NISTIR 5988

Seeking Validation and Consensus on Slip-Resistance Measurements and Standards

Report from the Workshop on: Evolution of Slip-Resistance Standards November 21-22, 1996

Geoffrey J. Frohnsdorff
Jonathan W. Martin

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

United States Department of Commerce
Technology Administration
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ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the members of the Steering Committee for their invaluable contributions to the planning of the workshop. Also, on behalf of the Steering Committee, they wish to thank all who participated in the workshop to help advance the development of standards needed to reduce the risks of slips and falls.

Last, but not least, the authors wish to thank Nancy Wilkin, Vicki Glennie and Nancy Evans for their help with the arrangements for the workshop, and Janice Hagood for preparing the manuscript for this report for publications.

Executive Summary

In view of widespread confusion about slip-resistance measurements, standards and criteria, a workshop on "Evolution of Slip-Resistance Standards" was held at the National Institute of Standards and Technology on November 21 and 22, 1996. The participants in the workshop represented a cross-section of interested parties, including members of ASTM, ANSI, and ACI committees which are more-or-less independently developing slip-resistance and related standards, manufacturers of flooring materials, forensic engineers and private consultants, academic researchers, and representatives of several federal agencies concerned with safety in buildings and other facilities. The workshop objectives were:

1. To decide if there is a need for either or both of improvement and harmonization of standards for the performance -- specifically relating to slip-resistance -- of floors and other surfaces in buildings.
2. To decide if there is a need for consensus performance criteria for slip-resistance of floors and other surfaces.
3. If there is agreement that there is a need for improved or harmonized standard test methods and performance criteria for slip-resistance, to identify ways in which the desired result could be achieved and recommend actions to be taken.

To provide a background for working group discussions, four invited speakers provided their perspectives on the status of the development of slip-resistance standards and of the needs. Four working groups then addressed the objectives and prepared to present their recommendations at a final plenary session. The final session produced a wide range of recommendations, which differed substantially from working group to working group, but were not in conflict. Examples of needs to which the groups drew attention in their reports to the plenary session were needs for:

- A common vision among code bodies, product manufacturers, and users as to what slip-resistance standards should be like.
- Recognition of the importance to industry of having slip-resistance standards.
- Recognition that there should be different slip-resistance standards for different circumstances.
- A hazard analysis assessment of slip-resistance using studies of slips and falls to identify relevant variables.
- A uniform way of gathering statistics on slips,
- A determination of economic losses from slips, and of the costs in terms of pain and suffering,
- Performance criteria for evaluating slip-resistance test methods,
- Evaluation and inter-comparison of currently available slip-meters,
- A standard guide on slip-resistance for architects and others,
- A multi-pronged approach to reducing the frequency of occurrence of slips and falls.

At the end of the final plenary session, the following statements received unanimous agreement from those present:

1. There is a need for improvement of standards for the performance -- specifically relating to slip-resistance -- of floors and other surfaces in buildings.
2. There is a need for consensus performance criteria for slip-resistance of floors and other surfaces.
3. In view of the need for improved standard test methods and performance criteria for slip-resistance, a nationally-respected organization should arrange for an independent, authoritative committee to be set up to recommend actions needed to reduce the number of slips and falls and the seriousness of the injuries caused.

   Steps to be taken by the committee should include:

   a) a critical review of existing information on the causes of, and ways of preventing, slips and falls,

   b) an assessment of the scientific basis for existing slip-resistance measurements and their relationship to actual slips and falls, and

   c) recommendations as to actions to be taken to meet the needs for standards.

Abstract

In view of widespread confusion about slip-resistance measurements, standards, and criteria, a workshop on "Evolution of Slip-Resistance Standards" was held at the National Institute of Standards and Technology on November 21 and 22, 1996. The participants in the workshop represented a cross-section of interested parties, including members of ASTM, ANSI, and ACI committees which are developing slip-resistance and related standards, manufacturers of flooring materials, forensic engineers and private consultants, academic researchers, and representatives of several federal agencies concerned with safety in buildings and other facilities. The main workshop objective was, essentially:

- To decide if there is a need for improved or harmonized standard test methods and performance criteria for slip-resistance and, if so, to identify ways in which the desired result could be achieved and recommend actions to be taken.

Four working groups addressed the objectives and presented their recommendations at a final plenary session. At the end of the workshop, unanimous agreement was received to the following statements:

1. There is a need for improvement of standards for the performance -- specifically relating to slip-resistance -- of floors and other surfaces in buildings.
2. There is a need for consensus performance criteria for slip-resistance of floors and other surfaces.
3. In view of the need for improved standard test methods and performance criteria for slip-resistance, a nationally-respected organization should arrange for an independent, authoritative committee to be set up to recommend actions needed to reduce the number of slips and falls and the seriousness of the injuries caused.

Keywords: Buildings, floors, measurement, need for standards, performance criteria, recommendations, slip-resistance, standards, workshop.

ACRONYMS:

ACI	American Concrete Institute
AFL/CIO	American Federation of Labor/Congress of Industrial Organizations
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BFRL	Building and Fire Research Laboratory (NIST)
BOCA	Building Officials and Code Administrators
COF	coefficient of friction
COS	Committee on Standards (ASTM)
CPSC	Consumer Product Safety Commission
FTC	Federal Trade Commission
HUD	U.S. Department of Housing and Urban Development
NEISS	National Electronic Injury Surveillance System
NIST	National Institute of Standards and Technology
NRC	National Research Council
OSHA	Occupational Safety and Health Administration
SENRAC	Steel Erection Negotiated Rulemaking Advisory Committee

Contents

1. Introduction

Injuries resulting from slips and falls are among the most common injuries suffered by U.S. citizens. The large magnitude of the economics losses can be deduced from workers compensation claims reported by a single private insurer [1] who is believed to have about 10 percent of the private insurance business. For this insurer, claims resulting from slips and falls in 1990 accounted for 17 percent of the number of claims, and about 28 percent of the total cost (about $650 million) of claims for workplace illnesses and injuries. From the total cost of the claims in 1990, it may be estimated that the cost to the whole private insurance industry of claims for injuries resulting from slips and falls in the workplace is of the order of $6 billion/year. This figure, which does not include the cost of injuries from slips and falls outside the workplace, is only quoted to suggest that anything that could be done cost-effectively to reduce the frequency of slips and falls, and the seriousness of injuries resulting from them, would be of substantial economic importance in addition to its importance in reducing pain and suffering.

While reducing the number of slips and falls and the injuries resulting from them is clearly a worthy goal, it has been given new emphasis with the publication of the "National Construction Goals" by the Subcommittee on Construction and Building of the Committee on Civilian Industrial Technology of the National Science and Technology Council [2]. These goals are:

50% Reduction in Delivery Time;
50% Reduction in Operation, Maintenance and Energy Costs;
30% Increase in Productivity and Comfort;
50% Fewer Occupant Related Illnesses and Injuries;
50% Less Waste and Pollution;
50% More Durability and Flexibility;
50% Reduction in Construction Work Illnesses and Injuries.

In a commentary concerning the goal of "50% Fewer Occupant Related Illnesses and Injuries," the report stated:

> *"Buildings are intended to shelter and support human activities, yet the environment and performance of buildings can contribute to illnesses and injuries for building users. Examples are avoidable injuries caused by fire or natural hazards, slips and falls, ..."*

and, in connection with the goal concerning "50% Reduction in Construction Work Illnesses and Injuries," which includes slips and falls, the report stated:

> *"... although the construction workforce represents about 6 percent of the Nation's workforce, it is estimated that the construction industry pays for about one-third of the Nation's Workers' Compensation. Workers' Compensation Insurance Premiums range from 7 to 100 percent of payroll in the construction industry. Construction workers die as a result of work-related trauma at a rate that is 2-1/2 times the annual rate for workers in all other industry sectors (13.6 deaths per*

100,000 construction workers, as compared to 5.5 deaths per 100,000 workers in all other industry sectors.) Construction workers also experience a higher incidence of nonfatal injuries than workers in other industries."

It seems obvious that if the National Construction Goals are to be achieved, serious attention must be given to reducing the number of injuries from slips and falls.

While it is not known precisely what fraction of slips and falls are a result of slipping, a 1977 publication of the National Safety Council [4] quoted in Reference 3 of the present report, stated that "*In more than half of the falls, slippery surfaces were identified as a major contributing factor.*" If this is still the case, understanding and quantitative knowledge of the factors contributing to slipping should be important in seeking to reduce the frequency of slips and falls. An indication of the large number of possibly significant variables can be obtained from the list given in the recently-issued ASTM F1694-96, Standard Guide for Composing Walkway Surface Evaluation and Incident Report Form for Slips, Stumbles, Trips, and Falls [5]. The list of factors includes:

footwear sole
footwear heel
walkway type
walkway construction material
walkway load
walkway surface
surface levelness
surface texture
surface contaminants
maintenance record
handrails/guardrails
weather conditions
safety program
signs and warnings
walkway illumination
natural outdoor light
number of people involved

Because of the number of possible factors that may influence the sequence of events in any slip and fall occurrence, and the difficulty in collecting reliable data about them, much remains to be learned about this subject. It is generally agreed that there is a need to be able to measure the "slipperiness" or "slip-resistance" of surfaces involved in human locomotion, but agreement is lacking about how to define slip-resistance, or how to measure it and standardize its measurement. This lack of agreement probably hinders progress in reducing the number of slips and falls because of the time and effort expended trying to develop appropriate standards, and because it raises questions about the significance of the data that are collected. Also, the lack of agreement on appropriate test methods leads to confusion in the presentation of evidence in law suits, and hinders the development of rational regulations and codes relating to slip-resistance.

The difficulty in establishing slip-resistance criteria for use in building codes was pointed out in a recent letter (see Appendix VIII) from the Vice President, Codes and Standards, of the Building Officials and Code Administrators International, Inc., in which he stated that:

"... there is a lack of consensus among interested parties, including manufacturers of products affected by this regulation and experts in the field, on appropriate performance criteria, test apparatus and acceptable thresholds. The regulatory community cannot be expected to adopt any particular proposal when the industry is in such apparent disarray."

The extent of the "disarray" is indicated by the number of committees in ASTM (the American Society for Testing and Materials) that are developing standards for slip-resistance. The committees include:

C21 onCeramic Whitewares and Related Products
D01 on Paint and Related Coatings, Materials, and Applications
D21 on Polishes
F06 on Resilient Floor Coverings
F08 on Sports Equipment and Facilities
F13 on Safety and Traction for Footwear

Because of the disarray, an author of this report (GJF), asked several persons who are actively involved in standards activities related to slip-resistance if it might be helpful to hold a workshop to discuss what could be done to clarify the situation. With encouraging responses, the decision was made to organize the workshop described in this report.

2. Workshop Organization

The workshop was planned and organized by a steering committee consisting of the persons listed in Appendix I. The steering committee defined the workshop objectives; drew up the workshop program; drew up the invitation list which included a cross-section of interested parties; and identified persons to be invited to give special presentations or to chair working groups. The workshop program is given in Appendix II, a typical letter of invitation in Appendix III, the list of participants in Appendix IV, and a list of the organizations and standards committees represented in Appendix V.

At the workshop, opening remarks were followed by invited presentations which provided perspectives on the status of slip-resistance standards. The invited speakers were: the chairman of the ASTM Committee on Standards; the chairman of ANSI Committee 1264 on Safety Requirements for Workplace Floor and Wall Openings, Stairs, and Railing Systems; a forensic engineer; and a researcher. Next, every participant was given the opportunity to speak for not more than three minutes about what he or she hoped would result from the workshop. Then the participants were divided into working groups of about eight persons representing diverse interests for the main workshop discussions,. (The memberships of the working groups are listed in Appendix VI.) The working groups were instructed to address the workshop objectives and be prepared to present recommendations at the final plenary session. In case they wished to use them in promoting discussion, each working group chairperson was provided with a list of issues that had been suggested in advance by the invitees (the list is given in Appendix VII.) At the final plenary session, each group's recommendations were presented. Then, during a break, the workshop chairman, with help from a small task group, drafted a response to the workshop objectives. When the plenary session was reconvened, a discussion of the proposed responses led to their unanimous endorsement.

In this report, the remaining sections present: the workshop objectives (Section 3); summaries of the invited presentations (Section 4); brief comments about the recommendations from the individual working groups (Section 5); the position statements from the workshop as a whole (Section 6), and concluding remarks (Section 7).

3. Workshop Objectives

The workshop objectives were selected in recognition of the fact that, even though the "slip-resistance" of surfaces used for human locomotion is of widespread interest and importance, there is a lack of agreement as to precisely how slip-resistance should be quantified. In the circumstances, it seemed necessary to ask what, if anything, should be done to improve the situation. To address this question, the workshop objectives were:

- To decide if there is a need for either or both of improvement and harmonization of standards for the performance – specifically relating to slip-resistance – of floors and other surfaces in buildings.
- To decide if there is a need for consensus performance criteria for slip-resistance of floors and other surfaces.
- If there is agreement that there is a need for improved or harmonized standard test methods and performance criteria for slip-resistance, to identify ways in which the desired result could be achieved and recommend actions to be taken.

4. Invited Presentations

Presentations from four invited speakers provided valuable background information for the working group discussions. Summaries of these presentations, which the speakers provided, follow.

A View from the ASTM Committee on Standards

Malcolm Chase
Chairman, ASTM Committee on Standards

It is a pleasure to be able to say a few words on behalf of ASTM. I represent the Committee on Standards (COS). The scope of this committee is:

> The Committee on Standards is responsible for the review and approval of all technical committee recommendations for actions on standards and provisional standards. COS verifies that the procedural requirements of the Society's regulations and its criteria for due process have been satisfied. The committee acts to resolve jurisdictional disputes with respect to standards and provisional standards. COS develops, maintains, and interprets the 'Form and Style for ASTM Standards' manual and reviews all requests from technical committees for exceptions to the manual.

As a result of recent jurisdictional concerns within ASTM and in the interest of improving communication among the various ASTM committees, COS has instituted a management plan in order to develop a better understanding as to the nature of slip-resistance and its appropriate place within the ASTM structure. COS is interested in reducing the confusion in the market place, reducing any overlap in the various standards, and fostering a cooperative approach in the development of sound technical standards that will aid in the advancement of public safety.

The ASTM Management Plan (as developed by COS) has three major objectives:

- to ensure that ASTM technical committees develop slip-resistance standards only within their main committee's scope of activity;
- to maximize communications between ASTM technical committees developing slip-resistance standards;
- to coordinate slip-resistance standards to best meet marketplace needs and minimize redundancy of standards.

To complement this plan, COS is also holding focus group meetings, much like these NIST working group discussions. This is an attempt to handle the slip-resistance discussions within the broader umbrella of ASTM, rather than within a specific ASTM committee. COS would certainly hope that any results derived from this meeting would be fed back into ASTM.

Continuing discussions on the issue of slip-resistance may evolve into new standards. COS is very aware of the need for sound research behind these standards, and is pushing for the development of data supporting this work. It is not the role of COS to assess technical data; our role is to ensure that due process is received. However, with good resolution of the technical aspects of the standards, due process is easier to assess, and is not confused with technical issues. With a clear definition in the scope of the various committees and their commitment to the development of numerous standards, the development of standards will be better understood, and confusion will be reduced.

COS recognizes the importance of providing a forum for the stakeholders in this industry to come together to identify and develop needed technical information.

For the future, with successful meetings, such as this NIST Workshop and the ASTM focus groups, coupled with the COS Management Plan, we hope that we can more quickly move to new research and new standards. To do this well, we need to identify all key stakeholders and experts. Where are they and what is their expertise? How can we pull this together? Today is a start. ASTM will follow with its focus groups early in the year. We look forward to working together in identifying and developing needed technical information that will help to quantify slip-resistance and reduce slip incidents.

To reiterate, COS does not rule on technical data. However, the importance of technical data and its interpretation should be emphasized. The availability of such information, standing behind each standard and reached by consensus of all stakeholders, leads to a sound reliable basis for the treatment of slip resistance.

Slip Resistance Standards Development in ANSI

Keith Vidal
Chairman, ANSI Sub-Committee 1264.2
and
Thomas Bresnahan
American Society for Safety Engineers

In the American National Standards Institute, slip-resistance measurements and criteria are a responsibility of Committee A1264 on Safety Requirements for Workplace Floor and Wall Openings, Stairs and Railing Systems. Committee A1264 was formed in 1980 by combining Committees A12 (Guardrails, Wall Openings and Toeboards) and A64 (Industrial Stairs), with the American Society for Safety Engineers (ASSE) as the Secretariat. About three years ago, the A1264 Committee established Subcommittee A1264.2 to address the need for a standard for slip-resistant surfaces. The project was registered by ANSI through the Project Initiation Notification System (PINS).

Starting with the recognition of a need to further define the term "slip-resistance," the A1264.2 Subcommittee began writing a standard with the intent of reducing falls due to conditions which, in some fashion, are manageable in the workplace. The standard that has been drafted has three main parts:

- Provisions for reducing hazards
- Test equipment
- Slip-resistance criteria.

The first area – provisions for reducing hazards -- constitutes the largest part of the standards and addresses:

- Footwear applications and considerations
- Mats and runners
- Housekeeping
- Warnings
- Symbols
- Controlled access
- Selection and/or treatment.

The second part - test equipment – essentially refers to ASTM standards and test methods. And the third part – slip-resistance criteria – addresses a subject about which all members of the subcommittee felt strongly. The entire subcommittee felt that, in order for the standard to be meaningful, the criteria issue had to be addressed, but with a middle-of-the-road approach.

Now that our draft standard is almost ready for ballot*, we in A1264 hope that it will go a long way towards filling the need for a generally-accepted slip-resistance standard.

*The draft standard was sent out for public comment in January, 1997

Perspectives of a Forensic Engineer

David H. Fleisher, P.E.
Vice-President, Consulting Engineers. Inc., Malvern, PA
and Vice-Chairman, ASTM Committee F-13, Safety and Traction for Footwear

Restrictive funding available to the public sector and a tight business climate in the private sector justify:

- an early liability assessment of the effect of footwear and walkway surfaces in slip and fall accidents
- preventive measures to reduce the rate of slip and fall incidents.

Certain jury verdicts in slip and fall trials involve perceived interpretations of technical slip resistance measurement methods. Various designs of test equipment yielding different readings are utilized to assess slip resistance. With a variety of measurement devices and criteria used by experts, standards are needed to clarify what equipment should be used and how it should be operated. The equipment ranges from devices described in ASTM standards to one-of-a-kind home made devices.

Multiple factors affect the slip-resistance of a walkway surface. Slip-resistance is controlled by three components: the person, the walkway surface, and the environment. The characteristics of a person related to slip-resistance may include: footwear, age, vision, fall biomechanics, ambulating ability, knowledge of the premises, and attentiveness. The walkway surface component is separated into natural and artificial conditions. The newly constructed condition of a stair, hallway or sidewalk is the natural walkway surface. As a walkway surface ages, artificial changes, such as slope, wear, changes in elevation, and depressions, may cause alterations from the properties of the new surface. Weather conditions, spills, debris, contaminants, noises, lighting, and dirt are examples of environmental components affecting slip resistance. The physical characteristics of these components can vary through the course of time.

Slip-Resistance: Research Needs

Mark Marpet, Ph.D., P.E.
St. John's University, New York City

There is a primary need to develop slip-resistance standards based on test methods and instruments which will give researchers and practitioners consistent, repeatable, meaningful results. In order to accomplish that goal, an appropriate research plan must be developed.

A number of traditionally separate research areas must come together to develop a sound research plan. In more-or-less alphabetical order:

- ***Economic analysis***: We must establish what the cost of slip accidents are to society, with appropriate analysis of the cost of externalities. This is necessary so that trade-offs which shift

the costs of accidents and preventing accidents may be rationally accomplished. This will enable cost-benefit analysis to be applied in a meaningful way to slip accidents. Specifically, the cost to society of raising or lowering a slip-resistance threshold, e.g., the 0.5 static-coefficient-of-friction used as an acceptance threshold for floor polish qualification, needs to be rigorously analyzed.

- ***Gait dynamics*:** The forces, pressures, and velocities at the instant of heelstrike need characterization for both ordinary and mobility-impaired pedestrians. This is a necessary precursor to determining the friction needs of pedestrians in various activities.

- ***Human factors***: Perception issues need to be addressed to determine what factors cause perceptual 'traps' for pedestrians. The subjective evaluation of floor slipperiness vis-a-vis objective tribometric test results is needed. The effect of age on a pedestrian's perception needs to be systematically addressed. The effect of a pedestrian's knowledge (or lack of knowledge) of a surface being slippery needs to be established, so the value of WARNING signs, and warnings in general, can be quantified. The relationship between bone strength and injury probability needs investigation, as does the role of alcohol and drugs (both prescription and recreational) in falls and fall injury.

- ***Mechanics of friction***: The systematic characterization of tribological properties of typical shoe and floor materials in the force/pressure/velocity regime of heelstrike needs to be accomplished, as does a determination of the significant variables for squeeze-film friction in the heelstrike pressure regime. The interactions between tribological factors such as contaminant characteristics, tread pattern, etc., need to be explored.

- ***Probability and risk assessment***: The development of a Comprehensive Slip-Prediction Model is a priority. The analysis of the meaning of "hazardous conditions" based upon low-probability-event theory can be used to help define what constitutes a hazard. Data gathering and epidemiological studies on slip and fall injuries is a useful precursor to economic analysis.

- ***Tribometry*:** Tribometry and gait must be correlated. From the gait-dynamics based upon determination of pressure/velocity at heelstrike, define an appropriate pressure/velocity regime for walkway-safety tribometry. Determine acceptable levels of surface roughness and test-foot preparation protocols for reliable, repeatable, tribometric testing. Determine test methods, devices, and protocols to test non-smooth test feet.

- ***Other research areas*:** The micro- and macro-structures of floors, floor-polish, and shoe bottoms to optimize pedestrian safety need exploration, as do the effects of floor, floor-polish, and shoe-bottom wear and their effects on pedestrian friction. Friction needs on stairs, ramps, and other non-flat-and-level walking surfaces, and fall hazard as a function of specific stair-step dimensional variations -- a phenomenon frequently confounded with slip-initiated falls -- also need to be quantified.

5. Working Group Recommendations

Each of the four working groups spent about five hours in discussion and preparing recommendations for presentation at the final plenary session. A compilation of the working group recommendations, which covered a wide range of subjects, is given in Appendix X. They provided a good basis for discussion in the final plenary session that led to agreement on the statements presented in the next section of this report. They could also provide the basis for a future workshop addressing more technical issues.

Examples of needs to which the working groups drew attention in their reports to the final plenary session were needs for:

- A common vision among code bodies, product manufacturers, and users as to what slip-resistance standards should be like.
- Recognition of the importance to industry of having slip-resistance standards. Recognition that there should be different slip-resistance standards for different
- A hazard analysis assessment of slip-resistance using studies of slips and falls to identify relevant variables.
- A uniform way of gathering statistics on slips. A determination of economic losses from slips, and of the costs in terms of pain and suffering.
- Performance criteria for evaluating slip-resistance test methods.
- Evaluation of currently-available slip-meters.
- Standard materials for calibrating slip-meters.
- A standard guide on slip-resistance for architects and others.
- A multi-pronged approach to reduction of slips and falls.

From this list, it appears that much needs to be done to help understand factors affecting slips and to obtain agreement as to how slip-resistance should be quantified.

6. Responses to the Workshop Objectives

The final plenary session of the workshop began with the presentation of reports and recommendations from the four working groups. Then, following a lengthy discussion about how to respond to the workshop objectives (See Section 3), the following statements received unanimous agreement from those present:

1. There is a need for improvement of standards for the performance - specifically relating to slip-resistance - of floors and other surfaces in buildings.

2. There is a need for consensus performance criteria for slip-resistance of floors and other surfaces.

3. In view of the need for improved standard test methods and performance criteria for slip-resistance, a nationally-respected organization should arrange for an independent, authoritative committee to be set up to recommend actions needed to reduce the number of slips and falls and the seriousness of the injuries caused.

Steps to be taken by the committee should include:

a) a critical review of existing information on the causes and prevention of slips and falls,

b) an assessment of the scientific basis for existing slip-resistance measurements and their relationship to actual slips and falls, and

c) recommendation of actions to be taken to meet the needs.

7. Concluding Remark

Through this report, the statements in Section 6 relating to slip-resistance standards that were unanimously agreed to at the closing session of the workshop will be publicized. It is hoped that the strong support for these statements by a broad cross-section of interested and knowledgeable persons will stimulate actions which will help overcome the present confusion concerning slip-resistance standards.

8. References

1. Murphy, Patrice L., Sorock, Gary, S., Courtney, Theodore, K., Webster, Barbara S., and Leamon, Tom B., "*Injury and Illness in the American Workplace: a Comparison of Data Sources*," American Journal of Industrial Medicine, vol. 30, pp. 130-141 (1996).

2. "*Construction and Building: Federal Research and Development in Support of the U.S. Construction Industry*," Subcommittee on Construction and Building, Committee on Civilian Industrial Technology, National Science and Technology Council, Washington, DC (1995).

3. Adler, Sanford C., and Pierman, Brian C., "*A History of Walkway Slip-Resistance Research at the National Bureau of Standards*," NBS Special Publication SP-565 (1979).

4. US National Safety Council, "*Accident Facts,*" 1977 Edition, Chicago, IL (1977).

5. ASTM F1694-96, "*Standard Guide for Composing Walkway Surface Evaluation and Incident Report Forms for Slips, Stumbles, Trips, and Falls,*" Annual Book of Standards, V.15.07, End Use Products, ASTM, West Consohocken, PA (1996).

Appendix I

STEERING COMMITTEE FOR THE WORKSHOP ON EVOLUTION OF SLIP RESISTANCE STANDARDS

Geoffrey Frohnsdorff, Chairman
NIST

Drew Azzara
ASTM

Robert Brungraber
Consultant

Ann Fendley, M.D.
University of Arkansas for Medical Sciences

David Fleischer
Consulting Engineers, Inc.

Peggy Rosol
Armstrong World Industries, Inc.

Daniel Schutter
Congoleum Corp.

*Patrice Murphy (as of January 1997)
Liberty Mutual Insurance Co. - Research Center

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*Patrice Murphy was invited to join the Steering Committee to help with preparation of the workshop report.

Appendix II

WORKSHOP SCHEDULE

WORKSHOP ON EVOLUTION OF SLIP-RESISTANCE STANDARDS
National Institute of Standards and Technology
Gaithersburg, Maryland
November 21- 22, 1996

Thursday, November 21, 1996

8:30 Registration (Lecture Room D, NIST Administration Building)

9:00 Welcome to NIST (Lecture Room D)

9:10 Introductory Talks

Malcolm Chase	*The View from the ASTM Committee on Standards*
Keith Vidal	*Slip-Resistance Standards Development in ANSI*
David Fleisher	*Perspectives of a Forensic Engineer*
Mark Marpet	*Status of Slip-Resistance Research*

10:30 Introductory Comments from Workshop Participants (up to 3 minutes each)

12:30 **Lunch**

1:30 Working Group discussions

4:30 Review of progress

5:15 Adjournment

Friday, November 22, 1996

9:00 Working Group discussions (continued)

12:30 **Lunch**

1:30 Plenary session -- Working Group reports

2:30 General discussion and formulation of recommendations

3:30 Adjournment (followed by drafting of report by WG chairs)

Appendix III

A TYPICAL LETTER OF INVITATION

Bldg.226 Rm. B368 Phone: 301-975-6706
FAX: 301-990-6891 Telex: 197674 NISTUT
E-Mail: geoffrey.frohnsdorff@nist.gov

October 22, 1996

Dear

The Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST) receives many requests for information from persons who cannot find, or are uncertain about, slip-resistance standards, test methods, and criteria appropriate to surfaces and conditions in which they are interested. This may reflect the fact that many standards committees with an interest in slip-resistance measurements are developing standards.

To review the situation to see if there is a need to clarify, or otherwise improve, standards for slip-resistance of surfaces relating to human locomotion, the Building and Fire Research Laboratory of the National Institute of Standards and Technology (NIST) is to hold a workshop, Evolution of Slip-Resistance Standards, to address issues such as the possible needs for new methods of measurement of slip-resistance and for harmonization of slip-resistance standards and performance criteria. The workshop should also suggest, in broad terms, how to meet any needs that may be identified.

Specifically, the objectives of the workshop are to be:

1. To decide if there is a need for either or both of improvement and harmonization of test method and other standards for the performance -- specifically slip-resistance -- of surfaces relating to human locomotion.

2. To decide if there is a need for consensus performance criteria for slip resistance of surfaces relating to human locomotion.

3. If there is agreement that there is a need for improved or harmonized standard test methods and performance criteria, to recommend actions to be taken.

The workshop is to be held at NIST in Gaithersburg, Maryland on Thursday and Friday, November 21-22, 1996. A tentative schedule for the workshop is enclosed.

To foster in-depth discussion, participation in the workshop is to be limited and by invitation only. In view of your ACI committee's interest in standards for flooring, we are inviting you, personally, to participate in the workshop. However, if you wish, you may designate someone else to participate in your place.

We hope your committee will be represented at the workshop and, in the hope that it will, I have enclosed information about hotel accommodations and how to reach NIST. It would help us in making the arrangements for the workshop if you or your designee would complete the enclosed response forms and return them by Friday, November 8.

If you would like more information about the workshop or the arrangements, please call my secretary, Nancy Wilkin, or me at 301-975-6706.

Sincerely,

Geoffrey Frohnsdorff
Chief, Building Materials Division
Building and Fire Research Laboratory

Enclosures

Appendix IV

WORKSHOP PARTICIPANTS:

Drew Azzara
ASTM
West Conshohocken, PA

Mony Ben-Bassatt
NIST Guest Researcher
Israel Building Research Institute
Gaithersburg, MD

Henry Boyles
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Atlanta, GA

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HUD, Minimum Property Standards
Washington, DC

Thomas Bresnahan
American Society of Safety Engineers
Des Plaines, IL

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Malcolm Chase
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Zion, IL

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Washington, DC

Mark Elbert
CPSC
Bethesda, MD

William English
William English, Inc.
Alva, FL

Ann Fendley, MD.
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Pine Bluff, AR

David Fleisher
Consulting Engineers Inc.
Malvern, PA

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Artech Footwear Testing Laboratory
Chantilly, VA

Dan Schutter
Congoleum Corporation
Mercerville, NJ

Terence Smith
U.S. Dept. of Labor, OSHA
Washington, DC

Kenneth Snyder
NIST
Gaithersburg, MD

David Underwood
Procter and Gamble
Cincinnati, OH

Keith Vidal
Vidal Engineering, Inc.
St. Louis, MO

Appendix V

ORGANIZATIONS INVITED TO PARTICIPATE IN THE WORKSHOP ON EVOLUTION OF SLIP-RESISTANCE STANDARDS

ASTM Committees

- C21 on Ceramic Whitewares and Related Products
- D01 on Paint and Related Coatings, Materials and Applications
- D04 on Road and Paving Materials
- D21 on Polishes
- E06 on Performance of Buildings
- F06 on Resilient Floor Coverings
- F13 on Safety and Traction for Footwear
- F15 on Consumer Products

ANSI Committees:

- A1264 on Safety Requirements for Workplace Floor and Wall Openings, Stairs and Railing Systems

ACI Committees:

- 117 - Tolerances
- 302 - Construction of Concrete Floors

Federal Agencies:

- Department of Commerce, National Institute of Standards and Technology
- Department of Labor, Occupational Safety and Health Administration
- Department of Justice, Speakers Bureau
- Department of Veterans Affairs, Space Management Division
- General Services Administration, Public Building Service
- US Army Corps of Engineers, Safety Office (CESO-E)
- Housing and Urban Development, Min. Property Standards
- US Naval Facilities Engineering Command

Professional and Technical Organizations:

- American Institute of Architects
- Building Officials and Code Administrators International
- Building Owners and Managers Association
- Construction Specifications Institute
- National Institute for Building Sciences
- International Association of Bridge, Structural, and Ornamental Ironworkers

Trade Associations

- American Iron and Steel Institute
- Building Owners and Managers Association

Appendix VI

WORKING GROUPS

Working Group 1

Leslie Breden, Minimum Property Standards, HUD (Chair)
Mony Ben-Bassatt, Israel Building Research Institute
and NIST Guest Researcher (Recorder)
Drew Azzara, ASTM
Joseph Chess, Akzo-Nobel Coatings, Inc.
Steve Cooper, International Association of Bridges &
Ornamental Ironworkers, (AFL/CI0)
David Fleisher, Consulting Engineers Inc.
Paul Guevin, P.R. Guevin Associates
Mark Marpet, St. John's University

Working Group 2

Henry Boyles, Margaret & Co., Inc. (Chair)
Jonathan Martin, NIST (Recorder)
William English, William English, Inc.
Bill Rowe, Consumer Product Safety Commission
Patrice Murphy, Liberty Mutual Insurance Company
Peggy Rosol, Armstrong World Industries
David Underwood, Procter and Gamble
Keith Vidal, Vidal Engineering, Inc.

Working Group 3

Ann Fendley, University of Arkansas for Medical Sciences (Chair)
Kenneth Snyder, NIST (Recorder)
Thomas Bresnahan, American Society of Safety Engineers
Robert Brungraber, Consultant
Mark Elbert, Consumer Product Safety Commission
Arthur McKinney, McKinney & Co.
William Marletta, William Marletta Safety Consultants
JoAnna Sampson, Artech Footwear Testing Laboratory

Working Group 4

Geoffrey Frohnsdorff, NIST (Chair)
James Pielert, NIST (Recorder)
Paul Kyed, Bethlehem Steel
Don Meserlian, Consultant
Alex Sacher, Consultant
Dan Schutter, Congoleum Corporation
Terence Smith, U.S. Department of Labor, OSHA

Appendix VII

SOME ISSUES FOR DISCUSSION SUGGESTED BY INVITEES

1. In the case of concrete, should the required slip-resistant finish be achieved by the finisher?

2. Should the amount of traffic be considered when deciding on the required slip-resistance?

3. Is there a need for standard shoe sole surrogates for testing floors, and standard surrogate floors for testing shoes?

4. If shoe sale surrogates are needed, should they be (a) consistent, (b) representative, and (c) of low slip-resistance?

5. If shoe sale surrogates are needed, how can they best be selected?

6. Is NIST needed to help in the selection of shoe sale surrogates?

7. Is NIST needed to develop performance criteria for use in evaluating testers? Or to help in other ways in the standardization of slip-resistance testers?

8. Are coefficient of friction standards needed for the interaction between humans, footwear, and walking surfaces under non-contaminated and contaminated conditions? If so, what types of standards are needed? On what do you base your opinions?

9. Is the state of current knowledge/research sufficient to decide on a coefficient of friction standard (or standards) for the human/footwear/contaminant/walking surface interaction? On what do you base your opinion?

10. If the current state of knowledge/research/ tribometry is not sufficient to decide on a COF (coefficient or friction) standard, what further steps need to be taken, and by whom, to lead to a standard/standards?

11. What factors should be taken into account in determining any necessary standards? Type of surface? Activity? Likely contaminants? Likely footwear? Etc.?

12. If standards are needed, how can tribometers and test foot materials currently available be used appropriately, given that different tribometers give different readings on a given surface? Would it be perceived as restraint of trade if certain instruments were chosen over others?

13. From time to time, the federal government has planned to establish minimum coefficient of friction values. An example from the past is the Federal Trade Commission (FTC) establishing a minimum value of 0.5 for surfaces tested with the James Machine, and a

minimum of 0.4 when the Sigler instrument was used. Similarly, for painted structural steel beams and decks that are walked on by erection personnel, the Steel Erection Negotiated Rulemaking Advisory Committee (SENRAC) attempted to establish a minimum value of 0.75 when tested with the English XL instrument, and a minimum value of 0.60 when tested with the Brungraber Mark II. What relevance, if any, does this have to the purposes of this workshop?

14. Why should slip-resistance standards be needed? What conditions are they intended to help avoid?

15. Do different situations demand different standard test methods? Or different slip-resistance criteria? Is harmonization of slip-resistance test methods and/or criteria a realistic goal?

16. What would be the preferred organizational structure for standardization of slip-resistance test methods? For standardization of slip-resistance criteria? What, if anything, should be recommended to ASTM or ANSI, or other organizations?

17. What bodies are responsible for slip-resistance standards in other countries? And in the U.S.?

18. Does any other country have an approach to slip-resistance standards and measurement that we should consider as a model for the US?

19. Is the slip-resistance problem sufficiently difficult to resolve, and sufficiently important to resolve, that we recommend that it be addressed by such a body as the National Academy of Science?

20. How big an investment would be required to develop any needed standards for slip-resistance? And how long would it take to do what is needed? What is needed? Who should be responsible for providing the necessary support?

Appendix VIII

LETTER FROM THE BUILDING OFFICIALS & CODE ADMINISTRATORS INTERNATIONAL, INC.

BUILDING OFFICIALS & CODE ADMINISTRATORS INTERNATIONAL, INC.

4051 WEST FLOSSMOOR ROAD
COUNTRY CLUB HILLS, ILLINOIS 60478-5795

Telephone 708/799-2300
Facsimile 708/799-4981

November 18, 1996

Mr. Geoffrey Frohnsdorff
Chief, Building Materials Division
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001

RE: Workshop on Slip Resistance Standards

Dear Mr. Frohnsdorff:

Your invitation to the November 21 workshop reached me after the response date and as it turns out we would have been unable to attend due to schedule conflicts. However, I wanted to express my comments on the subject and indicate that BOCA does have an interest in where the issue of slip resistance standards and test methods is headed.

BOCA's primary interest is in the area of slip resistance of walking surfaces within buildings and sites insofar as they are regulated by building codes. The model building codes, particularly the BOCA National Building Code, have long contained provisions that require floor surfaces to be slip resistant primarily for purposes of safety in the means of egress. Slip resistance also is more broadly regulated in buildings through the provisions in the model building codes and Federal law on accessibility for people with disabilities. The Americans with Disabilities Act Accessibility Guidelines (ADAAG) and CABO/ANSI A117.1 both require all floor and walking surfaces to be slip resistant in areas that are required to be accessible.

While these codes and regulations require slip resistance, there is a distinct lack of uniformity and in some cases silence on test methods, pass/fail criteria and performance measures. At various points in time, codes attempted to address criteria without much success. For example, the 1978 BOCA National Building Code defined the term "non-slip" as a coefficient of static friction of 0.40 as determined in accordance with NBS Research Paper RP-1879. In 1980, a proposal was considered to change the criteria to 0.50 based on ASTM D 2047. The resulting action was to delete the definition without substitution and the code has been without any criteria since that time.

Various proposals other proposals have been considered in the development of codes over the years and as recently as this year in the updating process for CABO/ANSI A117.7. This indicates that there is a lack of consensus among interested parties, including manufacturers of products affected by this regulation and experts in the field, on appropriate performance criteria, test apparatus and

acceptance thresholds. The regulatory community cannot be expected to adopt any particular proposal when the industry is in such apparent disarray.

There is, in my view, an absolute need to achieve all three of the workshop objectives you identified. They are essential to having reasonable, technically justified and enforceable provisions on slip resistance available for adoption and enforcement in building regulations.

I would be interested in learning of the results of the workshop and offer my best wishes for a productive and successful session.

Sincerely,

Kenneth M. Schoonover, P.E.
Vice President, Codes and Standards

KMS/ke

cc: TFrost
DBowman

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REGIONAL OFFICES
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Appendix IX

LETTER FROM KALMAN FLOOR COMPANY

Kalman
FLOOR COMPANY
1202 BERGEN PARKWAY, SUITE 110
EVERGREEN, COLORADO 80439
(303) 674-2290 FAX (303) 674-1238

ESTABLISHED 1916

ABSORPTION PROCESS® CONCRETE FLOOR TOPPING
MONOROCK® MONOLITHIC CONCRETE FLOOR SURFACING

November 20, 1996

Mr. Geoffrey Frohnsdorff
Chief, Building Materials Division
Building and Fire Research Laboratory
Bldg 226 Room B368
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001

Re: BFRL/NIST Workshop
Evolution of Slip-Resistance Standards

Dear Mr. Frohnsdorff:

I regret to advise you that I will not be attending the Slip-resistance Workshop tomorrow and Friday. I am obliged to spend that time instead on company matters.

At Kalman Floor Company we have become aware of the liability facing our clients: Owners of distribution centers, Architects/Engineers/Designers of distribution centers; as well as ourselves, specialty exposed concrete floor contractors. Such liability stems from a lack of knowledge regarding slip resistance standards (which have not been used heretofore); difficulty constructing slip resistant surfaces that are also durable and easy to clean; difficulty in determining what a slip resistant floor finish is: rough? textured?, when wet?/dry?, for all shoe types? for equipment use?

For about 80 years Kalman has been installing industrial floors. Is the floor finish the issue - or today's legal system? There is a need for improved and harmonized standard test methods and performance criteria. It is very important to determine the extent that the floor finish, shoe sole, equipment wheel, and worker habits should be adjusted for the operating environment.

Thank you very much for the chance to have participated in your workshop. We believe that it is an especially important endeavor.

Very truly yours,

Carl N. Ytterberg
President

Via Fax/Mail: (301) 990-6891

cc: Vicki Glennie, NIST

Appendix X

COMPILATION OF WORKING GROUP RECOMMENDATIONS

1. Because credible, scientifically-justified standard test methods and guidelines are needed by manufacturers, architects, engineers and other end-users to avoid confusion and to benefit the market place, a standard guide and a standard test method with performance criteria should be prepared. To assist with the latter, the following should be developed: a) a mathematical model of human locomotion, b) instrumentation to be carried by human test subjects to replace the force plates usually used in human tests, and c) a robotic test foot; in addition, information needed as input to a hazard analysis should be gathered.
2. Preparation of the guide mentioned in the preceding item should be started immediately. The sequence for development of the standard test method is outlined in the accompanying figure (Figure 1). To achieve the desired result, a public-private partnership, to be managed by ISA with NIST (and perhaps, an academic institution) should be formed; it should be steered by a balanced working group comprised of representatives of industry, government (NIST), and academia.
3. Concise guidelines for preparation of a slip and fall investigation form should be provided.
4. Incidence study of slips and falls in restaurants should be carried out with the National Restaurant Association.
5. Minimum criteria for accepting a slip-resistance tester should be established.
6. A comparison of ASTM and non-ASTM apparatus should be carried out under a set of identified conditions.
7. A multivariate analysis of variables affecting slipperiness should be carried out. The analysis must include materials, environmental, processing, application, and design variables. The objective of the studies would be to identify important and unimportant variables.
8. ASTM Committee F13 should establish a list of criteria for minimum acceptance of slip-resistance testing machines. It should seek the assistance of an independent laboratory (e.g., NIST) in establishing a precision and bias evaluation, and possible improvement, of test methods. (This recommendation is addressed to ASTM and an independent laboratory such as NIST.)

   Commentary: *While it is acknowledged that the definitive test for evaluating slip-resistance of floors has not yet been identified, there are, and will continue to be, tests that can give results that correlate reasonably well with human/floor interactions. A means is needed to fairly and objectively assess current devices for standardization. To this end, it is recommended that appropriate standards committees, such as ASTM F13, establish a set of guidelines for assessing testing machines for inclusion into the setting of standards. Additionally, an independent laboratory could assist in establishing rational precision and bias statements and, possibly, suggest improvements in the test method.*

9. Have an independent laboratory develop a user-friendly interface to the National Electronic Injury Surveillance System (NEISS) data with public access. Also, use ASTM Form F-1694 as a starting point to bring insurance data collection companies and government agencies such as OSHA together to modify existing injury report forms to reflect data that are needed to uniquely categorize slips, trips, stumbles, falls, shoe-wear, floor surface, etc. (This recommendation is addressed to ASTM and an independent laboratory such as NIST.)

   Commentary: *To assist the future research expenditures, and to assist rational testing of both floor and shoe-wear surfaces, a coherent, accessible, and up-to-date data set is needed that can be used to make accurate statistical studies of slip injuries. The NEISS data is comprehensive, but lacks a user-friendly means of accessing and analyzing the raw data. Additionally, the NEISS data do not distinguish among slips, trips, stumbles, and falls. Therefore, a new approach to slip injury data collection is required.*

10. Research should be carried out to provide a basis for a fair and representative test to evaluate the interactions of various women's footwear materials and footprints with various floor surfaces. (This recommendation is addressed to an independent laboratory such as NIST and to OSHA and CPSC.)

    Commentary: *If we want to reduce accidents at the workplace, we could substantially reduce injuries to women by addressing the slip-resistance of women's footwear. Women's footwear commonly has hard heels, with both small and large contact areas, which are highly susceptible to slip and wear. Research is needed to create a fair and representative test to evaluate the interactions of various women's footwear materials and footprints with various floor surfaces. Additionally, consideration must be given to the effect of wear at the heel, and the exposure, under load, of underlying heel nails.*

11. A rational and effective protocol must be developed for the evaluation of floor and footwear surfaces which are susceptible to property changes due to exposure, aging, wear, and contamination which induce a time-dependent slip-resistance response. (This recommendation is addressed to OSHA and CPSC.)

    Commentary: *It is clear that the effects of contamination, exposure, aging, and wear complicate the evaluation of both floor and shoe-wear surfaces. Surfaces subjected to contaminants and wear will require extensive testing. Complicating the situation further is the fact that these surfaces exhibit time-dependent properties. A rational and effective protocol must be developed for the evaluation of floor and footwear surfaces under these conditions.*

12. Use-specific standards which account for various types of activities, footwear (controlled and uncontrolled), environment, housekeeping, contaminants, and construction means and methods should be established. (This recommendation is addressed to ASTM, HUD, and ACI.)

    Commentary: *Test methods are needed for both a dry and clean conditions and for situations where gait, environment, and expectations differ greatly from a dry office floor situation. A rationale is needed to evaluate a fairly wide range if possible footwear/floor situations.*

13. Research to correlate both human perception of slipperiness and incidence of slip injuries to test measurements of the coefficient of friction should be carried out.

14. A nationally-respected organization (e.g., NRC, NIST) should arrange for an independent, authoritative committee to be set up to recommend actions needed to reduce the number of slips and falls and the seriousness of the injuries caused. Among actions to be taken by the committee should be: a) critically review existing information on slips and falls for its adequacy, b) if the information is adequate, prepare a report on what is known about the causes of slips and falls, factors affecting their probability of occurrence, the economic and human losses sustained, and the need for slip-resistance standards; the number, scope, and structure of the needed standards should be indicated, c) if the existing information is not adequate, report on why it is not, and recommend how appropriate data can be obtained most cost-effectively, d) in any case, produce a critical synthesis of knowledge about the relationship between the characteristics of surfaces relevant to human locomotion and the probability of slips and falls, and e) recommend performance criteria for evaluating slip-resistance test methods for usefulness and suitability for standardization.

15. ASTM, or some other respected national organizations, should appoint a task group to recommend to ASTM's COS what standards are needed to reduce the inequities that may arise through the legal system's lack of knowledge about slips and falls

16. ASTM should establish a mechanism for promoting communication among committees developing standards for slip-resistance as it relates to slips and falls.

17. Standards relating to slip-resistance should be developed to the following ends:
    - To measure conditions in the field;
    - To allow manufacturers to evaluate products and establish appropriate quality control measures;
    - To protect consumers and prevent accidents;
    - To establish baselines of minimal acceptability of footwear and walking surfaces;
    - To help establish correlation with slip/fall accidents;
    - To develop consistent databases;
    - To provide protection against frivolous law suits;
    - To provide standard definitions.