and fall event and related injuries. We therefore urge the CPSC to take immediate action to approve this petition as a means of protecting consumers from the unnecessary risk of a slip and fall.

Sincerely,



Russell J. Kendzior
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cc: Ms. Patricia M. Pollitzer
Assistant General Counsel
U.S. Consumer Product Safety Commission
4330 East West Highway
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Referenced Attachments

1. ANSI/NFSI B101.5-2014 “Standard Guide for Uniform Labeling Method for Identifying the Wet Static and Wet Dynamic Coefficient of Friction (Traction) of Floor Coverings, Floor Coverings with Coatings, and Treated Floor Coverings.”
2. ANSI/NFSI B101.3-2012 “Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values).”
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8. CNA Insurance Company study: “Measuring the Risk of Slips and Falls: An Injury Reduction Study Using Tribometry” (2015)
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Attachment #1

American National Standard

B101.5 Standard Guide for Uniform Labeling Method for Identifying the Wet Static and Wet Dynamic Coefficient of Friction (Traction) of Floor Coverings, Floor Coverings with Coatings, and Treated Floor Coverings

(Product Information Marking)

Secretariat

NFSI
NATIONAL FLOOR SAFETY INSTITUTE

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Approved January 29, 2014
by
American National Standards Institute, Inc.

American National Standard

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Published January, 2014 by

National Floor Safety Institute
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Southlake, Texas 76092
(817) 749-1700 www.nfsi.org

Printed in the United States of America

Foreword

(This Foreword is not part of the proposed ANSI/NFSI B101.5-2014 Standard)

This standard was developed by a subcommittee of the National Floor Safety Institute (NFSI) B101 Main Standards Committee, national in scope, functioning under the procedures of the American National Standards Institute with the NFSI as the ANSI Accredited Standards Developer. The NFSI was founded in 1997 with the mission: "To aid in the prevention of slips, trips and falls through education, research and standards development." The development of the ANSI/NFSI B101.5-2014 Standard is a direct result of the mission of the NFSI answering a need for consumer education to ameliorate the effects of falls.

As a standards developing organization, NFSI sought and was accredited by the Executive Council of ANSI on June 6, 2006 to develop standards addressing the prevention of slips, trips and falls. The American National Standard/NFSI B101.5-2014: *Standard Guide for Uniform Labeling Method for Identifying the Wet Static and Wet Dynamic Coefficient of Friction (Traction) of Floor Coverings, Floor Coverings with Coatings, and Treated Floor Coverings* answers the perceived need for this standard, through an educational approach, to stem the growing number of slips and falls as they relate to insufficient walkway surface traction by defining three separate ranges of traction. Given that the consumer of floor coverings is rarely provided information relevant to the slip resistance characteristics of the floor coverings they purchase, and are unable to comprehend technical information relevant to the measurement of coefficient of friction (COF) the need for an easy-to-understand, consumer driven label using a tested symbol graphic to do so has been brought forth.

The B101 Standards series are targeted at slip, trip and fall prevention which, in this context, set standards for maintaining a safe wet coefficient of friction on various walking surfaces members of the public may encounter. The B101.5 Standard is a part of that development project and exists to provide a consumer friendly symbol graphic to be displayed on these products so purchasers of flooring and floor maintenance products are educated and informed of the inherent slip resistance of that particular product. By referring to this graphic the consumer can make an educated buying decision on flooring and floor maintenance products by being easily able to compare the relative slip resistance properties of competing products. By affixing the graphic this standard establishes a product labeling method which specifies three levels of traction derived from the ANSI/NFSI B101.1-2009 *Test Method for Measuring Wet SCOF of Common Hard-Surface Floor Materials standard. and/or three levels of traction derived from the ANSI/NFSI B101.3-2012 Test Method For Measuring Wet DCOF of Common Hard Surface Floor Materials.*

The symbol graphic presented in the standard was developed from a field of several collected by the accredited standards developer. From this collection the B101.5 Subcommittee selected three (3) symbol graphics for purposes of referent testing. In turn a nationally recognized independent ergonomic and safety signage research firm tested these referents using the protocols and meeting the guidelines of the ANSI Z535.3 Criteria for Safety Symbols. Based upon the results of testing a diverse and most likely affected consumer population the gauge symbol is the validated norm for this informational standard.

This standards use of color is, in part, based on those developed by the ANSI Z535.1-2006 Safety Colors Standard, which focused on improving labeling safety through uniformity in safety color coding. Like the ANSI Z535.1 standard, the safety color codes used in this standard were selected to provide the best feasible discrimination for observers with either normal or color-deficient (colorblind) vision.

Neither the B101 Main Standards Committee, nor the accredited standards developer, perceive that this standard is perfect or in its ultimate form. It is recognized that new developments in communications are to be expected, and that revisions of the standard may be necessary as the combination of science and art progresses and further experience is gained. The committee does believe, however, that the standard in its present form provides a comprehensive a guide when selecting flooring materials and floor maintenance products. To this end it is intended that the requirements contained herein will be adopted by the affected general public, contractors, property owners, and relevant professionals as they seek to make a more informed decision in selecting appropriate floor materials.

NOTICE AND DISCLAIMER

The use of American National Standards is voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will not provide a interpretation of any American National Standard. Requests for interpretations or suggestions for improvement of this standard should be directed to the National Floor Safety Institute (NFSI).

This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

The information in this publication was considered technically sound by the consensus of persons engaged in the development and approval of the document at the time it was developed. Consensus does not necessarily mean that there is unanimous agreement among every person participating in the development of this document.

NFSI standards and guideline publications, of which the document contained herein is one, are submitted and developed through the ANSI voluntary consensus standards development process. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While the NFSI administers the process it does not write the document and it does not independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in these standards and guideline publications.

NFSI disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. NFSI disclaims and makes no guaranty or warranty, express or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any of your particular purposes or needs. NFSI does not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this standard or guide.

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

Chairman	Howard W. Harris, M.D.
Secretary	Russell J. Kendzior
Assistant Secretary	Jim E. Lapping, MS, PE, CSP

Organization Represented	**Representative**
Accident Prevention Services	Craig Schilder
American Slip Meter	Craig Stephenson
CED Investigative Technologies	Douglas M. Hrobak
Cintas Corporation	Richard Bing
Concrete Polishing Association of America	Roy Bowman
Crossville, Inc.	Noah Chitty
Engineering Systems, Inc. (ESI)	Zdenek Hejzlar
GT Grandstands, Inc.	Brian Wilson
Impact General, Inc.	Bill King (P)
	Dr. Fred Johnson (Alt)
Institute of Inspection, Cleaning and	Claudia Lezell (P)
Restoration Certification (IICRC)	Lindell L. Lummer (Alt)
ISSA-The Worldwide Cleaning Industry Association	Daniel Wagner
Jessup Manufacturing	Al Carlson
Maximum Floor Safety	Chad Frenette
Mike Payne & Associates, Inc.	Mike Payne
Moore Engineering Services, LLC	Scott D. Moore PE
Mountville Mills, Inc.	David Watterson
National Floor Safety Institute	Russell J. Kendzior
Nu-Safe Floors	Ken Fisher
Professional Safety Consultants	Jim E. Lapping, PE, CSP
Regan Scientific Instruments, Inc.	Peter Ermish (P)
	Larry Gallant (Alt)
Safety Systems America	Tom Baird
SlipDoctors	Greg Cohen
State Farm Insurance	Steve Spencer
StonePeak Ceramics	Rodolfo Panisi
Stripe-A-Zone	David Sargent
Traction Auditing, LLC	Howard Walker Harris, MD (P)
	Brent Johnson (Alt)

Subcommittee B101.5 on Uniform Labeling Method, which developed this standard, had the following members:

J. Terrence Grisim, Chairman
Thomas F. Bresnahan, Secretary

Organization Represented:	**Name of Representative:**
Accuform Signs	Elroy Lundblad
Bresnahan Consulting Associates	Thomas F. Bresnahan, CSP
Everglow NA, Inc.	Charles V. Barlow
Marble Institute of America	Charles Muehlbauer
Product Safety Solutions	Dan Levine
Safety Management Consultants, Inc.	J. Terrence Grisim, CSP, CDS, CPSM, ARM

Table of Contents

B101.5 Standard Guide for Uniform Labeling Method for Identifying the Wet Static and Wet Dynamic Coefficient of Friction (Traction) of Floor Coverings, Floor Coverings with Coatings, and Treated Floor Coverings

Section 1 Scope/Application/Purpose

1.1 Scope: This guideline sets forth a uniform product labeling method which identifies the wet static and wet dynamic coefficient of friction (traction) of floor coverings, floor coverings with coatings, and treated floor coverings.

1.2 Application: This standard applies to floor products used primarily on public and private areas where pedestrians are not supervisory controlled. The term "floor products" refers to floor coverings, coatings, and treatments intended for floor coverings except carpeting, rugs, mats, runners, and artificial turf.

1.3 Purpose: The purpose of this standard is to offer, at the point of product sale, guidance to users/purchasers on the traction capabilities of the contents of the package through display of labels and markings.

Section 2 Reference to Standards and Other Documents

2.1 ANSI/NFSI B101.1-2009 Test Method for Measuring Wet SCOF of Common Hard-Surface Floor Materials

2.2 ANSI/NFSI B101.3-2012 Test Method For Measuring Wet DCOF of Common Hard Surface Floor Materials

2.3 ANSI Z535 Signs and Colors Standards Series[1]

Section 3 Definitions

3.1 label (informational) - any printed or stenciled information affixed or otherwise applied to a container or package to inform the user/purchaser of the degree of traction provided.

3.2 package / packaging / container

3.2.1 package (consumer) - a primary and / or secondary container designed to contain, store, and protect from the point of manufacture to the point of use (a product intended for household or individual use

3.2.2 packaging - wrapping or bundling a single item or bundling a set or quantity of the same item into a single unit.

[1] See ANSI Z535 2006 Color Chart, NEMA Rosslyn, VA 22209 for more information regarding Pantone Matching System.

3.2.3 container - a portable receptacle designed to provide material or item integrity for storage, distribution, retailing and use.

3.3 symbol - a graphic representation intended to convey a message without the use of words.

3.4 traction - the friction between a body and the surface on which it moves, i.e., between footwear and flooring.

3**.5 cleaner** - a solvent used to remove foreign matter, soil, or other treatments from a surface.

3.6 coatings - a layer of any substance, liquid, or semi liquid applied to a surface that dries or cures to form a solid protective finish to enhance its functional or decorative characteristics.

3.7 floor covering - an essentially planar material, combination of resilient materials or combination of resilient material and rigid materials used to provide a finished walking surface on a floor to enhance the beauty, comfort, and utility of the floor.

3.8 treatments - any method, technique, or process designed to change the physical character of a floor surface to render it less hazardous and safer for pedestrian ambulation.

3.9 floor (in a building) -surface, usually horizontal on which persons typically walk or run.

Section 4 General Requirements of Label/Marking

4.1 Location on Package

4.1.1 The symbol and markings shall be placed in the principal panel of the package or container within the normal field of view.

4.2 Symbol/Marking Specifications

4.2.1 Black symbol and shades of black and markings on white or other background in a rectangle shape shall be formatted in the principal panel.

4.2.2 Color within the symbol (see Figure 1 A to C) shall be permitted to enhance the message

4.3 Symbol size

4.3.1 The symbol shall be legible at the intended viewing distance.

4.3.2 The print font within the symbol shall be Ariel and no less than 8 point size.

4.4 Graphic presentation of the symbol and marking

4.4.1 Figures 1 A to C shall be used in the principal panel of the product package or container based upon the test values derived from the requirements established by the ANSI/NFSI B101.1-2009 Standard.

4.4.2 Figures 2A to 2C shall be used in the principal panel of the product package or container based upon the test values derived from the requirements established by the ANSI/NFSI B101.3-2012 Standard.

4.4.3 The indicating arrow within the symbol shall point to the numerical value of traction provided by the product across the scale from lowest value of one (1) to highest value of ten (10).

4.4.4 If color is used, the safety color code in Figures 1 A to C shall use the Pantone Numbers as follows:

Pantone No.	Color	SCOF Gauge No.	DCOF Gauge No.
485 C	Red	1 thru 4 (low traction)	1 thru 3 (low traction)
109 C	Yellow	5 thru 6 (moderate traction)	4 thru 5.2 (moderate traction)
3415 C	Green	7 thru 10 (high traction)	5.3 thru 10 (high traction)

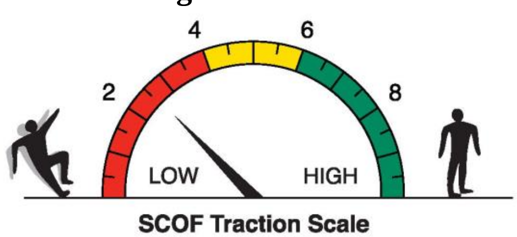
NOTE: The above parenthetical reference of traction and its corresponding gauge Segment numbers are derived from Section 5: Calculations Data Interpretations/Table 1 in, respectively, the ANSI/NFSI B101.1-2009 and ANSI/NFSI B101.3-2012 standards. These Tables also provide remediation guidance for the type of floor surfaces corresponding to these levels or degrees of traction.

4.4.5 While SCOFs and DCOFs are cited as decimal values, the symbol graphic uses whole numbers ranging from 1 to 10. Because decimal values would be meaningless or confusing to the public, manufacturers should multiply their product (s) COF test result values by 10.

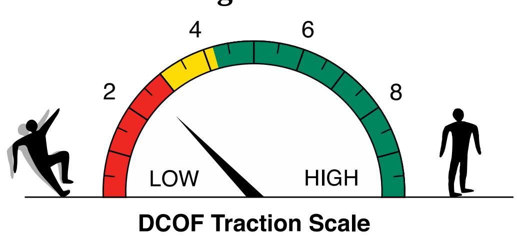
NOTE: To accommodate and make more precise the decimal values, each Traction Scale segment is divided in half by a mid-point marker (1/8") allowing the indicating arrow to point to the exact value of the decimal reading which may be either below or above the marker.

4.5 Exemplars of Figures 1 and 2

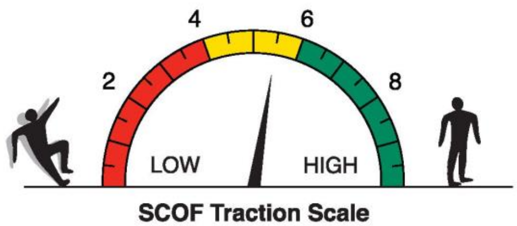
4.5.1 Figure 1 A



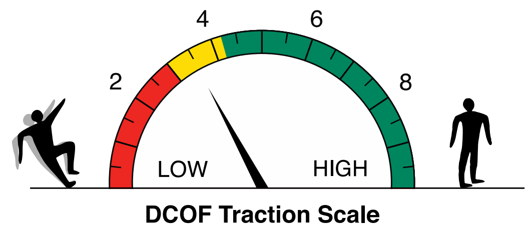
4.5.4 Figure 2 A



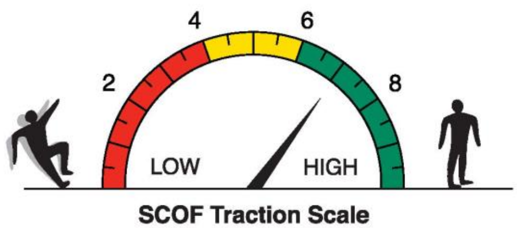
4.5.2 Figure 1 B



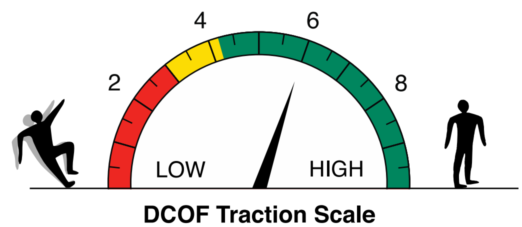
4.5.5 Figure 2 B



4.5.3 Figure 1 C



4.5.6 Figure 2 C



Section 5 Package/Container Marking

5.1 The package/container holding flooring materials or products shall bear on the principal display panel the symbol marking as described in 4.2, 4.3, 4.4, and 4.5. In addition, and if warranted the message may contain the following phrase (or equivalent): “Read and follow all safety information and instructions.”

5.2 So that purchasers can identify floor materials and products conforming to all of the requirements of this guide, producers, importers, and distributors may include a statement of compliance in conjunction with their name and address on product labels, invoices and sales literature. For example, “This product meets all the requirements of the ANSI/NFSI B101.5-2014 Standard (name and address of producer, importer, or distributor)”.

Attachment #3

ANSI/NFSI B101.3-2012

American National Standard

B101.3 Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials

(Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values)

Secretariat

NATIONAL FLOOR SAFETY INSTITUTE

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Approved January 18, 2012
by
American National Standards Institute, Inc.

American National Standard

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Published January, 2012 by

National Floor Safety Institute
P.O. Box 92607
Southlake, Texas 76092
(817) 749-1700 www.nfsi.org

Printed in the United States of America

Suggestions for improvement of this standard should be sent to the Accredited Standards Developer: National Floor Safety Institute, P.O. Box 92607, Southlake, TX 76092.
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:

Chairman	Howard Harris, M.D.
Secretary	Russell J. Kendzior
Assistant Secretary	Jim E. Lapping, MS, PE, CSP

Organization Represented	**Representative**
Accident Prevention Services	Craig Schilder CSP, PE (Liaison)
American Slip Meter	Craig Stephenson
Centers for Disease Control (CDC)	Ileana Arias, Ph.D. (Liaison)
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Nu-Safe Floors	Ken Fisher
Procter & Gamble	William Campbell
Professional Safety Consultants	Jim E. Lapping, PE, CSP
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SGS-U.S. Testing Company, Inc.	Scott Parkhurst
State Farm Insurance Company	Steven C. Spencer
Stone Peak Ceramics	Noah Chitty
Traction Auditing, L.L.C.	Howard Harris, M.D. (P) Brent Johnson (Alt.)

At the time it approved this standard procedure, the B101.3 subcommittee had the following members:

Chairman	Peter Ermish
Organization Represented	**Representative**
Batterman Engineering	Scott D. Batterman, Ph.D., P.E.
Nu-Safe Floors	Ken Fisher
Regan Scientific Instruments, Inc.	Peter Ermish (P)
	Larry Gallant (Alt.)
Tile Council of North America (TCNA)	Eric Astrachan (P)
	Katelyn Simpson (Alt.)

Table of Contents

Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials
(Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values)

Section 1: Scope/Purpose/Application/Exception

1.1 Scope

This test method specifies the procedures and devices used for both laboratory and field testing to measure the wet dynamic coefficient of friction (DCOF) of common hard-surface floor materials.

1.2 Purpose

This test method provides a measurement procedure setting forth DCOF ranges which facilitate remediation of walkway surfaces when warranted.

1.3 Application

This test method does not apply to carpeting of any type, however does address the common hard-surfaced flooring materials such as: ceramic and porcelain tile, polished concrete, stone, vinyl floor coverings, wood and synthetic laminates, and such materials with coatings or polishes 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 slip resistance.

1.4 Exceptions

This test method is not recommended for dry surface testing and does not propose to be an accurate measurement method for determining dry surface slip resistance. Dry surface test data should not be compared to wet surface data. No inferences should be implied or concluded regarding dry vs. wet DCOF test results or data.

Section 2: Reference to other Standards and Publications

The specification for the SBR sensor material called for in this standard is covered by the following DIN Standards: 53273, 53479, 53504, 53505, 53507-B, 53516. See attachment "A" for the related values.

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

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 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 Dynamic Friction - the resistance opposing the force required to perpetuate the movement of one surface on or over another.

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 such as wood that may exhibit directional bias as it relates to slip resistance.

3.7 Incline – A walkway with a maximum slope no greater than 1:12 (4.76 degrees)

3.8 Slip Resistance - the property of a floor or walkway surface that acts in sufficient opposition to those forces and movements exerted by a pedestrian under all normal conditions of human ambulation.

3.9 SBR - Styrene Butadiene Rubber

3.10 Surfactant Solution – A solution employed to reduce the water surface tension when testing on wet hard-surfaced floor materials.

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 or unfilled.

3.13 Traction - the friction between the sole material of a shoe and the fixed surface it moves upon.

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

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

3.14.1.1 The tribometer shall demonstrate reliability and reproducibility in measuring the Dynamic Coefficient of Friction per the NFSI: Inter-Laboratory Study (ILS) for

Tribometers Designed to Measure the Wet Dynamic Coefficient of Friction (DCOF) of Common Hard Surfaced Walkways

3.14.1.2 The tribometer manufacturer shall be capable of providing calibration, repair, and maintenance, and a reference tile 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.

Section 4: Test Procedure

This test procedure shall be conducted using an approved tribometer designed to measure the wet dynamic coefficient of friction (DCOF) of a floor or walkway surface under anticipated use. Materials that are excluded from this test method include: sand or gravel beds, pebbles, rough asphalt, any cloth or textile materials, or any surface that would inhibit the normal operation of the testing device.

4.1 Testing Device

This test method shall be carried out using a tribometer device that is fitted with SBR contact material that complies with the standard set forth herein. The tribometer manufacturer's operating and calibration directives shall be followed.

4.2 Measuring the Reference Check Tile

Follow the tribometer manufacturer's procedures for measuring the reference check tile(s). Report the results and verify that the values measured fall within + or - 5% of the reference check tile value(s).

4.3 Measuring the Wet DCOF of Uninstalled Flooring Material (Lab Procedure)

4.3.1 Randomly select three samples of the tiles or test areas under evaluation. Submitted samples shall be sized and formatted to enable laboratory testing of the DCOF.

4.3.2 Clean the test surface with a mild detergent and distilled water. Wipe dry with an untreated paper towel. Avoid contamination of test surfaces by fingerprints, chemicals dust, etc. Do not use "low lint", or "lint free" paper towels, as they may contain chemicals that can affect the DCOF test results.

4.3.3 Wet the test surface with a surfactant solution of 0.1 ± 0.005 percent sodium lauryl sulfate in distilled water. Follow the tribometer manufacturer operating instructions for performing wet DCOF testing.

NOTE: The test surface of the SBR material shall be maintained as to prevent buildup of contaminants which may affect the DCOF test results. Follow the tribometer manufacturer's instructions for conditioning the SBR material.

4.3.4 Place the measuring device on the test surface and conduct five (5) tests in one direction. Record all five DCOF readings.

4.3.5 Rotate the measuring device clockwise by 180 degrees, place it on the tiles and conduct five (5) tests in the second direction. Record all five DCOF readings.

4.3.6 Rotate the test surface clockwise by 90 degrees, place the measuring device on the tiles and conduct five (5) tests in the third direction. Record all five DCOF readings.

4.3.7 Rotate the measuring device clockwise by 180 degrees and conduct five (5) tests in the fourth direction. Record all five DCOF readings.

NOTE: Additional surfactant solution may be applied to the test surface as needed.

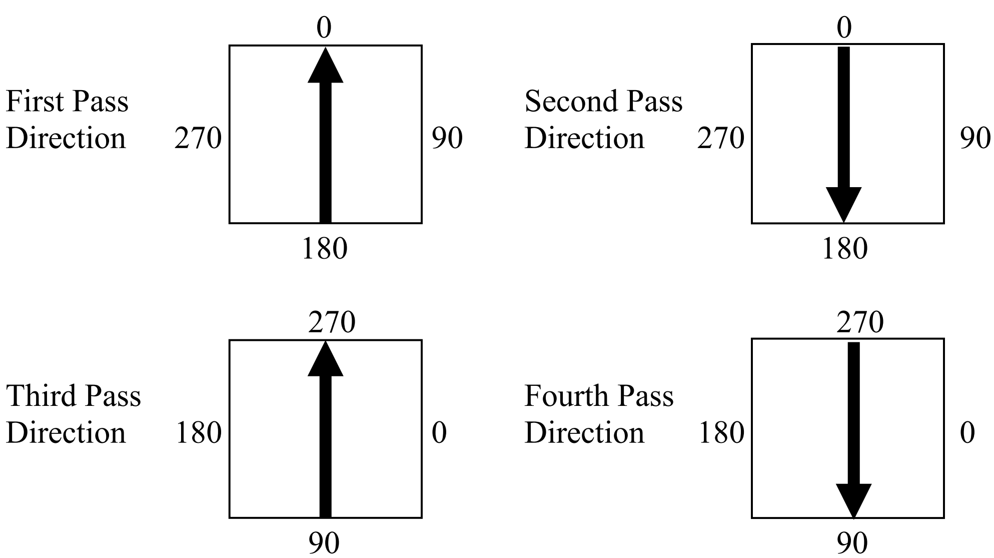
4.3.8 Repeat items 4.2.2 through 4.2.7 on three (3) separate tiles or test areas.

4.3.9 Calculate and record the average and sample standard deviation for all 60 readings taken from the three sample tiles or test areas (see computational instructions in appendix C.).

4.3.10 Divide the sample standard deviation by the average and record the coefficient of variation (COV) (see computational instructions in appendix C).

4.3.11 Evaluate the data set:

- If the COV is less than 0.10 (< 0.10), then evaluate the walkway's DCOF per the instructions set forth in section 5.0 of this standard.
- If the COV is greater than 0.10 (> 0.10), then reject the data set and re-test or correct the testing procedure and/or tribometer as required.



4.4 Measuring the Wet DCOF of Installed Flooring Material (In-Situ Procedure)

4.4.1 Select the Test Area - The floor/walkway surface area to be tested must be spacious enough to fully accommodate the normal operation of the testing device without restriction. Effort should be made to test each sample area using a minimum of two directions, 90 degrees apart; often referred to as an “X-Y” pattern. One of the tests should be performed in the direction of normal pedestrian traffic if possible. If a situation exists where both X-Y test directions prove impossible to perform, (such as a stairway step) the final test report should indicate the restricted test area. In no instance should a testing device be modified or manually “helped” to compensate for a difficult situation. This may include, but not be limited to; pushing, pulling, lifting, tilting, or other such manipulation methods. When testing on tiled floors, every attempt should be made to avoid testing directly on tile joints wherever possible.

4.4.2 Prepare the Contact Material - The test surface of the SBR material shall be maintained as to prevent buildup of contaminants which may affect the DCOF test results. Follow the tribometer manufacturer’s instructions for conditioning the SBR material.

4.4.3 Create a wet test path using a surfactant solution of 0.1 ± 0.005 percent sodium lauryl sulfate in distilled water of sufficient length and width in accordance with the test device instructions for wet DCOF testing.

4.4.4 First Directional Test

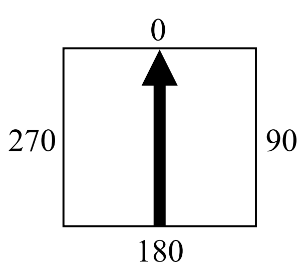
4.4.4.1 Place the measuring device on the surface and conduct three (3) tests in one direction. Record the resulting DCOF values.

4.4.4.2 Dry the test surface by blotting with an untreated paper towel. Use care to not contaminate the surface condition.

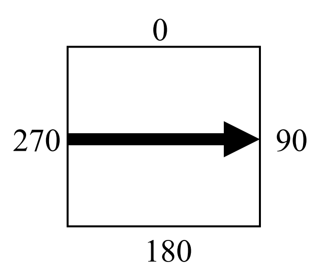
4.4.4.3 Check the SBR testing material for contamination or deformation after each test and recondition per the device manufacturer directions if required.

4.4.5 Second Directional Test - Repeat the above procedure at a 90 degree angle rotated clockwise from the original test path.

First Pass Direction



Second Pass Direction



4.4.6 Calculate the average for the six (6) readings collected from the test area.

4.4.7 Create upper and lower limit bounds of plus or minus 10 %, based upon the following:

- Lower Limit = Average – (Average X 0.10)
- Upper Limit = Average + (Average X 0.10)

4.4.8 Evaluate the six (6) readings relative to the upper and lower limit bounds established in 4.4.7 above:

- If all readings fall within the established limit bounds, accept the average and evaluate the walkway's DCOF per the instructions set forth in section 5.0 of this standard.
- If any readings fall outside of the established limit bounds, reject the test and re-test or correct the testing procedure and/or tribometer as required.

NOTE: If a test area surface exhibits an obvious directional bias or grain (such as a wood floor tile) the test should be conducted in four (4) directions, ninety (90) degrees apart.

Section 5: Calculations/Data Interpretation

Calculate the test result data in accordance with the testing device manufacturer's directions. The final test results shall be recorded as DCOF values on a linear scale from 0.00 to 1.00 μ_D.

Table 1.

Wet DCOF Value (μ_D)	Slip Resistance Potential	Action
>0.45 (inclines) >0.42 (level)	High - Lower probability of slipping	Monitor DCOF regularly and maintain cleanliness.
0.30 - 0.45 (inclines) 0.30 – 0.42 (level)	Acceptable - Increased probability of slipping	Monitor DCOF regularly and maintain cleanliness. Consider traction enhancing products and practices where applicable for intended use
< 0.30	Low - Higher probability of slipping	Seek professional intervention. Consider replacing flooring and/or coating with high traction products.

NOTE: It is important to note that these categories are not indicative of all possible conditions. There are numerous variables that may add to, or take from the available slip resistance potential of any given floor surface. (ie: type or style of footwear, types and frequency contaminants, pedestrian preoccupation, etc). These ranges were established based on research done in Europe utilizing empirical and mathematical techniques and were validated in the *laboratory and field through extensive testing with the following standardized methods: DIN 13287 - BST Tester; DIN 51130 – German Ramp; DIN 51131 – GMG 200 Tester. These values would be applicable to other test methods or devices which can produce an R correlation of greater than 0.80 to one of these three reference standards. . Data produced by tribometers which are not designed to measure wet DCOF do not necessarily correlate to the values listed in Table 1.*

Section 6: Test Report

The Test Report shall include as a minimum:
6.1 types of floor or walkway materials tested
6.2 location(s) of test areas and sites
6.3 individual values for each area tested
6.4 average values for each area tested
6.5 description of areas tested (e.g. greasy, always wet, dusty, damaged tile, etc.)
6.6 copies of test results
6.7 signature of auditor / technician
6.8 value of reference check tile

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, even if they are obvious. Always wipe dry the residual solution left on a floor or walkway after each test, even if you plan on returning shortly. It is recommended to place a safety cone, barrier, or sign alerting personnel to the situation.

7.2 Testing Environment

The tribometer manufacturer instructions or procedures regarding temperature and humidity requirements for the proper operation and storage of the device shall be followed.

User Notes:

Appendix A

Note: To provide additional data/information this appendix offers significant reference materials. 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. This appendix is not a part of the standard and is for informational purposes only.

Batterman, S.D. and Batterman, S.C. (2005) Biomechanical Analysis of Slip, Trip, and Fall Accidents. *Forensic Medicine of the Lower Extremity, Humana Press*

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The Institute of Physics

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ATTACHMENT A

SBR Physical Specifications for ANSI/NFSI B101.3-2012
Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials

TEST METHOD	STANDARD	VALUE	UNIT OF MEAS.
THICKNESS	N/A	4.0 ± 0.2	mm
DENSITY	DIN 53479	1.23 ± 0.2	g/cm³
HARDNESS	DIN 53505	95 ± 3	SHORE A
TENSILE STRENGTH	DIN 53504	> 10	MPa
FLEXIBILITY	DIN 53504	> 250	%
WEARABILITY	DIN 53516	< 250	mm³
ADHESION 2 MIN. @ 23 DEG. C	DIN 53273	> 1.0	N/mm
ADHESION 5 DAYS @ 23 DEG. C	DIN 53273	> 8.0	N/mm
TEAR STRENGTH	DIN 53507-B	> 12	N/mm

ATTACHMENT B

Sodium Lauryl Sulfate Surfactant Specifications for ANSI/NFSI B101.3-201X

Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials

CHEMICAL NAME: Sodium Lauryl Sulfate
SOURCE: The Chemistry Store (www.thechemistrystore.com)
FORM: Liquid
SUPPLIED STRENGTH: 29% solution
CONTAINER SIZE: 1 US Gallon
CAS #: [151-21-3]
MOLECULAR FORMULA: $C_{12}H_{25}NaO_4S$
APPEARANCE: Hazy light yellow in color
SYNONYMS: Sodium Dodecyl Sulfate, Dodecyl Sodium Sulfate, SLS, Lauryl Sodium Sulfate, Sodium Laurylsulfate, Sulfuric Acid Monododecyl Ester Sodium Salt

Note: Dilute the 29% SLS down to 0.1% SLS. For example, to obtain 0.1% SLS mix 13 mL of 29% SLS with 1 gallon of distilled water.

NOTE:
The sole source of supply of the surfactant known to the committee at this time is:
The Chemistry Store (www.thechemistrystore.com)
1133 Walter Price St.
Cayce, SC 29033
Phone: 800-224-1430
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If you are aware of alternative suppliers, please provide this information to NFSI B101 Standards Committee. PO Box 92607, Southlake, TX 76092.

ATTACHMENT C

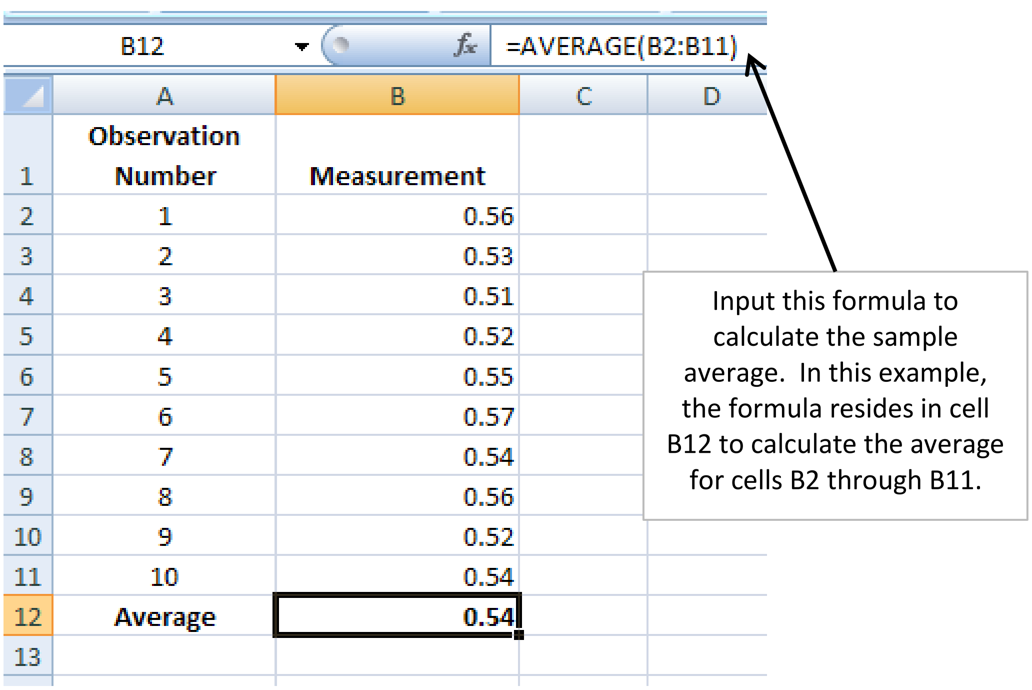
Explanation of statistical methods employed for the measurement of DCOF.

1. **Sample Average** – A measure of central tendency, the sample average shall be calculated by summing all the observations and then dividing by the number of observations. The following formula is employed to calculate the sample average.

$$\overline{X} = \frac{\sum X_i}{n}$$

Where:
$\bar{X}$= Sample average
$\sum$ = Summation
X_i = A single observation
N = Total number of observations

If using Microsoft Excel™, the average may be simply calculated using the averaging function. This process is described in figure 1.



	A	B	C	D
1	Observation Number	Measurement		
2	1	0.56		
3	2	0.53		
4	3	0.51		
5	4	0.52		
6	5	0.55		
7	6	0.57		
8	7	0.54		
9	8	0.56		
10	9	0.52		
11	10	0.54		
12	Average	0.54		
13				

Figure 1 - Instructions for calculating the sample average using Microsoft Excel™.

2. **Sample Standard Deviation**. A measurement of dispersion, the sample standard deviation is more mathematically complex to calculate by hand. The following formula is employed to calculate the sample standard deviation.

$$s = \sqrt{\text{var}} = \sqrt{\frac{\sum(X - \bar{X})^2}{n-1}}$$

Where:
S = Standard deviation
Var = Variance
∑ = Summation
X = A single observation
$\bar{X}$= Sample average
N = Total number of observations

While the formula is complex, the standard deviation is very easy to calculate in Microsoft Excel™. This process is described in figure 2.

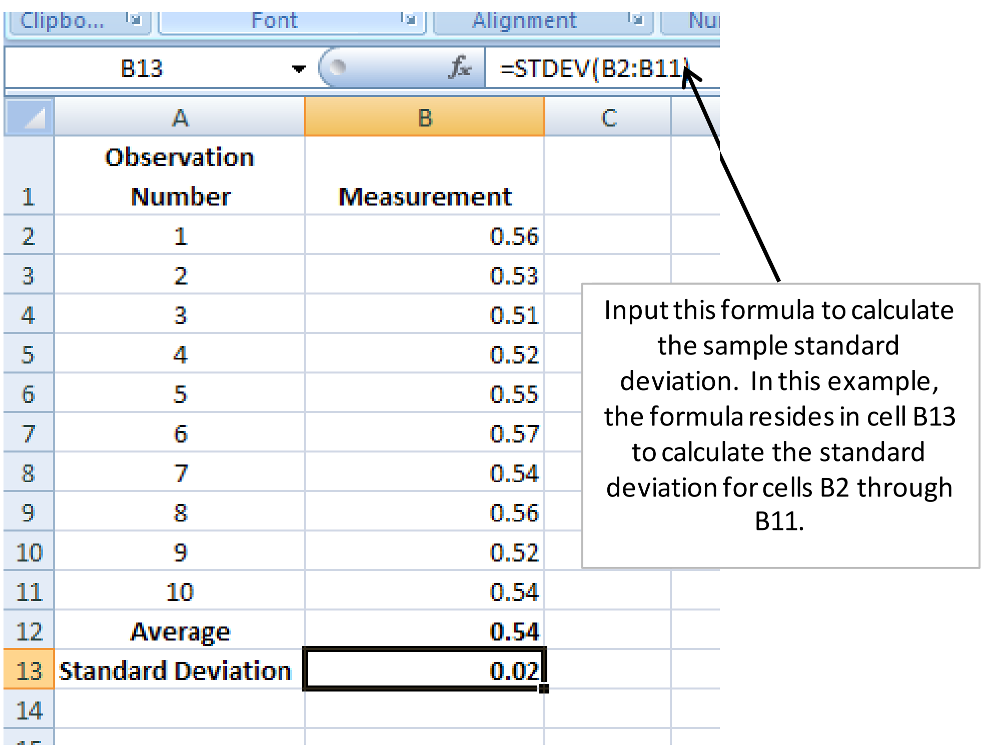


Figure 2 - The sample standard deviation, while complex to compute by hand, may be easily computed using a standard function in Microsoft Excel™.

3. **Coefficient of Variation**. The coefficient of variation is simply the standard deviation divided by the sample average. It too can be very easily computed in Microsoft Excel™. This process is illustrated in figure 3.

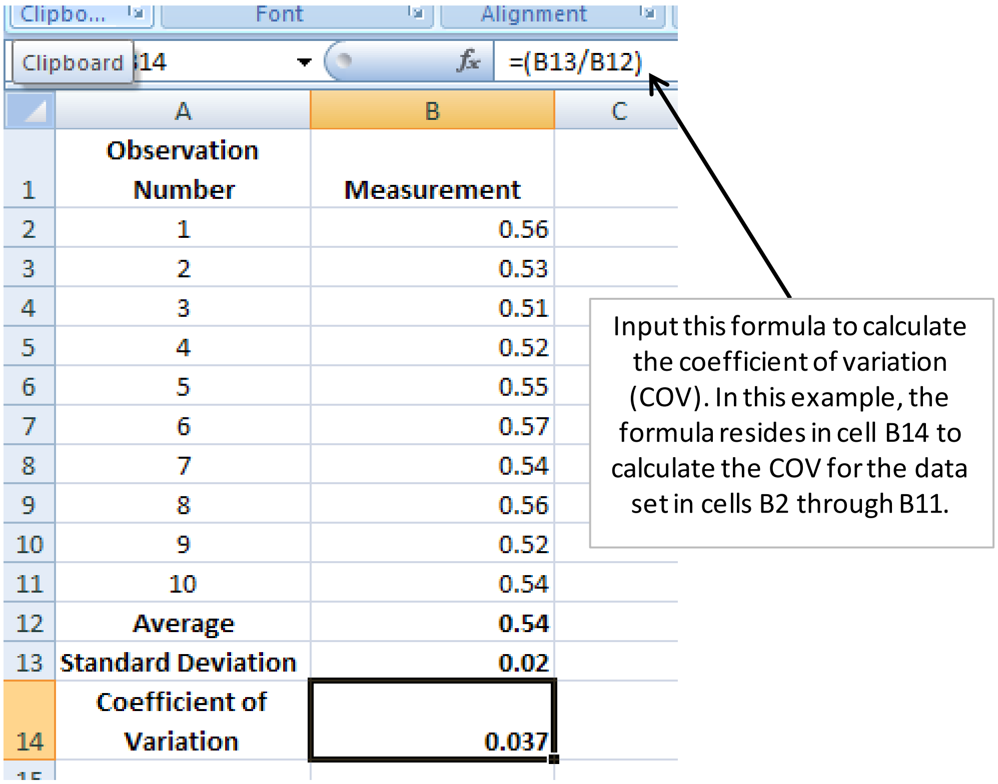


Figure 3 - Figure three illustrates the process for calculating the coefficient of variation using Microsoft Excel™.

A worked example for a data set evaluated in the laboratory for common hard surface flooring is illustrated in figure 4.

Observation Number	Surface Sample 1	Surface Sample 2	Surface Sample 3	
1	0.56	0.58	0.56	
2	0.53	0.53	0.54	
3	0.51	0.55	0.59	
4	0.52	0.57	0.53	
5	0.55	0.53	0.54	
6	0.57	0.52	0.52	
7	0.54	0.56	0.55	
8	0.56	0.55	0.52	
9	0.52	0.59	0.51	
10	0.54	0.54	0.50	
11	0.57	0.57	0.52	
12	0.55	0.58	0.55	
13	0.56	0.53	0.53	
14	0.52	0.52	0.55	
15	0.54	0.55	0.56	
16	0.53	0.56	0.58	
17	0.51	0.54	0.57	
18	0.49	0.59	0.51	
19	0.57	0.50	0.55	
20	0.56	0.53	0.54	
			Average	**0.54**
			Sample Standard Deviation	**0.02**
			Coefficient of Variation	**0.04**

Figure 4 - Illustration of evaluating a data set using Microsoft Excel™.

APPLIED SAFETY AND ERGONOMICS, INC.

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Ann Arbor, MI 48108
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www.appliedsafety.com

August 22, 2008

Mr. Thomas Bresnahan
8078 Garfield Avenue, #9-3
Burr Ridge, Illinois 60527-7914

Re: Summary of user testing for traction/slip symbols

Dear Tom:

As we discussed, I have prepared a summary of user testing activities for the traction/slip symbols.

OVERVIEW OF ASSIGNMENT

On February 20, 2008, ASE was provided with potential candidate symbols for communicating the level of traction provided by floor covering products (see Attachment A). With feedback from Tom Bresnahan and Terry Grisim, ASE edited and modified the symbols. From April 5 through April 15, 2008, ASE conducted two phases of symbols testing based on the recommendations in ANSI Z535.3 (2007) "Criteria for Safety Symbols." Phase 1 consisted of a judged comprehension test (ANSI Z535.3 Annex B2.4), in which four variants of the traction/slip symbol were tested with 50 participants. Phase 2 consisted of an open-ended comprehension test, in which the modified symbols from Phase 2 were tested with another 50 participants. The following sections describe the activities, findings, and recommendations from this testing. Supporting attachments A, B, and C are also included.

PHASE 1: JUDGED COMPREHENSION TESTING

The initial test phase consisted of a judged comprehension test as recommended in ANSI Z535.3 (2007) "Criteria for Safety Symbols." The purpose of this testing was to identify symbol variants that were most likely to be well comprehended by asking participants to estimate the percentage of the population that would comprehend the meaning of each of several symbols representing the same concept. The following section describes participant recruitment and demographics, questionnaire design, and results of this phase. The selection of the symbols for Phase 2 open-ended comprehension testing is also discussed.

Participant Recruitment and Demographics

From April 4 through April 9, 50 participants were recruited in southeastern Michigan and Arlington, Virginia at flooring and hardware stores, a Home and Garden show, and contacts of ASE employees who are "do-it-yourselfers". Thirty-two were male and 18 were female. The average age was 43.5 years (range: 21-68 years). Thirty participants had at least a four-year college degree. Twenty-nine participants had business or sales-related occupations (e.g., manager, customer service), 13 had professional-related occupations (e.g., doctor, accountant), 5 participants had trade-related occupations (e.g., construction, electrician), 2 participants were retired, and 1 had other type of employment (i.e., "PSA"). All participants were offered $5 for their participation.

Questionnaire Design

The questionnaire used in this phase is shown in Attachment B. The first page consisted of the following script for the interviewer to read:

> "We are developing symbols that would appear on packaging for floor coverings (tile, vinyl, etc.). Here is a photo of potential products that may have these symbols. And, here are several symbols that are all intended to convey how slippery the floor might be. What I would like for you to do is compare each of the symbols with the meaning in the center and tell me how many people out of 100 would understand the symbol. If no one would understand the symbol, please tell me 0. If you believe everyone would understand the symbol tell me 100. Feel free to use any numbers in between 0 and 100. You may use any number as often as you like."

The interviewer showed four symbol variants to the participant and wrote down the participant's responses. The interviewer also asked participants if they had any suggestions for improvements to the symbols and wrote these suggestions on the response form.

Results

The results of the judged comprehension testing are shown in Figure 1.

Symbol Selected for Modification and Further Testing

ANSI Z535.3 suggests that a variant receiving a score below 65% (mean or median) is unlikely to meet the 85% criterion on final open-ended testing (ANSI Z535.3, Annex B2.4). Given this, ASE selected the highest mean value percentage (60.9%)[1] and modified the symbol based on feedback received from participants. Suggestions included the addition of descriptive text (i.e., traction) and adjusting the location of the person to the horizontal rather than along the gauge. The modified symbols are shown in Figure 2.

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[1] We used the mean scores to select the symbol for open-ended comprehension. The median score for the selected variant was 68.5%. All other variants had 50% as a median.

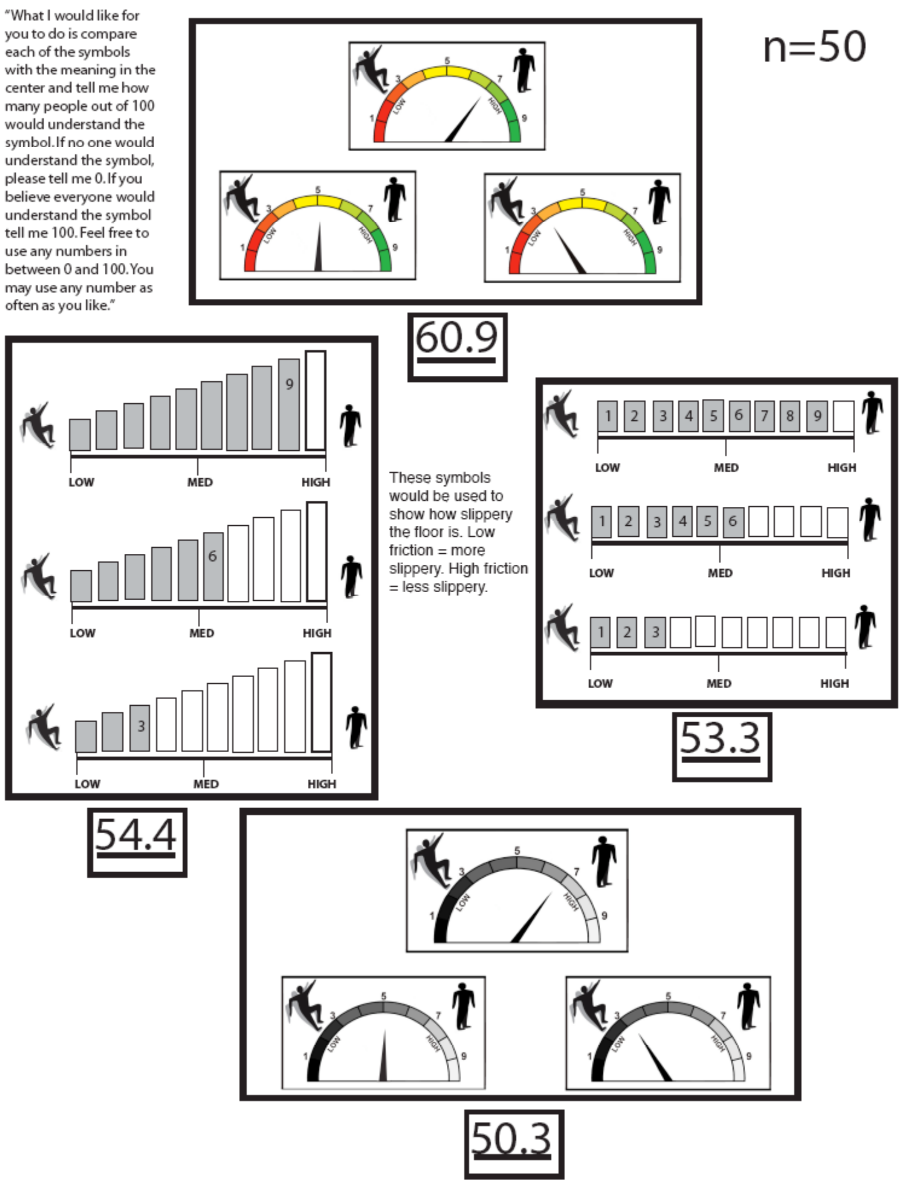


Figure 1. Results from judged comprehension testing (shows mean values)

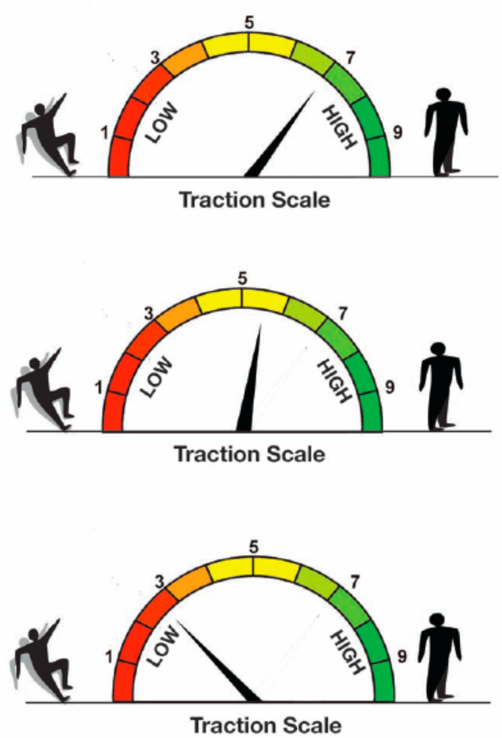


Figure 2. Modified symbols for Phase 2 comprehension testing.

PHASE 2: OPEN-ENDED COMPREHENSION TESTING

The second phase of testing consisted of an open-ended comprehension test as recommended in ANSI Z535.3. The purpose of an open-ended comprehension evaluation is to identify how well symbols are actually comprehended and, if comprehension difficulties occur, to develop improvements to symbol features to increase comprehension. The following sections describe participant recruitment and demographics, questionnaire design, and results for this phase.

Participant Recruitment and Demographics

From April 11 through April 15, 50 participants were recruited in southeastern Michigan at a Home and Garden show, a Habitat for Humanity build, and flooring and hardware stores. Twenty-nine were male and 21 were female. The average age was 37 years (range: 18-85). Thirty-three participants had less than a four-year college degree. Twelve participants had business or sales-related occupations (e.g., manager, customer service), 7 had professional-related occupations (e.g., doctor, accountant), 3 participants had trade-related occupations (e.g., construction, electrician), 6 participants were retired, 16 were students, 4 were unemployed, and 2 had other types of employment (e.g., mail clerk, automotive worker). All participants were offered $5 for their participation.

Questionnaire Design

The questionnaire used in this phase is shown in Attachment C. The first page consisted of the following script for the interviewer to read:

> "We are developing symbols that would appear on packaging for floor coverings (tile, vinyl, etc.). Here is a photo of several boxes of floor covering. And, here is a symbol set that might appear on the package. I would like to ask you a few questions about these. Just do the best that you can, and take an "educated guess" if you are not sure of the meaning. Remember, it is the symbols that are being tested, not you."

The interviewer showed the symbol set to the participant and asked the participant to assume that they were shopping for floor coverings at a store and noticed the symbol set on packaging for different products. The interviewer asked, "What do you think these symbols mean?" (and asked "is there anything else?" until the participant said no). The interviewer wrote down their responses. The interviewer also asked participants if they had any suggestions for improvements to the symbols.

Results

Forty-four participants (88%) correctly reported the meaning of the symbol set. Of the six participants that incorrectly reported its meaning, four (8% of total participants) reversed the meaning of the symbol (i.e., the "low traction" was thought to mean "low slipperiness" or "high traction"). In an Annex to ANSI Z535.3, these responses are referred to as critical confusions in that the acceptance criterion is no more than 5% of this type of responses. The two participants that reported incorrect responses correctly identified that there was a low to high measure, but did not equate it with traction. One thought it was "quality" of the product and the other thought it was related to product use (but could not articulate what kind). Based on ANSI Z535.3, the symbol exceeds the comprehension criteria (85%) for correct responses, but also exceeds that of the "critical confusions". Therefore, it meets one, but not both criteria according that particular protocol.

RECOMMENDATIONS

To accept a symbol, ANSI Z535.3 recommends a criterion of 85% correct responses with a maximum of 5% critical confusions (assuming a sample of 50 participants). If a symbol does not meet this criteria, ANSI recommends rejecting, modifying and retesting, using a supplementary word message, or having specialized training to supplement the symbol. For this particular situation, 88% of the participants were able to correctly comprehend the meaning of the symbols. This is actually an encouraging result because many symbols used in the marketplace are not tested or, if they are tested, do not pass the ANSI Z535.3 criteria. There are many possibilities to explain why a symbol might not pass the criteria, including symbol factors and person factors. However, the number of participants who gave incorrect responses (6 total, 4 with critical confusions) is not large enough to draw any conclusions regarding possible person factors, and no trends were evident in the demographic information that we collected (age, gender, education, occupation).

Because the current symbols did not meet the ANSI Z535.3 comprehension criteria, **we**

recommend modifying the symbols to include additional text. This approach is consistent with ANSI Z535.3 and **additional testing is not required.** Therefore, considering the responses received by the participants with critical confusions, we recommend adding the supplemental word “Traction” to the “LOW” and “HIGH” text to clarify that it is traction rather than “slipperiness” being indicated.

It is important to note that the protocol within ANSI Z535.3 is intended for testing the comprehension of symbol elements, not words. The confusion seen in the 4 responses in this study seems to be related to the clarity of the existing words and not the symbol elements. Therefore, strictly applying the ANSI Z535.3 critical confusion criteria to these symbols seems to be outside the range of the standard. Furthermore, even the ANSI Z535 standard that addresses warning labels with words, ANSI Z535.4, does not require testing when wording changes are made to labels.

In addition, to enhance the readability of this additional text and the existing text, we also recommend orienting the text “LOW” and “HIGH” on the horizontal plane rather than angled and on top of the horizontal traction line. Figure 3 (on the following page) shows an example of these modifications.

Please let me know if you have any questions regarding this report.

Sincerely,

Elaine Wisniewski

Elaine Wisniewski, MSE, MA, CPE, CPSM

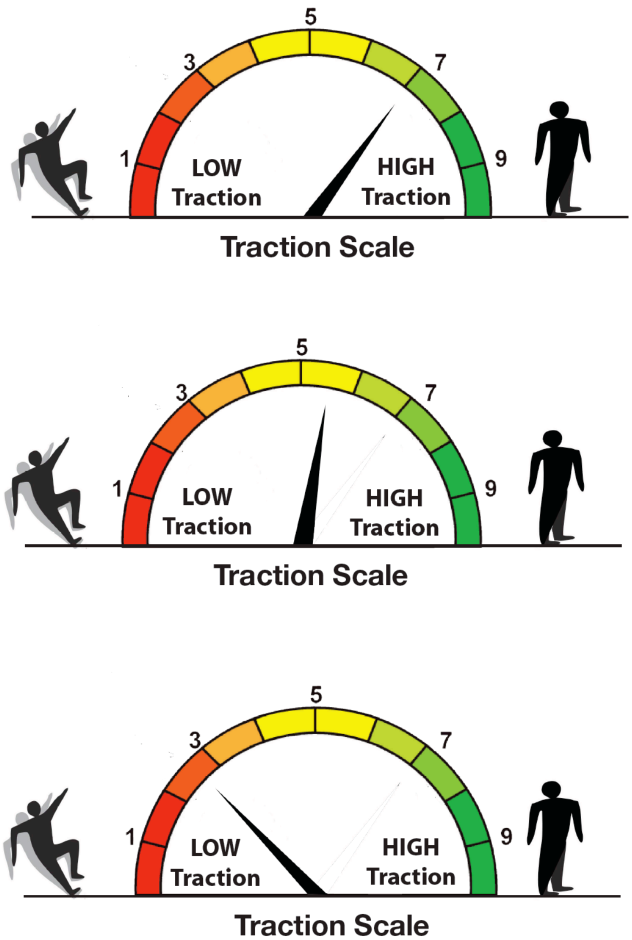
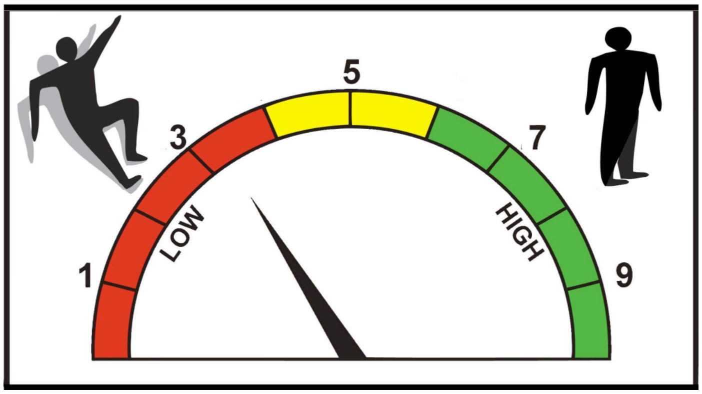
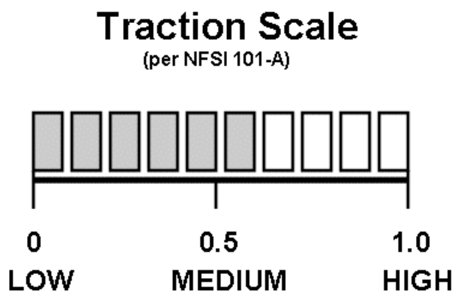
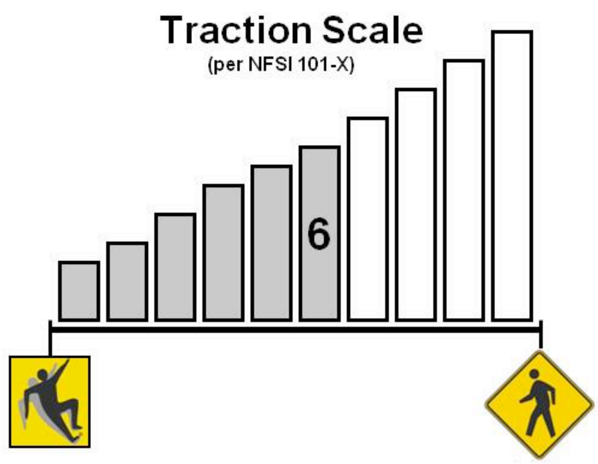


Figure 3. Modifications to symbols.

Attachment A: Example Symbols Received







Introduction

“Hello, I am conducting a brief study regarding symbols that might appear on the packaging of flooring materials such as tile or vinyl. I will pay you $5 for 5 minutes of your time. Would you be interested in participating?”

If no, “thank you for your time.”

If yes, “thank you, I appreciate it (hand money to participant)”

Instructions

“We are developing symbols that would appear on packaging for floor coverings (tile, vinyl, etc.). Here is a photo of potential products that may have these symbols.”

(Show photo pages to participant)

“And, here are several symbols that are all intended to convey how slippery the floor might be.”

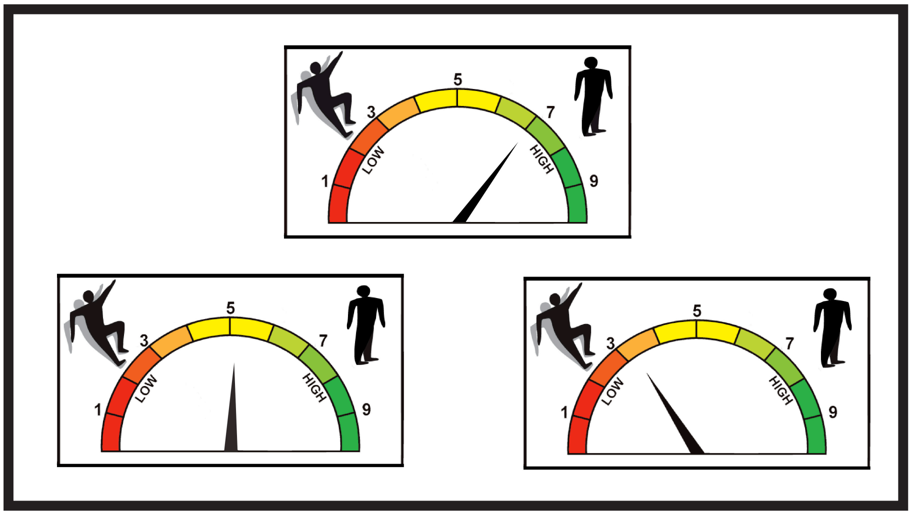
(Hand sheet of symbols to participant)

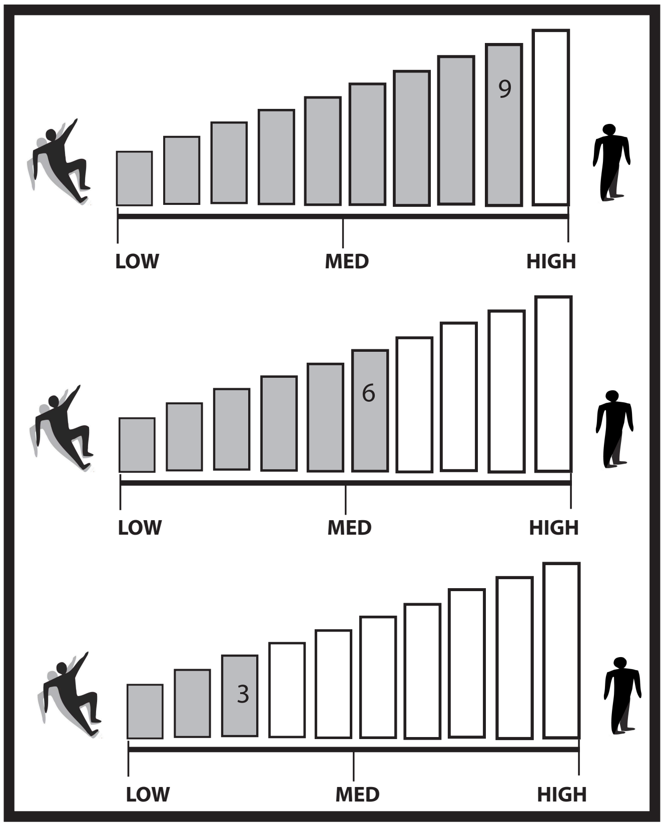
“What I would like for you to do is compare each of the symbols with the meaning in the center and tell me how many people out of 100 would understand the symbol. If no one would understand the symbol, please tell me 0. If you believe everyone would understand the symbol tell me 100. Feel free to use any numbers in between 0 and 100. You may use any number as often as you like.”

Date ________

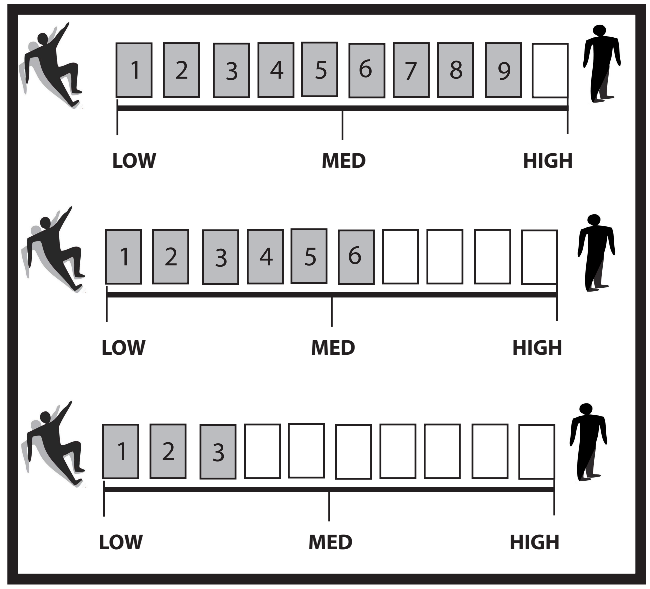
Participant # _______

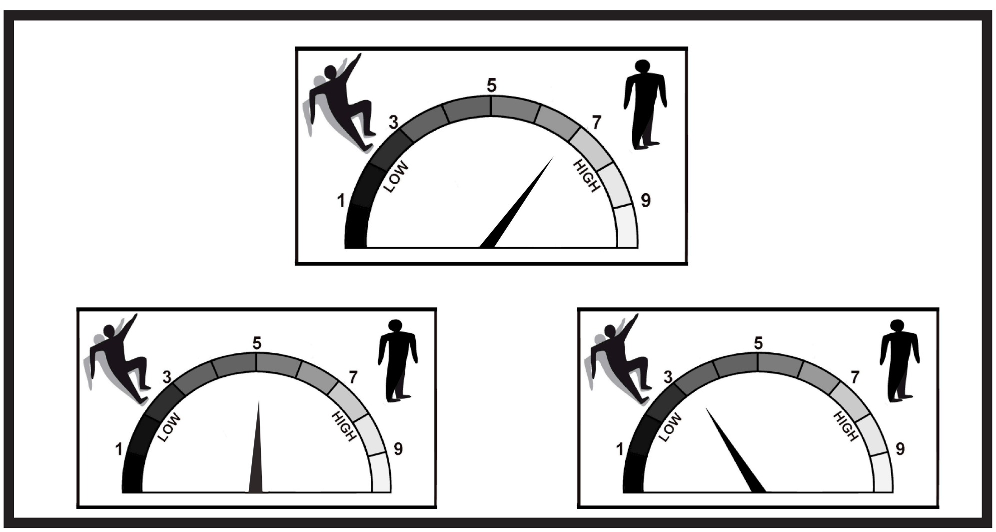
Interviewer Initials_______





These symbols would be used to show how slippery the floor is. Low friction = more slippery. High friction = less slippery.



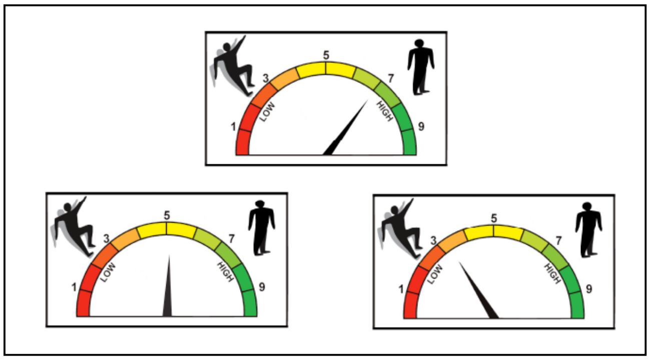


Date: ______

Participant #____
Interviewer Initials _____

Questions

Do you have any suggestions for improvements to these symbols?



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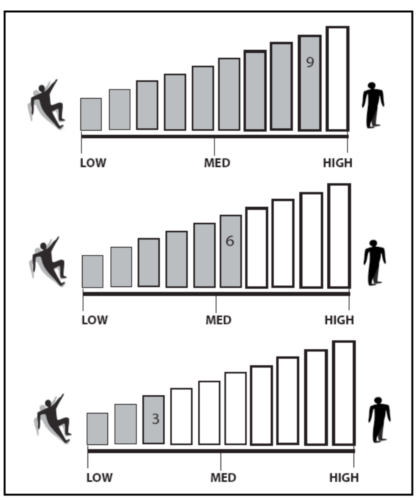

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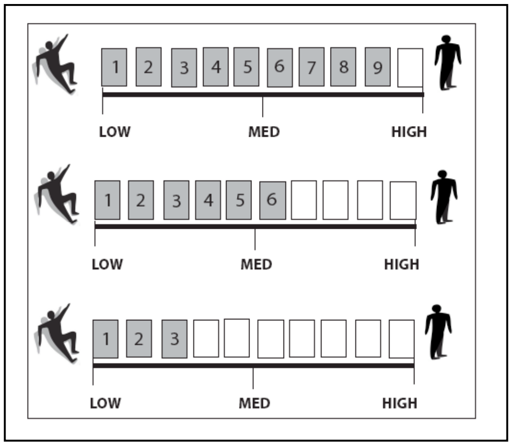
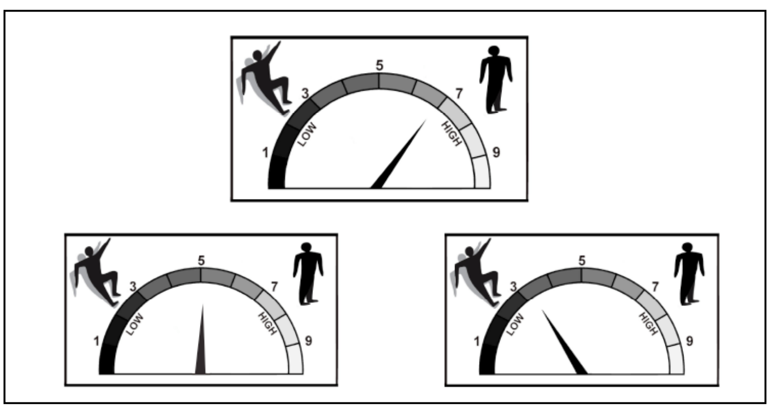
Date: ______

Participant #____
Interviewer Initials _____





Date: ______

Participant #____
Interviewer Initials _____

Participant Background Information

Age: _______

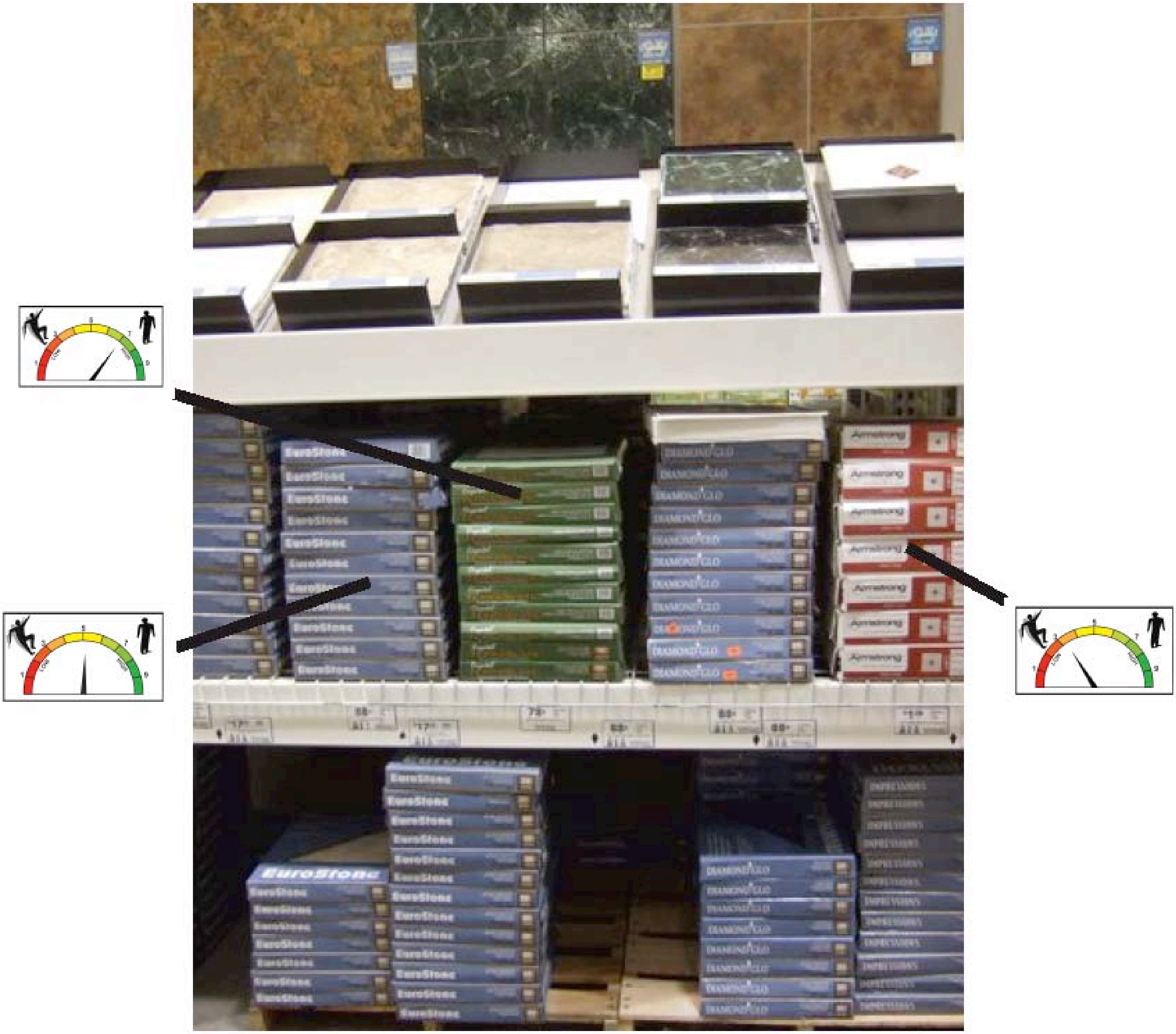
Gender (please circle) Male Female

Education (please circle)

- Less than high school
- High school
- 2-year college
- Trade school
- 4-year college
- More than 4-year college

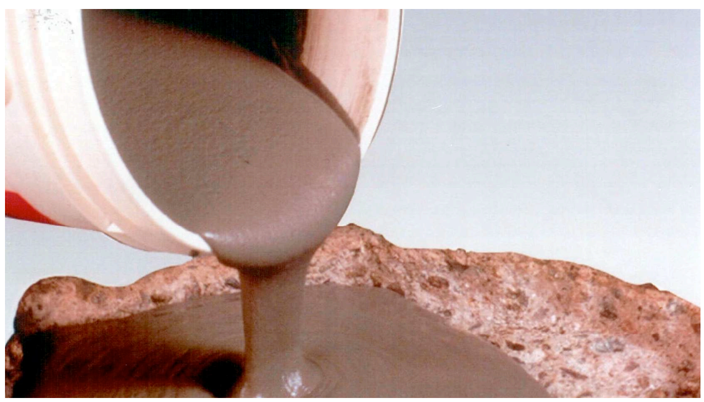
Occupation: _________________

Thank you for your time today!


EuroStone
DIAMOND GLO
Armstrong

Floor Coverings

Floor Covering Materials



Introduction

"Hello, I am conducting a brief study regarding symbols that might appear on the packaging of flooring materials such as tile or vinyl. I will pay you $5 for 5 minutes of your time. Would you be interested in participating?

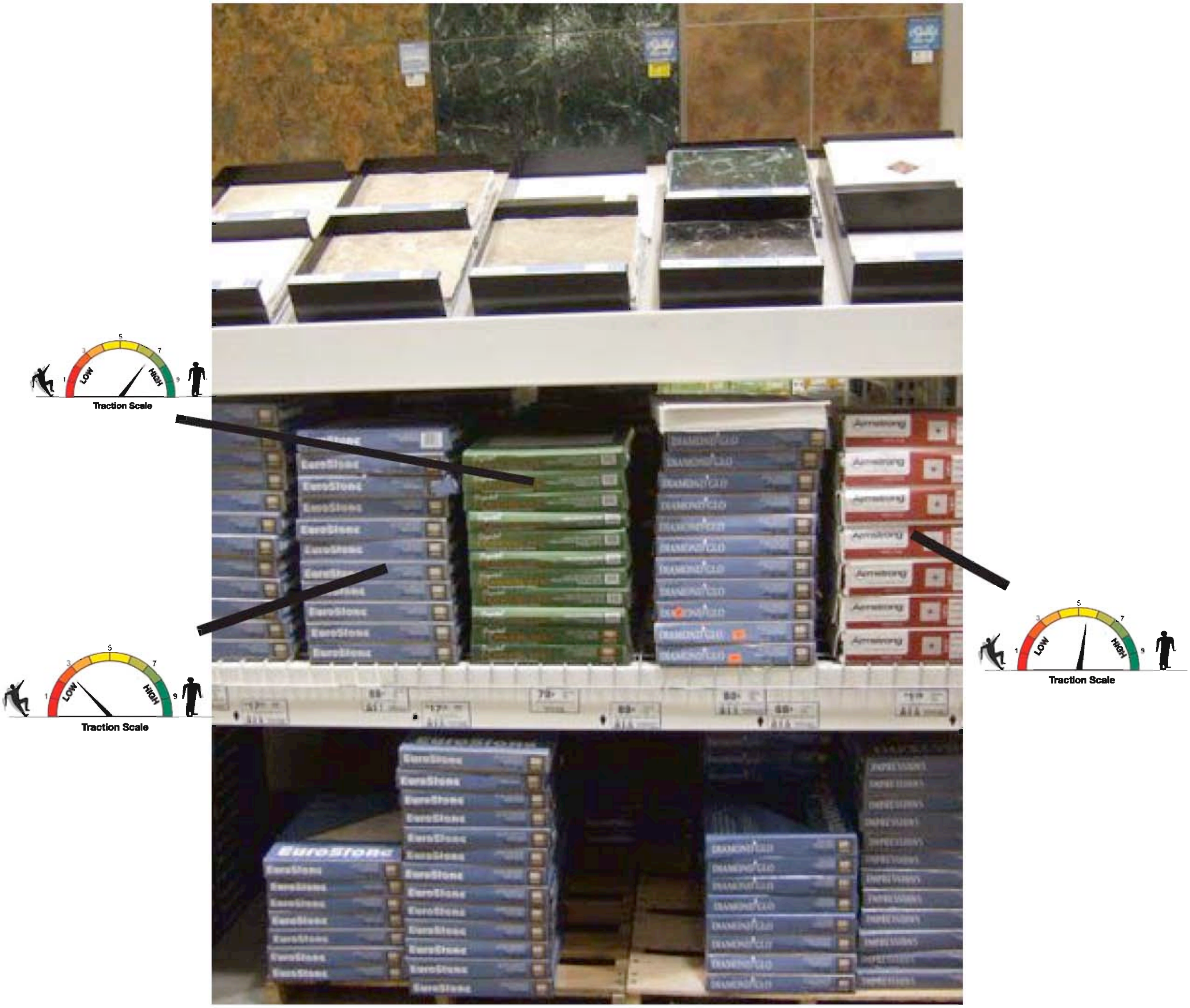
If no, "thank you for your time."

If yes, "thank you, I appreciate it (hand money to participant)"

Instructions

"We are developing symbols that would appear on packaging for floor coverings (tile, vinyl, etc.). Here is a photo of several boxes of floor covering. (Show photo page to participant)."

"And, here is a symbol set that might appear on the package." (give sheet of symbols to participant) I would like to ask you a few questions about these. Just do the best that you can, and take on "educated guess" if you are not sure of the meaning. Remember, it is the symbols that are being tested, not you."



LOW
HIGH
Traction Scale
LOW
HIGH
Traction Scale
LOW
HIGH
Traction Scale
EuroStone
DIAMOND GLO
Armstrong
IMPRESSIONS

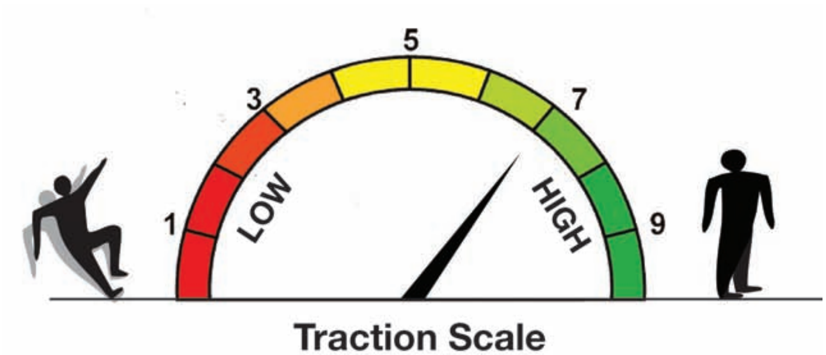
Floor Coverings

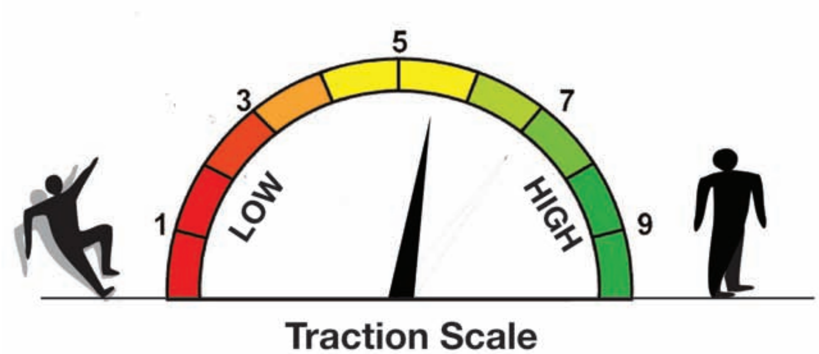
Floor Covering Materials

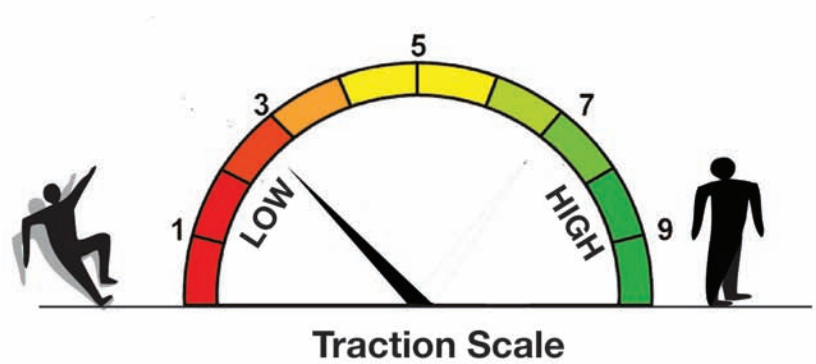
Questions Regarding Symbols

Assume that you are shopping for floor coverings at a store. You notice the following symbols on the packaging for different products.

What do you think these symbols mean? (ask "is there anything else?" until participant says "no")







Do you have any suggestions for improvement?

Date: ______

Participant #____
Interviewer Initials _____

Participant Background Information

Age: _______

Gender (please circle) Male Female

Education (please circle)

Less than high school
High school
Some college
2-year college
Trade school
4-year college
More than 4-year college

Occupation: _________________

Thank you for your time today!

Does underfoot coefficient of friction affect slip-initiated events or injuries?

Wen-Ruey Chang, Ph.D., P.E.

Chang WR Falls Prevention, LLC
P.O. Box 1651
Washington, DC 20013

In preparation for

Mr. Russell Kendzior
National Floor Safety Institute
P.O. Box 92607
Southlake, TX 76092

July 16, 2017

Executive Summary

Injuries caused by slips and falls have been substantial. A typical intervention is to increase the friction between footwear and floor. In this limited literature review, scientific evidence to support such an intervention is summarized. Intervention studies are very rare in the literature. A direct link between a particular intervention and injury outcomes is very limited. An important initiating event related to the friction between footwear and floor is slips. In this report, an attempt was made to provide a link between friction of the footwear and floor and slip outcomes. The results included in this summary show that an increase in underfoot friction, indeed, can reduce slip initiated incidents.

Introduction

Data from the Liberty Mutual Workplace Safety Index (Liberty Mutual Research Institute for Safety, 2016) showed that the direct costs for disabling workplace injuries in 2013 due to *falls on same level* in the United States were estimated to be approximately 10.17 billion U.S. dollars or 16.4% of the total cost burden. A *slip or trip without fall* accounted for an additional 2.35 billion U.S. dollars or 3.8%. For falls on the same level, slippery floors, mostly caused by contaminants, are a critical factor (Chang et al., 2016). Bell et al. (2008) identified liquid contamination as the most common cause (24%) of slip, trip and fall incidents for healthcare workers. Falls on the same level continue to be a serious occupational injury problem.

To reduce slip-initiated injuries, a typical intervention is to increase the friction between footwear and floor (underfoot friction). The term underfoot friction is used in this report rather than floor friction because friction is determined by floor, footwear and contaminants. In this limited literature review, scientific evidence to support such an intervention is summarized. However, intervention studies are very rare. An important initiated event related to the friction between footwear and floor is slips. In this report, a link between underfoot friction and slip outcomes was established. The supporting data are divided into the results from four categories:

actual field intervention studies, laboratory studies in which the participants were exposed to slippery floors unexpectedly, field observations in which no intervention was introduced, and the results based on a theoretical computation.

Field intervention studies

Field intervention studies are limited in number. In order to achieve an overall reduction in injuries, multiple interventions are often utilized. Bell et al. (2008) reported an intervention study involving three hospitals in the U.S., applying a comprehensive package of intervention measures, phased in over three years and then monitored during a three-year post-evaluation period. The intervention measures, which were based on analysis of the hospitals' historical accident reporting data and on-site risk assessment, were developed around 11 main components. Measures to increase the underfoot friction, such as slip resistant footwear and floor cleaning, were included in the interventions. Their results showed that the overall workers compensation slip, trip and fall injury claim rate for the hospitals declined significantly (over 50%) during the post-intervention time period. However, the contributions of each component of the interventions were unclear. Therefore, a direct link between an increase in underfoot friction and injury outcomes cannot be established with these results.

Ballance et al. (1985) reported an intervention study in which a high incidence of falls on the same level in a refectory building at University of Sussex was significantly reduced through the replacements of two floor surfaces, smooth ceramic tiles and untreated woodblock. Each of these surfaces accounted for 25% of fall incidences within the refectory building. Static and dynamic coefficients of friction were measured with a drag-sled device. These floors were replaced with high slip-resistance glazed ceramic tile, carpet, and rubber-based sheet floor material. These new surfaces were selected based on friction measurements as well as consideration of cost and ease of cleaning. Prior to the intervention, the coefficient of friction (COF) values were low: 0.24 to 0.35 in dynamic COF and 0.34 to 0.60 for static COF for the smooth ceramic tile and 0.21 to 0.42 in dynamic COF and 0.37 to 0.53 in static COF for woodblock. After the interventions, COF values were raised to 0.36 to 0.41 in dynamic COF and 0.54 to 0.63 in static COF for the glazed ceramic tile, 0.49 to 0.65 in dynamic COF and 0.66 to 0.79 in static COF for carpet, and 0.31 to 0.54 in dynamic COF and 0.43 to 0.75 in static COF for rubber-based floor. As a practical matter, after their installations, no fall occurred on these new floor surfaces prior to the publication of their paper and the overall fall rate was reduced from approximately 30 injuries to 20 injuries in the whole refectory building.

Laboratory studies

Kulakowski et al. (1989) exposed five participants to three floor surfaces wetted with detergent (rubber, galvanized steel, and the reverse side of linoleum). The static COF values measured with a Brungraber Mark I slipmeter were 0.26, 0.69 and 0.18 for the rubber, galvanized steel and linoleum, respectively. Although they did not report the number of times participants slipped on each surface, they did mention that participants slipped more often on surfaces which had a lower COF. However, they also observed that the process of slipping involved a considerable randomness.

Powers et al. (2007) evenly divided 84 human participants into six groups with equal numbers of males and females in each group (7). Each group was exposed to one of six different conditions generated with three different floor types and dry and wet surface conditions on a specially-built walkway. After several practice walks on the walkway, the desired floor type with the designated surface condition was inserted into a section of the walkway without the knowledge of the participants. The results of each trial were classified as no slip, heel slip or toe slip. In the meantime, the COFs of these surfaces were measured with nine different mechanical friction measurement devices (slipmeters). These slipmeters employed different measurement characteristics and, of course, the results differed. The authors compared the ranking of six different conditions from the results of the human subject experiment with that from the friction measurements obtained with each slipmeter in an attempt to identify whether the slipmeter rankings matched that from human subject experiment. Since the results of these slipmeters were very different and there has been no agreement about which slipmeters might be better than others, the results of all COF values were averaged across all these slipmeters in the current report for simplicity. The results of averaged COF value versus participant slip count are shown in Figure 1. The combined count is the sum of both heel slips and toe slips. The results clearly show a linear relationship, i.e., one factor is increased or decreased proportionally as the other factor increases, between the averaged COF and combined slip count when COF was lower than 0.5. One might argue that a heel slip is more dangerous than a toe slip since it is more difficult for people to recover from a heel slip (Leamon, 1992). An alternative is to explore the relationship between heel slip and averaged COF. The results in Figure 1 also clearly show a linear relationship between these two variables when the averaged COF value is below 0.36.

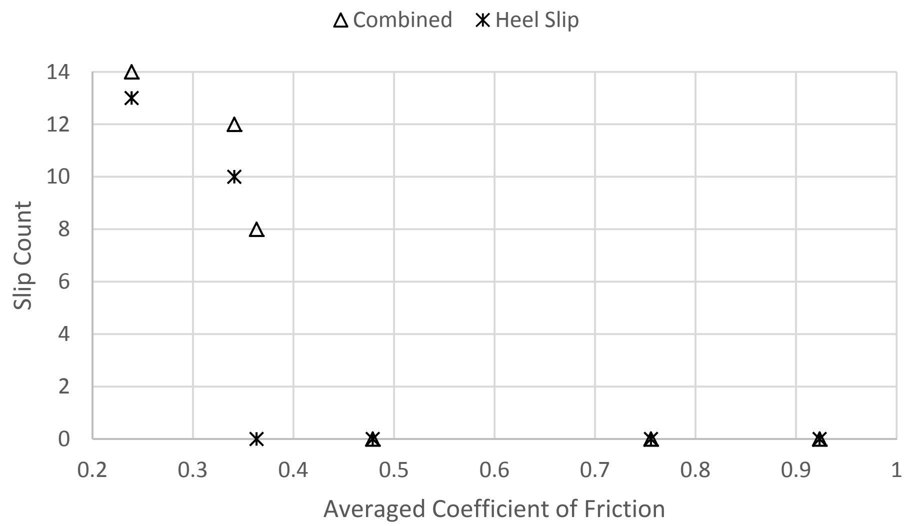


Figure 1 The relationship between the combined slip count (heel slips and toe slips) and averaged coefficient of friction across all the slipmeters used and between the count for heel slips and averaged coefficient of friction (Powers et al. 2007).

Powers et al. (2010) conducted a study to establish reference surfaces to validate slipmeter measurements. Eighty human participants were evenly divided into four groups and each group walked on one of the four reference surfaces on a specially-constructed walkway. After several dry trials on the walkway, water was applied to a section of the walkway without the knowledge of the participants. Each participant was exposed to the slippery condition only once. Depending on results, each trial was classified as no slip, heel slip and toe slip. Twelve slipmeters were used to measure the same four reference surfaces. For simplicity, in the current report, the results of all COF values were averaged across all these slipmeters. The results of averaged COF value versus slip count are shown in Figure 2. The combined count is the sum of both heel slips and toe slips. The results clearly show a linear relationship between the averaged COF and combined slip count, which supports the main mission of this report. Similarly, an alternative is to explore the relationship between heel slip and averaged COF. The results in

Figure 2 also clearly show that the slip count was not affected by averaged COF value when averaged COF was higher than 0.46 and they had a linear relationship when averaged COF was lower than 0.46.

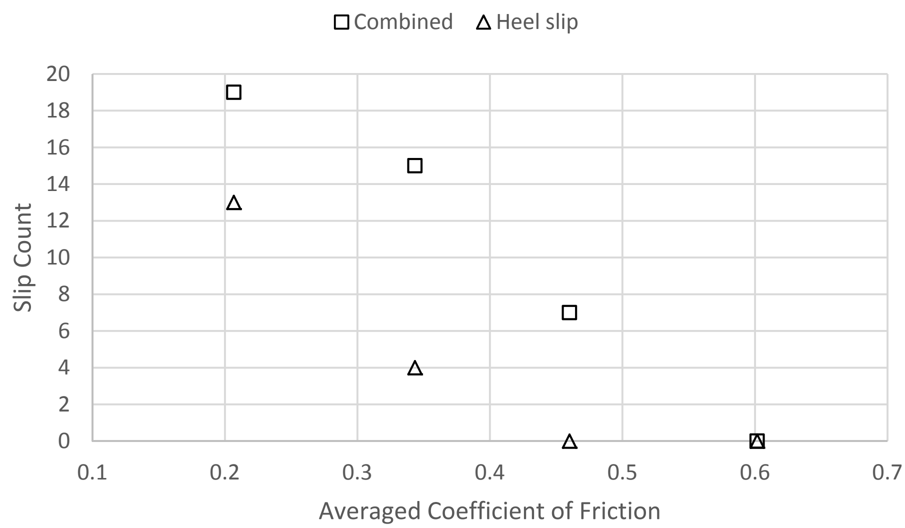


Figure 2 The relationship between the combined slip count (heel slips and toe slips) and averaged coefficient of friction across all the slipmeters used and between the count for heel slips and averaged coefficient of friction (Powers et al. 2010). This figure shows similar results to those reported in Table 1.

Field observations without intervention

Verma et al. (2011) conducted a field study to examine the association between floor surface characteristics, slip-resistant shoes, floor cleaning frequency and the risk of slipping in limited-service (fast food) restaurant workers. COF was measured in eight working areas of the kitchen and then averaged within each restaurant. Participants reported their slip experience and work hours weekly for up to 12 weeks. The mean of individual slipping rate varied among the restaurants from 0.02 to 2.49 slips per 40 work hours. After adjusting for age, gender, body mass index (BMI), education, primary language, job tenure and restaurant chain, it was found that for each kitchen, a 0.1 higher mean COF meant the rate of slipping was lower by 21%. Although this was an observational study, their results provide support for the use of measures to increase COF as preventive interventions to reduce slips, falls and injuries.

Theoretical computation

To determine if a slip is likely to happen, the required coefficient of friction (RCOF), also known as friction demand, is compared with the available coefficient of friction (ACOF) (Hanson et al., 1999; Chang, 2004). The RCOF, which represents COF needed underfoot in order to maintain safe walking, is typically measured with a force plate (a measurement instrument imbedded in the floor over which individuals walk). The ACOF represents the maximum friction that can be supported by the footwear and floor and is typically measured with a slipmeter. If the RCOF is higher than the ACOF, i.e., friction needed by an individual exceeds what the underfoot condition can support without a slip, a slip is likely to happen.

Chang et al. (2013) reported an investigation on different slip probabilities for level straight walking obtained when comparing a given ACOF value with the stochastic distribution of the RCOF. In the experiment, a participant would walk under the same condition repeatedly. However, each walk by this person was slightly different from the others by this same person. This variability contributed to the randomness of the outputs, leading to a stochastic distribution under the same condition for the same individual. The authors assumed that the RCOF of each foot for each walking condition by each of the 48 participants had a normal distribution based on the results reported in an earlier study by Chang et al. (2012). The slip probability was obtained by averaging the cumulative probabilities of the RCOF exceeding a given ACOF from both feet and evaluated at five levels, one out of 20, 200, 10,000, 100,000 and 1,000,000. The scenario for the slip probability based on Chang et al. (2013) is for an individual to walk on a dry surface with full confidence and no concern about any slip possibility, then suddenly, without warning, encounter a surface with a given ACOF value. The scenario could be a transition from one floor material to another or from a dry surface to another surface condition without prior knowledge. The results for different slip probabilities are shown in Table 1 for different age groups, genders, footwear types and walking speeds. The results clearly show that ACOF threshold value increases as the slip probability is decreased. In addition, there could be a drastic difference in slip probability even with a small change in ACOF. Therefore, it is beneficial to increase ACOF in any way we can to reduce slip incidents.

Summary

This report summarizes the results reported in the literature on whether an increase in underfoot friction could result in a decrease in slip-initiated incidents. The results are summarized in four categories, ranging from field intervention studies, laboratory studies, field observations to theoretical computation. All the results point to the same direction − that an increase in underfoot friction, indeed, could result in a decrease in slip initiated incidents. The data from the laboratory studies further suggested that an increased level of COF is directly proportional to a reduction in slips.

Table 1 The means with standard deviations in parentheses of the available coefficient of friction (ACOF) associated with different slip probabilities obtained by Chang et al. (2013).

		Slip Probability				
		1/20	1/200	1/10,000	1/100,000	1/1,000,000
Age group	18-25	0.262 (0.0338)	0.280 (0.0356)	0.301 (0.0385)	0.311 (0.0401)†	0.320 (0.0417)†
	26-54	0.264 (0.0293)†	0.280 (0.0332)†	0.298 (0.0383)†	0.307 (0.0409)†	0.315 (0.0433)†
	55 and older	0.252 (0.0290)	0.266 (0.0306)	0.283 (0.0332)	0.291 (0.0347)	0.299 (0.0361)
Footwear	loafer	0.256 (0.0306)	0.272 (0.0333)	0.291 (0.0372)	0.300 (0.0392)	0.308 (0.0410)
	sneaker	0.265 (0.0292)	0.280 (0.0328)	0.298 (0.0377)	0.307 (0.0402)	0.314 (0.0425)
Gender	female	0.257 (0.0303)	0.273 (0.0342)	0.293 (0.0395)	0.302 (0.0421)	0.311 (0.0446)
	male	0.264 (0.0298)	0.278 (0.0321)	0.296 (0.0355)	0.304 (0.0373)	0.312 (0.0390)
Walking speed	fast	0.272 (0.0266)‡	0.289 (0.0289)‡	0.308 (0.0323)‡	0.317 (0.0341)‡	0.326 (0.0358)‡
	normal	0.249 (0.0288)	0.263 (0.0325)	0.281 (0.0375)	0.289 (0.0401)	0.297 (0.0425)

† - statistically significantly different from group 3 (55 and older) ($p < 0.05$)

‡ - statistically significantly different from normal speed ($p < 0.05$)

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Curriculum Vitae

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Summary of Major Achievements

Dr. Chang is one of the leading researchers on slips, trips and falls in the world with the following recognitions:

Fellow, International Ergonomics Association (IEA), 2016
Fellow, American Society of Mechanical Engineers (ASME), 2005 in recognition of contributions to safety and ergonomics research in slips, trips and falls
Fellow, The Institute of Ergonomics and Human Factors (formerly known as The Ergonomics Society), UK, 2006 in recognition of contributions to safety and ergonomics research in slips, trips and falls
Recipient of the William Floyd Award, The Institute of Ergonomics and Human Factors (formerly known as The Ergonomics Society), UK, 2003 in recognition of contributions to the measurements of slipperiness
Recipient of National Occupational Research Agenda (NORA) Partnering Award for Worker Health and Safety, the National Institute for Occupational Safety and Health (NIOSH), 2006 in recognition of ergonomics interventions to reduce slips, trips and falls among healthcare workers
The Best Paper Award in *Ergonomics,* 2009 (JL Bell, JW Collins, L Wolf, R Grönqvist, SS Chiou, **WR Chang**, GS Sorock, TK Courtney, DA Lombardi, B Evanoff, 2008, Evaluation of a Comprehensive Slip, Trip, and Fall Prevention Program for Hospital Employees, *Ergonomics*, 51 (12), 1906-1925.)
The Outstanding Alumni Award, National Chung-Hsing University, Taiwan, 2006
Editor, *Ergonomics*
Leading editor in *Measuring Slipperiness - Human Locomotion and Surface Factors* (ed. **WR Chang**, TK Courtney, R Grönqvist, MS Redfern), Taylor & Francis, London, ISBN 0-415-29828-8, 2003.
Organizers and chairmen of international symposia at major ergonomics and safety conferences around the world
Guest Editor of special issues in *Ergonomics* (2001, 2008), *Safety Science* (2002, 2005) and *Industrial Health* (2008, 2014)
Chair (2006-2012), Past Chair (2012-present) and founder, technical committee on slips, trips and falls, International Ergonomics Association
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Professional Experience

Chang WR Falls Prevention, LLC, Arlington, Virginia
Principal, 2017 - present.

Liberty Mutual Research Institute for Safety, Hopkinton, Massachusetts
Senior Research Scientist, 1995 - 2017.

Aerospace Corporation, El Segundo, California
Member of Technical Staff, 1994 - 1995.

General Electric Corporate Research and Development Center, General Electric Company, Niskayuna, New York
Staff Engineer, 1990 - 1993.

Digital Equipment Corporation, Shrewsbury, Massachusetts
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Teaching Experience

Guest Instructor, School of Public Health graduate course EH 241: Occupational safety and injury prevention, Harvard University, 2009-2016.
Guest Instructor, Ergonomics and Human Factors: Applications in Occupational Health, Harvard University, 1998-2012.
Guest Instructor, Advanced Ergonomics, Liberty Mutual Insurance Group, 1996-2010.
Guest Instructor, Certified Safety Professional Review, Harvard University, 1997-98.
Teaching Assistant at University of California, Berkeley - Dynamics and Statics, 1982, 1983.
Instructor at Chinese Military Academy - Design of Machine Element and Strength of Materials, 1979-81.

Publications

Journal Papers

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11. TK Courtney, YH Huang, SK Verma, **WR Chang**, KW Li, A Filiaggi, 2005, Factors Influencing US Worker Perception of Floor Slipperiness, the UK Ergonomics Society Annual Conference, Hatfield, UK, April 5 - 7.

12. **WR Chang**, KW Li, YH Huang, A Filiaggi, TK Courtney, 2005, Using Objective and Subjective Measures to Assess Floor Slipperiness in Fast-Food Restaurants in Taiwan, XVIIth World Congress on Safety and Health at Work, Orlando, Florida, September 18 - 22.

13. **WR Chang**, CC Chang, 2005, The Probability of a Slip at the Base of Portable Ladders, XVIIth World Congress on Safety and Health at Work, Orlando, Florida, September 18 - 22.

14. **WR Chang**, S Matz, CC Chang, 2008, The Stochastic Distribution of Available Friction Coefficient for Human Locomotion, National Occupational Injury Research Symposium, National Institute for Occupational Safety and Health, Pittsburgh, USA, October 21 - 23.

15. CC Chang, MF Lesch, **WR Chang**, 2008, Assessing Floor Slipperiness: the Effects of Friction and Perception on Gait, National Occupational Injury Research Symposium, National Institute for Occupational Safety and Health, Pittsburgh, USA, October 21 - 23.

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17. S Verma, **WR Chang**, TK Courtney, D Lombardi, YH Huang, M Brennan, M Perry, 2008, Design, Evaluation of Multi-Modal Methods to Follow-up Multilingual Fast-Food Workers in a Prospective Cohort Injury Study, National Occupational Injury Research Symposium, National Institute for Occupational Safety and Health, Pittsburgh, USA, October 21 - 23.

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19. CC Chang, **WR Chang**, MF Lesch, 2009, Gait During Continuous Walking: Impact of Friction, Surface Condition, and Perception, International Society for Posture & Gait Research (ISPGR) Conference, June 21-25, Bologna, Italy.

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21. **WR Chang,** S Matz, CC Chang, 2011, An Investigation of Stochastic Distribution of Required Coefficient of Friction for Level Walking, National Institute for Occupational Safety and Health, Morgantown, WV, USA, October 18 - 20.

22. **WR Chang,** S Matz, CC Chang, 2012, A Comparison of Required Coefficient of Friction for Both Feet in Level Walking, 4th International Conference on Applied Human Factors and Ergonomics, San Francisco, USA, July 21 - 25.

23. **WR Chang,** CC Chang, MF Lesch, S Matz, 2015, Factors Affecting the Utilized Coefficient of Friction, National Institute for Occupational Safety and Health, Kingwood, WV, USA, May 19 - 21.

Invited Presentations

1. **WR Chang**, 2005, Preventing Slips at the Bases of Portable Ladders, Department of Mechanical Engineering, National Chung-Hsing University, Taichung, Taiwan.

2. **WR Chang**, 2006, Assessing Slipperiness in Fast-Food Restaurants in the USA Using Friction Variation, Average Friction and Perception Ratings, National Institute for Occupational Safety and Health, Morgantown, WV, USA.

3. **WR Chang**, 2007, Occupational Biomechanics: Applications in Manual Material Handling, and Slips, Trips and Falls, Department of Industrial Engineering, National Tsing-Hua University, Hsinchu, Taiwan.

4. **WR Chang**, 2009, Preventing Slips at the Bases of Portable Ladders, the XXIst Annual International Occupational Ergonomics and Safety Conference, International Society for Occupational Ergonomics and Safety, Dallas, USA, June 11 - 12. (**keynote address**)

5. **WR Chang**, 2009, Multidisciplinary Approaches to Reduce Slip and Fall Incidents, International Ergonomics Conference 2009 Humanizing Work and Work Environment, Kolkata, India, December 17 – 19. (**keynote address**)

6. **WR Chang**, 2010, Slips, Trips and Falls at Work: Research and Prevention, American Society of Safety Engineers (ASSE) Boston Chapter Meeting.

7. **WR Chang**, 2011, Multidisciplinary Approaches for Measuring Slipperiness, National Chung Cheng University, Minsyong, Chiayi, Taiwan.

8. **WR Chang**, 2011, Standards, Practices and Recent Research on Slips, Trips and Falls, Institute of Occupational Safety and Health, Sijhih, Taipei, Taiwan.

9. **WR Chang**, S Leclercq, R Haslam, T Lockhart, 2013, The State of Science on Occupational Slips, Trips and Falls on the Same Level, The Proceedings of the International Conference on Fall Prevention and Protection 2013, National Institute of Occupational Safety and Health, Japan (JNIOSH), Tokyo, pp. 33 - 40. (**keynote address**)

10. **WR Chang**, 2014, Multidisciplinary Approaches for Measuring Slipperiness, University of Illinois at Urbana-Champaign.

11. **WR Chang**, 2014, Multidisciplinary Approaches for Measuring Slipperiness, National Tsing Hua University, Hsinchu, Taiwan.

12. **WR Chang**, 2014, Slips, Trips and Falls at Work: Research and Prevention, Occupational Safety and Health Council and Hong Kong Ergonomics Society, Hong Kong.

<u>Honors & Awards</u>

Fellow, International Ergonomics Association (IEA), 2016
Fellow, American Society of Mechanical Engineers (ASME), 2005
Fellow, The Institute of Ergonomics and Human Factors (formerly known as The Ergonomics Society), UK, 2006
William Floyd Award, The Institute of Ergonomics and Human Factors (formerly known as The Ergonomics Society), 2003
The National Occupational Research Agenda (NORA) Partnering Award for Worker Health and Safety, The National Institute for Occupational Safety and Health (NIOSH), 2006
The Best Paper Award in *Ergonomics,* 2009 (JL Bell, JW Collins, L Wolf, R Grönqvist, SS Chiou, **WR Chang**, GS Sorock, TK Courtney, DA Lombardi, B Evanoff, 2008, Evaluation of a Comprehensive Slip, Trip, and Fall Prevention Program for Hospital Employees, *Ergonomics*, 51 (12), 1906-1925.)
The Outstanding Alumni Award, National Chung-Hsing University, Taiwan, 2006
The Distinguished Alumni Award, College of Engineering, National Chung-Hsing University, Taiwan, 2011
Bravo Award, Liberty Mutual Group, 2002
Recognition Award, Digital Equipment Corporation, 1987
Summa Cum Laude, National Chung-Hsing University, 1979

<u>Professional Memberships/Activities</u>

The Institute of Ergonomics and Human Factors (formerly known as The Ergonomics Society), UK
Member
American Society of Mechanical Engineers (ASME)
Member
Human Factors and Ergonomics Society (HFES, USA)
Member
American Society of Testing and Materials (ASTM)
Member-at-large (2012-2015), ASTM Committee F-13 on Pedestrian/Walkway Safety and Footwear
Member, ASTM Committee D-21 on Polishes
Founder, Chair (2006-2012) and Past Chair (2012-present), the Technical Committee on Slips, Trips and Falls, International Ergonomics Association
Technical Editor of slip, trip and fall contact group website: www.slipstripsfalls.org

<u>Conferences Organized</u>

Organizer, An International Symposium on the Measurement of Slipperiness, Liberty Mutual Research Institute for Safety, Hopkinton, Massachusetts, USA, July 27-28, 2000.

Convenor, An International Symposium on Slip, Trip and Fall Accidents (3 sessions), the 14th Triennial Congress of the International Ergonomics Association (IEA), San Diego, USA, July 31 – August 4, 2000.

Organizer, Special Sessions on Slip, Trip and Fall Accidents (3 sessions), National Occupational Injury Research Symposium, National Institute for Occupational Safety and Health, Pittsburgh, USA, October 17-19, 2000.

Organizer, A Special Session on Slip, Trip and Fall Accidents, The 6th Pan-Pacific Conference on Occupational Ergonomics, Beijing, China, August 21 - 24, 2001.

Organizer, Special Sessions on Slip, Trip and Fall Accidents (3 sessions), the XVIth International Annual Occupational Ergonomics and Safety Conference '2002, The International Society for Occupational Ergonomics and Safety (ISOES), Toronto, Canada, June 9-12, 2002.

Organizer, An International Symposium on Slip, Trip and Fall Accidents (4 sessions), the 15th Triennial Congress of the International Ergonomics Association (IEA), Seoul, Korea, August 25 – 29, 2003.

Organizer, An International Symposium on Slip, Trip and Fall Accidents (20 papers), The Ergonomics Society Annual Conference, Swansea, UK, April 14 – 16, 2004.

Organizer, An International Symposium on Slip, Trip and Fall Accidents (31 papers), The Ergonomics Society Annual Conference, Hatfield, UK, April 5 – 7, 2005.

Organizer, An International Symposium on Slip, Trip and Fall Accidents (6 sessions), the 16th Triennial Congress of the International Ergonomics Association (IEA), Maastricht, the Netherlands, July 10 – 14, 2006.

Organizer, The International Conference on Slips, Trips and Falls 2007: From Research to Practice, The IEA Technical Committee on Slips, Trips and Falls, 39 papers, 7 sessions, Hopkinton, MA, USA, August 23-24, 2007.

Organizer, An International Symposium on Slip, Trip and Fall Accidents, 22 papers and a field trip to visit the Health Safety Laboratory (HSL), The Ergonomics Society Annual Conference, Nottingham, UK, April 1 – 3, 2008.

Organizer, An International Symposium on Slip, Trip and Fall Accidents, 25 papers and Member of Program Committee, 17th Triennial Congress of the International Ergonomics Association (IEA), Beijing, China, August 9 – 14, 2009.

Chair, Scientific Committee on Slips, Trips and Falls, The 2010 International Conference on Fall Prevention and Protection, Morgantown, WV, USA, May 19 – 20.

Co-chair and co-organizer, the International Conference on Slips Trips and Falls, Health and Safety Laboratory, Buxton, UK, 29 presentations, April 6 – 8, 2011.

Co-chair and co-organizer, the International Conference on Stairway Usability and Safety, Toronto, June 9 – 10, 2011.

Organizer, An International Symposium on Slip, Trip and Fall Accidents and Member of Program Committee, 18th Triennial Congress of the International Ergonomics Association (IEA), Recife, Brazil, February 12 – 16, 2012.

Member of Technical Programme Committee, Ergonomics and Human Factors 2012 International Conference, the Institute of Ergonomics and Human Factors, Blackpool, UK, April 16-19.

Member of Technical Programme Committee, Ergonomics and Human Factors 2013 International Conference, the Institute of Ergonomics and Human Factors, Cambridge, UK, April 15-18.

Co-chair and co-organizer, the International Conference on Fall Prevention and Protection 2013, the National Institute for Occupational Safety and Health, Japan (JNIOSH), Tokyo, Japan, 41 presentations, October 23 – 25.

Member of Technical Programme Committee, Ergonomics and Human Factors 2014 International Conference, the Institute of Ergonomics and Human Factors, Southampton, UK, April 7-10.

Member of International Advisory Committee, the 4th International Conference on Healthcare Systems Ergonomics and Patient Safety, Taipei, Taiwan, June 23-26, 2014.

Member of Technical Programme Committee, Ergonomics and Human Factors 2015 International Conference, the Institute of Ergonomics and Human Factors, Daventry, UK, April 13 – 16.

Organizer, An International Symposium on Slip, Trip and Fall Accidents and Member of Program Committee, 19th Triennial Congress of the International Ergonomics Association (IEA), Melbourne, Australia, August 9 – 14, 2015.

Member of Technical Programme Committee, Ergonomics and Human Factors 2016 International Conference, the Institute of Ergonomics and Human Factors, Daventry, UK, April 19 – 21.

Member of Technical Programme Committee, Ergonomics and Human Factors 2017 International Conference, the Institute of Ergonomics and Human Factors, Daventry, UK, April 25 – 27.

Editorial Service

Measuring Slipperiness- Human Locomotion and Surface Factors (ed. **WR Chang**, TK Courtney, R Grönqvist, MS Redfern), Taylor & Francis, London, ISBN 0-415-29828-8, 2003.

Editor
- *Ergonomics* (2010-present)

Member of Editorial Board
- *Ergonomics* (2006-2010)
- *Applied Ergonomics* (2014-present)
- *Safety Science* (2011-present)
- *Journal of Testing and Evaluation*

Guest Editor
- *Ergonomics*, A Special Issue on the Measurement of Slipperiness, Vol. 44, No. 13, 2001, and a Special Issue on Slips, Trips and Falls, Vol. 51, No. 12, 2008.
- *Safety Science,* Special Issues on Slips, Trips and Falls Accidents, Vol. 40, No. 7-8, 2002 and Prevention of Fall-Related Accidents, Vol. 43, No. 7, 2005.
- *Industrial Health*, A Special Issue on Slips, Trips and Falls, Vol. 46, No. 1, 2008 and Global Cooperation for Preventions of STFs, Vol. 52, No. 5, 2014.

Associate Editor
- *Lubrication Engineering* published by Society of Tribologists and Lubrication Engineers (STLE) (1992-1994)

Reviewer
- *Accident Analysis and Prevention*
- *Age UK*
- *Applied Ergonomics*
- *Ergonomics*
- *Human Factors*
- *Human Factors and Ergonomics in Manufacturing and Service Industries*
- *International Journal of Industrial Ergonomics*
- *International Journal of Injury Control and Safety Promotion*
- *International Journal of Non-Linear Mechanics*
- *International Journal of Occupational Safety and Ergonomics*
- *Journal of Biomechanics*
- *Journal of NeuroEngineering and Rehabilitation*
- *Journal of Occupational and Environmental Hygiene*

Journal of Safety Research
Journal of Testing and Evaluation
Journal of Tribology
Material and Structure
Perspectives in Public Health
Safety and Health at Work
Safety Science
STLE *Tribology Transactions*
Tsinghua Science and Technology

Dissertation Committee

Santosh Kumar Verma, Risk Factors for Slipping in US Limited-service Restaurant Workers, Doctor of Science, Department of Environmental Health, School of Public Health, Harvard University, Boston, MA, USA, 2010.

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29 November 2011

To: Russ Kendzior, NFSI
From: Drew Troyer
CC:
RE: Project to Establish Standard COF Values for ASTM F2508-11 Standard Tiles

Executive Summary

At the request of NFSI, I supervised a process to establish standard COF values for the ASTM F2508-11 standard reference tiles. The purpose of the study is to establish reference DCOF values for the ASTM F2508-11 reference tiles using the DIN EN51131 method for measuring DCOF to support of the NFSI inter-laboratory study (ILS) to confirm repeatability and reproducibility of walkway tribometers used for laboratory and field testing. Then, expanding upon the DCOF testing using the DIN standard method, establish SCOF measurements for the ASTM reference tiles using the preferred NFSI method. ASTM F2508-11 is limited to evaluating the tribometer's discriminant validity. No standard DCOF and/or SCOF values are assigned to the reference standards. It is the opinion of the NFSI that the best way to establish "truth" for the ILS is by evaluating the ASTM standard materials using the DIN standard method.

Our study, which was conducted at the NFSI laboratory in South Lake, TX on 28 November 2011, had the following objectives:

1. Establish standard DCOF values for the ASTM F2508-11 tiles marked "B", "C" and "D" per the DIN EN51131 standard using the German GMG walkway tribometer.

2. Run a parallel trial with the BOT 3000 walkway tribometer and, if the two measures correlated strongly, utilize the BOT 3000 to measure the consistency between the eight ASTM F2508-11 reference trials used in the validation study. It was deemed necessary to utilize another instrument to evaluate the consistency between the individual reference tiles because the GMG tribometer and the DIN EN51131 standard require a minimum 50 cm testing pathway, which is larger than the standard 12" X 12" reference tiles supplied by ASTM. The BOT 3000 is the only NFSI-approved tribometer that can functionally evaluate the DCOF of a 12" X 12" tile, so it was the default choice.

3. Once DCOF measures were established, determine the SCOF using the NFSI UWT 3000 walkway tribometer.

Sigma Reliability solutions

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My conclusions are as follows:

1. The study established highly consistent DCOF values for ASTM F2508-11 “B”, “C” and “D” reference tiles employing the DIN EN51131 standard method and the GMG tribometer. The data were normally distributed and the coefficient of variation was low.

2. The study established a very tight correlation between the GMG method and the BOT 3000 when the 32” testing pathway was selected with the BOT to mimic the 50 cm pathway of the GMG device. As such, the BOT was determined to be a suitable tool for evaluating the DCOF of individual tiles.

3. The variation from tile to tile on the eight (08) ASTM F2508-11 standard reference materials supplied for the study was significant. It is my opinion that the standard reference tiles can’t statistically be called “identical” due to the high levels of tile-to-tile variation.

4. The Universal Walkway Tester (UWT) methodology was found to be suitable for testing SCOF on ASTM reference tiles “B” and “D”, but not for ASTM reference tile “C”.

My recommendations:

1. For the purpose of completing the NFSI DCOF ILS, establish standards values of validity for the ASTM standard tiles “B”, “C” and “D” when testing DCOF using the exact same tiles used in this study if they are configured exactly as they were configured for this study.

2. Schedule a meeting to discuss the selection of a single reference tile form ASTM reference tiles groups “B”, “C” and “D” for the purpose of completing the NFSI DCOF ILS.

3. Find another material to replace the ASTM “C” reference tile for the purpose of completing the SCOF ILS study. Perhaps ASTM reference tile “A” would prove to be a suitable candidate to fill the position of the third tile for the NFSI SCOF ILS.

4. Investigate the reasons behind the high degree variability observed among the ASTM F2508-11 “B”, “C” and “D” reference tiles.

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Testing Configuration

DCOF Testing

1. Each group of eight (08) tiles were numbered one thru eight and configured into a test rig as pictured below.

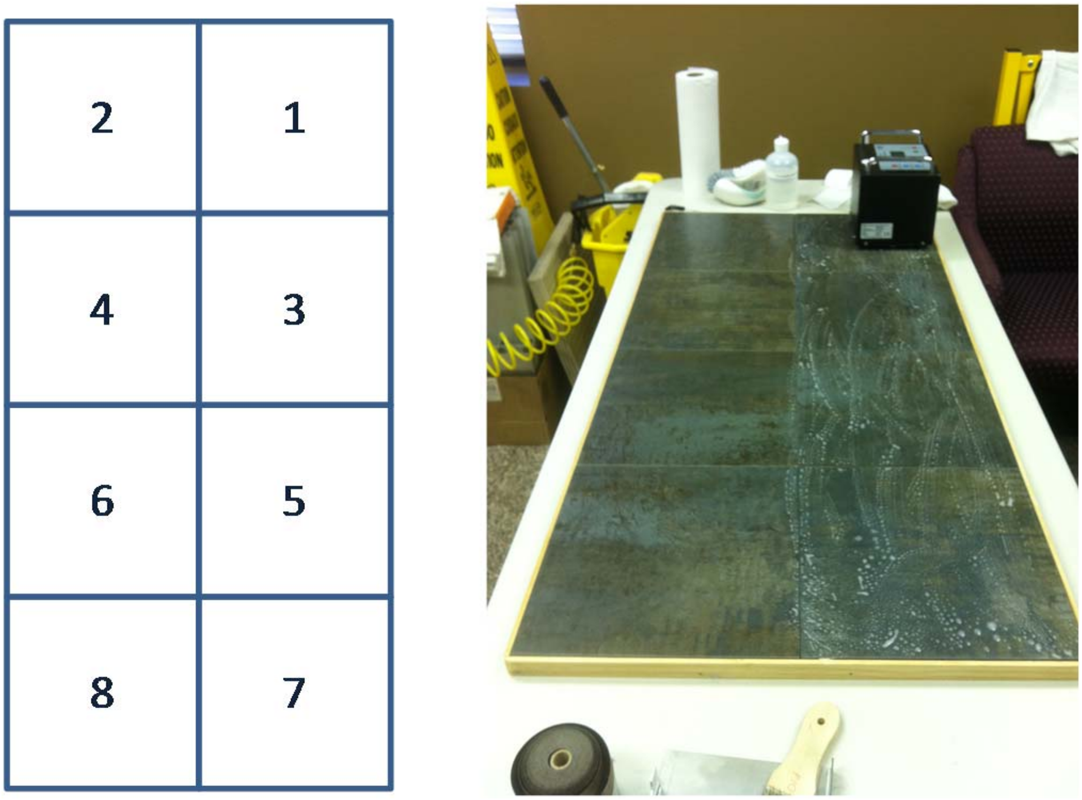

Figure 1 - Photo and configuration of the test rig used for DCOF testing.

2. Using a standard factory GMG tribometer and testing per the DIN EN51131 method, 30 readings were taken for each set of ASTM F2508-11 reference tiles. A total of 15 readings were taken from the odd tiles, moving in the direction from tile one toward tile seven and 15 readings were taken from the even tiles, moving in the direction from tile two toward tile eight.

3. The testing process in item 2 above was repeated using the BOT 3000 tribometer. For this round of testing, the BOT 300o was set for a 32" testing pathway to closely mimic the 50 cm testing pathway used by the GMG.

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4. In all cases, the lubricant was a 0.1% solution of sodium laurel sulfate and distilled water. The manufacturer's directions were followed for the use of each instrument. SBR rubber was used as the slider material in all cases.

5. Data were analyzed to determine if the GMG provided similar readings and similar levels of variation.

6. After confirming that the GMG and BOT 3000 provide similar readings and levels of variation, evaluate each tile individually using the BOT 3000 to determine consistency from tile to tile.

7. Analyze all data, to include:
    a. Univariate statistics
    b. Analysis of Variance (ANOVA) to determine consistency within ASTM standard reference tile groups.
    c. Time series analysis to identify drift.

<u>DCOF Testing Analysis</u>

Univariate analysis of the data revealed the following:

1. The standard DCOF value for ASTM F2508-11 reference tile "B" is 0.2143 per the DIN EN51131 testing methodology.

2. The standard DCOF value for ASTM F2508-11 reference tile "C" is 0.366 per the DIN EN51131 testing methodology.

3. The standard DCOF value for ASTM F2508-11 reference tile "D" is 0.759 per the DIN EN51131 testing methodology.

4. The data are believed to be normally distributed due to the closeness between the mean and median values.

5. The variation is acceptably low given the materials and the nature of the testing.

6. The similar values and, more importantly, similar levels of variation between the GMG tribometer and the BOT 3000 tribometer qualify the BOT 3000 as a suitable method for evaluating the variation within ASTM reference tile groups.

7. The correlation of the mean values between the GMG and BOT 3000 was good, but more data points comparing the two techniques on a wider range of tiles would be more revealing about the correlation.

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The results of the univariate statistical analysis are summarized in the following figure:

ASTM F2508-11 Reference Tile	**Observation**	**GMG**	**BOT**
Tile B	Mean	0.2143	0.2136
	Median	0.21	0.22
	StDev	0.020	0.021
Tile C	Mean	0.366	0.323
	Median	0.36	0.32
	StDev	0.077	0.016
Tile D	Mean	0.759	0.738
	Median	0.755	0.74
	StDev	0.018	0.026

Figure 2 - Summary of univariate statistics for DCOF testing.

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The correlation between the GMG and the BOT 3000 is summarized in the following graphic:

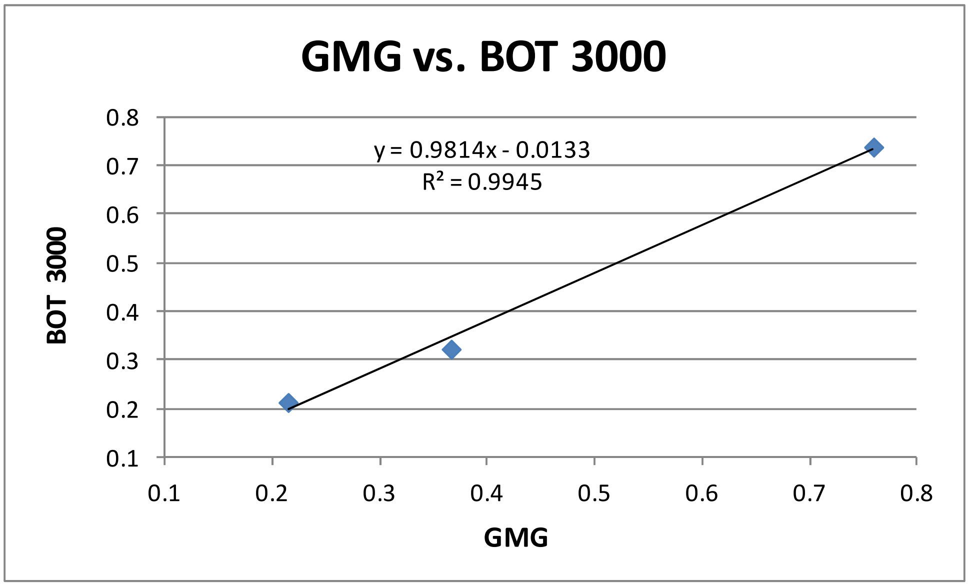

Figure 3 - Correlation between the GMG and BOT 3000 tribometers.

Analysis of Variance (ANOVA) revealed the following:

In sum, these tiles are all very different when tested individually. The ASTM F2508-11 “B” reference tiles exhibited a DCOF range from 0.186 to 0.29. The standard deviation within tile groups was similar to what was observed when running the tests with the 32” testing path length. The ANOVA revealed a very significant difference between tiles, with a p-value that is six significant digits right of the decimal point (figure 4).

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Groups	*Count*	*Sum*	*Average*	*StDev*	*Variance*	
Tile B1	5	1.28	0.256	0.047749	0.00228	
Tile B2	5	0.93	0.186	0.023022	0.00053	
Tile B3	5	1.02	0.204	0.035071	0.00123	
Tile B4	5	1.41	0.282	0.019235	0.00037	
Tile B5	5	1.33	0.266	0.026077	0.00068	
Tile B6	5	1.42	0.284	0.027019	0.00073	
Tile B7	5	1.45	0.29	0.02	0.0004	
Tile B8	5	1.27	0.254	0.018166	0.00033	
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.051198	7	0.007314	8.933043	4.55E-06	2.312741
Within Groups	0.0262	32	0.000819			
Total	0.077398	39				

Figure 4 - ANOVA for ASTM F2508-11 "B" reference tiles.

The ANOVA for the ASTM F2508-11 “C” tiles was even less encouraging. The average ranged from 0.234 to 0.352. Again, the standard deviation within tiles was similar to what was observed when testing using the 32” testing path length. The ANOVA showed even stronger difference from tile to tile than what was observed for the “B” group of tiles, with a p-value that is 11 significant digits right of the decimal point (figure 5).

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Groups	*Count*	*Sum*	*Average*	*StDev*	*Variance*	
Tile C1	5	1.32	0.264	0.023022	0.00053	
Tile C2	5	1.45	0.29	0.012247	0.00015	
Tile C3	5	1.48	0.296	0.030496	0.00093	
Tile C4	5	1.57	0.314	0.005477	3E-05	
Tile C5	5	1.54	0.308	0.010954	0.00012	
Tile C6	5	1.76	0.352	0.017889	0.00032	
Tile C7	5	1.17	0.234	0.011402	0.00013	
Tile C8	5	1.75	0.35	0.014142	0.0002	
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.05612	7	0.008017	26.61292	1.25E-11	2.312741
Within Groups	0.00964	32	0.000301			
Total	0.06576	39				

Figure 5 - ANOVA for ASTM F2508-11 "C" reference tiles.

The results were similar for the ASTM F2508-11 “D” reference tiles. Again, the standard deviation within each tile was low – similar to what was observed using the 32” testing path length. Again, the mean values of the individual tiles varied greatly, ranging from 0.666 to 0.806. ANOVA for the “D” reference tiles revealed a p-value of 21 significant digits right of the decimal point (figure 6).

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Groups	Count	Sum	Average	StDev	Variance	
Tile D1	5	3.51	0.702	0.008367	7E-05	
Tile D2	5	3.33	0.666	0.008944	8E-05	
Tile D3	5	3.51	0.702	0.010954	0.00012	
Tile D4	5	3.77	0.754	0.008944	8E-05	
Tile D5	5	3.36	0.672	0.013038	0.00017	
Tile D6	5	3.87	0.774	0.005477	3E-05	
Tile D7	5	4.03	0.806	0.015166	0.00023	
Tile D8	5	3.35	0.67	0.01	0.0001	
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.099057	7	0.014151	128.6461	1.36E-21	2.312741
Within Groups	0.00352	32	0.00011			
Total	0.102578	39				

Figure 6 - ANOVA for ASTM F2508-11 "D" reference tiles.

Discussion About DCOF Testing

While we have established “True” DCOF values for ASTM F2508 “B”, “C” and “D” reference materials, it is my conclusion that based on the ANOVA, NFSI either received some flawed reference tiles or that there is a control issue with respect to the COF for the ASTM F2508-11 reference tiles. Clearly, the matter deserves more research an analysis, but with such strong p-values for the ANOVA, it is my opinion that these reference tiles exhibit too much item-to-item variability to be utilized individually. Even when taken as a group, without further testing, I can’t say that if we reconfigured the tiles and repeated the validation test using the GMG that we’d get the same values observed in this study. And, that would preclude the validation of tribometers that can’t run a testing path length of close to 50 cm Moreover, the present study didn’t control for any possible directional bias as the ASTM reference tiles failed to identify “North” for the material. If a directional bias exists, the manner in which the tiles are oriented could conceivably affect the outcome of an ILS to establish the repeatability and reproducibility of a walkway tribometer.

SCOF Testing

Because the NFSI standard method for SCOF is a short path-length measurement, the following ASTM F2508-11 reference tiles were selected for SCOF testing: B8, C4 and D1. They were selected based upon their low standard deviation on the DCOF testing and for their closeness to the overall reference values. For each of the three selected reference tiles, 30 data points were collected for each selected reference

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material using the UWT 3000 tribometer using a Neolite slider and distilled water as the lubricant. Univariate statistics are summarized in figure 7.

ASTM F2508-11 Reference Tile	Mean	Median	StDev
B8	0.566	0.57	0.02
C4	0.989	1.00	0.015
D1	0.958	0.96	0.030

Figure 7 - SCOF readings for the three selected reference tiles.

Discussion

Except for tile C4, the data were normally distributed and exhibited an acceptable coefficient of variation for the material and testing method. The method is not suitable for the ASTM F2508-11 "C" material. In 16 of the 30 observations, the readings reached 1.00 – the maximum SCOF for the UWT 3000 instrument. As such, no true reading can be established. Figure 8 illustrates the SCOF and DCOF values for the individual tiles reviewed.

ASTM F2508-11 Reference Tile	SCOF	DCOF	SCOF/DCOF
B8	0.566	0.254	2.22
C4	0.989	0.314	3.14
D1	0.958	0.702	1.36

Figure 8 - SCOF versus DCOF comparative values.

I am available to discuss these data and my analysis at your convenience.

Regards,

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04 April 2012

To: Peter Kendzior
National Floor Safety Institute (NFSI)
From: Drew Troyer
CC: Stacey McCauley
RE: NFSI Interlaboratory Study (ILS) Process

Russ,

This memo is confirming our conversation this morning and our agreement that the NFSI ILS process for a walkway tribometer has formally been modified to include a Gage Repeatability and Reproducibility (Gage R&R) method for evaluating the reproducibility among tribometer/operator combinations (Labs).

It was out intention to encapsulate the relevant aspects of the ASTM E691 Standard Practice for Conducting and Interlaboratory Study to Determine the Precision of a Test Method. On my recommendation, we selected the very rigorous Analysis of Variance (ANOVA) method for evaluating the reproducibility of a walkway tribometer. I suggested this method because of the safety-critical nature of measuring the slip-resistance of pedestrian walkways. While I'm experienced in measurement and tribology, I'm somewhat new to the field of walkway tribometry. As such, I've learned that the given the current state-of-the-art, the ANOVA-based approach is not feasible and will impede progress toward NFSI's real goal of improving walkway safety. The reasons include:

1. Tremendous variation in walkway surface materials. When I proposed the ANOVA-based approach, I assumed that the materials specified in ASTM F2508-11 would offer a tremendous amount of uniformity. Through empirical observation, I've discovered that the reference materials provided by the ASTM vary tremendously from tile to tile when tested under controlled conditions. Moreover, there is a great degree of directional bias and even bias when sweeping different parts of the same material in the same direction.
2. Variation in slider material. While I've not researched this as extensively as the walkway surfaces themselves, I strongly believe that there is difficult-to-control variation in the material.
3. Tribometer to tribometer variations. A tribometer is a relatively complex mechanism designed to measure resistive forces between the variable slider and variable floor material.

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There is bound to be some degree in variation in the mechanics of these devices, the scope of which is beyond my current investigation.

4. Lubricant variations. Lubricants are water or water with a surface tension lowing additive. We can't be certain about the consistency of this material from batch to batch. Again, that's beyond the scope of this present investigation.

Based upon all these factors and my empirical observations pertaining to their effect, and per our discussions, the ILS process has been modified to include the following elements:

A. Pass-Fail Test for Validity and Repeatability. Per the spirit of ASTM E691, for each of the three standard surface materials, six "labs" shall be constructed from three tribometer instruments and two users. Each instrument shall be calibrated to NFSI standard reference materials. Each lab shall conduct 11 observations, for a total of 66 observations, on each of the three NFSI reference materials. To avoid complex data editing processes, the two highest and two lowest readings from the group of 66 shall be excluded, leaving 62 observations. At the 95% confidence level, the instrument must correctly measure the 62 observations within the confidence limits set forth by the NFSI (statistically derived from NFSI's reference "golden" tribometers). Any reading outside of that range shall constitute a failure.
B. Repeatability and Reproducibility – In lieu of the aforementioned ANOVA-based approach, the NFSI shall adopt a suitable variation of ASTM F1469-11 – Standard Guide for Conducting a Repeatability and Reproducibility Study on Test Equipment for Nondestructive Testing. This is commonly referred to the "Gage R&R" test. It is valid and appropriate for walkway tribometers, but not as statistically challenging as the ANOVA R&R. Given the nature of the testing process and associated materials, it is the appropriate approach, as we discussed.
C. ANOVA-based differentiation between tested materials. Using Reference Surfaces, the ILS shall require an ANOVA to ensure that a tribometer can differentiate between reference material that range from low to high COF values. This ANOVA shall not evaluate the performance of multiple instruments on a single surface, which as previously stated, is too onerous. Rather, it will confirm the technology's ability to differentiate between different reference surfaces with a required p-value < 0.05.

Two of the reference materials employed are specified in ASTM F2508-11 Standard Practice for Validation and Calibration of Walkway Tribometers – Tiles ASTM-B and ASTM-D. Tiles ASTM-A and ASTM-C were deemed unsuitable for the following reasons:

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1. ASTM-A was deemed unsuitable because the ASTM standard requires a specific lubricant that does not comply with ANSI/NFSI B101.1 or ANSI/NFSI B101.3. Moreover, ASTM-A is a natural material and is, therefore much more variable from tile-to-tile.
2. ASTM-C was deemed unsuitable because of its unusually high differential between DCOF and SCOF, which is believed to be attributable to stiction due to chemical bonding activity between the slider and surface materials. As such, it was replaced with a Formica material that is commonly available.

I understand that the German Statutory Accident Insurance Institute (DGUV) working in conjunction with the University of Wuppertal is experiencing similar problems of inter- and intra-tile variation. It is my hope that in the future we can restore the ANOVA-based R&R approach once suitable reference materials can be located.

I hope this document clearly summarizes our agreed upon plan of action based upon the significant amount of data that we've analyzed to date. I'm available for discussion and comments at your convenience.

All the best,

Drew D. Troyer, CRE

Standard Method for Conducting an Interlaboratory Study (ILS) to Establish Repeatability and Reproducibility of a Walkway Tribometer Measuring Wet Dynamic Coefficient of Friction (DCOF) for a Common Hard-Surface Walkway

1.1 Scope

This method specifies the procedure for conducting an inter-laboratory study (ILS) for a walkway tribometer used to measure the wet dynamic coefficient of friction (DCOF) of common hard-surface floor materials.

1.2. Purpose

This test method evaluates the validity, repeatability and reproducibility of instruments and methods employed to evaluate the wet DCOF of common hard-surface floor materials across a typical traction range.

1.3 Application

This ILS for evaluating test methods used to evaluate walkway traction does not apply to carpeting of any type or mechanically polished tile such as polished porcelain, marble, etc., but does address common hard-surface flooring materials such as ceramic tile, vinyl floor coverings, and wood laminates, as well as coatings, polishes, etc.

Note: The ILS for evaluating test methods used to evaluate walkway traction 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, for which instrument performance is evaluated by this ILS methodology set forth herein, in terms of slip resistance.

1.4 Exceptions

The ILS set forth herein does not pertain to methods employed for dry-surface testing.

Section 2: Reference to other Standards and Publications

ANSI/NFSI B101.1-2009 – Test Method for Measuring the Wet DCOF of Common Hard-Surface Floor Materials.

ANSI/NFSI B101.3-2012 Test Method for Measuring Wet DCOF of Common Hard-Surface Floor Materials (Including Action and Limit Thresholds for the Suitable Assessment of the Measured Values)

ASTM D297-93(2006) Standard Test Method for Rubber Products – Chemical Analysis

ASTM D2240-05 Standard Test Method for Rubber Property – Durometer Hardness

ASTME691-92 Standard Practice for Conducting and Interlaboratory Study to Determine the Precision of a Test Method

ASTM F1646-03 Standard Terminology Relating to Safety and Traction of Footwear

Section 3: Definitions

3.1 Analysis of Variance (ANOVA). A statistical technique that separates systematic variation that is attributable to the operator and/or testing instrument from random variation.

3.2 Friction. Resistance to the relative motion of two solid objects in contact. This force is parallel to the plane of contact and is perpendicular to the normal force.

3.3 High Traction. The physical property of a floor or walkway that is designed to mitigate slipping during normal human ambulation by providing a reasonably sufficient level of available contact friction.

3.4 Interlaboratory Study (ILS). A controlled study designed to evaluate the consistency of two or more laboratories purporting to measure the same object or phenomenon.

3.5 Laboratory. A combination of instrument, method and person or persons used to evaluate the wet DCOF of a flooring material.

3.6 Low Traction. The physical property of a floor or walkway that provides a comparatively low level of available friction, thus increase the risk of slipping during normal human ambulation.

3.7 Moderate Traction. The physical property of a floor or walkway that provides a moderate level of available friction, thus creating a moderate risk of slipping during normal human ambulation.

3.8 Normally Trained Operator. A tribometer operator who has received normal training on the operation of the walkway tribometer under review, but who does not possess expert-level knowledge on tribology and/or the specific tribometer being evaluated by the ILS.

3.9 P-Value. A statistical term that, for the purpose of this standard, quantifies the likelihood that variability in DCOF readings can be attributed to the use of different examples of the same tribometer instruments and/or different normally trained operators. For this ILS, a p-value < 0.1. constitutes an unacceptable degree of user and/or instrument-related variation.

3.10 Repeatability. Or, test-re-test reliability, is the variation in measurements taken by a single person or instrument on the same item and under the same conditions. Repeatability conditions include the same measurement procedure, the same observer, the same measuring instrument, used under the same conditions, the same location and repetition over a short period of time.

3.11 Reproducibility. Refers to the ability of a test or experiment to be accurately reproduced, or replicated, by independent parties evaluating the same material(s) under the same conditions.

3.12 Slip Resistance. The property of a floor or walkway surface that acts in sufficient opposition to those forces and movements exerted by a pedestrian under normal conditions of human ambulation.

3.13 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.

3.14 Dynamic Friction. The resistance opposing the force required to perpetuate the movement of one surface over another.

3.15 Traction. The friction between the sole material of a shoe and the fixed surface it moves upon.

3.16 Walkway Tribometer. An instrument or device specifically designed to measure the available level of traction upon a floor or walkway.

Section 4: Procedure for the Inter-laboratory Study of a Walkway Tribometer Method

This method for conducting an inter-laboratory study may be utilized to evaluate the performance of any tribometer designed to measure the wet dynamic coefficient of friction (DCOF) of a floor or walkway surface under the conditions specified herein.

4.1 Laboratory. A laboratory shall be defined as the combination of one instrument and one user. ILS participants shall create six (06) unique laboratories by combining three (03) different measurement instruments and two (02) normally trained operators. For the purpose of this ILS, data shall be collected from each instrument/user combination.

4.2 Data Collection. Each method seeking ILS validation shall collect data from each laboratory according to the following guidelines.

4.2.1 Designate a Qualified Observer. A qualified observer is a supplier neutral, third-party observer who is trained and qualified on techniques of measurement for quality assurance - ideally possessing certification as a quality engineer (CQE), reliability engineer (CRE) or quality auditor (CQA) from the American Society for Quality (ASQ). Observer candidates must be approved by the NFSI and shall be required to sign an affidavit as an attest to their neutrality.

4.2.2 Generate and Record Data. Data shall be generated, recorded and submitted to NFSI to the following guidelines:

4.2.2.1 Each of the six laboratories shall collect 64 observations on each of the three (03) standard materials utilizing standard wet DCOF measurement techniques set forth in the walkway tribometer supplier’s operating manual. One material shall be designated “low traction”, one material shall be designated “moderate traction” and one material shall be designated “high traction.” All standardized walkway surface materials shall be provided by the NFSI. All testing shall be conducted in conformance with ANSI/NFSI B101.1-2009 – Test method for Measuring the Wet DCOF of Common Hard Surface Floor Materials.

4.2.2.2 The neutral third-party observer shall confirm that each laboratory is conducting measurements in accordance with the methodologies set forth in the walkway tribometer supplier's operating manual and in compliance with ANSI/NFSI B101.3-2012 Standard.

4.2.2.3 The neutral third-party observer shall record all data on standard data collection forms provided by the NFSI.

4.2.2.4 The NFSI recognizes that mistakes can be made in measuring walkway traction. As such, the user may elect to exclude an observation prior to receiving visual or other sensory feedback about the measurement. Once the value from the observation is known to the user, the value may not be excluded from the data set. It is the responsibility of the third-party observer to decide when an observation may or may not be excluded.

4.2.2.5 The neutral third-party observer shall sign each data collection sheet as an attest to the data collection process, package the twelve (12) sheets into the pre-addressed, pre-paid shipping envelope provided by the NFSI and drop the envelope at an official station designated by the carrier.

Section 5: Method for Analyzing the Data Collected During a Walkway Tribometer Inter-laboratory Study

Upon receipt of data collection forms signed by the neutral third-party observer, NFSI's designated analyst shall evaluate the submitted data and render an official statement about the instrument/method's performance on the ILS.

5.1 Data Editing. For each data set of 64 observations from each of the six (06) laboratories employed to test each of the three (03) materials provided by the NFSI, the two (02) highest readings and the two (02) lowest readings shall be excluded from the data set, leaving a net total 60 observations.

5.2 Data Analysis. To qualify for NFSI recognition as a walkway tribometer, the instrument and method shall perform satisfactorily both on the Pass/Fail Evaluation and the Analysis of Variance (ANOVA) Evaluation.

5.2.1 Pass/Fail Evaluation. The NFSI has set-forth a methodology by which the walkway tribometer's performance in testing standard materials is evaluated using a Pass/Fail test.

5.2.1.1 Pass/Fail Criteria. Pass/fail criteria have been set forth by the NFSI that are approximately +/- 10% of the known value for the tested material. For example, if the wet DCOF for a material is known to be 0.60, any reading that is between 0.54 and 0.66 shall be designated a "Pass." Any reading that falls outside of these bounds shall be designated a "Fail."

5.2.1.2 Required Confidence Level. The NFSI requires that the pass/fail test shall allow for a five percent (5%) likelihood of a false reading and be statistically accurate at the 95% confidence level.

5.2.1.3 Pass/Fail Judgment for a Material. A laboratory shall be deemed to “Pass” in its ability to test a particular flooring material if all 60 observations of the wet DCOF for that material fall within the Pass/Fail criteria bounds set forth by the NFSI. The presence of any outlying observations in the edited data shall constitute a “Fail” for the laboratory/material combination.

5.2.1.4 Pass/Fail Judgment for a Laboratory. A laboratory shall be deemed to “Pass” if all 60 observations of the wet DCOF for each of the three (03) standard designated flooring materials fall within “Pass” category of the Pass/Fail criteria bounds set forth by the NFSI. The presence of any outlying observations in the edited data set shall constitute a “Fail” for the laboratory for the Pass/Fail evaluation.

5.2.1.5 Pass/Fail Judgment for a Walkway Tribometer Methodology. A walkway tribometer method shall be deemed to “Pass” if all observations made by each of the six (06) laboratories on each of the three (03) standard designated flooring materials fall within the pass/fail criteria set forth by the NFSI. The presence of any outlying observations in the edited data set shall constitute a “Fail” for the tribometer methodology for the Pass/Fail evaluation.

5.2.2 Analysis of Variance (ANOVA) Evaluation.

5.2.2.1 Methodology. NFSI shall employ a three-factor ANOVA process to evaluate the performance of each walkway tribometer instrument and method combination in testing materials with high, moderate and low traction. The analysis shall be conducted according to standard and customary statistical techniques. The following table summarizes the experimental design employed for the ANOVA.

		Instrument 1	**Instrument 2**	**Instrument 3**
User 1	NFSI Low Traction Material	60 Observations	60 Observations	60 Observations
	NFSI Moderate Traction Material	60 Observations	60 Observations	60 Observations
	NFSI High Traction Material	60 Observations	60 Observations	60 Observations
User 2	NFSI Low Traction Material	60 Observations	60 Observations	60 Observations
	NFSI Moderate Traction Material	60 Observations	60 Observations	60 Observations
	NFSI High Traction Material	60 Observations	60 Observations	60 Observations

5.2.2.2 Evaluation. The walkway tribometer method shall pass the ANOVA evaluation if the p-value is greater than 0.10, meaning that the likelihood of instrument and/or user interference is less than 10% when testing high or low COF material. A reported p-value of less than 0.10 constitutes a failure.

5.3 Overall Pass/Fail Criteria. The instrument/method shall be deemed to have passed the NFSI inter-laboratory study for a walkway tribometer only if it successfully succeeds in both the Pass/Fail and ANOVA evaluations.

5.4 Waiting Period for Reassessment. In the event that an instrument/method is unsuccessful in its attempt to achieve ILS validation from the NFSI, the supplier may attempt validation after a mandatory waiting period of six (06) months. There is no limit to the number of times ILS validation may be attempted.

Section 6: Report Generated Following Data Analysis for a Walkway Tribometer Inter-laboratory Study

For each instrument/method's submission, a confidential report shall be submitted to the sponsoring organization. The report shall serve to state whether or not the instrument/method passed or failed the NFSI ILS for a Walkway Tribometer. The report shall contain the following details and analysis.

1. A clear statement of overall Pass/Fail status.
    a. If the instrument method/passed, a certificate of confirmation shall accompany the report.
    b. If the instrument/method failed, a concise statement of weaknesses shall be provided so as to enable the supplier to modify the instrument and/or method.
2. Details about the Pass/Fail evaluation data for each instrument/user/material combination.
3. Details about the ANOVA evaluation to test for instrument/method and or user bias in the measurement.

Section 7: Term of Validation

7.1 Standard Term of Certification. If successfully validated by the NFSI inter-laboratory study method, the instrument/method's certification of ILS validation shall be valid for a period of five (05) years, after which to retain its certificate of validation, the instrument must be revalidated according to the then current methodology set forth by the NFSI.

7.2. Provision for Design Change. Any change in the design of a walkway tribometer instrument and/or method that materially alters the core method for measuring the wet DCOF of a walkway material invalidates the certification of ILS validation and the new instrument/method shall require revalidation.

Appendix 1 – Logic for Pass/Fail Analysis for Establishing Repeatability of a Walkway Tribometer

The NFSI opted to use a pass/fail test to establish repeatability of a walkway tribometer. To pass, each laboratory must produce 60 reading that fall within the range specified by the NFSI for a given tile. The logic for requiring 60 observations that fall within the specified range is based upon the following standard equation for determining the sample size of a pass/fail test.

$$n = \frac{\ln(1 - \frac{c\%}{100\%})}{\ln(1-p)}$$

Where:

n = The required number of observations without a "failure," which is an observation that falls outside of the specified parameters
ln = log normal
c% = The required confidence level, in our case 95%
p = Specified p-value – in our case, 0.05

For the pass/fail portion of the ILS for walkway tribometers, the equation is as follows:

$$n = \frac{\ln(1 - \frac{95\%}{100\%})}{\ln(1-0.05)} = 58.40$$

The resultant value of 58.40 was rounded to 60 – a slightly more conservative requirement than that produced by the standard equation. To circumvent complications associated with data editing, it was decided to require a total number of 64 observations per laboratory per tile type. The highest two and lowest two readings are automatically excluded by the data analyst. If the remaining 60 observations fall within the parameters set forth by NFSI for the pass/fail test, the specified laboratory passes for the specified tile. If all laboratory/tile combinations pass, the walkway tribometer passes the pass/fail portion of the ILS to establish repeatability.

Appendix 2 – Analysis of Variance (ANOVA) to Establish Reproducibility for a Walkway Tribometer

Overview

Analysis of Variance, or ANOVA, is a statistical technique employed to differentiate and analyze the significance of systematic variation relative to random variation observed in a sample data set. For the purposes of validating a walkway tribometer under the NFSI Interlaboratory Study (ILS) method, our objective is to differentiate variation specifically related to different tribometer instruments provided by a single supplier and/or different tribometer operators associated with each laboratory. The ANOVA is employed to establish the reproducibility of a walkway tribometer.

Significance to Walkway Tribometer Measurement

A valid walkway tribometer must produce repeatable and accurate results with no significant interference induced by the user or serial number on an instrument provided by a particular supplier. If an unacceptable level of user or instrument interference exists, it could result in false positive (measurements identify a problem when one doesn't actually exist) or false negative (measurements fail to identify a problem when one does actually exist) readings in the field.

Method

For the walkway tribometer ILS study, the ANOVA will compare the variation within the following "treatment" groups to the total amount of variation observed for all observations.

- Operator to Operator Variation
- Instrument to Instrument Variation
- Combined Operator/Instrument to Operator/Instrument Variation

ANOVA employs the Fisher Test, more commonly called the F-Test, which is based upon the Fisher Distribution first developed in the 1920s by Sir Ronald A. Fisher. The F-Test is the ratio of systematic variation to total variation. The result is reported as the p-value, which denotes the probability that the group responsible for systematic variation is the same as the larger sample population. As with most statistical techniques, the p-value penalized when the study includes a small number of observations. A larger sample size affords more "degrees of freedom" to the analysis. For the purpose of the walkway tribometer ILS, a $p\text{-value} < 0.10$ on any of the three treatment groups shall be deemed significant, causing the instrument seeking validation to fail.

Universal Walkway Tester (UWT) Evaluation Project

Purpose: The intent of this study is to evaluate the Universal Walkway Tester (UWT) for accuracy and consistency to assess whether it is a useful measurement tool for use in the field.

Background: The Universal Walkway Tester (UWT) is a robotic slip-resistance tester developed by the National Floor Safety Institute (NFSI) to evaluate the slip resistance of flooring surfaces. It can be used to test dry and wet floors. The device is about the size of a small shoebox and operates off a rechargeable battery. The UWT is integrated with electronics and mechanics and a small printer. It has a digital display, which gives brief test results. It is the first slip-resistance tester that is highly portable. It can be used numerous times on one battery charge. The UWT has four removable test foot sensors which can be inserted into the underside of the device one at a time. Each sensor is imbedded with a chip, which tells the UWT which sensor is installed and how many times it has been used. The two most useful sensors are the leather foot (for dry surfaces) and the neolite rubber foot (for wet surfaces). The UWT can be programmed to simulate other common slip-resistance test devices, such as the James machine. The UWT has two "run" buttons which initiate which program will run. On the test machine, button 1 is programmed with the UWT protocol and button 2 is the James machine protocol. When either button is pressed, the UWT "walks" across the surface and takes several measurements. When it is complete, the display outputs the average slip resistance reading. The user may also obtain a graphic printout by pressing the P button.

Testing Procedure: ES Staff obtained six common floor tile samples from a local home improvement center. Three 12x12 inch tiles of each type were glued to a board to make a 3-foot by 1-foot strip of flooring. No cleaners or polishes were put on the flooring samples. The floor samples are shown in Table 1. Pictures of floor samples are shown in the Appendix.

Table A. Floor Samples

Surface #	Type	Texture
1	Vinyl Composite Tile	Smooth – Dull
2	Ceramic Tile	Very Smooth
3	Vinyl Tile – Linoleum	Textured
4	Ceramic Tile	Textured
5	Vinyl Tile –Linoleum	Textured – Shiny
6	Ceramic Tile	Rough

Each floor surface was tested using the UWT using the Leather (Dry) and Neolite (Wet) sensors. Each test was repeated 10 times, except on surfaces where the friction was too high for the machine to register. The results were averaged. The tests were redone several days later to gage consistency. Results for the UWT are shown in Appendix Tables 1 through 6, columns 2 through 6. The UWT protocol (UWT #1) and James Protocol (UWT #2) were both tested as shown in the table results.

To gage accuracy, ES staff conducted a separate surface test using a sliding block fitted with a leather foot and a neolite rubber foot (See Figure 1). The block was placed on each surface and one end of the surface was raised until the block slid. The surface was wet for the neolite rubber sliding test. The angle that sliding first occurred was measured with a digital level. The test was repeated 10 times on each surface except on Surface 5, where the angle at which sliding occurred was very high. The results were averaged. Coefficients of friction were calculated from this angle. Test results are shown in Appendix Tables 1 through 6, columns 7 through 9.

Figure1. Slider Block

To gage how the UWT might be used in the real world, ES staff took measurements of the building lobby floor and stairwell. These results are shown in Appendix Table 7 and 8.

Analysis Summary: Surface #1 is a Vinyl Composite Tile similar to what might be used in an industrial or merchant setting. This tile type typically requires a polish for before everyday use. For the test, the floor was left in the original dull finish. With the dry leather sensor, the UWT # 1 protocol gave average slip resistance readings of 0.564 and 0.589 and UWT # 2 protocol gave an average reading of 0.555. The leather sliding block gave a reading of 0.726 for dry leather. The wet neolite rubber sensor UWT #1 gave readings of 0.994 and 1.000, UWT #2 gave readings of 1.000. The neolite sliding block test gave an average reading of 0.933 for wet neolite.

The readings for the UWT leather and neolite sensors were very consistent. The neolite sliding block test result of 0.933 compared well to the UWT readings of 0.994, 1.000 and 1.000. The leather sliding block test result of 0.726 was somewhat higher than the UWT readings of 0.564, 0.589 and 0.555.

Surface #2 is a Ceramic Tile similar to what might be used in a home setting. It has a very smooth un-textured surface. For the test, the floor was left in the original finish. With the dry leather sensor, the UWT # 1 protocol gave average slip resistance readings of 0.574 and 0.730 and UWT # 2 protocol gave an average reading of 0.742. The leather sliding block gave a reading of 0.564 for dry leather. With the wet neolite rubber sensor UWT #1 gave readings of 0.500 and 0.559, UWT #2 gave readings of 0.509. The sliding block test gave an average reading of 0.502 for wet neolite.

The readings for the UWT leather sensor were not very consistent from one week to the next. The UWT neolite sensor readings were consistent. Based on the neolite sliding block test result of 0.502 compared to the UWT readings of 0.500, 0.559 and 0.509, the UWT results could be considered accurate. The leather sliding block test result of 0.564 compared very well with the first UWT reading of 0.574.

It is unknown why the readings with the leather sensor were so discrepant between the two test dates. The battery required a recharge shortly after the second set of readings were taken. It is possible that as the battery was near the end of it's charge, it did not have enough energy to power the wheels against the friction and therefore recorded a higher friction result.

Surface #3 is a Vinyl Tile (Linoleum) similar to what might be used in a home setting. For the test, the floor was left in the original finish. With the dry leather sensor, the UWT # 1 protocol gave average slip resistance readings of 0.669 and 0.955 and UWT # 2 protocol gave an average reading of 0.928. The leather sliding block gave a reading of 0.860 for dry leather. With the wet neolite rubber sensor UWT #1 gave readings of 0.795 and 0.937, UWT #2 gave readings of 0.951. The neolite sliding block test gave an average reading of 1.054 for wet neolite.

The readings for the UWT leather sensor were not very consistent from one week to the next. The UWT neolite sensor readings were not very consistent either. Based on the neolite sliding block test result of 1.054 compared to the UWT readings of 0.795, 0.937 and 0.951, the UWT results could be considered fairly accurate. The leather sliding block test result of 0.860, was mid-range compared to the UWT readings of 0.669, 0.955 and 0.928.

It is unknown why the readings with the leather sensor were so discrepant between the two test dates. The battery required a recharge shortly after these second sets of readings were taken. It is possible that as the battery was near the end of it's charge, it did not have enough energy to power the wheels against the friction and therefore recorded a higher friction result.

Surface #4 is a Ceramic Tile similar to what might be used in a home setting. The surface is textured. For the test, the floor was left in the original finish. With the dry leather sensor, the UWT # 1 protocol gave average slip resistance readings of 0.436 and 0.464 and UWT # 2 protocol gave an average reading of 0.452. The leather sliding block gave a reading of 0.508 for dry leather. With the wet neolite rubber sensor UWT #1 gave readings of 0.441 and 0.543, UWT #2 gave readings of 0.502. The sliding block test gave an average reading of 0.608 for wet neolite.

The readings for the UWT leather sensor were very consistent. The readings for the UWT neolite sensor were somewhat consistent. Based on the neolite sliding block test result of 0.608 compared to the UWT readings of 0.441, 0.543 and 0.502, the UWT results could be considered somewhat accurate. The leather sliding block reading of 0.508 compared will with the UWT readings of 0.436, 0.464 and 0.452.

Surface #5 is a Vinyl Tile - Linoleum similar to what might be used in a home setting. For the test, the floor was left in the original finish. With the dry leather sensor, the UWT # 1 protocol gave an average slip resistance reading of 1.000. During the second trial with UWT #1 and UWT # 2 protocol the UWT was not able to measure the surface because the friction was too high. The leather sliding block gave a reading of 0.945 for dry leather. With the wet neolite rubber sensor UWT #1 and UWT #2 the UWT was not able to measure the surface because the friction was too high. The sliding block test gave an average reading of 1.814 for wet neolite. The UWT is not able to make a reading if the slip resistance is above 1.

The slip-resistance of this surface was very high. The UWT was only able to record readings on one occasion. The neolite sliding block test of this surface confirmed that the surface was indeed highly slip resistant with a reading of 1.814, which is too high for the UWT to measure. The leather sliding block reading of 0.945 was comparable to the UWT reading of 1.000

Surface #6 is a Ceramic Tile similar to what might be used in a home setting. The tile surface is very rough. For the test, the floor was left in the original finish. With the dry leather sensor, the UWT # 1 protocol gave average slip resistance readings of 0.691 and 0.664 and UWT # 2 protocol gave an average reading of 0.605. . The leather sliding block gave a reading of 0.718 for dry leather. With the wet neolite rubber sensor UWT #1 gave readings of 0.689 and 0.743, UWT #2 gave readings of 0.739. The sliding block test gave an average reading of 0.792 for wet neolite.

The readings for the UWT leather and neolite sensors were consistent. Based on the neolite sliding block test result of 0.792 compared to the UWT readings of 0.689, 0.743 and 0.739, the UWT results could be considered accurate. The leather sliding block reading of 0.718 was comparable to the UWT readings of 0.691, 0.664 and 0.605

Surface #7 is a polished-marble building lobby. With the dry leather sensor, the UWT # 1 protocol gave an average slip resistance readings of 0.701 for twenty runs. With the wet neolite rubber sensor UWT #1 gave a reading of 0.584. The sliding block test was not conducted on the surface since the floor could not be angled. Note that the first ten readings were conducted on one area of the lobby floor, the next ten were conducted on an area several feet away. The average slip-resistance for the first area was much higher than the second, possible due to floor polish wear do to pedestrian travel patterns.

Surface #8 is a painted-concrete building stairwell. With the dry leather sensor, the UWT # 1 protocol gave an average slip resistance readings of 0.470 for ten runs. With the wet neolite rubber sensor UWT #1 gave a reading of 0.727. The sliding block test was not conducted on the surface since the floor could not be angled. The readings for the leather sensor were very consistent. With the neolite sensor gave a much larger range of readings.

Conclusions & Recommendations: On most of the samples surfaces, the UWT readings were consistent from one weeks reading to the next. Since nothing had been purposely done to change the flooring samples during the test period, it is uncertain what could be the cause of the inconsistent readings on surfaces 2 and 3 from one week to the next. It is possible that atmospheric conditions such as temperature or humidity may have had some effect, though internal building conditions are fairly constant. Other possible reasons are the low battery charge or surface change due to rubbing up against other surfaces. It would be advisable to ensure the battery is near its peak charge to ensure proper UWT readings.

The sliding block test readings tended to vary more than the UWT readings (the standard deviationwas larger for the sliding block test). However, in comparing the average values of the UWT tests and the sliding block tests, the tests generally gave similar results. Therefore, the UWT could be considered an accurate recording device.

Based on the UWT readings of the building lobby and stairwell, it is apparent that the slip-resistance of a given floor surface can vary by fairly significant amounts from one location to the next due to inconsistencies in surface treatment and/or pedestrian traffic patterns. It would seem that this would require users to test floors over several areas and not rely on just one reading to gage slip resistance of a flooring surface. It also might be possible to program the UWT to travel a greater distance, perhaps several feet and provide a warning if there were any “slick” spots.

Appendix

Table 1. UWT and Sliding Block Test Results - Surface #1

	1 July 03	10-Jul-03	10-Jul-03	3-Jul-03	11-Jul-03	11-Jul-03		28 Jul 03	22 Jul 03
	Surface #1 - VCT - Smooth Surface - Dull								
	UWT #1	**UWT #1**	**UWT #2**	**UWT #1**	**UWT #1**	**UWT #2**		**Sliding Block**	**Sliding Block**
	Leather - Dry	Leather - Dry	Leather – Dry	Neolite - Wet	Neolite - Wet	Neolite - Wet		Leather – Dry	Neolite - Wet
Trial									
1	0.56	0.54	0.45	0.94	1.00	1.00		0.781	0.869
2	0.57	0.59	0.48	1.00	1.00	1.00		0.727	0.810
3	0.55	0.56	0.59	1.00	1.00	1.00		0.649	1.072
4	0.57	0.57	0.56	1.00	1.00	1.00		0.700	1.150
5	0.55	0.57	0.57	1.00	1.00	1.00		0.727	0.869
6	0.56	0.58	0.54	1.00	1.00	1.00		0.754	0.839
7	0.56	0.59	0.58	1.00	1.00	1.00		0.700	0.966
8	0.58	0.62	0.55	1.00	1.00	1.00		0.767	0.839
9	0.56	0.64	0.61	1.00	1.00	1.00		0.700	0.839
10	0.58	0.63	0.62	1.00	1.00	1.00		0.754	1.072
AVG	0.564	0.589	0.555	0.994	1.000	1.000		0.726	0.933
Std Dev	0.0107	0.0321	0.0540	0.0190	0.0000	0.0000		0.0396	0.1233

Figure 1a. Surface 1

Table 2. UWT and Sliding Block Test Results – Surface #2

	Surface #2 - Ceramic Tile – Very Smooth Surface								
	UWT #1	**UWT #1**	**UWT #2**	**UWT #1**	**UWT #1**	**UWT #2**		**Sliding Block**	**Sliding Block**
	Leather - Dry	Leather - Dry	Leather – Dry	Neolite - Wet	Neolite - Wet	Neolite - Wet		Leather – Dry	Neolite - Wet
Trial									
1	0.62	0.71	0.78	0.53	0.60	0.53		0.625	0.554
2	0.56	0.65	0.78	0.51	0.54	0.51		0.554	0.445
3	0.52	0.67	0.67	0.52	0.57	0.52		0.466	0.404
4	0.64	0.82	0.75	0.46	0.57	0.45		0.554	0.510
5	0.62	0.75	0.80	0.52	0.53	0.58		0.601	0.466
6	0.49	0.8	0.68	0.44	0.55	0.52		0.532	0.577
7	0.63	0.73	0.78	0.46	0.54	0.54		0.532	0.554
8	0.56	0.73	0.65	0.49	0.59	0.53		0.601	0.466
9	0.57	0.68	0.67	0.53	0.57	0.50		0.601	0.488
10	0.53	0.76	0.86	0.54	0.53	0.41		0.577	0.554
AVG	0.574	0.730	0.742	0.500	0.559	0.509		0.564	0.502
Std Dev	0.0517	0.0550	0.0702	0.0353	0.0247	0.0477		0.0469	0.0573

Figure 2a. Surface 2

Table 3. UWT and Sliding Block Test Results – Surface #3

	Surface #3 - Vinyl - Textured Surface								
	UWT #1	**UWT #1**	**UWT #2**	**UWT #1**	**UWT #1**	**UWT #2**		**Sliding Block**	**Sliding Block**
	Leather - Dry	Leather - Dry	Leather – Dry	Neolite - Wet	Neolite - Wet	Neolite - Wet		Leather – Dry	Neolite Wet
Trial									
1	0.75	0.98	1.00	0.83	1.00	1.00		0.933	0.869
2	0.68	1.00	1.00	0.82	0.95	0.95		0.933	0.966
3	0.71	0.98	0.99	0.83	0.99	0.81		0.900	1.000
4	0.68	0.99	0.94	0.88	0.95	1.00		0.900	1.150
5	0.64	0.96	1.00	0.82	0.91	0.98		0.839	1.111
6	0.66	0.93	0.93	0.77	0.93	0.99		0.727	1.111
7	0.63	0.95	0.90	0.77	0.94	0.96		0.810	1.111
8	0.63	0.83	0.85	0.75	0.85	0.83		0.754	1.036
9	0.63	0.95	0.70	0.74	0.92	0.99		0.900	1.000
10	0.68	0.98	0.97	0.74	0.93	1.00		0.900	1.192
AVG	0.669	0.955	0.928	0.795	0.937	0.951		0.860	1.054
Std Dev	0.0396	0.0488	0.0944	0.0474	0.0419	0.0713		0.0739	0.0977

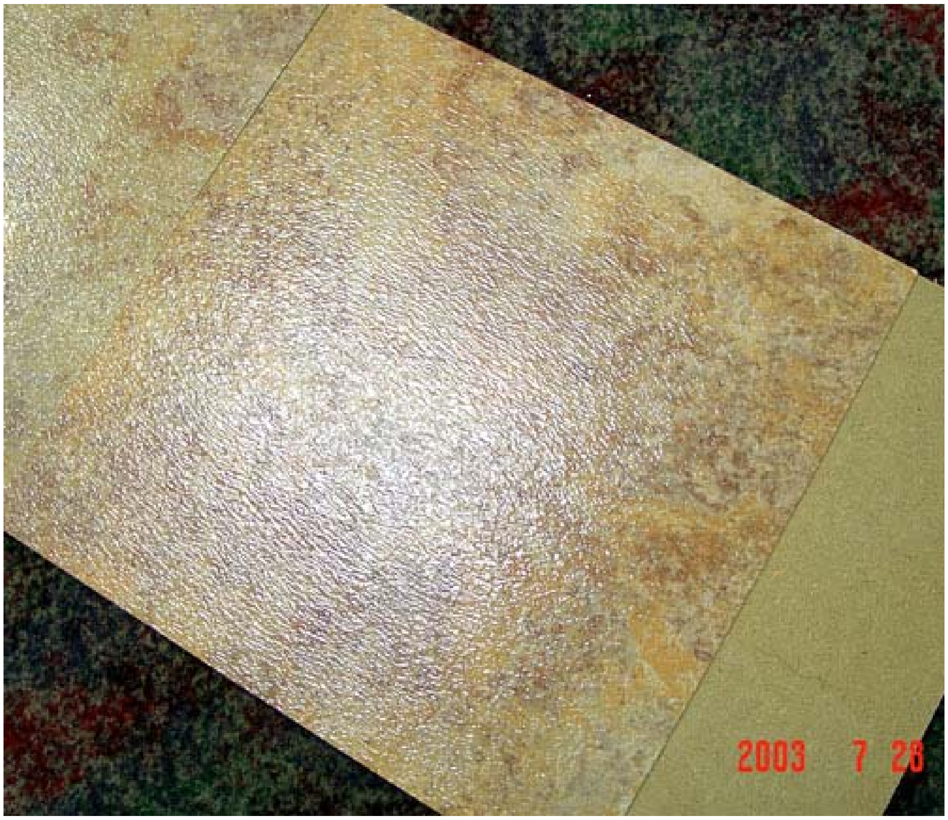


Figure 3a. Surface 3

Table 4. UWT and Sliding Block Test Results – Surface #4

	Surface #4 - Ceramic Tile – Textured Surface								
	UWT #1	**UWT #1**	**UWT #2**	**UWT #1**	**UWT #1**	**UWT #2**		**Sliding Block**	**Sliding Block**
	Leather - Dry	Leather - Dry	Leather – Dry	Neolite - Wet	Neolite - Wet	Neolite - Wet		Leather – Dry	Neolite - Wet
Trial									
1	0.41	0.50	0.41	0.45	0.57	0.56		0.454	0.510
2	0.43	0.45	0.42	0.45	0.61	0.48		0.489	0.577
3	0.43	0.43	0.45	0.50	0.57	0.52		0.559	0.700
4	0.43	0.45	0.46	0.41	0.52	0.52		0.454	0.577
5	0.44	0.44	0.46	0.46	0.59	0.47		0.471	0.700
6	0.45	0.49	0.45	0.42	0.55	0.52		0.489	0.577
7	0.44	0.46	0.47	0.39	0.52	0.48		0.419	0.532
8	0.43	0.47	0.45	0.44	0.50	0.47		0.454	0.601
9	0.46	0.47	0.47	0.44	0.49	0.54		0.489	0.601
10	0.44	0.48	0.48	0.45	0.51	0.46		0.419	0.700
AVG	0.436	0.464	0.452	0.441	0.543	0.502		0.508	0.608
Std Dev	0.0135	0.0222	0.0220	0.0300	0.0408	0.0343		0.521	0.0699

Figure 4a. Surface 4

Table 5. UWT and Sliding Block Test Results – Surface #5

	Surface #5 - Vinyl - Textured Surface - Shiny								
	UWT #1	**UWT #1**	**UWT #2**	**UWT #1**	**UWT #1**	**UWT #2**		**Sliding Block**	**Sliding Block**
	Leather - Dry	Leather - Dry	Leather – Dry	Neolite - Wet	Neolite - Wet	Neolite - Wet		Leather – Dry	Neolite – Wet
Trial									
1	1.00	n/a	n/a	0.99	n/a	n/a		0.900	1.376
2	1.00	n/a	n/a	1.00	n/a	n/a		1.036	1.540
3	1.00	n/a	n/a	1.00	n/a	n/a		0.900	2.605
4	1.00	n/a	n/a	n/a	n/a	n/a		n/a	1.192
5	1.00	n/a	n/a	n/a	n/a	n/a		n/a	2.356
6	1.00	n/a	n/a	n/a	n/a	n/a		n/a	n/a
7	1.00	n/a	n/a	n/a	n/a	n/a		n/a	n/a
8	1.00	n/a	n/a	n/a	n/a	n/a		n/a	n/a
9	1.00	n/a	n/a	n/a	n/a	n/a		n/a	n/a
10	1.00	n/a	n/a	n/a	n/a	n/a		n/a	n/a
AVG	1.000	FTH	FTH	0.997	FTH	FTH		0.945	1.814
Std Dev	0.0000	n/a	n/a	0.0058	n/a	n/a		0.0780	0.6272

Figure 5a. Surface 5

Table 6. UWT and Sliding Block Test Results – Surface #6

	Surface #6 - Ceramic Tile – Rough Surface								
	UWT #1	**UWT #1**	**UWT #2**	**UWT #1**	**UWT #1**	**UWT #2**		**Sliding Block**	**Sliding Block**
	Leather - Dry	Leather - Dry	Leather – Dry	Neolite - Wet	Neolite - Wet	Neolite - Wet		Leather – Dry	Neolite – Wet
Trial									
1	0.66	0.66	0.59	0.68	0.86	0.82		0.754	0.810
2	0.71	0.67	0.63	0.68	0.73	0.73		0.675	0.700
3	0.65	0.61	0.62	0.64	0.71	0.77		0.675	0.700
4	0.67	0.65	0.60	0.73	0.73	0.72		0.781	0.754
5	0.68	0.61	0.61	0.64	0.72	0.73		0.727	0.810
6	0.65	0.71	0.62	0.74	0.76	0.68		0.810	0.839
7	0.74	0.69	0.59	0.72	0.73	0.83		0.700	0.727
8	0.73	0.73	0.60	0.72	0.72	0.67		0.675	0.839
9	0.67	0.63	0.59	0.66	0.76	0.72		0.700	0.869
10	0.75	0.68	0.60	0.68	0.71	0.72		0.687	0.869
AVG	0.691	0.664	0.605	0.689	0.743	0.739		0.718	0.792
Std Dev	0.0381	0.0403	0.0143	0.0367	0.0447	0.0530		0.0483	0.0664

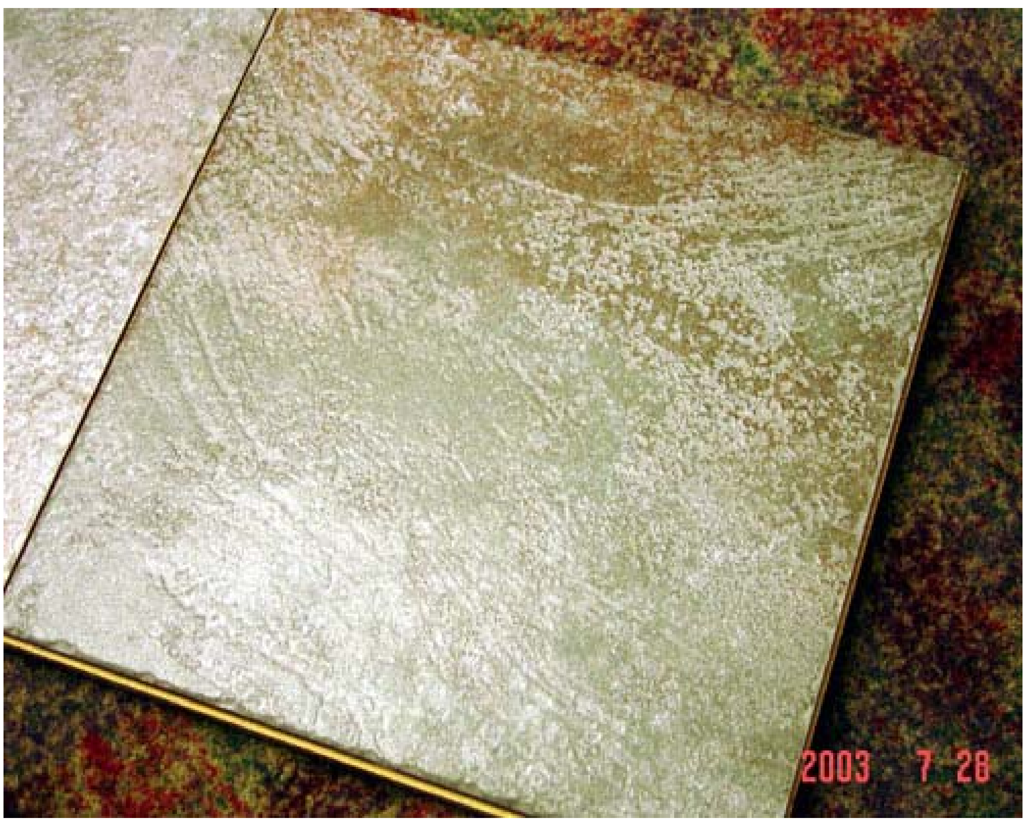


Figure 6a. Surface 6

Table 7. UWT In-Service Floor Tests – Surface #7

Surface #7 - Polished Marble Tile - CPSC Lobby

	10-Jul-03	11-Jul-03
	UWT #1	**UWT #1**
Trial	Leather - Dry	Neolite - Wet
1	0.72	0.54
2	0.86	0.53
3	0.87	0.51
4	0.95	0.50
5	0.78	0.61
6	0.80	0.52
7	0.81	0.59
8	0.88	0.53
9	0.87	0.58
10	0.81	0.52
11	0.58	0.58
12	0.52	0.63
13	0.53	0.59
14	0.50	0.60
15	0.50	0.61
16	0.64	0.64
17	0.66	0.61
18	0.57	0.65
19	0.57	0.66
20	0.59	0.68
AVG	0.701	0.584
Std Dev	0.1498	0.0540

Table 8. UWT In-Service Floor Tests – Surface #8

Surface #8 - Concrete - Painted - CPSC Stairwell

	10-Jul-03	11-Jul-03
	UWT #1	**UWT #1**
Trial	Leather - Dry	Neolite – Wet
1	0.49	0.77
2	0.48	0.65
3	0.52	0.70
4	0.47	0.66
5	0.47	0.69
6	0.47	0.70
7	0.48	0.81
8	0.43	0.59
9	0.44	0.89
10	0.45	0.81
AVG	0.470	0.727
Std Dev	0.0258	0.0908

Risk Control

Slips and Falls Study:

Objective Auditing Techniques to

Control Slips and Falls in Restaurants

June 2007

CNA

Risk Control

Slips and Falls Study:
Objective Auditing Techniques to Control Slips and Falls in Restaurants

More than 3 million food service employees and over 1 million guests are injured annually as a result of restaurant slips and falls, according to the National Floor Safety Institute (NFSI). The NFSI indicates that the industry spends over $2 billion on such injuries each year and that these injuries are increasing at a rate of about 10% annually.

According to the National Restaurant Association, slips and falls are the greatest source of general liability (GL) claims within the restaurant industry. CNA's loss results mirror the National Restaurant Association information. Slips-and-falls injuries continue to be the leading source of GL losses incurred by our policyholders.

According to the National Safety Council, slips and falls constitute one of the leading causes of accidental death in the United States.

With the aging baby boomer generation, the size and scope of this issue is expected to grow significantly. The NFSI estimates that between 2005 and 2020, the number of seniors in the U.S. will increase from 35 million to 77 million. Statistically, seniors are far more likely to experience a slip-and-fall accident. For those that are injured, the cost of treatment and recovery time is significantly greater than the average for non-seniors. According to the American Academy of Orthopedic Surgeons, these types of injuries are also the leading cause of hospital admission for older adults.

There are five major causes for slip-and-fall accidents:

1. Lack of slip resistance on walking surfaces
2. Poor walking surface conditions
3. Poor visibility
4. Lack or poor condition of handrails and guardrails
5. Poor accessibility

Wanting to help policyholders improve safety and continue profitable growth, CNA conducted a case study on slips and falls in the restaurant industry, which experiences more of these events than other industries we service. This paper reviews the approach taken by CNA Risk Control in our case study to deal with the first two causes stated above with a CNA policyholder, a large national restaurant chain.

Our white paper will focus specifically on the application of a new technology and a systematic auditing technique to help objectively identify problem areas and communicate findings and suggestions for improvement. One of the primary objectives of the study was to monitor and document the results of floor cleaning and maintenance activities so the decision was made early on to complete readings and measurements during non-business hours. Furthermore, since the primary issue for the company was customer slips and falls, the

decision was made to limit our study sampling to only "front of the house" areas of the stores, where customers have primary exposure to slips and falls.

BACKGROUND

Since 2001, CNA's policyholder had identified patron slips and falls as the leading source of GL claims. While the company, a fast-growing national restaurant chain, tried several remedies and experienced some progress in this area as measured on a per-store basis, falls continued to serve as their primary "loss leader" from a GL standpoint.

CNA initially began working with the customer on slips-and-falls issues in April 2004. At that time, a series of floor slip resistance tests were completed at selected locations. Guest slip-and-fall injuries were confirmed as the primary driving force of the company's GL losses, both in terms of frequency and severity. By December 2004, the company approached CNA for assistance in developing and implementing a more aggressive slip-and-fall prevention program.

In March 2005, the company rolled out an internal slip-and-fall prevention program nationwide. Over this same time frame, CNA formed a strategic partnership with the NFSI. The NFSI was founded in 1997 as a not-for-profit organization whose mission is to "aid in the prevention of slip and fall accidents through education, training and research." The NFSI, headquartered in Southlake, TX, is the only organization of its kind exclusively focused on slip-and-fall accident prevention.

Nationwide testing of floors began at selected sites in July 2006 and concluded in October 2006.

WHAT IS SLIP RESISTANCE?

Slip resistance is generally measured by defining the coefficient of friction (COF) between two surfaces. An example is the relationship between a shoe and a floor surface. There are two COF measures:

- Static – The force necessary to start a body moving
- Dynamic – The force necessary to keep this same body moving

In the U.S., the static COF is the customary method of measuring slip resistance.

The COF is generally measured between 1.0 for very rough surfaces (e.g., sand paper) and extremely slippery surfaces at 0.0 (e.g., water on ice).

The American National Standards Institutes' (ANSI) A 1264.2-2001 "Standard for the Provision of Slip Resistance on Walking & Working Surfaces" suggests a Static COF of $\geq$ .05 for walking surfaces under dry conditions.

However, the NFSI has developed an additional test method, NFSI B101,1. This standard defines a "High Traction" walkway as having a measured static COF of $\geq$ .06 for wet walking surfaces. The NFSI is the first standards developer to create a wet slip resistance

standard and estimates that more than 80% of slip-and-fall accidents take place on wet surfaces. According to the NFSI, floor surfaces maintaining this level of slip resistance when wet have proven to reduce slip-and-fall claims by between 50% to 90%. We chose to use this standard as part of our study because we felt it more closely replicated real world situations.

WHAT FACTORS INFLUENCE SLIP RESISTANCE?

Any factor that changes the level of friction between two surfaces affects its slip resistance. When the floor surface and the sole of an individual's shoe are clean and dry, there is generally a high level of friction between the surfaces. In this case, the likelihood of slips and falls is reduced. Over time, as flooring surfaces and shoe soles become covered by foreign materials or become wet, the level of friction is reduced. As this occurs, the likelihood of a slip or fall increases.

Foreign materials include dirt, grease and water. However, we also know that some cleaning products used on flooring surfaces can build up a film in the pores of flooring material. This reduces the friction produced by the surface, increasing the likelihood of slips and falls. We call this buildup of materials "polymerization" and know that the longer the buildup continues, the more difficult it is to remove. This becomes extremely important in cases where the floor surface occasionally becomes wet, such as in restaurants.

Frequently in the hospitality industry, we find occasional spills, weather-related hazards, wet and oily surfaces and changes in the degree of traction as the primary causes of slips and falls.

OUR APPROACH

In preparing for the study, a presentation was made to the top management of the restaurant chain. The purpose for the presentation was twofold.

- First, provide education on the slip and fall issue and also relay the study's potential benefits to their organization.
- Second, solicit their support and commitment for the project. We also used the session to discuss the equipment and suggest how the sampling could be accomplished.

With management commitment secured, the company communicated to the managers of the four restaurants selected about the project and what they should anticipate in terms of the onsite testing.

We decided to include a series of restaurants in our study whose layouts and interior finish materials were consistent with what would be included in new restaurants as the company expanded across the U.S. The sites were also located within a relatively tight geographic area to allow multiple retesting in an efficient manner.

Due to our existing relationship, we already understood the company's market and guest demographics, cleaning and floor maintenance procedures and products, and risk management/slip-and-fall prevention programs. Historical data of previous guest slip-and-fall incidents was reviewed and categorized. This information provided a historical perspective to losses and suggested keys to study during the upcoming onsite sampling.

For purposes of this study, we received onsite assistance from engineers representing Universal Walkway Tester LP, the Texas-based manufacturer of the equipment used to gather the data (BOT-3000). Their expertise in operational aspects of the equipment and knowledge of the NFSI-101A floor auditing guidelines helped us structure the study and interpret the resulting information.

For the purposes of the study, one lead and one back-up floor auditor were selected to work with the Universal Walkway Tester LP engineers and the management at the policyholder-selected locations.

WHAT WE DID

Our plan included securing two data sets for each location tested. The first slip resistance samples were obtained after the facility had closed for the evening. The walkway auditor would then return to the site the following morning, after the cleaning crew had completed their work but before the facility had opened for business. Back-to-back testing was employed to reduce the possibility of any intervening factors affecting the results of our operational and cleaning protocols.

Our pattern called for testing two facilities at a time, with all sites visited during a two-week period each month. The following month's testing would then be completed four weeks later and within the same week. In general, testing was completed the same week for each facility in the study.

Initial evaluations of the test sites were completed in a four-week period. During these visits, operations were observed and information was gathered from staff to help determine areas to be addressed in the sampling. Armed with detailed diagrams of each facility, an assessment was carefully completed to identify those locations that would serve as future sampling sites. One important component in the initial testing was taking the time to explain the equipment, purpose and nature of the testing and potential outcomes to facility staff and management. In each facility, this was their initial contact with the equipment and it was important they understood how it worked and what it was used for.

Criteria outlined in the NFSI's proposed floor auditing standard NFSI B101.0 "Walkway Surface Auditing Guideline for the Measurement of Walkway Slip Resistance"-101A served as a resource in location selection. The auditing guidelines subdivide floor surfaces into three groups: normally dry, normally wet and occasionally contaminated. The occasionally contaminated surface definition best fit the layout and operations present at the facilities selected.

THE TESTING PROCESS

For occasionally contaminated floor surfaces, we conducted tests using a Neolite™ (rubber) sensor on wet surfaces. Distilled water was used as the base of each test. Each test consisted of a pair of samples – one taken in an east-to-west orientation and the second completed in a north-to-south orientation. This allowed us to obtain samples both going with and against the grain of floor surfaces where grain was present.

Based on the layout and arrangement of facilities, between 9 and 13 individual sampling sites were selected for each location. Following our master diagram, subsequent sampling was to be completed at these specific sites. Areas tested included dining/seating, bar, beverage stations, serving routes, restrooms, hostess stations and entrance/exit points. Special attention was paid to high-traffic areas where different flooring materials met. These transition areas frequently were a source of slip-and-fall incidents.

Ultimately, a pattern was established with the auditor arriving at the store 15 to 30 minutes prior to closing. This was done to prepare and validate the equipment before each day's testing, as well as observe operations and determine if any additional information could be obtained regarding the firm's customer slip-and-fall injury trends. Once the facility was closed and free of guests, sampling began. Generally each set of samples would take 5 to 10 minutes to complete. During this time, sample media needed to be prepared, testing surfaces prepared with distilled water, samples run, date recorded and sample sites cleaned of water.

Subsequent testing the following morning generally went quicker as testing commenced following validation of the equipment upon arrival at the site.

Understanding the individual restaurant's loss history was very important in the planning of the study. Detailed incident reports identifying flooring material, location, time of day, nature of the incident and information on the claimant were used to help determine where and when to sample. The information helps train staff on situations and conditions likely to result in an incident.

Sampling in consistent locations month after month, both before and after cleaning, provided good information on the success and challenges faced by each facility's floor care and maintenance program. Having specific site diagrams that outlined sampling locations aided in the consistency of collecting information.

Following a consistent pre- and post-survey process helped ensure the proper operation of the equipment and consistency of the results achieved.

WHAT WE USED

We used a Binary Output Tribometer (BOT), Model 3000, manufactured by Universal Walkway Tester LP. The BOT-3000 is a self-propelled machine based on a modified drag-sled principle. The device can perform both wet and dry surface testing. The digital instrument can record, print and output data that can be cataloged and analyzed. One key feature of the unit is that it can be field calibrated, ensuring results are user independent. The BOT-3000 is currently the only device recognized by the NFSI.

WHAT WE LEARNED

More than 650 individual measurements of flooring surfaces in "front of the house" locations were compiled at four locations participating in the pilot throughout a four-month period. The results highlighted the importance of establishing and adhering to a regular floor care maintenance program. Study results showed consistent improvement in flooring slip resistance following cleaning.

We observed that the actual degree of improvement was in large part dependent on the training and technique of the cleaning personnel. Testing also highlighted the importance of floor mat care and maintenance in preventing cross contamination of flooring surfaces. Finally, our sampling revealed that the most heavily used traffic routes between the kitchen and seating areas must be the focal point in any cleaning and matting strategy.

Following a manufacturer's exact directions when applying floor cleaning compounds is crucial to the success of a floor maintenance program. Proper training and outfitting of applicators must be monitored. Targeting cleaning and floor maintenance activities to those areas known for producing low-slip resistance make a slip-and-fall prevention program more efficient.

Even though the flooring surfaces, facility layouts, operations and cleaning products used were consistent over the locations involved in the study, there were considerable differences in the slip resistance readings between locations. The common difference that each facility shared was that floor maintenance and cleaning was performed by an outside contractor. Allowing for all other factors, contractor application emerged as a critical variable in our study.

Following cleaning, each flooring surface exhibited a significant improvement in its individual slip resistance. The actual degree of improvement differed with each facility and sampling location. This was noted to be especially true in heavily contaminated areas, such as entrances to the kitchen, food preparation and beverage stations. Also, the improvement was generally consistent in sample areas, measured on a month-to-month basis.

The tracking of materials, such as grease, oil and water, from the kitchen to the serving and seating areas emerged as the primary controllable source of improving overall slip resistance. Our slip resistance readings consistently improved the further we moved away from the entrance to the kitchen or serving areas.

Floor mats, especially when used at the entrance to the kitchen and serving areas, effectively reduced the movement of materials, such a grease and water, from other portions of the facility. To maintain their effectiveness, the mats needed to be changed out at regular intervals before becoming saturated. We observed that saturated mats

can make the situation worse. Heavily soiled mats allowed contaminates to migrate to the clean dining area floor affecting its slip resistance.

Similarly, areas with permanently installed mats and carpet runners need to undergo regular maintenance and thorough cleaning to remove the buildup of contaminants that could otherwise be tracked throughout a facility.

Employing separate color-coded mops and buckets for "front of the house" and "back of the house" areas helped reduce cross contamination. Using mops that typically are used in the kitchen and preparation areas in the customer seating areas are a frequent source of the spread of materials that lower slip resistance.

RECOMMENDATIONS

Based on our study and findings, we made these general recommendations to the restaurant chain. These recommendations can be applied to most restaurants to help lower their risks for slip-and-fall incidents.

- Select high-traction, slip-resistant flooring materials when you build, expand or remodel facilities. Installation of such materials with proven high traction characteristics is one of the best ways to avoid slip-and-fall issues.
- Know what the "out-of-the-box" slip resistance is on the floor materials in your facility. These numbers provide a baseline when considering changes to cleaning and floor maintenance practices. Have flooring COF audited after installation to confirm slip resistance.
- Select floor cleaning and maintenance products with proven slip resistance characteristics that are compatible with the particular flooring surfaces in your facility. A good place to start are materials certified by the National Floor Safety Institute (www.nfsi.org).
- Be alert for workers substituting cleaning materials or supplies. Ensure sufficient supplies cleaning of supplies are available.
- Apply floor cleaning and maintenance products in accordance with the manufacturer's recommendations.
- Verify with the cleaning personnel that they are familiar with and are using the correct application procedures. If there is a change in personnel or contractor, monitor usage again.
- Remove any unauthorized or incompatible cleaning products and educate staff of the potentially dangerous consequences using the wrong products can have on the slip resistance of flooring surfaces.

Risk Control

- Separate cleaning materials and equipment between the "front of the house" and "back of the house" to reduce the likelihood of transporting a problem from one area to another. Color coding materials can provide instant recognition for personnel using the wrong equipment in the wrong area of the facility.

- Ensure that permanently installed features like carpet runners and mats are included in the maintenance and housekeeping program. These materials need to be regularly inspected for the buildup of contaminants and deterioration that could lead to the creation of fall hazards. Keep in mind that while mats reduce the likelihood of producing slips, improperly maintained mats can create trip hazards. Consider using mats that have been certified by the NFSI.

- Limit the difference in heights between flooring surfaces and mats to no more than ¼" to ½". Frequently inspect mats to ensure they have not buckled or curled. Make sure that your mats are firmly secured to the floor to prevent migration and that the floor beneath the mat is clean and dry. Make sure to evaluate the condition of these changes in height since they can deteriorate and create trip hazards.

- Regularly review all the slip-and-fall incident reports associated with your facility and understand the critical factors associated with them. Look for trends in location, time of day, etc., and focus staff training on your cleaning procedures for these factors. Train your workers how to properly respond to slip-and-fall incidents.

- Ensure that staff is well trained in spill prevention and response programs. They need to know where the materials are located and how to use them in the event of an emergency. It's also important that staff understand the importance of reporting incidents and conditions that could result in incidents, even if none have actually occurred. These will be your first indication of a potential issue that should be addressed.

- One of the surest ways to prevent the transmission of grease, water and other materials from the "back of the house" to the "front of the house" is to implement a good mat program. Ensure the mats are frequently inspected and checked regularly for wear and the buildup of contaminants. A poorly managed and maintained mat program can significantly increase your likelihood of reducing the slip resistance of flooring surfaces.

- A walkway auditing program can help identify trends within your facility that can result in reduced slip resistance to flooring surfaces. To be effective, the testing should be completed in a consistent manner and include more than a single set of measurements. Consider using NFSI Certified walkway auditors. A complete

list can be found on www.nfsi.org.

- Maintaining open and clear communication between the staff, cleaning personnel and the walkway floor auditor is crucial to the identification of trends and elimination of factors that could reduce the slip resistance on floor surfaces.

CNA Risk Control works with business owners in all industries on slip-and-fall programs. To learn more about how CNA Risk Control can work with you to help you mitigate risks, please speak with your local independent agent, call us toll-free at 866-262-0540 or view our other Risk Control tools online at www.cna.com/riskcontrol.

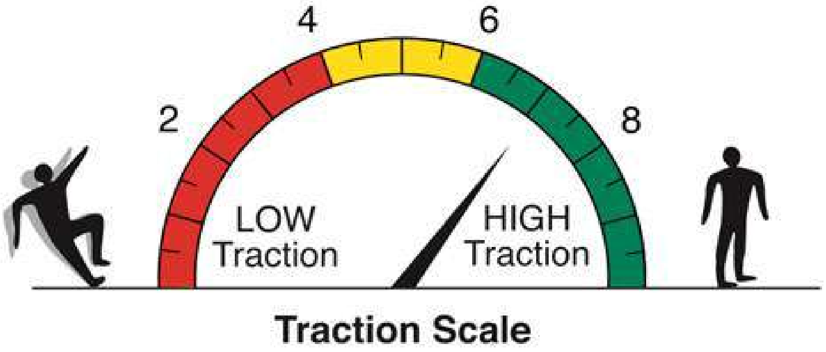
Measuring the Risk of Slips and Falls: An Injury Reduction Study Using Tribometry

Shari Falkenburg
Assistant Vice President
CNA

- **Objectives**
  - Learn how to use a walkway standard and co-efficient of friction results as a risk management tool for reducing slips and falls.
  - Aid in the prevention of slips and falls through research and education

Understanding…

- **Tribometry**
  - Measures the SCOF (Static Coefficient of Friction) or DCOF (Dynamic Coefficient of Friction) of a flat surface area
- **COEF**
  - The COEF is determined by the BOT that physically senses the slip resistance of a surface.
- **Slips and Falls**
  - Occurs when there is too little friction or traction between footwear and the floor surface



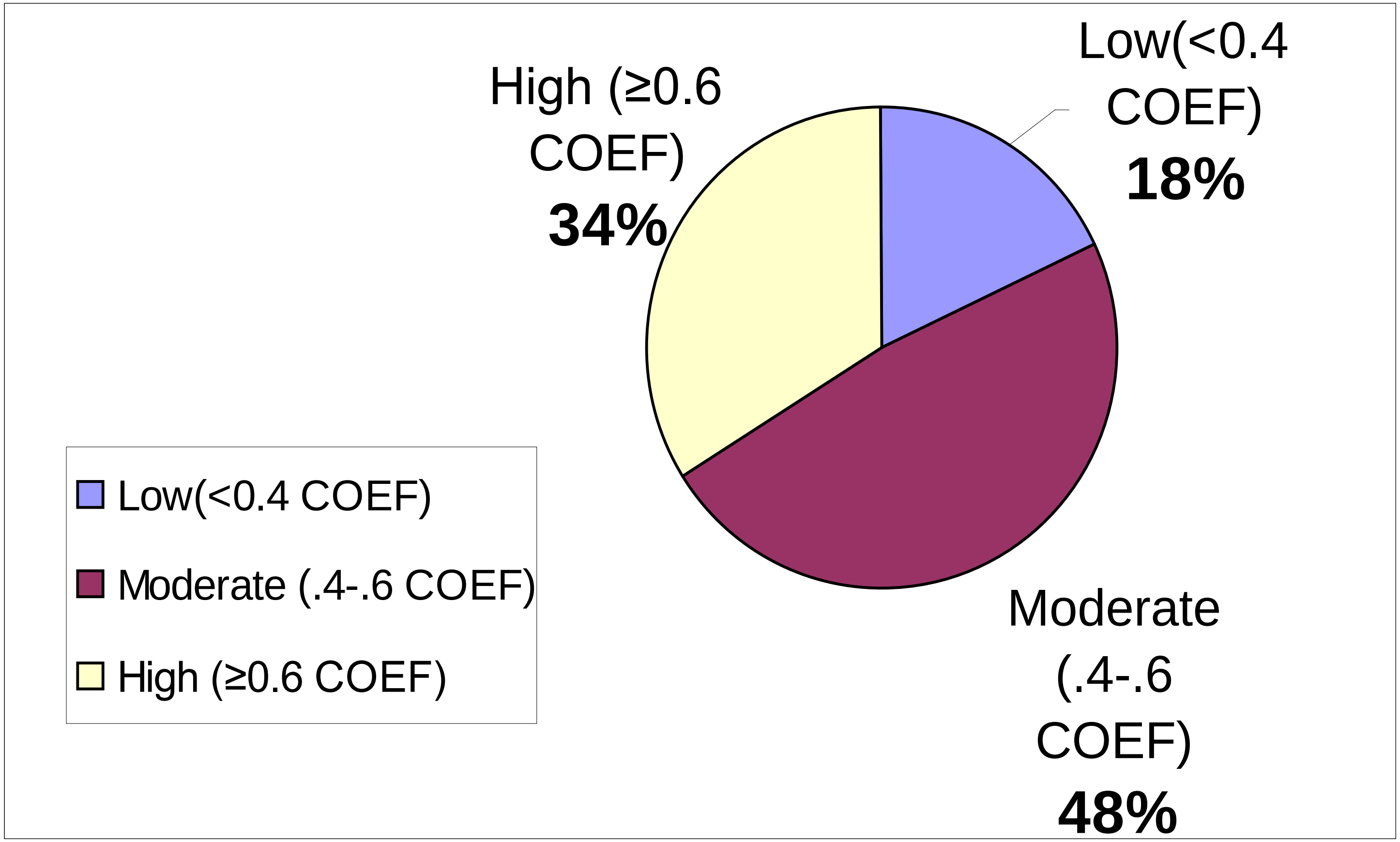
CNA

Customers with Tribometry Use

- **Top 5 Industries w/ slip/fall claims (CNA Claims data)**
  - Eating and Drinking Places
  - Real Estate
  - Apparel Stores
  - Food Stores
  - Hotels

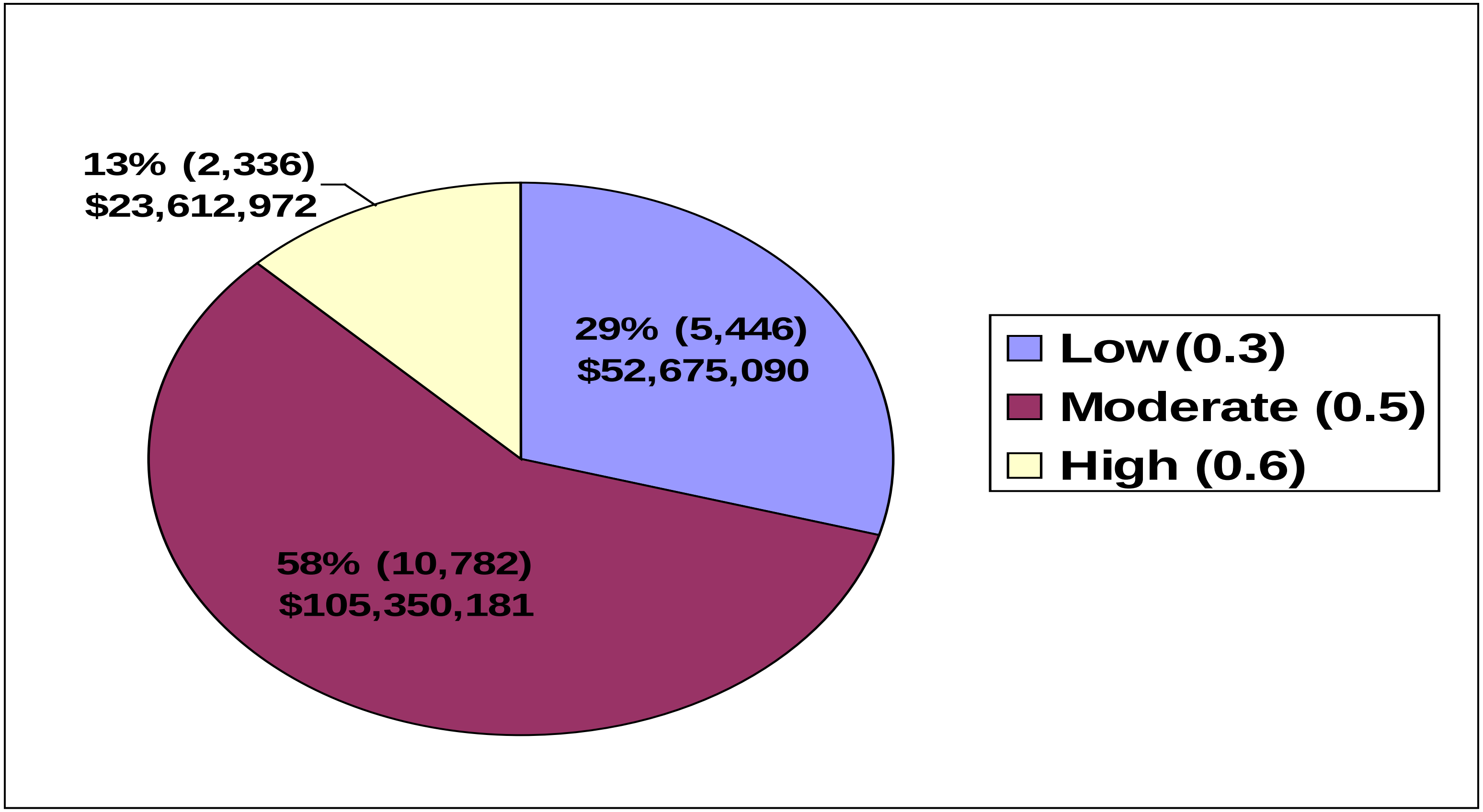
- **Top Industries Risk Control used tribometry**
  - Restaurants
  - Real Estate
  - Retail

Profiling Customers using Tribometry



Out of 362 **accounts** visited….112 have had tribometry service over a 3-year period.

Analysis of Claims by COEF



Results…

3 Year Financial Impact with tribometry

Customer COEF	Current Losses	Improvement in Loss	Savings (Range)
Low	$ 52,675,000	10% - 25%	$790,125 - $1,975,313
Moderate	$ 105,350,000	5% - 15%	$790,125 - $2,370,375
High	$ 24,000,000	0	$ -
Total			**$1,580,250 - $4,345,688**

CNA

Improvements using tribometry

If we improve the customers COEF of low friction by .05 to.125 we should expect to see a 10% to 25% reduction in claim costs. With these results we would achieve a savings greater than $1M.

Same applies to the customers with moderate friction. If we achieve a .025-.075 COEF improvement we would reduce claims by 5-15% or a savings of $1M.

Further investigation was needed with the customers with high friction.

CNA

Applied to a Customer

- Franchise retail
  - Number of stores owned/managed
  - Number of slip and fall events
  - Frequency of slip and fall
- Classified each store and set a target
  - .8 frequency = 2 stores
  - .4 frequency = 1 store
- Determined if they were in the low or high friction group
- Results, when customer properly cleaned and maintained floors showed reduction of 1 - 2 slips and falls per each store they owned/managed

Recommendations

- Risk Control continue to use tribometry with customers.
- Tribometry appears to have a positive return on its aid in preventing slip/trip/fall.
- Customers will continue to find a savings when maintaining their walkway surfaces.

CNA

Q&A

Disclaimer

CNA

We can show you more.®

SLIP AND FALL STUDY REPORT:

ENHANCING FLOOR SAFETY THROUGH SLIP RESISTANCE TESTING, MAINTENANCE PROTOCOLS AND RISK AWARENESS

RISK CONTROL

Table of Contents

INTRODUCTION

Careful attention to the slip resistance of interior floors is a critical component of your business's slip and fall prevention efforts. In the following study conducted by CNA Risk Control walkway specialists over a two-year period, hard surface floors in commercial settings were tested, in some cases pre- and post-cleaning, for their dynamic coefficient of friction (DCOF), i.e., the measurement of a surface's slip resistance during motion.

Executive Summary

Slips and falls can happen anywhere, any time and to anyone. Whether it's a visitor, customer or your own employee, what matters most is that your business is taking the necessary steps to develop and implement a slip and fall prevention program. CNA Risk Control has found that a critical component of these programs is addressing the slip resistance and maintenance of interior floors to reduce exposures.

In the following study, CNA Risk Control walkway specialists examined and tested hard surface flooring in commercial settings. The results found that a significant percentage of businesses are failing to adequately address flooring selection and ongoing maintenance of these surfaces.

Key findings:

- Half of all facilities with public access and common areas that CNA studied have potential for slips and falls. In a two-year study of hard surface floors in commercial workplaces, 50 percent of surveyed sites did not produce a dynamic coefficient of friction (DCOF) level, the measurement of a surface's slip resistance while in motion, above the minimum threshold set by the American National Standards Institute (ANSI).
- Slip and fall claims occur overtime with more frequency than severity. In a six-year review of slip and fall liability claims, CNA found trends of high frequency, but low severity – a finding consistent with claim experiences in the greater risk control industry for commercial buildings. While many employers may worry about the high cost of severe slip and fall claims, frequency should not be ignored. Frequent, smaller claims add up overtime, potentially creating a significant financial burden for your business. According to frequency data, retail trade and real estate businesses present the greatest potential for slip and fall accidents.

- Simple strategies can save you money by protecting the safety of your employees and clients, as well as your reputation. There are simple, yet effective strategies that your business can implement to reduce your slip and fall exposures. These include:
    - Selecting the right flooring. Many factors should be considered when selecting flooring for your commercial building. This includes not only the properties of the flooring itself, but also the space and environment. Make an educated decision by fully assessing the flooring material, surface qualities, flooring condition, required cleaning agents and equipment, and the finishing of the surface.
    - Testing your floors for slip resistance. CNA measures hard surface walkways, under prevailing conditions, using tribometry, the measurement of friction on a surface. By conducting routine slip resistance testing, your business is better prepared to comply with flooring manufacturers' specifications, and on how to remove contaminants on floors before a fall occurs. Testing further enables you to select cleaning agents, finishes and sealants that will help maintain a surface's original coefficient of friction.
    - Choosing the proper cleaning agent and method. Selecting the right cleaning products for your flooring is critical. In fact, the very products and methods used to clean and maintain floor surfaces can be the direct cause of slip and fall accidents. Choosing products that are compatible with your flooring is only part of the equation. It is essential to ensure maintenance vendors are aware of the proper cleaning products and confirm they are financially stable, ethically sound and operate under a strong risk management structure.
    - Promoting awareness of potential slip and fall hazards. Personal awareness of glare, surface variation and other risks, as well as removal of exterior contaminants (e.g., water, snow and dirt) are critical to safe walking. Promote awareness by removing walkway obstacles, displaying signage in areas with floor elevation changes, placing mats near doorway entrances with sufficient mat length for shoe contaminant removal, and using design/decorative selection to reduce glare and provide visual cues where needed. Reduced vision or environmental factors may delay the normal awareness of potential slip exposures. It is the business's responsibility to raise awareness about slip and fall prevention, and keep people safe on their feet.

The study tested walkways to determine:

- The presence of surface contaminants that potentially influence friction.
- The impact of the choice of cleaning equipment, agents or methods that potentially influence friction.

The results of the study reveal that tested floors in 50 percent of the surveyed sites failed to produce a DCOF level above the minimum threshold of 0.42 (American National Standards Institute (ANSI) A137.1-2012, which is now integrated into ANSI 326.3). These findings suggest that many businesses' fall prevention programs may overlook the effects of flooring selection and ongoing maintenance on slip resistance.

Whether your business is a data center, allied healthcare facility, financial institution or retail store, flooring dangers represent a major risk exposure and a key source of liability due to fall-related injuries.

Part One of this study examines CNA slip and fall claims that occurred over a six-year period. The data uncovered that slip and fall claims overtime occur with more frequency than severity, and continue to pose challenges for businesses. Furthermore, the findings underscore the need for attention to floor safety and regular surface resistance testing to avoid fall accidents and related injuries.

In an effort to help your business apply safety measures, Part Two of this study gathers the slip and fall study into four principles of floor safety:

1 Choose

Choose flooring that is slip resistant; consider its properties and the space and environment.

2 Test

Test floors for their resistance under wet conditions; use a tribometer to measure DCOF levels.

3 Use

Use cleaning agents and methods that are compatible with the floor type, and apply them as directed by the manufacturers.

4 Promote

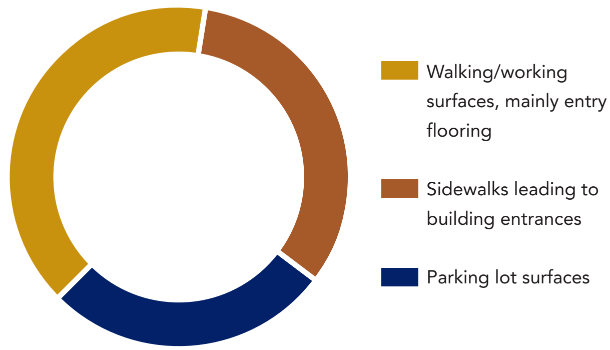
Promote awareness of risk conditions in the physical environment, along with those that are specific to the flooring

Part One:

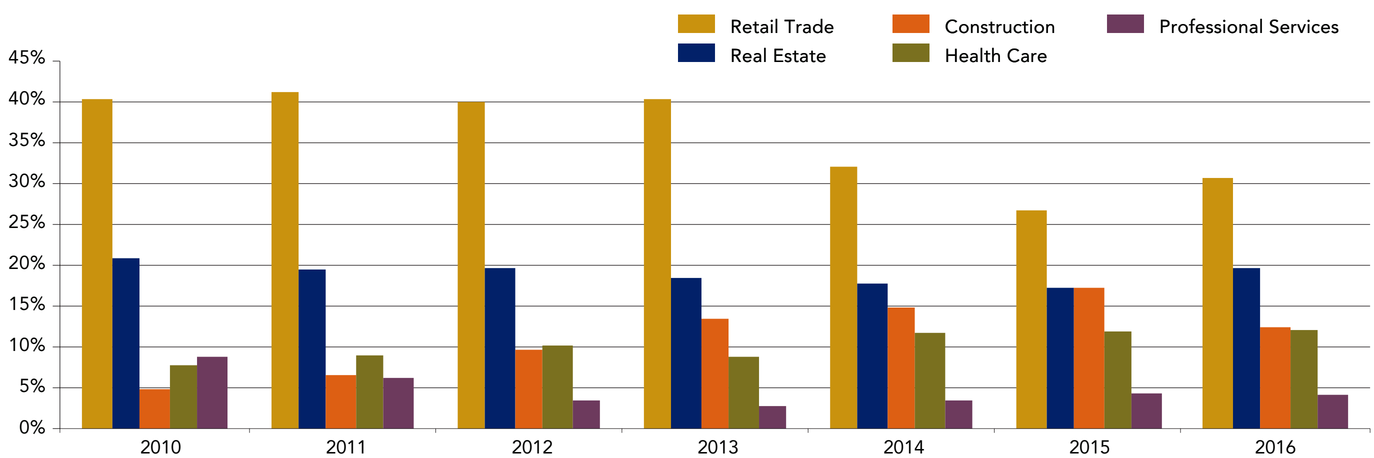
General Review of CNA Claims

A review of slip and fall liability claims occurring from Jan. 1, 2010, to Dec. 31, 2016, found high-frequency but low-severity trends. This finding is consistent with claim experiences in the greater risk control industry. *(See Figures 1 and 2)* According to frequency data, retail trade and real estate businesses present the greatest potential for slip and fall accidents, with harmful events occurring most often at these sites:

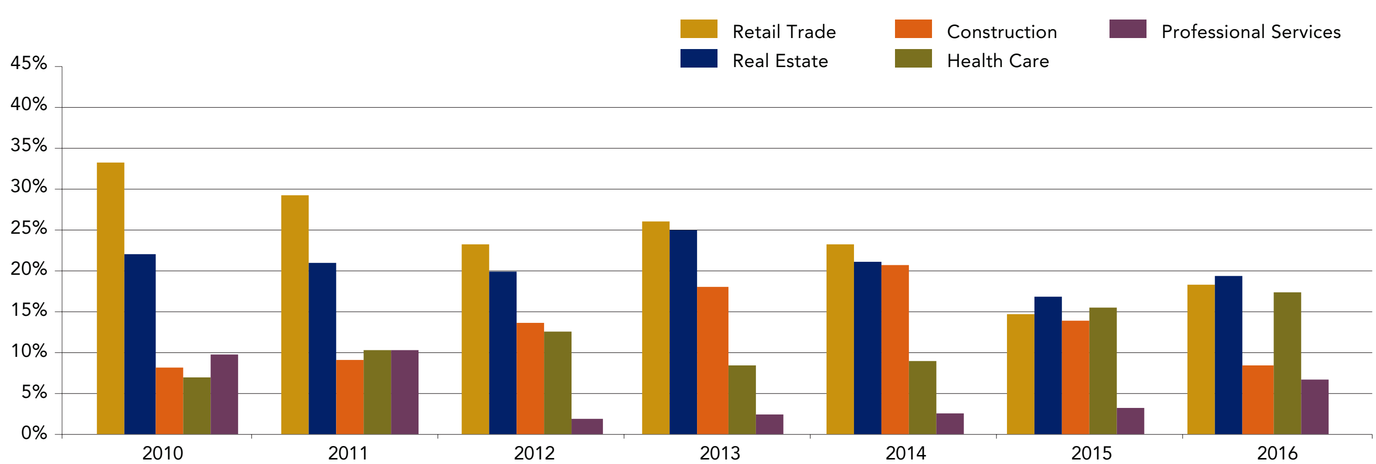
- 40 percent on walking/working surfaces, mainly entry flooring.
- 33 percent on parking lot surfaces.
- 27 percent on sidewalks leading to building entrances.
- Less than 1 percent on interior office floors.



1 **Figure 1 - Slip & Fall Frequency %**



2 **Figure 2 - Slip & Fall Severity %**

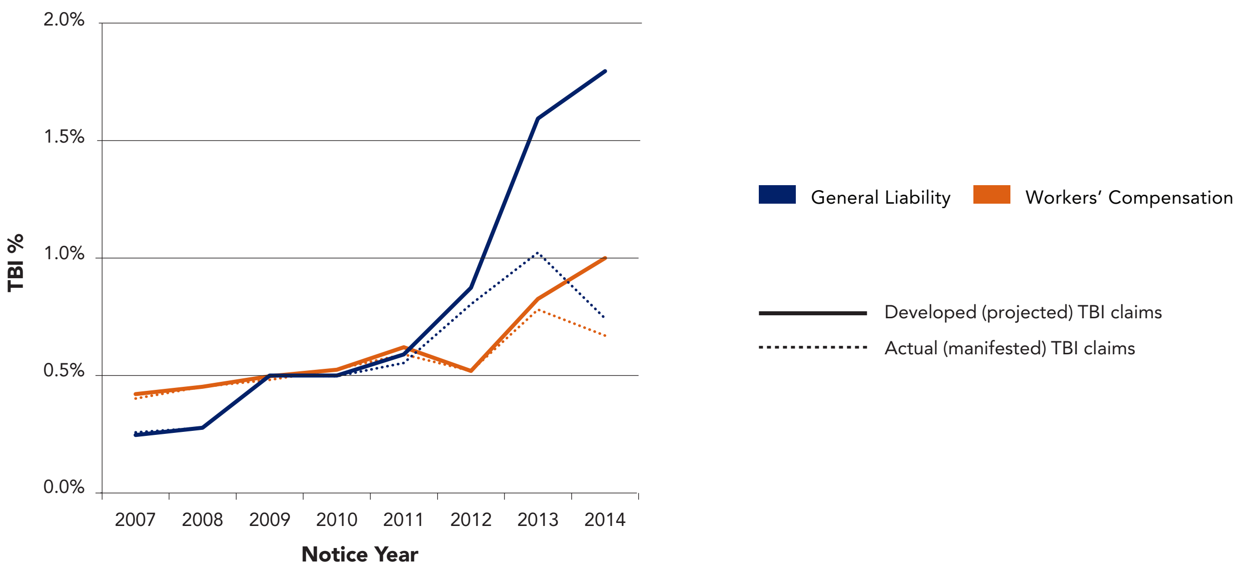


Part One:

General Review of CNA Claims (cont.)

Traumatic brain injury (TBI), i.e., the results from a violent blow or jolt to the head or body, is among the most severe of slip and fall claims. In fact, the Centers for Disease Control and Prevention (CDC) report that falls among adults are the most common cause of TBI. With the risks associated with TBI, this claim review used predictive modeling and data mining methods to link TBI in General Liability (GL) and Workers' Compensation (WC) claims between the years of 2007 and 2014. Based upon the results of the predictive analysis, both the rate and seriousness of claims involving TBI are higher for GL insureds than WC. (See *Figures 3, 4 and 5*) Of the GL insureds, small retail businesses experience the highest number of claims alleging TBI.

3 Figure 3 - TBI% of General Liability and Workers' Compensation Claims



4 Figure 4 - Frequency Summary: Change 2007 to 2014

	GL	WC
2014	1.79%	1.02%
2007	0.22%	0.42%
2014/2007	8.31	2.41

Development (ratio of the solid and dotted lines) varies tremendously across LOBs (examples for 2014):

GL: x2.6 (1.8/0.7)

WC: x1.6 (1.0/0.6)

This is because they have different development rates.

5 Figure 5 - Paid Loss: TBI vs. non-TBI

Closed claims, Notice years: 2007-2012, Excluding $0 claims

	GL	WC
TBI	$269,643	$259,153
non-TBI	$30,150	$26,158
Ratio (TBI/non-TBI)	8.94	9.91

Note:

This severity would be higher, especially for WC,if we included open claims, which (for older claims) tend to be more severe.

Part Two:

Principles of Floor Safety

Discussion of floor safety is not new, but the role these programs play is important in decreasing slip and fall exposures. However, the topic of promoting safe walking and working surfaces is timely given the updated regulation from the Occupational Safety and Health Administration (OSHA). The final rule creates new standards specific to same-level slip, trip and fall risks.

Given the focus on floor safety, it's important to revisit your prevention efforts, in order to guarantee that floors and walkways are safe through the application of the following safety standards.

Flooring Selection

Flooring decisions can have unfavorable results over the life of a commercial building. During the selection process, it is important that your business carefully consider the makeup of the flooring and whether it is a proper surface for use. For example, a high-traffic lobby may require durable, slip-resistant flooring over a conference room. Floor finishes, sealants and maintenance needs may differ depending on location of the flooring in the business. By considering the following five flooring properties and the questions they may elicit, your business can make a more educated and safe choice:

1 **Material**

Is the floor made of a natural slip resistant material, i.e., natural stone or a smooth ceramic tile?

2 **Surface**

Is the surface water resistant, and does it have a hard quality that is helpful to creating tension?

3 **Condition**

Is the floor surface new and clean, or does it display worn features that may invite hazards?

4 **Cleaning**

What cleaning agents, methods and equipment are best for the floor, and does your business have access to those supplies?

5 **Finishing**

Does the floor have a textured or smooth finish, and will aftermarket sealants, chemical treatments or coatings reduce the surface's DCOF?

OSHA Floor Safety Rule Update

The Occupational Safety and Health Administration's (OSHA) Walking-Working Surfaces regulation (29 CFR Part 1910, Subpart D) aims to protect workers from same-level falls and falls from heights. It has a two-fold goal:

1) To create a fall protection standard for industry

2) To enact new rules for minimizing the likelihood of same-level slip, trip and fall incidents in facilities.

The rule joins best practices from more than 30 industry standards and is performance-based. The rule offers you flexibility to correct walking-working surface risks in a way that fits your business and working conditions.

The following is a summary of the major changes in the rule. Businesses must:

- Regularly inspect all walkways to guarantee they are free of debris, contaminants, or other defects that could cause a slip, trip or fall injury.
- Correct and guard any known walking-working risks to prevent a slip, trip or fall injury.
- Revise and consolidate requirements for all types of ladders.
- Modify vertical clearance requirements in stairways.
- Ensure scaffold requirements mirror those used in construction industries.
- Add requirements for the use of rope descent systems.
- Guard against fall-from-height hazards.
- Add new performance, care and use criteria for all personal fall protection systems.

Source: New OSHA Floor Safety Rule Aims to Prevent Workplace Fall Incidents

1 Table 1 - Slip Resistant Features by Floor Material

Floor Material	Slip Resistant Features
Quarry tile	• Tends to have a naturally high coefficient of friction (COF)* value. • Offers good slip resistance when clean due to its rough micro surface. • Slip resistant, but resistance may lessen when the surface is wet or soiled, mainly when cooking grease is present.
Glazed ceramic tile	• Resistance depends upon the glaze used and the texture of the tile. • Smooth surfaces tend to have a naturally low COF. • Textured surfaces are generally designed to have a high COF. • Is receptive to anti-slip coating additives that enhance floor traction, but they later wear away with heavy foot traffic. • Smooth glazed surfaces can be slippery when wet.
Mosaic tile	• Unglazed porcelain has a naturally high COF and good slip resistant properties. • Can be slippery when wet if waxed, despite manufacturers' recommendations advising against waxing. • Glazed porcelain's slip resistance depends upon the type of glaze used. • Decorative mosaics' slip-resistance depends upon on tile size, grout joints and glaze. • Glass mosaics have a naturally low COF, but frequency of grout joints may help with drainage, thus improving traction.
Porcelain tile	• Unglazed porcelain is durable and offers good slip resistance when maintained properly. • Glazed porcelain is durable, but slip resistance depends upon the glaze used and texture of the tile. • Textured tiles also offer good slip resistant properties when wet. • Polished porcelain tiles are very slippery when wet and can only be used in dry applications.
Natural stone (e.g., granite, marble, limestone, slate and quartz)	• Most often available in polished materials, which are very slippery when wet and can only be used in dry applications. • Honed stone materials are also slippery when wet and generally have a low COF. • Flamed and texturized stone or concrete materials are typically recommended for exterior applications, but they must be properly maintained to preserve slip resistant properties.
Terrazzo	• Composed of granite and marble chips bonded with cement, then polished. • Is similar to polished natural stone in its slip resistant properties. • Can also be made with epoxy binder. • Has a naturally low COF. • Avoid at entrances in wet, humid climates or areas expected to come in contact with water.

*Coefficient of friction (COF) is the presence of traction between an individual's feet and a surface that allows the person to maintain an upright position.

1 **Table 1** (cont.) **- Slip Resistant Features by Floor Material**

Floor Material	Slip Resistant Features
Resilient (e.g., linoleum, vinyl, cork, rubber)	• Surface is polished with acrylic or other polymer coating. • Intended only for dry applications, per coating manufacturers' recommendations. • Has a naturally low COF. • Slippery when wet.
Laminate	• Composed of a wood layer with a clear, smooth polymeric protective layer on top. • Has a naturally low COF. • Intended for dry applications only. • Slippery when wet.
Concrete	• A honed stone, but not a sealed surface, in interior applications has a naturally high COF, as liquids from spills are absorbed into the concrete. • A honed stone, but not sealed surface, in exterior applications is slippery when saturated by rain or other sources of water. • When sealed, it has a naturally low COF and is intended for dry applications.

As a general rule, obtain a floor's designated COF from the manufacturer at the time of purchase. Flooring that is properly maintained should continue to yield a DCOF of greater than 0.42 as set by ANSI A326.3. However, the usage of coatings, sealants and other finishing treatments may change an original surface COF. Therefore before proceeding with aftermarket treatments, it's important for you to review the flooring manufacturer's testing data.

+

Key Takeaways:
The 3 C's of Floor Selection

- **C**arefully review flooring choices with architects, interior designers and manufacturers who understand walkway safety.
- **C**onsider a number of comparison points for different types of floors before making a selection, including, but not limited to: slip resistance, chemical resistance, durability, and care and maintenance factors.
- **C**onsult the original DCOF from the manufacturer at the time of purchase and whenever any finishing product is considered.

Slip Resistance Testing

The science of tribometry (slip resistance testing), is the measurement of friction on a surface, as carried out with a tribometer. Tribometry measures a floor's coefficient of friction (COF), which is the presence of traction between an individual's feet and a surface that allows the person to maintain an upright position. The industry method for measuring COF changed in 2012. It shifted from a focus on resting objects to the preferred dynamic coefficient of friction (DCOF). DCOF measures the resistance force while an object is in motion. There are two well-recognized DCOF testing methods: ANSI A137.1-2012 (hereafter ANSI A137.1) and the National Floor Safety Institute (NFSI) standard ANSI/NFSI B101.3, which measures the wet DCOF of common hard-surface floor materials.[1]

ANSI A137.1-2012 supplanted the ASTM International test method C1028 because the latter is unable to measure resistance when people are in motion, which is a relevant measurement in slip and fall prevention since individuals are technically moving when they lose their balance.

The Tile Council of North America (TCNA) published a new standard, ANSI A326.3, on April 20, 2017. ANSI A326.3 provides consumers, insurers and building owners a method to measure the DCOF of hard surface floors using the same core AcuTest® methodology as in ANSI A137.1.[2] Specifically, ANSI A326.3, Test Method for Measuring Dynamic Coefficient of Friction of Hard Surface Flooring Materials, provides the test practice to measure DCOF for all types of hard surface flooring. The standard reflects years of collaboration among various professional flooring representatives, which first resulted in the adoption of the practice supported in the A137.1 tile standard, and now, the creation of the stand-alone A326.3 standard. The new standard is available for free download on the TCNA website.

The new standard employs the same testing procedure for the BOT 3000E as does standard A137.1-2012.

When conducting resistance testing, CNA utilizes the Binary Output Tribometer (BOT) – 3000E, which employs the self-propelled drag sled principle originally defined by prominent safety researchers and scientists in Germany. The device has been designed to avoid the use of springs, actuators, dials, heavy weights or other components that can lead to premature device wear or mechanical fatigue.

CNA is proud to offer walkway safety guidance and tribometry testing with complete statistical analysis though its partnership with Safe Space Ingenuity, Inc. (SSI). SSI developed slip and fall software exclusive to CNA. Through computer-generated renderings, as represented in *Figures 6 and 7*, CNA is able to test outcomes and discern where walkways require immediate improvements, such as in the review of floor cleaning protocols.

[1] ANSI A137.1-2012 supplanted the ASTM International test method C1028 because the latter is unable to measure resistance when people are in motion, which is a relevant measurement in slip and fall prevention since individuals are technically moving when they lose their balance.

[2] The new standard employs the same testing procedure for the BOT 3000E as does standard A137.1-2012.

Background Information on the Tile Council of North America

The Tile Council of North American (TCNA) is a trade association of companies that produce ceramic tile, tile installation materials, tile equipment, raw materials and other tile-related products. It is a recognized leader in supporting the development of global quality standards intended to benefit tile consumers.

TCNA is the secretariat for the ANSI Accredited Standards Committee A108, which develops standards for ceramic, glass, stone and other hard surface tiles and panels. TCNA also represents ANSI on the International Standards Organization Technical Committee on ceramic tile and related installation materials (commonly referred to as ISO TC/189). It is active in various committees sponsored by the American Society of Testing and Materials, including C21 on Ceramic Whitewares and Related Products, F13 on Pedestrian/Walkway Safety and Footwear, C18 on Dimension Stone, E60 on Sustainability and E35 on Pesticides, Antimicrobials and Alternative Control Agents.

Regularly, the TCNA conducts independent research and product testing, and advises trade and government agencies. In addition, it publishes installation guidelines, standards, economic reports and marketing materials for the industry.

By conducting routine slip resistance testing, your business is better prepared to comply with flooring manufacturers' specifications, and on how to address the level of contaminants on walkway surfaces. Testing further enables you to select cleaning agents, finishes and sealants that will help maintain a surface's original COF. Surface testing may strengthen your defense of fall-related claims by starting a database of slip resistance measurements — taken both before and directly after an incident — which may prove beneficial in a later litigation setting.

In order to highlight the value of tribometry testing, CNA recently conducted case studies in a variety of industry settings, measuring the DCOF of primary walkway surfaces.[3] Findings revealed that floor surfaces in many different facilities fail slip resistance testing. To read the results of the studies in further detail, see "Case Studies on Slip Resistance Testing" on page 21.

[3] When conducting resistance testing, CNA utilizes the Binary Output Tribometer (BOT) – 3000E, which employs the self-propelled drag sled principle originally defined by prominent safety researchers and scientists in Germany. The device has been designed to avoid the use of springs, actuators, dials, heavy weights or other components that can lead to premature device wear or mechanical fatigue.

6 **Figure 6 - Example of Good Walkway Results**

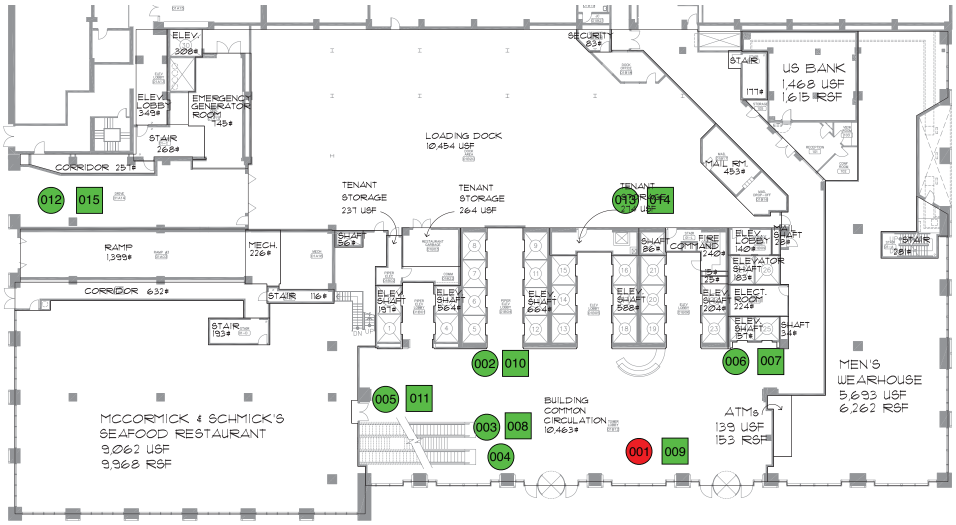


Diagram Key

- DCOF > 0.42
- DCOF < 0.42

Square Indicates Post Clean

7 **Figure 7 - Example of Bad Walkway Results**

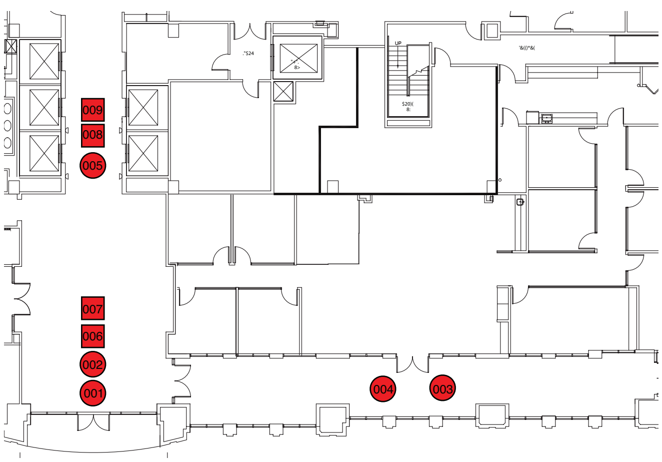


Diagram Key

- DCOF > 0.42
- DCOF < 0.42

Square Indicates Post Clean

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Key Takeaways:
The 4 C's of Slip Resistance Testing

- **C**onsult certified walkway specialists who are trained to conduct tribometry testing, in order to help in your analysis of current risks.
- **C**onform to the new industry standard, ANSI A326.3, for measuring DCOF of flooring surfaces.
- **C**reate a comprehensive floor safety program, which includes regular resistance testing of hard floors by a certified walkway specialist.
- **C**reate a database of DCOF measurements, and use it to inform both your cleaning product selection and your slip and fall prevention program.

Floor Maintenance

The choice of cleaning products that are friendly with a type of floor is a key element of a floor safety program. When flooring is not cleaned and maintained according to manufacturers' recommendations, floor contaminates — i.e., gravels, water, dirt and cleaning particles — can layer over an original surface, rendering your slip resistant floor dangerous. In fact, the very products and methods used to clean and maintain floor surfaces can be the direct cause of slip and fall accidents.

The following examples of floor maintenance-related errors may give rise to unnecessary risk exposures:

- Untimely removal of spills or accumulations of water.
- Improper selection of a cleaning product or finish for a type of flooring.
- Inadequate cleaning technique or drying time, leaving soap residue or water on the floor.
- Failure to clean a surface in accordance with the manufacturer's recommendations.
- Applying too much of a product, or too often.
- Failure to strip a surface of previously applied products and treatments.
- Failure to change dirty water before the rinse phase, thus contaminating a clean surface.
- Noncompliance with surface buffing specifications, when indicated.

Cleaning products are designed to sustain a floor's original COF. If they are improperly selected or applied, the friction measurement may be reduced. Cleaning products are derived from four major categories.

1 **Alkaline-based**

2 **Acidic-based**

3 **pH neutral**

4 **Microbial enzymatic**

To help ensure your business selects appropriate products, see *Table 2* on the following page for an overview of the four categories of cleaning agents and some of their attributes.

2 Table 2 - Cleaning Agents and Attributes

Cleaning Agents	Attributes
Alkaline-based	• May react with fats and oils, thereby converting contaminates into soap. • Floors must be fully rinsed with hot water to prevent polymerization, i.e., a buildup of contaminates. • May remove sealers, finishes and waxes. • Is often used in restaurants and dining areas. • Not recommended for natural stone surfaces.
Acidic-based	• Utilizes oxide reduction to remove rust, scale and other buildup from flooring surfaces. • Requires thorough rinsing after cleaning for maximum effectiveness. • Commonly used for cleaning porcelain, ceramic tile and grout. • Can scratch the flooring surface if used improperly. Eco-friendly agents, however, will not.
Neutral pH-based	• Often used on floors with glossy finishes, or surfaces damaged by acid or base cleaners, e.g., terrazzo and natural stone, such as marble and granite. • Requires thorough rinsing to be effective.
Microbial enzymatic	• Composed of scientifically created bacterial enzymes. • Requires no surface rinse post-cleaning. • Often used to clear drains and clean concrete, tiles and grout.

In addition to the type of product selected, the cleaning method plays an equally important role in achieving ideal maintenance results.

Wet and dry mopping are the most commonly used methods. Dry mops are designed to pick up soils before adding liquid and tend to make the cleaning process easier. Since this cleaning method requires no water-based solution, it permits cleaning while the soiled area remains in use. For an overview of the intended uses, benefits and/or drawbacks of different types of dry mops, see *Table 3* "Dry Mop Variations" below.

3 Table 3 - Dry Mop Variations

Dry Mop Type	Description
Cotton	• A natural fiber that works well to absorb or collect dirt and debris, but is not very helpful for fine dust particles, which can get lodged in the mop fibers. • Often used in combination with a dust mop spray,i.e., a spray applied to the mop head to trap dust. Most sprays consist of natural oil, e.g., banana oil. Controlling the amount of spray used is important as floors can become slippery following application. Water-based solutions are less effective at trapping dust. • To remove residue, a degreasing chemical is needed, which may cause damage to the floor finish. • In high humidity situations, cotton dust mops can catch and drag over walkways, affecting their ease of use.
Synthetic	• Made of plastic or man-made yarn. • Often stitched in a looped end pattern that easily attracts particles and prevents fraying. • Plastic mop heads collect dust by static electricity, instead of using a dust mop spray. • Yarn mop heads create minimum static electricity, so they are easy to shake out. • Can be laundered. • Not affected by moisture and are much lighter to push regardless of humidity or presence of liquid.
Microfiber	• Similar to synthetic dust mops but are made of plastic fibers. • Can be used on both dry and damp floors. • Channels in the separate plastic fibers grab fine dust particles, stopping them from going airborne. • Can be rinsed clean or laundered, increasing their life.

Based, in part, upon information from *Katom Restaurant Supply, Inc.*

With respect to wet mopping, the rate of absorbency is determined by the size of the mop head rather than the material. The use of a two compartment bucket — one side for clean and another for dirty water – is ideal for cleaning. The importance of clean water to rinse walkaways after cleaning cannot be emphasized enough. Finish becomes less effective when applied to an unclean walkway. For an overview of the different types of wet mops, see *Table 4* "Wet Mop Variations" below.

4 Table 4 - Wet Mop Variations

Wet Mop Type	Description
Cut End	• Least expensive wet mop option. • Often disposable. • Cannot be laundered.
Looped End	• Designed to pick up floor contaminants. • More durable than cut-end mops because of its yarn ply-twisted design. • May be laundered. • Can be made with fibers locked into the yarn that kills or stops the growth of bacteria, mold, mildew and yeast.
Microfiber	• Made from a blend of polyester and synthetic fibers that easily traps dirt. • Tends to be the most sanitary of all mop types. • Designed to be hypo-allergenic and non-abrasive. • May be laundered. • Considered an eco-friendly mop as it requires fewer chemicals to clean.

Source: Webstaurant Store

Key Takeaways:
The 4 C's of Floor Maintenance

- **C**omplete full background checks on all likely maintenance vendors to confirm they are financially stable, ethically sound and operate under a strong risk management structure.
- **C**hoose cleaning products that are compatible with walkways, and ensure that floor maintenance vendors are aware of the proper cleaning products.
- **C**onfirm your vendor contracts are reviewed by your legal representation to minimize your liability exposure.
- **C**onsider compliance with the Leadership in Energy and Environmental Design (LEED) certification requirements with respect to the selection of cleaning products and maintenance methods.[4]

[4] Organizations may earn points toward LEED certification through the selection of sustainable tile, as well as installation and maintenance products. The ANSI A138.1 standard — known as Green Squared® — contains specifications for sustainable ceramic tiles, glass tiles and tile installation materials. In particular, the use of tiles, mortar and grouts made by North American manufacturers that contribute to a North American Environmental Product Declaration may earn LEED points. For more information on the benefits of sustainable and eco-friendly selections, see Tile: The Natural Choice – 2016 Edition. Also see the website of TCNA's Green Initiative.

Risk Awareness and Control Measures

Most people are naturally aware of hazards that affect the safety of floors, and change their behaviors to avoid such hazards, such as slowing down while walking on a visibly wet floor. Known as "risk awareness," changes in your gait and posture occur when the brain receives signals from body sensors. This triggers your body to adjust and position for the purposes of safety. When age, reduced vision or environmental factors delays the normal awareness of exposures, it is the businesses responsibility to raise a person's "risk awareness."

Insights to Slip and Fall Variables: Human Gait and Vision Acuity

Human Gait

Knowledge of gait can help you offset the risk of slip and fall accidents in your business. Walking requires both horizontal and vertical forces to work together. Friction is a horizontal force created when feet contact the floor surface. Friction is strongest when a person pushes off from one foot and the weight shifts to the other foot. Gravity is a downward force that alters the body's center of gravity as a person shifts weight walking. The two forces create an altered center of gravity that is near constant, which results in people walking on average 80 percent of the time on one foot and 20 percent with both feet on the ground.

In addition, slip and fall accidents in certain phases of gait occurs. *Figure 1* illustrates the phases of walking. The first phase, i.e., the heel strike is the most common point at which a slip can occur. The increased heel speed between Phases 3 and 4 may increase the potential of a slip and fall on a slippery floor.

1 **Figure 1 - Four Phases of Walking**

1. Heel Strike 2. Support 3. Toe off 4. Leg lift

Personal awareness of glare, surface variation and other risks are critical to safe walking. Signage and other reminders, including flooring design choices, play a key role in keeping people standing and safe.

Vision Acuity

People with visual disorders may have a higher risk of slip and fall. Changes in depth perception and spatial relationships due to aging eyesight can impact a person's awareness of flooring and its properties. Designers must research and select flooring for the individuals who will walk on it — whether they are employees, customers, patients or residents.

Interior designers need to consider lighting that optimizes a person's vision. The science of syntonics, which influences the function of light through the eyes focuses on selected visible-light frequencies delivered through the eyes can improve vision. Optometric phototherapy is a growing field, helping to define the effect of light on the body's sensors, including the ability to focus and balance. Lighting choices that excite rather than delay the body's natural sensors can be helpful in businesses that serve people subject to weakened vision.

The following risk control actions safeguard against risks in your internal environment and help promote an increased awareness of safety on the part of people and employees:

Be proactive.
Conduct a needs analysis of your walkway safety management efforts, including documentation of surface DCOF values and maintenance requirements by both floor type and usage. Understand premise liability and your obligation to customers, visitors and employees. Manage your walkway risks though property premise modifications and/or contract agreements.

Train employees, property managers or contracted vendors on fall-related safety principles.
Education is key in any sustained fall-management effort. This should include specific skill training in terms of both how to clean and maintain floors, escpecially walkways. Select proper cleaning equipment, including mops/buckets, for each floor type. Turn to floor experts for proper finish and sealant products.

Design safe walkways.
Make sure walkway routes and building entrances are visible, free from obstacles. Water should quickly drain away from pedestrian areas to keep feet dry when entering the building. Snow/ice management is also important. Post signs near building entrances to show walkway elevation changes.

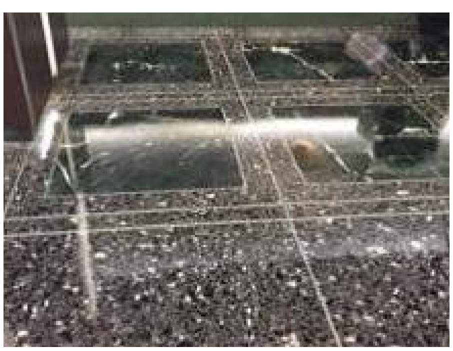
Place floor mats inside each doorway entrance.
Mats help trap outside walkway dirt and water before they reach your floors and create a possible exposure. To be most effective, purchase floor mats with slip resistant backing and beveled edges, position the mats flat on the floor and ensure they are cleaned on a regular basis. Lastly, floor mats should cover an area for people to take three to four strides, approximately six to eight feet, before coming into contact with the flooring underneath. For more information on floor mat considerations, see the ANSI/NFSI standard B101.6-2012.

Remain vigilant to the effects of glare and design contrast when selecting floors.
Slip and fall investigators have reported conditions in which a slip hazard could not be seen due to excessive glare and/or contrast in flooring color and design. (See *Figure 9*)

To help reduce floor glare, add a decorative planter or object that is away from the flow of traffic. In addition, create surroundings where color and design contrasts help signal changes in floor elevations rather than hinder their perception, in particular at door entrances. Keep in mind that the human brain requires time to adjust to changes in its surroundings before it signals a slowing of the gait. Limiting design-related barriers that may distract the brain from detecting hazards is a necessity.

9 **Figure 9 - Glare and Contrast Hazards**

1. Excessive glare



2. Too many contrasts

3. Excessive glare

Adhere to maintenance protocols.
Cleaning equipment should be regularly maintained and inspected. Mops should be the correct type for the floor and cleaned before each use. To avoid the risk of contamination between different floors in your facility, replace dirty mop heads before cleaning a new area. Likewise, when using a floor scrubber, examine the scrub brush or pad to ensure cleanliness. Clean mops should be hung up to dry to avoid damaging their ends.

Labeled equipment can help your maintenance workers select the proper equipment for marked areas. When cleaning takes place, your maintenance workers should display signage warning of wet hazards. This sign should be removed once the floor is dry. If an area is off-limits to people during cleaning, maintenance workers should know the procedure for setting up signage.

While a certain number of falls are usual in an active business, increased attention to floor safety standards can help reduce legal exposures. Floor care and maintenance are vital parts of a useful slip and fall program. Nevertheless, success requires flooring surfaces that are appropriate for their intended use, as well as cleaning products that maintain a desirable surface COF. By focusing on slip resistance testing, maintenance procedures and ongoing care to the surrounding and human-based risks, you can help keep people safe on their feet.

Resources

Fact Sheet: *OSHA's Final Rule to Update, Align, and Provide Greater Flexibility in its General Industry Walking-Working Surfaces and Fall Protection Standards*, from the Occupational Safety and Health Administration. November 2016.

Frequently Asked Questions: Walking-Working Surfaces and Personal Fall Protection Systems Final Rule, from the Occupational Safety and Health Administration.

Jabr, Ferris. "*Why Walking Helps Us Think.*" The New Yorker, September 3, 2014.

Lehtola, C., et al. "*Preventing Injuries from Slips, Trips and Falls.*" University of Florida Extension, Institute of Food and Agricultural Sciences. Updated February 2001.

Preventing Slips, Trips, and Falls in Wholesale and Retail Trade Establishments, from the National Institute for Occupational Safety and Health. October 2012.

Tile Council of North America, Inc.

Traumatic Brain Injury and Concussion, from the Centers for Disease Control and Prevention.

Case Studies on Slip Resistance Testing

Case Study 1: Real Estate

In this case study, floor surfaces in eight Class A, LEED-certified facilities were tested for slip resistance using the BOT-3000E digital tribometer. (See *Table 1* for floor type, cleaning methods and solutions used by facility.)

The surface DCOF was measured applying the wet testing method on pre-cleaned floors in all eight locations, and post-cleaned floors in four locations, following each facility's maintenance procedure. (See *Table 2*)

1 Table 1 - Flooring Type, Cleaning Methods and Solutions Used by Facility

Facility	Floor Type	Dry Mop	Wet Mop	Scrubber	Cleaning Solution
1	Terrazzo and Ceramic	X	X	X	Neutral
2	Natural stone	X	X	X	Neutral
3	Natural stone	X	X	X	Alkaline
4	Natural stone	X			Neutral
5	Natural stone	X	X		Neutral
6	Natural stone	X	X	X	Neutral
7	Terrazzo	X	X		Neutral
8	Natural stone	X	X		Neutral

2 Table 2 - Testing Conditions and DCOF Measurements by Facility

Facility	Pre-cleaned floor	Post-cleaned floor	DCOF measurement pre-cleaning*	DCOF measurement post-cleaning*
1	Yes	No	0.46	X
2	Yes	No	0.55	X
3	Yes	Yes	0.39	0.37
4	Yes	No	0.48	X
5	Yes	Yes	0.41	0.41
6	Yes	Yes	0.24	0.28
7	Yes	Yes	0.31	0.33
8	Yes	No	0.47	X

*Averages of various areas tested at each site.

The results showed that four of the eight facilities (signaled in red in *Table 2*) failed the slip resistance testing, as defined by a DCOF of less than 0.42. For many of the tested floor surfaces, both the pre- and post-cleaning results were similar, showing slight improvement after floor cleaning. In one test, a company ignored the manufacturer's proposed cleaner for a natural stone floor, using an alkaline-based cleaner. In most cases, failed results included the presence of floor debris, use of dirty water and/or cleaning equipment, and failure to use a two-compartment bucket.

RISK control lessons:

- **R**eview recommended proper cleaning products and uniform maintenance flooring protocols for floor surfaces.
- **I**nform and educate maintenance vendors and workers to understand the appropriate floor cleaning products in their native language.
- **S**tick to the manufacturer's specifications on regarding the proper application method technique.
- **K**eep strong adherence to maintenance protocols, including clean water during regular floor maintenance.

Case Study 2: Banking

In this case study, a financial institution tested 11 bank branches for slip resistance of their walkways using the BOT-3000E digital tribometer. The testing occurred during winter months when floor surfaces are most hazardous. The branches selected for testing had suffered an overall higher level of slip, trip and fall claims.

Applying the wet testing method, all 11 locations measured the surface DCOF on pre-cleaned floors. Floors were tested at high traction levels with the exception of four bank branches. (See *Table 1*)

1 Table 1 - Floor Type and BOT Reading by Branch with Substandard Testing

Branch	Floor Type	BOT reading post-cleaning
1	Terrazzo	0.36
2	Terrazzo	0.37
3	Terrazzo	0.33
4	Vinyl tile	0.30*

**Average of various areas tested*

Post-testing, the bank took measures to decrease the slip and fall risk exposures. Branch four completed the scheduled replacement of the vinyl flooring prior to the testing date, and branch two, covered the small area of terrazzo flooring with adhesive-backed carpet.

The terrazzo floors at branches one and three posed a greater challenge, since related costs made it expensive to replace or cover with alternative flooring. The application of an anti-slip trend activator corrected the challenging floor surfaces.

In order to demonstrate the efficiency of the activator, branch three was tested in a pilot application, creating an increase in the BOT reading of 0.21 from pre- to post-application. A decision was later made by the bank to apply a more cost-effective, anti-slip floor restoration compound to the terrazzo floors.

RISK control lessons:

- **R**emove prior coatings, sealants or debris from original floor surface before applying anti-slip tread activators.
- **I**mplement standardization of cleaning products and uniform maintenance protocols.
- **S**tress adopted guidelines and plans for the purchase of flooring types to ensure adequate DCOF rating.
- **K**eep slip and fall hazard signage on hand, and replace worn floor mats as needed.

Case Study 3: Healthcare

In this case study, the BOT-3000E digital tribometer tested the vinyl composition tile in four assisted living facilities for slip resistance. Applying the wet testing method, the measured surface DCOF on post-cleaned floors in all four locations and on one pre-cleaned floor, resulted in a DCOF of greater than 0.42, the desired level.

Prior to testing, a complete review of the floor maintenance program resulted in all four facilities demonstrating compliance with these five basic elements:

1) Regular floor inspections of surfaces and finishes recorded in a timely manner.
2) Thorough messaging strategy that simplified sharing of floor safety issues between business management and maintenance vendors and their workers.
3) Floor cleaning rules that outline equipment and product requirements for specific floor surfaces, and considered the adverse impact of climatic, traffic, and slip resistance.
4) Risk reduction through the use of floor mats, signage and ample lighting. A fall reporting and tracking system to allow quick treatment of fall victims, and address contributing factors.
5) Contractual safeguards between a business and its floor maintenance vendors in the form of waivers, hold-harmless agreements and proof of insurance.

RISK control lessons:

- **R**eoccurring cleaning and maintenance protocols can consistently yield slip resistant surfaces. Dedicate time and resources to improving your business's floor safety program.
- **I**mprove floor safety communication between business management and maintenance vendors.
- **S**erve the population your business supports.
- **K**eep people from falls (e.g., the elderly and people with disabilities) and proactively take safety measures in your business to ensure these individuals remain standing.

Case Study 4: Healthcare

In this case study, the BOT-3000E digital tribometer tested floor surfaces in five long-term care facilities during the spring and summer months for slip resistance. The floors lie in high-traffic exposure or prone to slip and fall accidents areas due to water, food or other debris.

The location of the tested surface nine areas:	
1) Main entrances	6) Resident bathrooms and shower rooms
2) Elevator lobbies	7) Physical therapy rooms
3) Main corridors and hallways	8) Kitchens and dining halls
4) Stairwell landing areas	9) Laundry areas
5) Resident rooms	

Floor coverings consisted of wood and tile laminate, linoleum, vinyl composition tile, concrete and concrete surfaces treated with an epoxy grip finish. No surfaces received additional cleaning prior to the test. Testing occurred under normal conditions with all floors kept on regular cleaning schedules. Using the wet DCOF testing method, each location received four tests.

The tests resulted in these seven findings:

1) Floors found in main entrances, resident rooms and shower rooms scored the lowest DCOF and, in some cases, less than the standard of 0.42 as set by the ANSI A137.1.

2) In all cases, scheduled cleaning complete cleaning of the area and/or the wrong cleaning method lead to poor results.

3) The buildup of soap on floor surfaces in bathrooms and shower rooms was a factor in low test results.

4) Despite similar floor types and cleaning schedules, DCOF measurements often varied from one resident room to another.

5) Floors in common areas that were not exposed to water hazards on a regular basis rated higher than 0.42, and had concrete, laminate or vinyl surfaces.

6) Covered surfaces that scored above the 0.42 threshold were wood or tile laminate.

7) Kitchens and laundry areas with traction-enhancing products improved testing results when applied in high risk areas.

Case Study 4: Healthcare (cont.)

Post-testing, in some instances, a facility had no record of scheduled cleanings or maintenance reporting. In other cases, increased DCOF occurred upon surface recleaning due to the initial low test scores. The resulting meetings resulted in discussions with maintenance workers regarding cleaning schedules, procedures and task. Lacking results caused a singular agreement with each facility to change their floor maintenance program.

RISK control lessons:

- **R**equire a written log of floor maintenance activities for tracking dates, areas cleaned, methods utilized and personnel assigned to various tasks.
- **I**nsist maintenance workers clean the full floor surface because buildup of debris or cleaning product can increase a slip and fall risk.
- **S**crub floors in bathing areas where soaps are regularly used by residents. Regular pressure washing and/or steam vacuuming of these areas can remove slip-inducing particle buildup.
- **K**eep the same maintenance schedules for private resident and non-private rooms. Select floor surfaces with a high DCOF when renovating spaces.