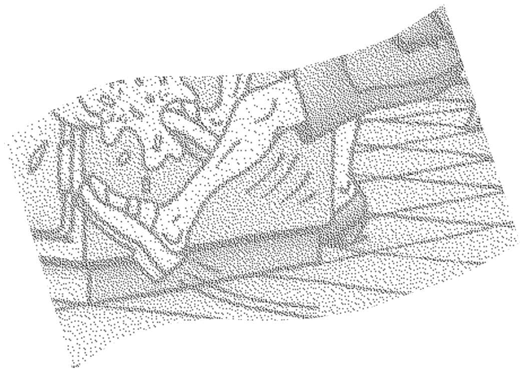
Floor cleaning as a preventive measure against slip and fall accidents



François Quirion

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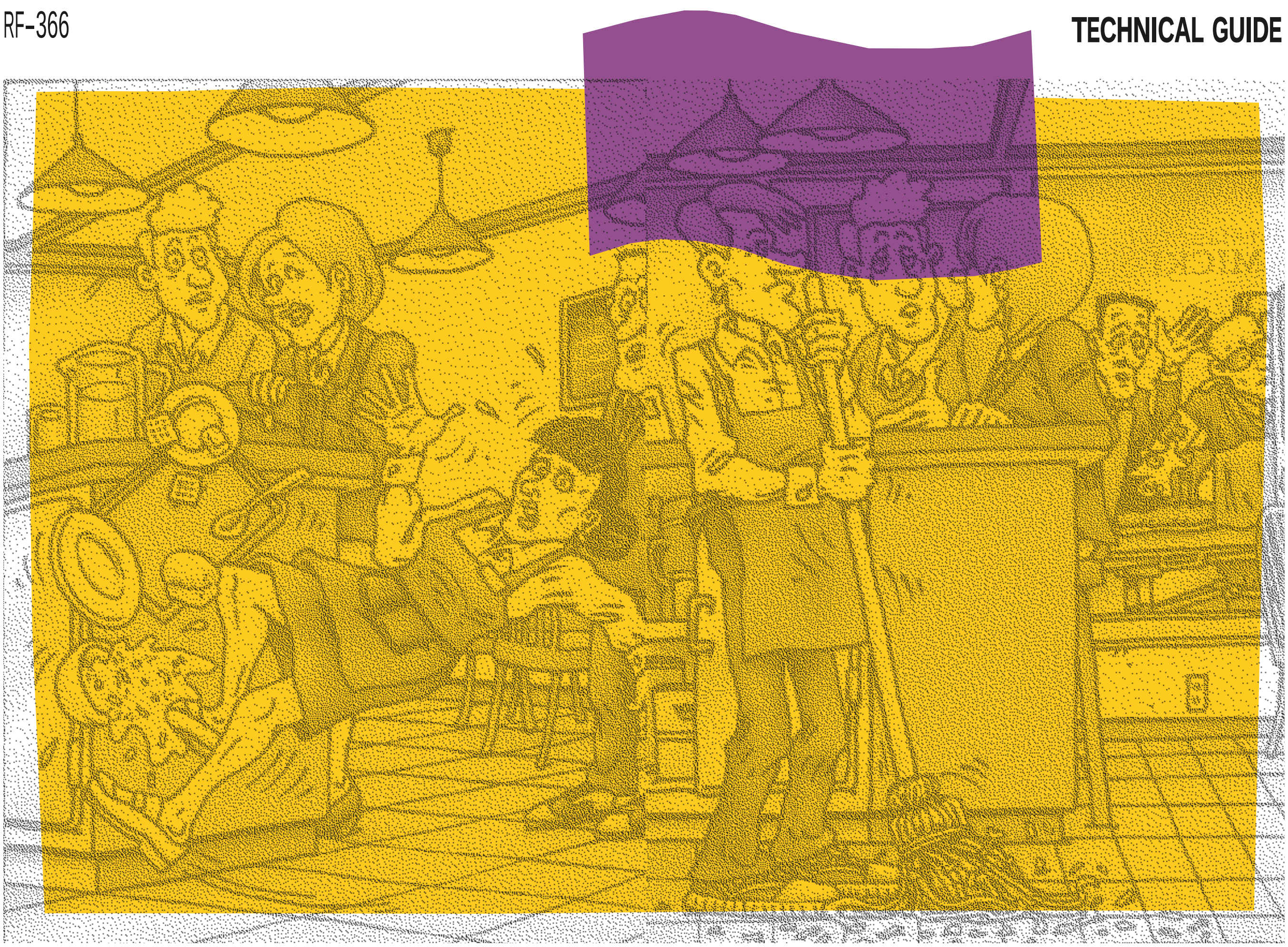
TECHNICAL GUIDE



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Floor cleaning as a preventive measure against slip and fall accidents

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FLOOR CLEANING AS A PREVENTIVE MEASURE AGAINST SLIP AND FALL ACCIDENTS

FOREWORD

Over the past six years, **QInc** has been mandated by the **Institut de recherche Robert Sauvé en santé et en sécurité du travail** (IRSST) to conduct research activities that would help to reduce the incidence of slip and fall accidents in Québec. QInc has performed laboratory and field experiments in order to identify the conditions that lead to the optimal cleaning of floors. At QInc, we believe that a cleaner floor should also be less slippery.

Although very informative, our technical reports suffered a lack of the simplicity necessary to interest non scientists. This document summarises the research activities of QInc during the 1997-2002 period and it is addressed to everyone devoted to occupational health and safety.

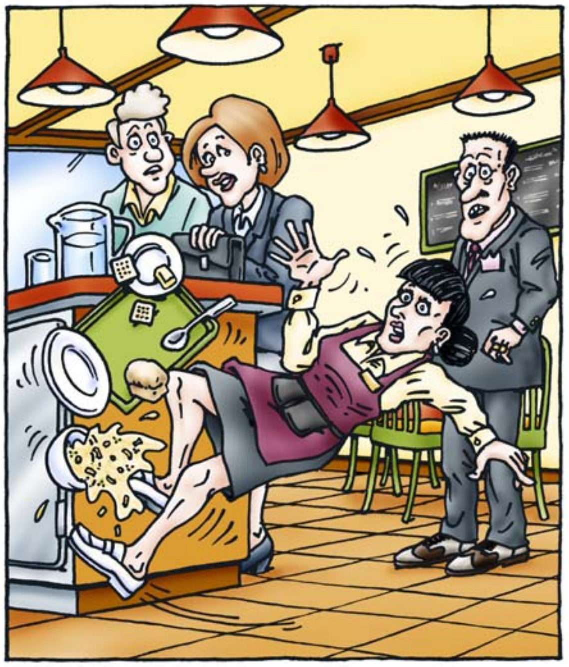
It has three levels of detail, depending on the interest of the reader. The first level has no details. It presents the major issues that we addressed in the form of a cartoon. Two colleagues have a conversation on slip and fall accidents in Québec while bad cleaning habits are being illustrated by the personnel of the restaurant. Notice that it could have been the personnel of any institution that offers a food service. The second level is found in the yellow rectangles on the following pages where 13 figures and 3 tables describe, with a little more details, the major results that we have obtained. The third level, under the yellow rectangles, gives more details on the results and the way they were obtained. For more details, the reader is referred to our technical reports (see last page of this document for references).

The examples given in the next pages represent some of the thousands of results that were obtained through the years. They were chosen solely to illustrate our sayings. We sincerely hope that the following information will convince you that "floor cleaning is a preventive measure against slip and fall accidents".

GLOSSARY

Cleaning efficiency	The amount of fat left on the flooring after it has been cleaned. The lower the better.
Cleaning residues	Non volatile components that dry on the floor, including dirt, fat and chemicals.
Cleaning solution	A solution of floor cleaner and water diluted in the appropriate ratio.
Damp mopping	Pass a damp mop on the floor and letting it dry.
Finish	An acrylic coating formulated as a white aqueous suspension. Clear once dried.
Floor cleaner	A formulation containing active ingredients that needs to be diluted with water.
Foul	To fill and clog the pores of a porous material with contaminants.
Friction	The force between the shoe sole or heel and the floor that prevents slipping.
Gloss	The reflection of light by a flooring or coating.
Gravity, Gr	The time a worker is kept away from work after an injury.
Immersion mopping	Wet the floor with a dripping mop and remove the solution with a wrung mop.
Incidence, Tx	The number of injured workers for every 1 000 workers.
Normal cleaning	Damp mopping as usually performed by workers.
Optimal cleaning	A cleaning that accounts for the type of fat and flooring to clean.
Quarry tile	Reddish to brownish tiles. It is porous when they are new.
Regeneration	The action of bringing the friction of a flooring back to its original value.
Rinse	To remove cleaning residues with water and a damp mop.
Saturation	The amount of fat necessary to cover entirely the surface of a flooring.
Significant	That changes more than the uncertainty on the absolute values.
Vinyl tile	A resilient tile, typically 12"x12" or 9"x9" (asphalt tiles).
Zones	A test area where a characteristic was measured.

FLOOR CLEANING AS A PREVENTIVE MEASURE AGAINST SLIP AND FALL ACCIDENTS



♥Have you seen the latest statistics on slip and fall accidents in Québec ? An average of 6 456 work injuries per year for the last five years.
♦And the workers are away from work for more than 8 weeks. This costs CSST more than 25 million dollars each year in compensations only.

♥ It is not surprising that the IRSST has mandated researchers to come up with solutions to the problem of slippery floors.
♦ I heard of a team that works on the optimisation of floor cleaning to prevent slip and fall accidents in the workplace.

♥ So did I. Don't you remember? We discussed that subject with Louis last week.
♦ You're right! He told us that optimal cleaning makes floors less slippery. Do you remember what he meant by "optimal cleaning" ?

♥ I sure do. It begins with the choice of an adequate floor cleaner that helps to remove dirt.
♦ That makes sense. But how can you tell if a floor cleaner is adequate ? There are several hundreds of brands on the market.

FLOOR CLEANING AS A PREVENTIVE MEASURE AGAINST SLIP AND FALL ACCIDENTS

♥ Don't panic! The CSST has come up with a brochure «Choisir un nettoyant pour plancher : Guide de l 'acheteur » that helps identify the optimal categories of floor cleaner according to the type of flooring and the type of fat that is most likely to accumulate on the floor.

♦ I got the brochure, but I thought it was intended for buyers only. I will look at it in more details when I am back at the office.

♥ Ha Ha !! Very funny. It gives many tips such as clean the mop after you use it and change the cleaning solution frequently.

♦ That seems rather obvious to me. If you use a greasy mop or a dirty cleaning solution, you end up spreading fat on the floor.

♥ You do that. For myself, I found out that my cleaning method is not appropriate for the type of flooring I have at home.

♦ That does not surprise me at all. You probably use cold water to save on electricity.

♥ I agree. But floors can become slippery for other reasons. For instance, the misuse of floor cleaners and the wear of floorings.

♦ I guess you heard that from Louis too ?

Excuse me! Your friend Louis … Does he give trainings on "How to clean a floor" ?

"Each year, slip and fall accidents cause 6 456 work injuries with a total of 25 million dollars in compensation by the CSST."

In Québec, for the 1996-2000 period, the CSST has reported an average of 6 456 slip and fall accidents per year. As shown in **Table 1**, the average time lost from work (gravity) is 57 days per accident with annual compensations totalling more than 25 million dollars.

T 1	1996-1998	1998-2000
Number of injuries	19 581	19 157
Annual mean	6 527	6 386
Gravity (weeks)	9.2	7.2

Activity Sector T 2	Number
Low contamination	
Health and social services	2 002
Teaching services	880
Local and provincial administration	1276
Food contamination	
Hotels and restaurants	1 780
Food industries	991
Whole and Retail food sale	778
Chemical contamination	
Chemical industries	215
Metalugical industies	690
Plastic industries	301

Slip and fall accidents occur in every field so that almost all workers are at risk. Slipping is often associated with the presence of contaminants on the floor such as grease, shortening, oil or water. But sometimes, slip and fall accidents occur on floors that show no sign of contamination. In **Table 2**, the number of slip and fall accidents is reported for some economic sectors with low floor contamination, as well as economic sectors where floors are exposed to food or chemical contamination. That classification allows us to better address the different causes of slipperiness.

We all fell on a slippery floor, either at home or at work or both. For most of us, the experience was harmless, except maybe for our pride. Others got hurt but could still manage to perform their job or activity. For the others, the slip and fall became an accident that caused an injury important enough to keep them away from their job.

Table 1 shows the evolution of the statistics between the period 1996-1998 and 1998-2000. During that period, in Québec, slip and fall accidents accounted for 5,5% of all work injuries with an average of 6 456 accidents a year totalling over 25 million dollars a year in compensations by the CSST.

During the same period of time, the average incidence rate, **Tx**, i.e. the number of accidents per 1000 workers, has remained stable around 2,4 for all workers while the gravity, **Gr**, i.e. the time away from work, was around 8,2 weeks.

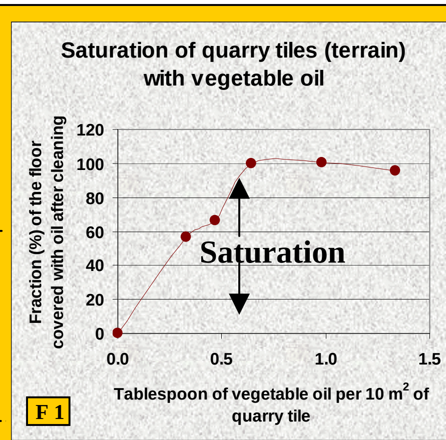
Slip and fall accidents occur to all workers, male and female, and in every field. For the 1998-2000 period, 32% of the injuries caused by a slip and fall accident occurred to women with an incidence rate of 2,0 and a gravity of 7,9 weeks. During the same period, the incidence rate for men was 2,7 with a gravity of 6,9 weeks. Because everyone is at risk, sectors that employ more workers should statistically generate more claims. That is the case for ***Health care and social services*** (2 002 accidents), ***Transportation*** (1 231 accidents) and ***Teaching services*** (880 accidents).

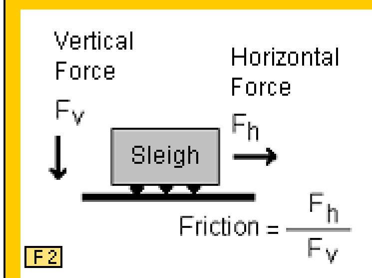
Some sectors present more risks for both female and male workers, i.e. their incidence rate is way over the average. For example, the ***Food industry*** (**Tx** = 7,5) and the ***Plastic industry*** (**Tx** = 7,3). In other economic sectors, female workers are more exposed to slip and fall accidents than their male co-workers. For instance, ***Lodging and catering*** (**Tx** women = 7,9 compared to **Tx** men = 4,3) and ***Restaurant trade*** (**Tx** women = 4,6 compared to **Tx** men = 2,7). At the opposite, male workers from the ***Machinery industry*** are more at risk than their female co-workers (**Tx** men = 6,8 compared to **Tx** women = 1,4) and so are the male workers from the ***Transformation and fabrication of metal products*** (**Tx** men = 4,2 compared to **Tx** women = 2,2).

The approach proposed by QInc to reduce the incidence of slip and fall accidents in Québec is to make floors less slippery through the optimisation of floor cleaning. Our research concentrates on the elimination of the contaminants that make floors slippery. In **Table 2**, some economic sectors have been grouped according to the type of contaminant that is most likely to be found on the floors. There are mainly three groups : ***low contamination***, ***food contamination*** and ***chemical contamination***. To this day, our research has dealt mostly with the cleaning of floors contaminated with food as well as floors with low contamination.

"Contaminants make the floor slippery by reducing the friction between the shoe sole or heel and the flooring."

Contaminants accumulate on floorings up to a point where the surface is saturated. In the case of fat, only little amounts are required to cover the surface of a flooring and once it is saturated, it becomes very slippery. **Figure 1** shows that a little more than ½ a tablespoon of vegetable oil is necessary to cover 10 m^2 (108 square feet) of worn quarry tiles similar to those found on kitchen floors. At QInc, we have defined that the cleaning is optimal when it reduces the amount of fat (vegetable oil, shortening, chicken fat) well below the saturation limit of the fat on that type of flooring.





The removal of floor contaminants should improve the friction between the floor and the shoe sole or heel. At QInc, we use the dynamic friction coefficient to evaluate the impact of floor cleaning on the slipperiness of dry floorings. As shown in **Figure 2**, the dynamic friction coefficient is simply the ratio between the horizontal force (**Fh**) necessary to maintain a sleigh at a constant speed and the weight of that sleigh (**Fv**).

If we accept that contamination makes floors more slippery, then we also accept that an improvement in floor cleaning should make the floors less slippery. That is exactly what QInc has proposed, as a working hypothesis, to the ***Institut de recherche Robert-Sauvé en santé et en sécurité du travail***. Since 1997, QInc has conducted laboratory and field investigations to better define optimal cleaning conditions and their impact on floor slipperiness. To do so, we had to develop test methods to characterise the efficiency of floor cleaners according to the type of flooring, type of fat, cleanness of the tools, cleaning methods and temperature of the cleaning solution.

At QInc, an optimal cleaning picks up dirt but most importantly, leaves very little contaminants on the floor. That residual quantity is expressed relative to the quantity required to saturate the flooring. Hence, the first step of the test method is to evaluate the amount of a given fat necessary to cover the surface of a given flooring. As shown in **Figure 1**, only ½ tablespoon of vegetable oil is needed to saturate 10 m^2 of a worn quarry tile flooring often encountered in restaurant kitchen floors. Notice that new quarry tile are rougher and more porous than their worn counterparts and their saturation limit is higher, around 4 tablespoon for 10 m^2.

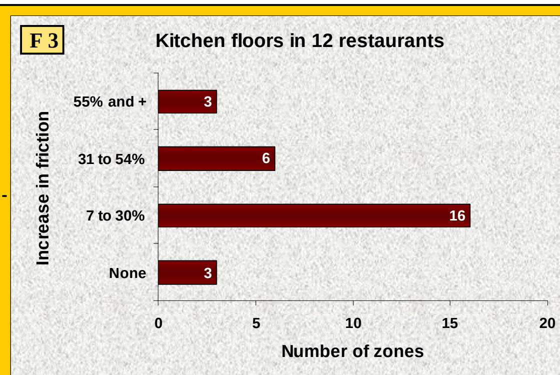
Once the saturation limit is determined, the flooring is covered with fat at about twice its saturation limit. It is then cleaned using a laboratory procedure. The residual amount of fat is determined and expressed as the percentage of the flooring still covered with fat. Using this test method, we find that a cleaning is optimal if it leaves less fat than 30% of the saturation limit of the flooring.

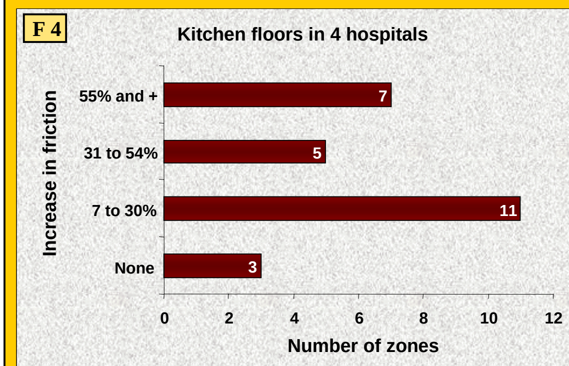
This approach puts the emphasis the contaminants left on the floor because they make the floor slippery by reducing the friction between the shoe sole or heel and the flooring, making it slippery. Experimentally, the friction is obtained as the ratio of the force necessary to pull a sleigh on a surface and the weight of that sleigh (see **Figure 2**). For example, if I have to pull a 500 g sleigh with an horizontal force equivalent to to 250 g, than the friction coefficient between that sleigh and the flooring is 0.5. If the force initiates the movement of the sleigh, than on obtains the static friction coefficient. If the force is applied to maintain the sleigh at a constant speed, than one obtains the dynamic friction coefficient. The dynamic friction coefficient is always smaller or equal to the static friction coefficient. That is why it is tougher to move a furniture on a flooring than to keep it moving.

To this day, there is no international consensus on a test method to evaluate the slipping resistance of flooring and shoes. Moreover, the scientific community disagrees on the type of friction to use (static or dynamic), the test conditions (dry, wet, oily) and on the standards that should represent a typical flooring (for shoe evaluation) or a typical shoe sole or heel (for flooring evaluation). At QInc, we determine the dynamic friction coefficient but we use these values only to evaluate the impact of an action, for instance cleaning, on slipperiness.

"Optimal cleaning results in a significant improvement of the friction for 89% of the zones tested."

The hypothesis that drives our research is that a clean floor should be less slippery, thus safer. In other words, optimal cleaning should make floors safer. That hypothesis was verified during a preliminary field study conducted on the kitchen floors of twelve restaurants. **Figure 3** shows that "optimal" cleaning increased significantly (> 6%) the dynamic friction of dry floorings for 25 of the 28 zones tested with an average gain of 24% overall.





Similar results were obtained on the kitchen floors of four hospitals. In that case **(Figure 4),** "optimal" cleaning increased the dynamic friction for 23 of the 26 zones tested with an average gain of 38% overall. This suggests that the need for an improvement in floor cleaning is generalised.

The impact of floor cleaning on its dynamic friction has been investigated during a preliminary field study where QInc personnel performed tests on the kitchen floors of twelve restaurants and four hospitals. At each location, zones exposed to fat accumulation and zones less exposed to fat were tested.

First, the dynamic friction coefficient was determined on each zone prior to cleaning. Then, the workers were asked to clean the floor using their usual procedure. The dynamic friction coefficient was determined again on the test zones.

Finally, QInc personnel proceeded with an optimal cleaning and the dynamic friction coefficient was determined for a third time. The impact of the cleaning was expressed as the percentage increase in the friction following the "normal" or "optimal" cleaning with respect to the friction of the dirty floor. During this investigation, we found that an impact smaller than 7% was not significant. So, to be significant, the cleaning should increase the dynamic friction coefficient by 7% and more. The **Table** below compares the results obtained for zones "not directly exposed to fat accumulation" with those obtained for zones "exposed to fat accumulation".

Dynamic friction on twelve restaurant floors	Not exposed to fat		Exposed to fat	
	Noted improvement	Average impact	Noted improvement	Average impact
Normal cleaning	7 out of 14 zones	+ 6 %	5 out of 23 zones	+ 1 %
Optimal cleaning	15 out of 17 zones	+ 28 %	25 out of 28 zones	+ 24 %

Although preliminary, these results confirm that the optimisation of floor cleaning leads to a substantial increase in the dry dynamic friction coefficient of floor more frequently than the "normal" cleaning. For instance, optimal cleaning results in a significant improvement of the friction for 89% of the zones tested, no matter the amount of fat accumulated. On the other hand, "normal" cleaning was effective for 50% of the zones with little fat accumulation and that number dropped to 22% when the zones were "exposed to fat".

Very similar results were obtained during the visit of four hospitals (see **Figure 4**). Optimal cleaning improved the friction significantly for 23 of the 26 zones tested with an average gain of 38% in the dynamic friction coefficient of all the zones tested.

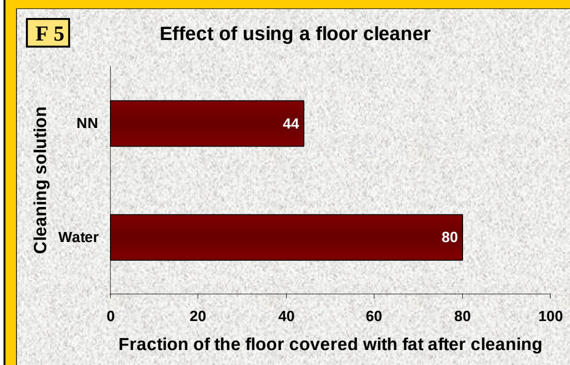
During that preliminary field study, we observed that, in most cases, the workers never had a training on "how to clean floors". But we also noticed that, both the workers and the employers, were eager to obtain more information on adequate cleaning methods.

"Laboratory experiments showed that the use of floor cleaners improves the cleaning efficiency."

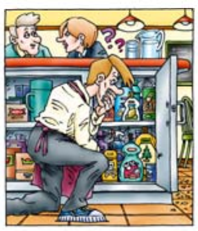
Optimal cleaning begins with the use of an adequate floor cleaner. Since there are hundreds of floor cleaners made in Québec, QInc has proposed to classify them into six categories based on the chemical nature of the main ingredients. **Table 3** summarises the characteristics of these categories: Neutral Anionic (**NA = 1**) ; Neutral Non-ionic (**NN = 2**) ; Degreaser Anionic (**DA = 3**) ; Cationic (**C = 4**) ; Degreasers based on Glycol Ether (**DG = 5**) ; Degreasers based on Limonene (**DL = 6**). (yes = present, no = absent, nothing = may be present).

T 3

Category	Surfactant			Glycol Ether	D-Limonene	Alkaline salts
	Anionic	Non-ionic	Cationic			
1 NA	yes		no		no	
2 NN	no	yes	no		no	
3 DA	yes		no	yes	no	yes
4 C	no		yes		no	
5 DG			no	yes	no	yes
6 DL			no		yes	



The surfactants present in all floor cleaners are designed to remove fat from the flooring and disperse it into the cleaning solution. For that reason, cleaning a floor with a floor cleaner will always be more effective than without one. This is shown in **Figure 5** for a type **NN** cleaner. Cleaning with just water left twice the amount of vegetable oil on a finished vinyl floor than cleaning with the floor cleaner.



All laboratory tests show that the use of a floor cleaner helps water to remove accumulated fat from dirty floors. However, all floor cleaners are not equal and the choice of an appropriate cleaner may become a difficult task. For instance, there are hundreds of floor cleaners made in Québec.

In 1997, QInc suggested six categories of floor cleaners based on the chemical nature of the main ingredients. That approach drastically reduced the number of variables and allowed us to make recommendations without naming a single product.

Table 3 summarises the main ingredients of the six floor cleaner categories. The ***surfactants*** help disperse dirt and fat in the cleaning solution. The ***co-solvents*** facilitate the penetration of the cleaning solution through the fat and dirt. The ***alkaline salts*** cut fat into smaller molecules that are easier to remove. Strongly alkaline floor cleaners that contain an appreciable amount of cosolvent are often designed as ***degreasers***. Those with a lower alkalinity and no or very little cosolvent are often referred to as ***neutral***. The ionic nature of the surfactant, ***anionic***, ***cationic*** or ***non-ionic***, is also an important distinction for the determination of the six categories.

Two types of co-solvent are often added to degreasers : ***glycol ethers*** are water soluble and ***limonene,*** extracted from citrus fruits, is not. More and more, alkaline salts such as ***hydroxides,*** are being replaced by ***metasilicates*** to generate the high pH of degreasers.

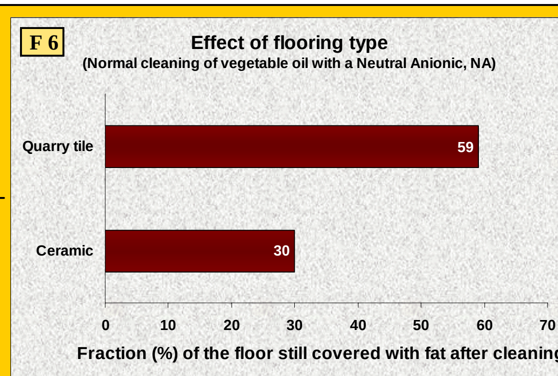
Putting that information together, QInc defined six categories of floor cleaners which are : ***1) NA*** : neutral anionic, ***2) NN*** : neutral non-ionic, ***3) DA*** : degreaser anionic, ***4) C*** : cationic, ***5) DG*** : degreasers based on glycol ethers, and ***6) DL*** : degreasers based on limonene. A rapid look at the MSDS of 350 floor cleaners allowed us to classify 96% of these cleaners into one of the six categories proposed. That classification is certainly not perfect, but we believe that it is a good starting point.

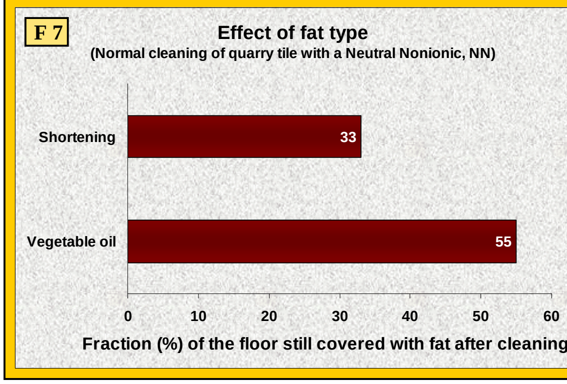
The addition of a cleaner to water will always improve the cleaning efficiency. This is shown in **Figure 5** where normal cleaning with a type **NN** cleaner left two times less vegetable oil on the finished vinyl flooring than water alone. Laboratory experiments also confirmed that floor cleaners from different manufacturers, but belonging to the same category, had similar efficiencies.

In 2003, the CSST has published a document based on our work in order to guide "buyers" in their selection of floor cleaners. The document « ***Choisir un nettoyant pour plancher : Guide de l'acheteur*** » also reports the co-ordinates of manufacturers from Québec as well as the categories of floor cleaners that they offer. But most importantly, it gives valuable information on the category needed for the optimal cleaning of floors with respect to the type of flooring and the type of fat that need to be cleaned.

"The choice of a floor cleaner depends on the type of flooring to clean and the type of fat to remove."

Laboratory tests showed that the efficiency of floor cleaners depends on the type of flooring that is cleaned. This is shown in **Figure 6** where "normal" cleaning with a type **NA** cleaner leaves twice as less vegetable oil on a glazed ceramic flooring than on quarry tiles. The glazed ceramic is less permeable to oil than the porous quarry tiles. Hence, the vegetable oil stays at the surface of the glazed ceramic flooring where it is easier to clean.





The permeability of a flooring to fat will depend on the viscosity of the fat. For example, **Figure 7** shows that "normal" cleaning with a type **NN** cleaner leaves less shortening than vegetable oil on new quarry tile floors. Indeed, shortening is more viscous than vegetable oil and it penetrates less rapidly within the porous quarry tiles. It thus remain longer at the surface where it is easier to clean.

At QInc, we believe that all floor cleaners are good if they are used properly. The main problem resides in the definition of "proper use". Laboratory experiments showed that the efficiency of a floor cleaner depends on the ***type of fat*** that has to be removed and the ***type of floorings*** to be cleaned.

Our work has focused on common floorings, i.e. ***vinyl with and without an acrylic finish***, porous ***quarry tiles*** and ***glazed ceramic***. The glaze and the acrylic finish make the floorings impermeable to fat while stripped vinyl and porous quarry tiles are relatively permeable to it.

Fat penetrates more deeply into porous floorings (quarry tiles and stripped vinyl) while it remains at the surface of impermeable floorings (finished vinyl and glazed ceramic). Permeable floorings are more difficult to clean because fat is trapped within the floorings. Impermeable floorings are much easier to clean because fat is accessible at the surface. An example is given in **Figure 6** for the normal cleaning of vegetable oil with a type NA floor cleaner. There are twice as less fat left on the ceramic than on the quarry tiles. Notice that the use of aggressive degreasers (***DG*** and strongly alkaline ***C***) may remove part or all the acrylic finish leaving the flooring unprotected against fat penetration.

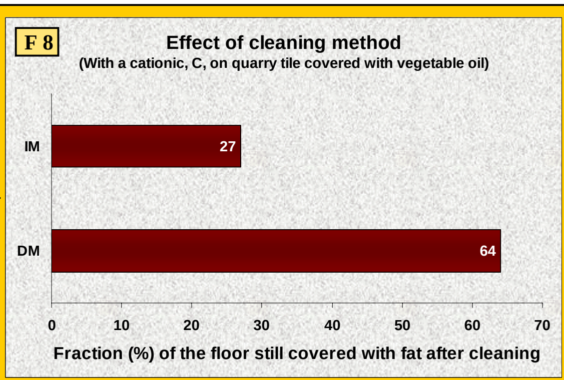
The ***fats*** typically found in the kitchen may be vegetal (***shortening*** and ***vegetable oil***) or animal (pork and ***chicken fat***). Shortening is more viscous than vegetable oil and cooked chicken fat has a viscosity intermediary between the two. On an impermeable flooring, fat remains at the surface and their ability to be cleaned is almost the same. In the case of porous floorings, the cleaning efficiency depends on the penetration of the fat into the porous structure of the flooring. Shortening will remain longer at the surface and will generally be easier to clean than vegetable oil that penetrates rapidly due to its lower viscosity. In the example of **Figure 7**, a normal cleaning of quarry tiles with a type NN cleaner left twice as less shortening than vegetable oil.

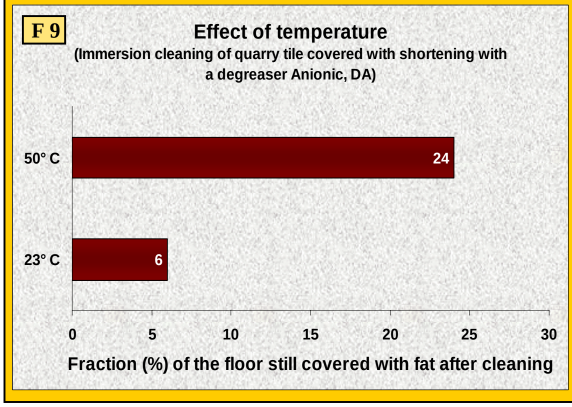
If the cleaning is not performed frequently, then fats at the surface will migrate or be pushed deeply into the floorings. In that case, the higher the viscosity of the fat, the tougher its removal will be. Vegetable oil penetrates rapidly into the pores but its low viscosity facilitates its dispersion and removal with an adequate floor cleaner and cleaning method. Shortening, with its higher viscosity, becomes very difficult to disperse once it has been trapped within a porous flooring.

Cooked chicken fat has a viscosity low enough for rapid penetration into the porous floorings and high enough to be difficult to disperse and remove. In a general manner, we found that cooked chicken fat was more difficult to clean from porous surfaces than shortening and vegetable oil.

"The longer the cleaning solution is in contact with dirt, the better the cleaning efficiency."

Efficiency also depends on the method used to clean the floor. We have tested damp mopping, **DM**, and immersion mopping, **IM**. **Figure 8** shows that immersion mopping with a type **C** cleaner leaves three times less vegetable oil on a porous quarry tile floor than damp mopping. In this document, damp mopping is also referred to as « normal » cleaning because it is the method mostly used by workers.





It is also a common belief that the use of hot water to prepare the cleaning solution will improve the cleaning efficiency.This is not always true, especially for porous floorings. **Figure 9** shows that the amount of shortening left on quarry tiles after immersion mopping with a type **DA** cleaner is four times higher with a hot solution (**50°C**) compared to a warm one (**23°C**). The hot cleaning solution melts the shortening, reduces its viscosity and facilitates its penetration within the porous quarry tile.

As noticed during our field studies, kitchen floors are cleaned with a mop, a bucket, a wringer and a cleaning solution. The most common method is by far ***damp mopping*** which consists in passing a damp mop on the floor. The mop passes about two times on the same surface and the wet floor is left to dry. The cleaning solution is applied during the first pass and removed, together with the dispersed dirt, during the second pass. This leaves only seconds for the ingredients of the floor cleaner to penetrate, disperse and cut the the fat at the surface and within the pores of floorings. It becomes clear that a cleaning method where the floor cleaner has more time to act on fat, would represent an improvement over damp mopping.

We investigated ***immersion mopping***, a method used by workers when they have to deal with very filthy floors. Immersion mopping proceeds in two steps. First, the cleaning solution is applied on a section of the floor with a dripping mop. After a couple of minutes, the cleaning solution is removed with a wrung mop. It is important that the cleaning solution does not dry between the two steps because the active ingredients of the floor cleaner need water to remain active.

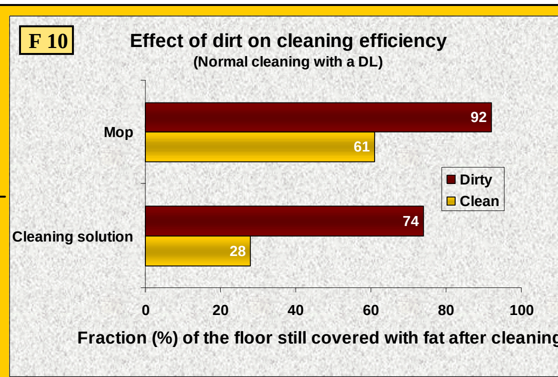
In the laboratory, immersion mopping has proven to be superior to damp mopping. An example is given in **Figure 8** for the cleaning of porous quarry tiles with a type **C** cleaner. Immersion mopping left two times less vegetable oil on the floor than damp mopping.

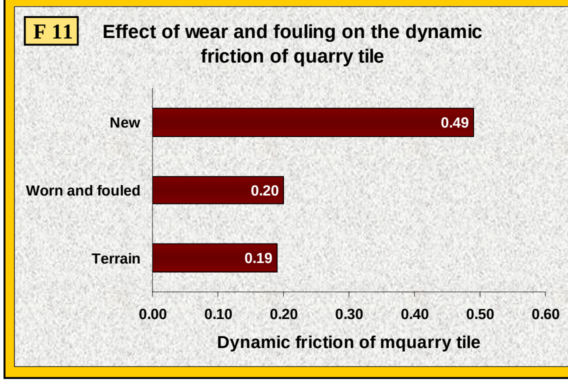
Immersion mopping has many advantages over damp mopping. It leaves more time for the penetration of the floor cleaner so that it can act deeper into the flooring. The wrung mop is more absorbent than the damp mop and it leaves less dirty solution on the floor. Laboratory experiments showed that the efficiency of immersion mopping is less affected by high concentrations of fat, while that of damp mopping is drastically reduced. However, the method takes a little more time so that the floors are wet for a longer period of time than for damp mopping. ***It is thus preferable to use immersion mopping at time of the day where there is very little circulation and to clearly indicate that the floor is wet and slippery***.

It is a common belief that using hot water to prepare the cleaning solution will improve the cleaning efficiency. However, laboratory investigations showed that this is not always the case, in particular for porous floorings. **Figure 9** shows that immersion mopping with a hot cleaning solution (50°C) left four times more shortening on quarry tiles than with a warm solution (23 °C). In that particular case, the high temperature of the cleaning solution melts the shortening, favouring its penetration into the flooring. In some other cases, the use of hot cleaning solutions may be more efficient, for instance for the cleaning of fat on glazed ceramic.

"Cleaning a floor with a filthy mop and cleaning solution reduce significantly the cleaning efficiency."

The cleaning efficiency, even with a good floor cleaner, is limited by the cleanness of the tools used. For instance, **Figure 10** shows that « normal » cleaning with a type **DL** cleaner leaves more vegetable oil on a stripped vinyl flooring when a dirty mop or cleaning solution is used. This emphasises the importance of using clean tools and changing the cleaning solution as it becomes dirty.





With time, the residues left on the floor clog the pores of the flooring and reduce its friction. We have developed a laboratory procedure to reproduce the wear and fouling of quarry tiles as it occurs on a kitchen floor. **Figure 11** shows that the dynamic friction on the tiles worn and fouled in the laboratory is very close to that of the tiles tested during a field study (terrain). In both cases, the friction is and more two times less than that of a porous new tile.

As one might expect, the efficiency of a floor cleaner depends on the cleanness of the mop and cleaning solution used. The whole idea of cleaning is to transfer dirt from the floor to the cleaning solution and then discard the dirty cleaning solution.

By doing so, dirt and fat accumulates both in the mop and in the cleaning solution. **Figure 10**, shows that cleaning a floor with a filthy mop or with a filthy cleaning solution or both, does reduce significantly the efficiency of the floor cleaner.

At the beginning, the cleaning solution contains water and a floor cleaner. As the dirt is transferred to the cleaning solution, some of it remains stuck in the mop. The dirtier the mop and the cleaning solution, the more the solution left on the floor after the cleaning will be dirty. As the solution dries, non volatile components like surfactants, alkaline salts, dirt particles and fat, will remain on the floor and become "cleaning residues". Adding more floor cleaner to a dirty cleaning solution does not make it cleaner. Actually, ***overdosing the floor cleaner will generate more cleaning residues that may make the floor more slippery, especially when wet.***

To reduce the amount of "cleaning residues" left of the floor, it is important to : ***use adequate dosage of the floor cleaner***, to ***change frequently the cleaning solution*** and to ***change (or clean) the mop*** as it becomes dirty. Rinsing the floor with a damp mop is the best way to eliminate most to the cleaning residues.

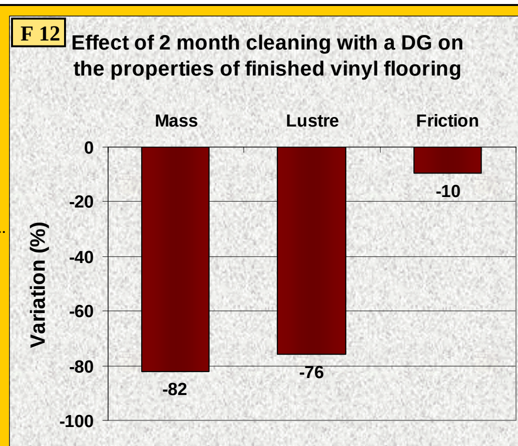
For very similar reasons, the tools used to clean the floor should not be used to pick-up food spills. A scraper and a shovel, as well as paper towels, should be used to pick-up the most of the spill. Then only, should the mop be used to clean the floor. Each time a floor is cleaned, the cleaning solution should be discarded and the mop rinsed with clear water.

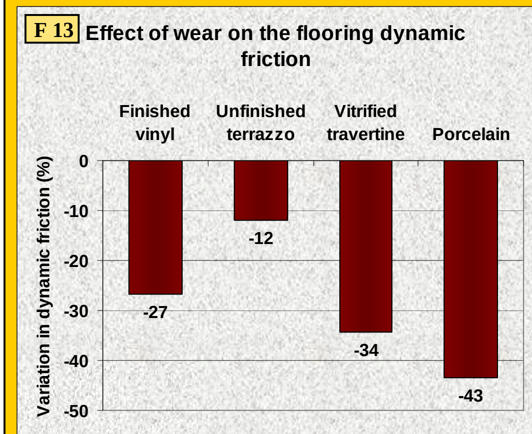
"Cleaning residues" and floor contaminants that are not removed during the cleaning process, remain trapped in the floorings where they may react with air and other materials and eventually fill and clog the pores. With time, the fouling action combined with the wear of the flooring, will even the surface and make it more slippery. **Figure 11** shows that the dynamic friction coefficient measured on quarry tile floors of restaurants (terrain) is 2½ lower than that of porous quarry tiles (new).

To better comprehend that effect, we developed a laboratory procedure that allows us to artificially prepare fouled and worn quarry tiles (Figure 9) that have characteristics (friction, roughness and gloss) very close to those encountered in the field. That procedure is very promising because it will facilitate the laboratory investigation of the regeneration of fouled and worn floorings. It uses successive cycles of fat baking, abrasive wear and tile cleaning to accelerate the ageing of the flooring.

"A shiny dry floor is not necessarily more slippery than a mat dry floor."

Floors can be slippery for other reasons than fat contamination. In **Figure 12,** we show how two months of daily cleaning of a finished vinyl floor with a type **DG** cleaner led to a 10% reduction in the dynamic friction. During that period, most of the finish was stripped and its gloss was drastically reduced.





The normal wear due to pedestrian circulation can also make floorings more slippery. This was observed in a field study where the friction of different floorings was measured on test areas exposed to and concealed from circulation. **Figure 13** shows that, for the four floorings tested, the dry dynamic friction of the worn flooring was significantly lower.

As mentioned at the beginning of this document, slip and fall accidents do not always occur on greasy kitchen floors. A great deal of the flooring surface of local and provincial administration buildings, health care institutions and schools is encountered in corridors, offices and rooms that are not necessarily exposed to food or chemical contamination. Nevertheless, there are many slip and fall accidents in these economic sectors. One possible explanation lies in the impact of floor cleaning on the slipperiness of floorings. In 2000-2001, we have looked at the impact of repeated cleaning on the integrity of floorings and in particular of vinyl covered with an acrylic finish.

We found that daily damp mopping of a finished vinyl flooring for 6 month with a neutral cleaner (type ***NN*** or ***NA***) had almost no impact on its physical characteristics, except for the low speed finish tested who suffered a 30% weight loss. That number increased to 80% when the finished vinyl was cleaned with a scrubber.

When a type **DG** floor cleaner was used to mop the a finished vinyl flooring (see **Figure 12**), the weight loss of acrylic was up to 82% after only 2 months of daily damp mopping. The finished vinyl also suffered a 76% loss in gloss accompanied by a slight reduction of its dry dynamic friction coefficient (10%). In other words, ***the dry floor was slightly less slippery when its gloss was higher***.

The correlation between a loss of gloss and a loss of dynamic friction was also observed for other types of floorings. During a field study in a hospital, we have collected the dynamic friction coefficient of dry floorings on test areas exposed to and concealed from circulation. The difference between exposed and concealed areas was attributed to the impact of circulation (wear) on the dynamic friction coefficient of dry floorings.

In **Figure 13**, these differences are expressed relative to the friction of concealed areas. If we assume that floorings have a lower gloss when they are worn, than we find again a correlation between the decrease of the dynamic friction coefficient and the loss of gloss due to circulation, and that for the four types of flooring reported. This is evidenced from the results obtained on vitrified travertine floorings. It seems that the vitrification, in addition to generating a higher gloss, also generates a higher friction coefficient, at least when the floor is dry.

The choice of a flooring should take into account its initial friction coefficient but also its ability to maintain that friction with time. In the example above, the concealed porcelain flooring had the highest dry dynamic friction coefficient. However, after 1½ years of normal circulation, its friction dropped at the same level than that of the worn finished vinyl. The big difference here is that the impact of circulation on porcelain is irreversible while for vinyl flooring, a new coat of acrylic finish will bring back the dry dynamic friction to its original value, i.e. significantly higher than that of the worn porcelain tested.

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