SIMPLE STEPS STOP SLIPS

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Pedestrian slips are one of the biggest causes of serious injuries. In this paper, we study the common places where slips occur and examine the causes of change to slip risk in each of these areas. In a kitchen or factory the slip resistance of the floor will change dramatically in the course of a day, whereas for a swimming pool floor the changes to slip resistance will be gradual as a layer of body fat builds up in high traffic areas. We look at the importance of understanding the changing slip risk and the imperative of an effective cleaning regime. We examine the best way to measure, manage and minimize slip risk in all buildings. The value of this paper is a focus on simple steps that will stop slips.

Introduction: Simple Steps to Understand Slip Matters

Most businesses lack the knowledge or incentives to tackle slip risks and as long as ignorance and apathy remain, slips will remain the cause of many thousands of preventable injuries. If business managers understood how to measure and manage slip risks then many serious injuries could be prevented. Many slips are predictable, accidents waiting to happen. Most people wouldn't ignore a loose wire on an electrical appliance, or a broken rung of a ladder, but many of us are guilty of ignoring slippery floors, and sadly most business managers are blissfully unaware how to reduce slip risks. To change the level of slip injuries we set out to define simple steps that will help managers to understand the causes and risks of slipping and to help them take simple steps to massively reduce slip risks.

Researching Floor Slip Resistance and Slip Accidents

In researching this paper we measured the slip resistance of hundreds of floors in different locations and different situations. We took many measurements on each floor and looked in detail at how the slip resistance changed over time. We examined the link between the changing slip resistance of the floor and the incidents of reported slip injuries. As with other studies, we found obvious links between some floors with low slip resistance and incidents of reported slip accidents but also some interesting cases where the *apparent* slip risk of the floor and reports of slip incidents do not match up. We have also examined slip test data from the HSE (UK Health and Safety Executive) and other reputable slip consultants including Dr M Bailey. A key focus of this research included the link between duty holder attitudes to slips and the incidents of slip accidents or injuries.

The problems that face duty holders in trying to prevent slips

Duty holders, managers responsible for aspects of floor safety in commercial or government funded organizations, include Health and Safety Managers, Operations Managers, Cleaning Managers and those responsible for the purchase or maintenance of flooring. Our research suggests that most duty holders are confused by conflicting advice and a lack of understanding of how to measure or manage slip risks.

Which measure?

The first problem is what measure to use. Some duty holders make decisions based on erroneous measures or wrong assumptions about slip measures. The HSE dismiss pull along devices, trundle tests or motorized trundle tests of the type that fail to re-create the effects of hydrodynamic squeeze film and therefore cannot usefully measure the slip resistance of wet or contaminated floors. Roughness measures cannot be taken on wet or contaminated floors. R numbers from the German Ramp test may be useful, but we cannot tip the building to test a floor in-situ. SlipAlert and the Pendulum correlate (R= 0.95) with each other and both appear to match actual slip experience.

Countering Apathy, Embarrassment and Fear of Litigation

Duty holders do not always appreciate the importance of managing slip risk especially if there has not been a recent case of serious injury. People who slip will often walk away more worried about injured pride than physical injury or risk to others. In walking away embarrassed the slip risk remains unnoticed until more slips, falls and injuries are noticed. When the wrong cleaning solution is used, the manager responsible will often fail to fully consider the implications and the risk of future injuries. Fear of litigation discourages some duty holders from testing floors where they fear the test results will increase their liability. There is a pressing need to educate duty holders, managers and staff to understand the importance of slips and to mandate monitoring of slip risks.

Different Flooring Situations present different slip risks

Different things cause different slip risks in different flooring situations. A swimming pool changing room, a kitchen floor, external decking, and a factory floor can all become slippery, but the causes are very different and it is vital that duty holders fully understand the causes and the frequency of change to the slip risk. In kitchens we measured the slip resistance at different times of day and found a range of slip resistance from very safe when the floor is clean and dry, through medium risk when the floor is clean and wet, to very high risk as the contamination on the floor increased between cleaning. The slip risk of poolside tiles or the slip risk of external decking may not change significantly in the course of one day, but both may change over time and so the duty holder responsible for floor safety needs a way to measure that changing slip risk.

Most floors do not achieve PTV of 36 or better in the wet

It seems from our research and from tests conducted by the HSE and others that only a small percentage (25% or less) of floors achieve a low slip risk when wet. It would seem impractical to impose a rule that all floors should achieve a wet PTV of 36 or better when we know that so many floors do not achieve this level of wet slip resistance, especially when we know that many of these floors are rarely wet and do not experience high levels of slip incidents. Clearer guidance should be given and new floors that will often be wet/contaminated should have appropriate slip resistance, though perhaps 36/40 is too high a figure to expect from floors that are rarely wet.

Most Shopping Mall floors do not get close to PTV of 36 when wet. For areas of floor that are never wet this is not a problem and most Malls spend a great deal of energy keeping the floors clean and dry. The most dangerous area in Malls are the entrances which have water ingress. Even if there are good barrier mats the floors around the entrances present a risk. It appears that over time the slip resistance of floors around Mall entrances can change as cleaning buffs up the floor. Some Malls reported several accidents on the first rainy days after a change to the cleaning regime.

A single measure may not fully assess the slip risk of a floor

Too many duty holders make assumptions about slip risk based on one measurement of the slip resistance of the floor at one point in time. A single measure of slip risk rarely tells the whole story. A measure of 36/40 PTV (Pendulum test Value or STV (SlipAlert Test Value) of 130 shows the floor should be safe, but if that is a measure in clean dry conditions it tells you very little about the slip risk in the different circumstances the floor will experience. If a single measure is taken with a hard rubber such as Four S, it may not give a realistic indication of the barefoot slip risk or the risk in sports halls where people are running turning, twisting and may be in socks, bare feet or trainers.

People wrongly assume a connection between wet/dry/contaminated slip risks
Many duty holders are happy to measure only the dry slip resistance of a floor and some assume that improving the dry slip risk will also improve the wet/contaminated slip risk.

Defining the risk in a meaningful way: every point counts
The original GLC estimates of slip risk differ slightly from the HSE estimates where the boundaries between low, medium and high risk occur at 24 PTV and 36 PTV rather than 20 PTV and 40. In both cases there is a wide spread of risk in the medium category. In table1, the high risk category begins when 1:2 people require more friction than is available. The low risk category begins when less than 1:1million people require more friction than is available. Managers should understand that every point counts. Floors with PTV 36+ are at least 5,000 times safer than floors with PTV <24.

Table 1. Slip Risk Estimates and PTV/STV values

Estimated Slip Risk	Risk Category	PTV	STV
<1:1 million	Low Risk	40+	Below 130
1:100,000	Medium Risk	35	138
1:20	Medium Risk	24	160
>1:2	High Risk	<20	173+

Drawing a line in the sand is not the whole answer
It may be unhelpful to specify an exact measure for a safe floor. With a measure of 36/40 PTV, there is no doubt that a floor should be safe in the conditions the measurement was made. However, a floor with at least PTV 35 in wet/dry/contaminated conditions when measured with both TRL and Four S rubber may be safer overall than a floor that achieves 40 PTV on one measure. New floors often have safe values when the floor is tested clean and dry, but it is far more important to understand how the level of slip resistance will hold up over time, after wear, normal contamination and cleaning.

Understanding the slip risk probability is vital for safe floors
Duty holders should be taught to appreciate the relative risk. Over specifying a dry test value does not compensate for a poor wet slip risk. Safe enough is good enough. A dry PTV of 60 may be no safer than 40 PTV. Improving dry slip risk will probably not improve wet slip risk. Slicks give excellent grip on dry roads, but you wouldn't want to drive on slicks on a wet road. At least half of us will find difficulty walking a wet floor with 19 PTV regardless of how safe it is when dry. We tested a new MOD floor specifically purchased to have high PTV in the dry. Sadly, many cadets running in with wet boots were falling over because the wet PTV was below 19. Duty holders should be encouraged to take positive steps to raise the PTV as close to 36/40 as possible but not to over-specify one measure to the detriment of other more crucial measures such as wet slip resistance.

A new cleaning regime that raises the PTV from 19 to 33 may not make the floor perfectly safe, but if the floor can be maintained at a level of PTV 33 by improved cleaning then the risk could be 5,000 lower and the floor may now be safe enough for its intended use. Such changes reduce risks should be encouraged despite not making the floor perfectly safe.

Three Layer Model for Slip Risk

Factors from all three layers in table 2 can contribute to the overall risk of slipping. Measures of the slip resistance of the floor should include measures of the floor when clean and dry, when wet/contaminated and should also allow for the different types of footwear that will be used on the floor. The probabilities shown in table 1, account for the differences in the way people walk.

Table 2. Three Layer Model and Slip Risk

Layer	Factors that may affect the risk of slipping
Human Layer	The shoe/heel: wet, dry, dusty, level of wear, type of rubber or other material, height and size of heel, hardness of the rubber Pedestrian Characteristics**:** height, weight, walking gait, speed of step, length of stride, wearing shoes/trainers/socks/bare feet, direction and speed that the foot strikes the floor
Barrier Layer	Contamination on floor: Dust, water, oil, grease, Contamination on shoe heel Additional barriers on floor surface: banana skin, grape, plastic
Floor Layer	Flooring Material, Coatings or paints, wax or polish, micro roughness of surface (Rz, Ra, Rp, Rs etc.), macro roughness, profiling of the surface, hardness of surface materials, porosity of surface materials, absorbency, temperature, drainage

Interdependency between the three layers and managing slip risk

Each layer has some scope for management or change. Floor surfaces can be coated or treated. Contamination on the floor surface or shoes can be reduced by good housekeeping or improved cleaning. The human layer can be influenced by changing the way people use the floor when the slip risk is high. If two layers of the three layer model are fixed, then the third must be managed carefully. If we know the slip risk of the floor including any likely contamination is high, and these factors cannot be changed, then the only option is to manage the human layer. For example in a kitchen, some contamination will get on the floor while food is being prepared. In this case we can warn kitchen staff, reduce the rate of walking by rearranging the layout, enforce the use of safety shoes, restrict access to areas of wet floor and teach people to wipe up spills with absorbent kitchen paper.

Toilet Floors – a good example of the human layer reducing overall slip risk

We conducted extensive testing of toilet floors and found that a surprising number of toilet floors have poor slip resistance when wet. Despite high slip risk and very obvious sources of water, there seem to be few incidents of reported slips in toilets. Partly that is due to the layout of the space which almost always requires the walker to slow down and move with caution.

Another interesting example of human factors and toilets emerged in a large newly refurbished office with a row of decorative tiles around the edge of the main reception. The arrangement of the building was such that most of the decorative tiles would never be wet. The main entrance to the building through revolving doors had barrier mats and most people entered straight onto main flooring. The only people who walked on the tiles when wet were men entering the building heading for the gents directly to the right of the entrance. We tested the floor and predicting the risk. It transpired that on the first wet day a man had slipped en route to the gents. This is a good example of an accident that could easily have been prevented.

Human Factors can be accidents or design

The Health and Safety Manager of a major retail brand confided that their level of slip incidents has fallen dramatically because of a happy coincidence. Their strategic move to new stores within shopping malls has reduced incidents of slips caused by water ingress around the entrances. The friction required to prevent slip is directly related to the horizontal velocity, so slowing pedestrians reduces the risk of slipping. A major company reported fewer slips after security barriers were installed in their entrance hall. Managers should be taught to design human factors that reduce risks.

The Solution Lies with Simple Steps that will Stop Slips

There is not a single answer for all floors, just as there is not a single value of fuse for all electrical circuits. However, the rules for each flooring situation can be clear and if followed the risk of slips will be dramatically reduced. For every flooring situation we need a minimum specification for slip

resistance in wet/dry/contaminated conditions and also a means of measuring, understanding and managing any changes to the slip risk.

Simple steps: Flooring layer

- All new floors should achieve a PTV of 36 or even 40 in the conditions they will normally be used, i.e. swimming pool surrounds need wet PTV of 36+ with both TRL and Four S rubber.
- Additionally, specify appropriate slip risk for wet/dry/contaminated conditions appropriate for the use of the floor, i.e. a Shopping Mall entrance may not always be wet, but the entrance areas will need far better wet slip resistance than the rest of the Mall floors
- For new floors take slip risk measures before/during/after installation and again after one month of floor in service with wear/cleaning/polishing
- Before applying anti-slip coatings/treatments/paints, always conduct a patch test and measure slip resistance before/after application and again after some wear and normal cleaning.
- Ask flooring/coating suppliers for guarantees based on the ongoing performance of the floor surface rather than on its theoretical slip risk. Test floor performance over time against performance targets.
- After coating/polishing/treating the floor, test the floor before/after the treatment and look for improved slip resistance. Periodically re-test slip risk wet/dry with both soft and hard rubber.

Simple steps: Barrier layer

- Periodically audit the slip risk of all floors and establish the causes and speed of change to slip risks and if there is a need for improved cleaning
- Identify floors where the slip risk changes i.e. decking, shower rooms, kitchens etc. Understand the periodicity of change for each floor, and ensure adequate slip resistance is maintained
- Improve "housekeeping" to ensure spills are cleaned quickly and effectively while avoiding spreading the slip risk i.e. avoid wet mopping of oil spills

Simple steps: Human layer

- Where safety shoes are required, ensure the soles/heels are cleaned regularly
- Teach managers and staff about slip risks and the importance of reporting any slip incident. Even if there was no resultant injury, all slip incidents should be investigated and causes understood.
- If the slip resistance of floors cannot be maintained consistently at safe level, then consider ways to reduce risk by changing behavior and slowing pedestrians
- Be wary of durable shoe heels which can increase slip risk, especially on low heeled shoes.

Final Steps

- It should be required in law that every large business has a defined floor safety regime including checks on cleaning and maintenance. Duty holders should be accountable for keeping all floors within defined levels deemed safe enough for the current use of the floor.

References

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Sigler, P.A. (1943). *Relative Slipperiness of Floor and Deck Surfaces*

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A full list of reference materials, electronic copies of this paper, graphs of test data and links to reference websites will be available from www.slipalert.com/conference