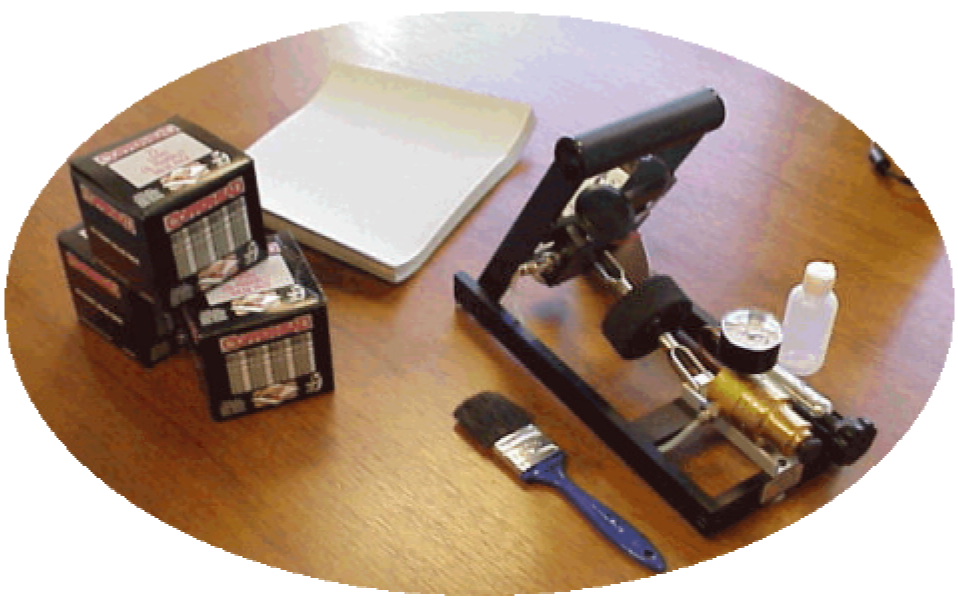
ESIS Risk Control Services

Slip Resistance Treatment

Study 2000



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ESIS Risk Control Services

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References to laws, regulations, standards and guidelines are not intended to be legal opinions concerning the interpretations of those documents. They are the authors' opinion only. The information contained herein is not intended as a substitute for advice from a safety expert or legal counsel you may retain for your own purposes. It is not intended to supplant any legal duty you may have to provide a safe operation, product, workplace or premises. ESIS makes no representation that either using or avoiding any of the products tested will reduce the frequency or severity of accidents.

Introduction

This study represents a refinement of earlier research completed in 1998. Both studies, however, were conducted in response to our loss control clients' need to develop a more proactive or solutions-oriented approach to reducing their slip and fall risk.

There are currently hundreds of floor surface treatment products on the market that claim to provide slip resistance. The true efficacy of these products – apart from the manufacturers' claims – is, however, unknown.

Most products tested provided some improvement in slip resistance. Others offered a dramatic improvement. In some cases, resistance was actually reduced. Overall, effectiveness varied widely, particularly on wet test surfaces.

The results offer the first clear evidence from a scientific study that noteworthy differences among slip resistance floor treatment products do exist. They also suggest that manufacturers' product information may not be a reliable guideline in selecting the right products to assist in reducing slip and fall loss costs.

Slip and fall accidents account for a majority of general liability claims in real estate, financial and retail operations. They also represent the second most frequent type of occupational injury. Their causes and control are therefore critical to successful loss control.

The study findings are not intended as opinions on the quality, merchantability, or fitness for the intended purpose of any product. Neither ESIS nor the authors of the study express any opinion on whether any products are defective in any way, and the study draws no conclusion, inference or implication that any product is in any way dangerous, defective or manufactured or designed improperly. No opinion is intended or offered with respect to the adequacy of any product warning.

Goals

The goal of this study was to compare the relative effectiveness of a variety of slip resistance floor treatment products.

This study was conducted for the purpose of increasing the existing body of knowledge among safety professionals concerning a particular type of safety hazard. All findings are relative only in that all comparisons are between and among the products tested. No opinions are offered with respect to any product not tested.

Overview

Two types of floor surfaces were selected for testing. Test surfaces were (1) glazed ceramic tile and (2) marble in 12" x 12" squares, purchased at a retail facility.

A number of slip resistance floor treatment product manufacturers were contacted and invited to participate. The ten (10) vendors who agreed to be a part of this study are identified as Group One through Group Ten.

Each set of two surfaces was pre-tested as indicated below. One set of surfaces for each vendor was packed and shipped via UPS with instructions regarding application, documentation, and return transit.

Once the treated surfaces were returned to ESIS RCS from the vendors, they were re-tested under the same conditions. The results were recorded and compared. David Underwood, Ph.D., an analytical chemist and member of the American Society for Testing and Materials (ASTM) technical committee F-13, performed the statistical analysis. ASTM F-13, *Safety and Traction for Footwear*, develops standards and methodologies for slip resistance testing. Dr. Underwood compared the results obtained during pre-testing with those obtained from the treated tiles.

Protocol

The test instrument for this study was a Variable Incidence Tribometer [VIT], which was inspected and calibrated by the manufacturer prior to pre-testing and again prior to the testing of treated tiles. The English XL has undergone a series of "round robin" workshops, conducted by the American Society for Testing and Materials (ASTM) over several years to demonstrate repeatability and reproducibility of test results.

The test foot material for this study was Neolite® test liner*, a generic and durable substance that is one of the most commonly used materials for slip resistance testing. Unlike leather, the properties of which are affected by moisture and wear, the characteristics of Neolite test liner do not change under normal conditions. Neolite test liner is recommended by the tribometer manufacturer, and specified by ASTM D-5859, *Standard Test Method for Determining the Traction of Footwear on Painted Surfaces Using the Variable Incidence Tribometer.*

Testing was done in accordance with:

- *ASTM F-1679 Standard Test Method for Using a Variable Incidence Tribometer* (VIT), released in 1996, which recognizes the English XL VIT as a valid slip resistance field testing device for wet and dry surfaces.
- The most recent release (updated June 1999) of the instruction manual and supplement published by the manufacturer for the English XL Slip Resistance Tester.
- The test foot preparation protocol was done in accordance with the manufacturers' current specifications, using 180 grit silicon carbide sandpaper.

*Neolite® is a registered trademark with Goodyear Tire and Rubber Company.

Other Specifications

Pre-testing and treated testing were completed at a single location, in a temperature-controlled environment, and on the same level surface. Treated tile testing was performed on the same portions of the test quadrants identified and tested during pre-testing. All testing was completed by the same operator, a member of ASTM F-13 and F-06 (*Resilient Floor Coverings*) who is ESIS-certified in slip resistance testing and has five (5) years of experience with the tribometer.

For statistical reliability, three sets of four readings (one for each quadrant) were taken.

Surface Preparation

Each surface was marked using an indelible marker on the underside of each tile, indicating:

- testing quadrant (A, B, C, D)
- group number (1B10)

The tiles were cleaned by running them through a dishwasher, and were allowed to air dry.

Test Notes

- Tested each quadrant dry, then each quadrant wet
- Completed all dry testing for all surfaces first, then performed wet testing

Dry Testing		**Wet Testing**	
Relative Humidity	*39% - 42%*	*Relative Humidity:*	*41% - 43%*
Temperature (F):	*75° - 77°*	*Temperature (F):*	*72°*

Packing & Shipping

Each group (set of two pre-tested tiles) was packed and shipped to vendors in the following manner:

- Each tile was packed with three layers of bubble wrap, secured with cellophane packing tape
- A layer of packing "peanuts" was placed at the bottom of the shipping carton
- A layer of packing peanuts was placed between the tile packages and on top of the last tile to the top of the box
- Shipping was done by UPS ground transportation
- The tiles were returned by the same method shipped (UPS Ground Ship – prepaid)
- Return packaging used the same method and materials (e.g., bubble wrap and box) as the outgoing shipment
- Condition of packing and tiles upon receipt was good: no visible damage was noted

Treated Tiles Testing

Dry Testing		**Wet Testing**	
Date of Test: 09/08/99		*Date of Test: 09/09/99*	
Relative Humidity	*42% - 47%*	*Relative Humidity:*	*41% - 44%*
Temperature (F):	*72° - 75°*	*Temperature (F):*	*72° - 73°*

Treated tile testing was completed using the same process and protocol as pre-testing.

Notes on Maintenance

This study was completed under relatively ideal conditions. Treatments were applied to the test surfaces by the vendor. Testing of the treated tiles was completed fairly soon after application of the product. Since there was no wear due to use (e.g., walking on the surfaces), the treatment remained in pristine condition for testing.

Under real life conditions, treated surfaces are continuously exposed to wear from pedestrian traffic, which can compromise the integrity and effectiveness of the product. As a result, proper maintenance is essential to sustaining effective slip resistance.

The extent and mechanics of maintaining treated surfaces varies considerably by the type of treatment. When selecting a given treatment, consideration should be given to the nature of the maintenance requirements. For effectiveness of a treatment over time, the manufacturer's instructions must be observed.

Notes on Appearance

A degree of dulling of the glossy surface occurred with most treatments, some more prominently than others. The amount of dulling depends upon a number of variables, including the type and quality of flooring material to which the treatment is applied. Appearance is another factor that must be considered when selecting the appropriate treatment for a given facility. To assure the suitability of the appearance, it is strongly recommended that treatments be applied to a sample of the surface to be treated, or in a small remote area prior to full-scale use.

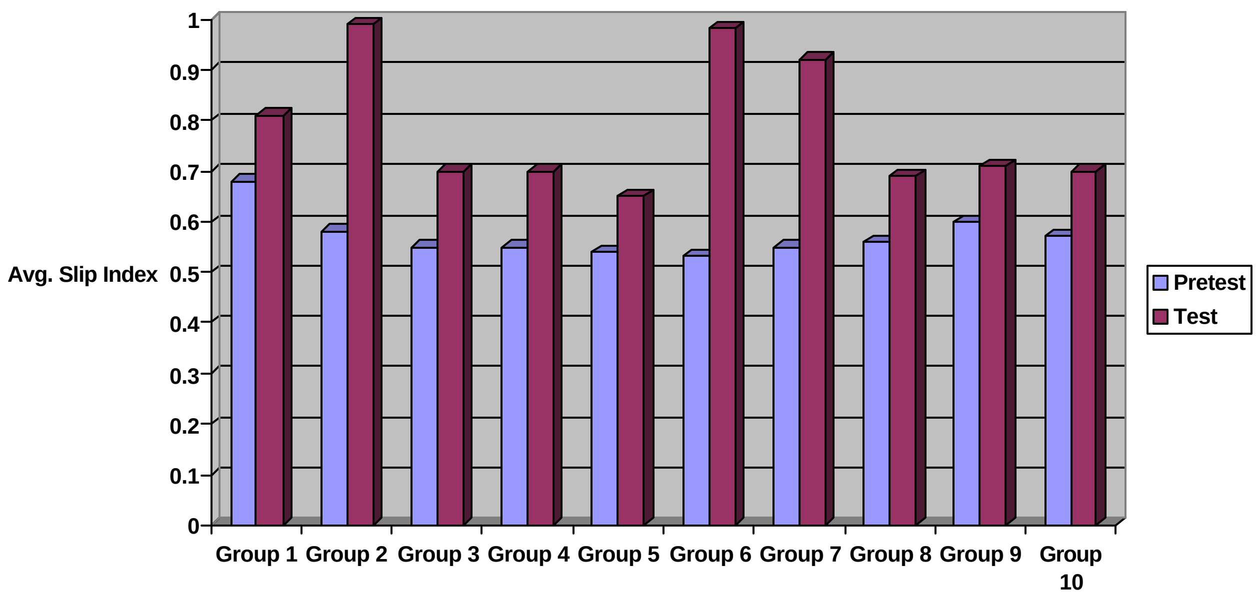
Other Notes

There are a wide variety of treatments on the market, some of which have been developed to be effective only when used on specified types of flooring material. Care must be taken to assure that the treatment selected is suitable for the floor to which it is to be applied.

Another important factor to consider in selecting a floor treatment is the method of application. Some treatments involve the use of harsh chemicals and require expertise to apply properly, while others are non-toxic and are designed for use by the non-professional.

Comparison of Results B Ceramic

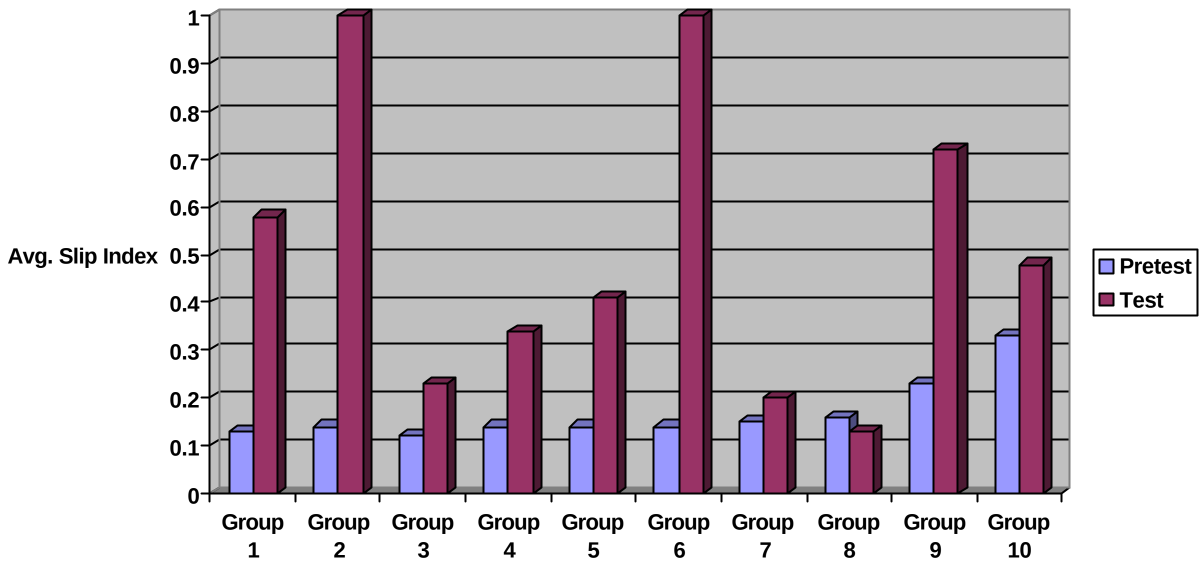
Ceramic – Dry



On dry ceramic, even the untreated tiles exceed the generally recognized 0.50 guideline. While all treatments increased slip resistance to some degree, some treatments (such as Groups 2, 6, and 7) provided substantial improvement, exceeding 0.9.

Comparison of Results B Ceramic

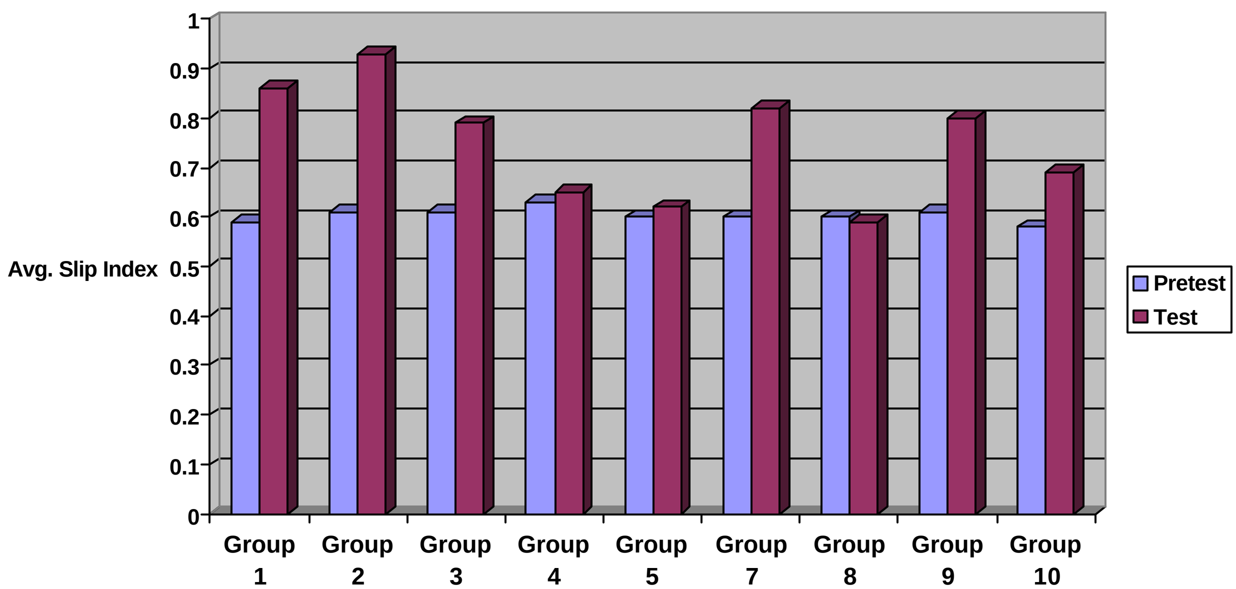
Ceramic – Wet



Wet ceramic untreated tiles were mostly between 0.1 and 0.2 X very low slip resistance. All but one treatment (Group 8, which actually decreased) increased slip resistance, and Groups 1, 2, 6, and 9 provided improvement beyond 0.50. Additionally, Groups 2 and 6 did not slip, even at 1.0, the most horizontal position of the tribometer. This is a remarkable result, since both treatments managed to increase slip resistance from approximately 0.1 to more than 1.0, a ten-fold improvement.

Comparison of Results B Marble

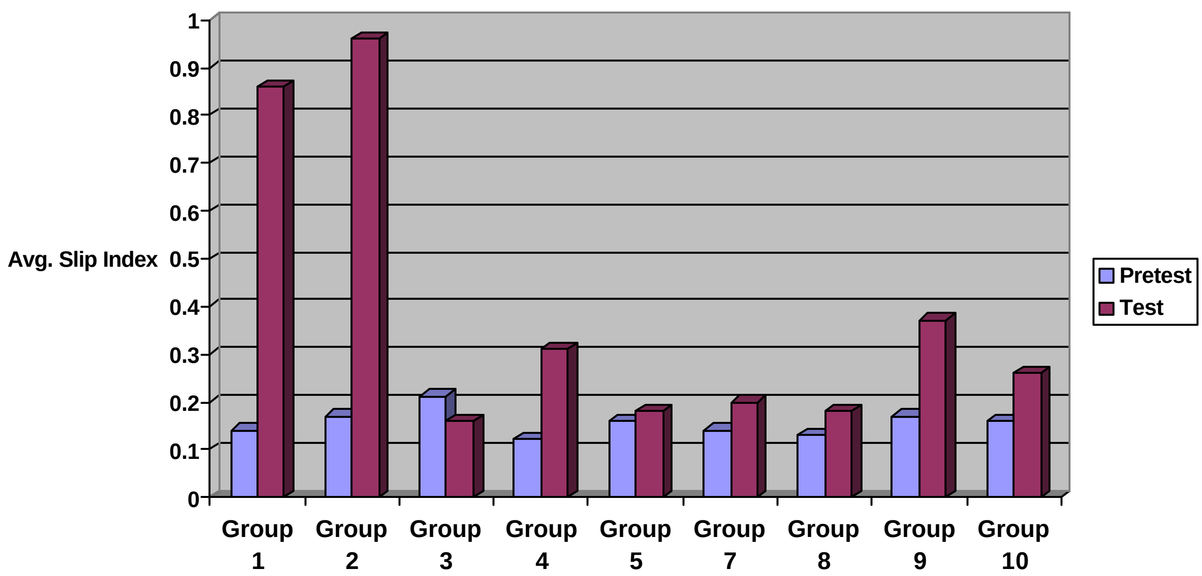
Marble – Dry



Like dry ceramic, untreated dry marble exceeds the generally recognized 0.50 threshold. While some treatments (such as Groups 1, 2, and 7) provided the most improvement (exceeding 0.8), others showed minimal improvement (Groups 4 and 5), and one demonstrated an actual decrease in slip resistance (Group 8).

Comparison of Results B Marble

Marble – Wet



Wet marble untreated tiles pre-tested in a way similar to wet ceramic, mostly in the 0.1 to 0.2 range. It is clear that Group 1 and 2 treatments demonstrated dramatic improvements (beyond 0.8 and 0.9 respectively). Others, such as Group 5, 7, and 8, showed minimal increases. The Group 3 treatment showed a reduction in slip resistance from the untreated condition of the wet marble.

Note: Group 6 was omitted from marble results, since no testing was performed.

Credentials and Claims*

The product information available on products falls into one of two primary categories. Some vendors advertise that their products will meet or exceed applicable federal laws. Many state they meet industry consensus standards by engaging an independent testing firm or by testing the product in-house. In comparing the claims of vendors against the study results, there appeared to be low correlation between product claims and the efficacy of the product.

*The information for this section was gathered from additional and prior research, and is not limited to the vendors that participated in this study.

Federal Laws and Standards

The two most cited federal laws with regard to slip resistance are from the Occupational Safety and Health Administration (OSHA) and the Americans with Disabilities Act (ADA). Some vendors claim to meet or exceed the "standards" or "requirements" contained within these laws.

The OSHA "standard" for slip resistance is not a law, nor is it a standard. It is a proposed non-mandatory appendix item set by OSHA and was never adopted as a standard (it specifies slip resistance of 0.50 or higher for the workplace). While it is possible for an OSHA inspector to cite this guideline under the "General Duty Clause," we could find no evidence that this is done in practice. What makes this particularly difficult is that OSHA has specified no test protocol or device upon which to base a citation X effectively making it unenforceable.

The ADA "law," like OSHA, is also a guideline, since the specification appears in an appendix. And because no test protocol or device is specified, even this recommendation is difficult to apply. The ADA specifies slip resistance of at least 0.60 for level surfaces and 0.80 for ramps, where accessible by persons with disabilities. Subsequent to enactment of the ADA, it was determined that the study conducted to validate the specified level of slip resistance was faulty. The study used a laboratory force plate to measure traction demand for the handicapped.

The Architectural and Transportation Barriers Compliance Board (also known as the ATBCB or Access Board) of the U.S. Department of Justice was created to ensure federal agency compliance with the Architectural Barriers Act (ABA). The Access Board adopted the ADA recommendations, and has stated these specifications as a guideline, not a requirement or a standard. Again, no test protocol (e.g., device or test method) is specified.

Consensus Standards

Meeting or exceeding a consensus standard is another often-cited feature in the advertising of slip resistance floor treatments. In some cases, these standards provide only a testing methodology, not a measure of safety; in others, the test method of a standard is modified or not followed properly. Finally, the standards themselves may be obsolete.

<u>American Society of Testing and Materials (ASTM)</u>

The ASTM is the most active organization in the development of standards for measuring slip resistance. The ASTM has promulgated standards for a number of tribometers, including the Variable Incidence Tribometer (VIT or English XL) and the Portable Inclineable Articulated Strut Slip Tester (PIAST or Brungraber Mark II).

However, with the exception of Standard D-2047 (involving a specification of 0.5 for the James Machine – see UL below), the ASTM has never offered a slip resistance threshold of safety, making it impossible to “exceed” an ASTM slip resistance standard. Most ASTM standards are “test methods,” or steps to follow in arriving at a measure of slip resistance. “Meeting” an ASTM test method standard only means that the proper steps were followed using the appropriate test device. It is not relevant to the results of the testing, just to the method of reaching those results.

Tests to demonstrate the effectiveness of a treatment are often done using a horizontal dynamometer pull-meter method, a device requiring the use of a 50-pound weight. It is known by experts for overestimating the slip resistance of wet surfaces due to a phenomenon known as “sticktion.” This ASTM document, *Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method* (C1028) has not been updated in many years. In addition, ensuring proper design and calibration of a self-constructed instrument brings into question the validity of the results.

One vendor cited ASTM D-56 in relation to the slip resistance qualities of the product. ASTM D-56 is titled *Standard Test Method for Flash Point by Tag Closed Tester*, and is not related to slip resistance.

Ceramic Tile Institute (CTI)

Some vendors will market a slip resistance floor treatment on the strength of meeting or exceeding requirements as required by the Ceramic Tile Institute (CTI), an industry group representing the interests of the ceramic tile industry. CTI specifies use of ASTM C1028, which is a test method only and does not specify a level of safety. C1028 cannot be exceeded, since it specifies no “safe” or “unsafe” level of slip resistance.

Underwriters' Laboratories (UL)

Many vendors state that their products are classified or certified by Underwriters' Laboratories (UL) as to slip resistance.

While UL does not “certify” products as to slip resistance, it does “classify” products as such. UL will apply the treatment to a surface and test it to UL 410, using the James Machine. To qualify for classification and be permitted to use the UL Classification Marking, test results must show a slip resistance of greater than 0.50, and the manufacturer must pay a fee. Documentation of classification does not provide actual test results, but states only that it was greater than the minimum of 0.50.

The James Machine is a laboratory device designed to test under ideal conditions only for merchantability (the suitability of the product for sale) of new flooring products. This standard is inappropriate for application for field testing.

The James Machine is a complex device for which there are still no standard set-up, operating procedures, or precision and bias from any independent laboratory or consensus standards-making organization.

Complicating the situation, there have been several manufacturers of this device, and in each instance the apparatus was designed and built somewhat differently. Most important, the James Machine is not designed (or even listed by UL) for wet testing. Thus, testing done using this device can be considered questionable.

Independent Laboratory Testing*

The use of independent laboratories for testing products is a frequent component of marketing for slip resistance floor treatments. In most cases, these laboratories use the ASTM or UL standards. However, information demonstrating that the laboratory is qualified to perform such specialized testing is rarely available, and details on the conditions and results of testing are likewise unavailable.

*The examples used in this section are not quotes from any specific product or vendor, but are intended to illustrate the types of claims a consumer may have to interpret.

Example:
… the increase in friction of wet surfaces was between 150% to 500%, based on independent testing with the James Machine.

Aside from the lack of details on the testing, the James Machine is not designed (or listed by UL) for wet testing, making these results irrelevant.

Example:
… tested by one of America's leading independent testing laboratories ... results exceeded all national standards for dry floors, with a 300% increase on wet ceramic tile and 100% on wet marble.

Again, testing was done using the James Machine, inappropriate for all but dry laboratory testing of pristine surface materials. And while our tests also showed a 300% increase in ceramic tile when wet, our results showed 0.41, still below 0.50, the generally recognized safety level of slip resistance. For wet marble, our testing did not show an increase of 100%, but of 12.5%.

Example:
… thoroughly tested and approved by an independent testing laboratory.

The testing laboratory is a provider of insurance and financial services to automotive-related businesses. No details of test device, protocol, and results were provided.

Example:
Independent testing was done in 1993 in accordance with ASTM C1028.

Aside from the age of this testing, the testing laboratory specializes in providing environmental and geo-technical consulting services, and does not appear to have expertise in slip resistance testing.

Conclusions and Summary

The measurement of slip resistance is an emerging field. New technology that was unavailable 10 years ago has pushed reliability far forward. But, it is essential that consensus organizations like the ASTM continue to oversee and refine standards and practices in slip resistance. At the same time, there needs to be a more sophisticated awareness about how current standards and technology might be applied appropriately, as well as their limitations.

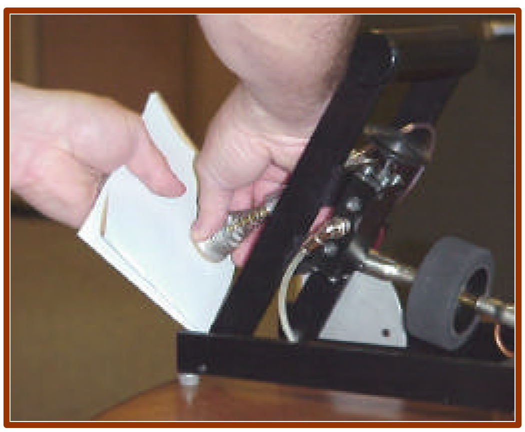
With regard to slip resistance floor treatments, it is clear that more work needs to be done in evaluating the efficacy of these products. Hopefully, the results of this study will help demonstrate the wide range in effectiveness, as well as what is involved in interpreting marketing approaches used by manufacturers of these products.

Test Preparation

The English XL VIT was visually inspected before each testing session to ensure the security of fastenings, the alignment of the thrust cylinder, and the indicating pointer on the protractor.

Operating pressure of 25 PSI + or - 1.5 PSI was maintained for all tests.

Sanding was done according to the June 11, 1999 *Supplement to the XL Operations Manual.*



The Neolite test liner disk was sanded after each stroke that produced a slip. For wet testing, sanding was completed before each test session.

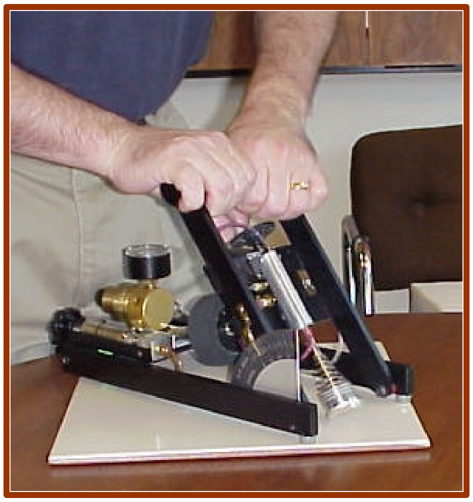
First, the XL was moved away from the tile (so that sanding dust would not fall onto the test zone).

The Neolite test liner disk was prepared by lightly sanding in a circulator motion for five cycles with180 grit silicon carbide sandpaper with a hard backing. Fresh sandpaper was used when the paper became visibly worn. The test foot was then brushed off and returned to the testing position. In addition to sanding, the disk was rotated about ¼ turn after each slip. The combination of sanding and rotation of the disk avoids the potential for polishing of the disk, which could affect test results.

Wet Testing

Surfaces were first tested dry and then tested wet. Water was used for wet testing. Surfaces were wet in advance of actual testing to ensure that the surface material was adequately saturated. A thin, unbroken film of water was maintained on the surface.

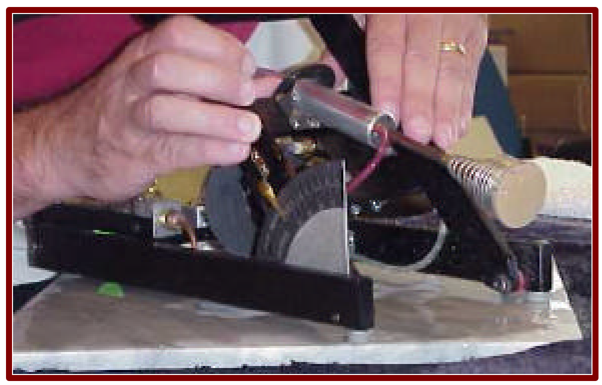
Testing Process

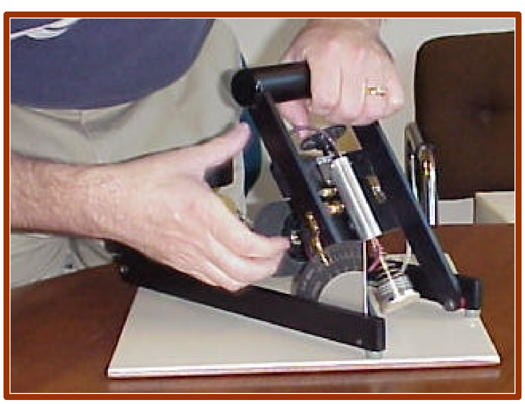


The starting point of the mast angle was estimated conservatively, to minimize the potential of an immediate slip. A relatively low slip index (a more vertical mast, such as 0.2 slip index reading) was used, gradually working up to higher slip index (more horizontal mast).

The hand wheel was turned about ¼ turn for each stroke. The actuating button was pressed for ½ second and released.

The process was repeated until the first full-stroke slip occurred. The results were then read from the slip index protractor (rounded to the nearest 0.01), and documented using the attached spreadsheet.





To ensure statistical reliability, three sets of four readings (one for each quadrant) were taken for each round of tests (e.g., readings on quadrants A, B, C, and D were taken three times for dry ceramic tile pretest).

Test Results by Group

The statistical analysis of test results was performed by David Underwood, Ph.D. A paired-comparison t-test was done, using the average from each set of four readings to obtain the probability of whether the numbers are the same. This probability ranges from 0 (no chance they are the same) to 1 (100% chance they are the same). Generally, if the probability is 0.05 or less, the numbers can be considered different. If a p value of 0.05 translates to 100* there is 95% confidence that the numbers are different (1. - .05 = 95%).

Where the confidence factor is in the 95% range, the results of the testing are considered to be statistically sound and reliable.

Sample	P Value	Confidence
Group One		
Ceramic Dry	0.19	81%
Ceramic Wet	<0.001	+99%
Marble Dry	0.003	+99%
Marble Wet	<0.001	+99%
Group Two		
Ceramic Dry	<0.001	+99%
Ceramic Wet	<0.001	+99%
Marble Dry	<0.001	+99%
Marble Wet	<0.001	+99%
Group Three		
Ceramic Dry	0.02	98%
Ceramic Wet	0.004	+99%
Marble Dry	0.01	+99%
Marble Wet	0.148	85%
Group Four		
Ceramic Dry	0.001	+99%
Ceramic Wet	0.002	+99%
Marble Dry	0.10	90%
Marble Wet	0.006	+99%

Test Results by Group
(continued)

Sample	P Value	Confidence
Group Five		
Ceramic Dry	0.02	98%
Ceramic Wet	0.002	+99%
Marble Dry	0.34	66%
Marble Wet	0.53	47%
Group Six		
Ceramic Dry	0.01	99%
Ceramic Wet	<0.001	+99%
Marble Dry	N/A	N/A
Marble Wet	N/A	N/A
Group 7		
Ceramic Dry	<0.001	+99%
Ceramic Wet	0.06	94%
Marble Dry	<0.001	+99%
Marble Wet	0.07	93%
Group Eight		
Ceramic Dry	0.02	98%
Ceramic Wet	0.13	87%
Marble Dry	0.52	48%
Marble Wet	0.03	97%
Group Nine		
Ceramic Dry	0.03	97%
Ceramic Wet	<0.001	+99%
Marble Dry	0.02	98%
Marble Wet	0.02	98%
Group Ten		
Ceramic Dry	0.04	96%
Ceramic Wet	0.02	98%
Marble Dry	<0.001	+99%
Marble Wet	0.06	94%