Linoleum floors—properties, maintenance and effects on indoor air quality—recommended methods for cleaning and maintenance

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ABSTRACT
Linoleum floors must be cleaned and maintained properly in order to avoid damages. Excessive use of water and/or wrong maintenance procedures may lead to damages to the floor like water damages, abrasion damages, chemical removal of linseed oil (binder) from the linoleum, or powdering of floor finish. These problems can affect the indoor air quality. Linoleum floors are mainly maintained by use of polyacryl based polish systems. In the last years, wax-based maintenance systems for use on linoleum floors have been introduced in the Scandinavian cleaning market, in order to avoid powdering problems. The pros and cons of the two different systems are discussed, including properties like cleaning performance, need of maintenance, gloss, floor friction, effects on the indoor air quality, and cleaning costs. Wax-based systems have higher cleaning and maintenance costs, lower gloss and higher friction than polish systems, but no risk of powdering problems. Guidelines for cleaning and maintenance of linoleum floors are given.

INDEX TERMS
Linoleum floors; Maintenance; Polish; Wax; Properties

INTRODUCTION
Linoleum floors are widely used in the Scandinavian countries, and cover approximately 10–20% of the floorings market. It can be used as flooring in all dry environments with low to moderate traffic. Linoleum consists of a binder made from oxidized linseed oil and resin (30–40%), fillers made from stone dust and wood dust (60–70%) and a carrier web made from jute. The surface is normally treated with an acrylic-based coating at the factory, which is later maintained during cleaning operations with either acrylic-based floor polish systems or wax based systems. Incorrect cleaning and maintenance of floors may affect the indoor air quality (Bakke *et al.*, 2002; Bjørseth *et al.*, 2002). In Scandinavia, linoleum floors mainly have been maintained with polyacryl based polish systems. Powdering is a degradation of the floor surface that can occur when linoleum floors are maintained with acrylic-based floor polishes (Selin, 1995). In order to avoid powdering problems wax-based maintenance systems have been introduced in the Scandinavian cleaning market. This study was initialized by the Norwegian Defence Estates Agency after having experienced problems with powdering of floor polish on linoleum floors in the northern part of Norway. The aim of the study was to elucidate the occurrence and causes of powdering, measure air quality during scrubbing and application of polish on linoleum floors, measure degree of dust generation in buildings with powdering problems, and develop new guidelines for maintenance and use of linoleum floors. Results from measurements of degree of powdering and air quality are given elsewhere (Nilsen *et al.*, 2003). This part of the study deals with the properties of the two maintenance systems used on linoleum floors. The results from the study have been supplemented with results from other buildings examined by the same group.

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METHODS

Literature studies were conducted in order to reveal the properties of and experiences with linoleum floors. In addition, measurements of maintenance properties were performed in problem and non-problem buildings.

Floor friction and surface gloss on the floor were measured as described in the interNordic standard NS INSTA 800 (Norwegian Standards Association, 2000; Nilsen *et al.*, 2000). The floors were cleaned with dry disposable mops with good cleaning effect (Schneider *et al.*, 1994; Dahl *et al.*, 2002) before the measurements were performed.

Cleaning costs for floors were calculated using Excel and cleaning times published by the International Sanitary Supply Association. Calculations were based on cleaning and maintenance routines as recommended by the suppliers of the chemicals, and recommendations published by the Norwegian Building Research Institute. Cleaning frequencies of 2 days a week and 5 days a week were used. Maintenance (burnishing) frequency of two times per month was used for the wax system, and once per month was used for the polish system. Frequency for re-establishing the polish system was every fifth year.

RESULTS

Literature studies revealed that linoleum floors have been used for both domestic and public areas for more than 100 years. Linoleum is made from renewable materials, and is claimed to be an environmentally friendly product. The product is also claimed to be wear resistant, with a normal lifetime of 20–30 years. Up to 80-year-old floors can be found in good condition. The wear resistance decreases in wet condition, and linoleum is not recommended for use in areas where the floors become wetted frequently. Linoleum can be damaged by alkaline solutions. Frequent use of strong alkaline cleaning agent will gradually remove the linseed oil and by that desiccate the linoleum.

Linoleum was originally maintained with floor waxes, and wax was applied as a protective coating at the factory. In the early 1960s, polymer-based floor polishes were introduced, and soon after the first powdering problems occurred. Modern linoleum floors have a protective coating based on acrylic polymer applied at the factory, making the surface better adapted to future maintenance with acrylic-based polish systems.

Linoleum manufacturers have until recently recommended acrylic-based floor polishes for maintenance of linoleum floors. In the late 1990s some manufacturers changed their opinion, and started to recommend the softer wax-based maintenance systems. The recommended conditions for application of the two systems on new linoleum floors and methods for cleaning and maintenance can be seen in Table 1.

Results from calculation of cleaning and maintenance costs for floors can be seen in Table 2. The results are given in Norwegian crowns per square metre floor and year.

Results from measurements of friction and gloss on linoleum floors maintained with wax- and polish-based systems can be seen in Table 3.

Table 1 Recommended conditions for application and methods for cleaning and maintenance of new linoleum floors with polish- and wax-based maintenance systems

Activity	Property/method	Polish-based system	Wax-based system
Scrubbing	Floor heating	Turn off the day before	Turn off the day before
	Rest humidity in underlying concrete floor	To be avoided	To be avoided
	Method	Light rinse with red scrubbing pad, low speed scrubbing machine and mild alkaline solution	Light rinse with red scrubbing pad, low speed scrubbing machine and mild alkaline solution
	Drying time after scrubbing	24 h	No recommendations
Application and drying	Air temperature	15–25°C	15–25°C
	Relative humidity in air	Minimum 20%, >35% is preferred	No recommendations
	Air velocity	Maximum 0.15 m/s	No recommendations
	Method	Polish applicator or mop	Polish applicator or mop
	Type of product	Semi-hard primer and top coat	Floor wax
	Number of coats	Primer: 1–2; top coat: 1–2	1
	After-treatment	No	Dry buffing, high-speed
Cleaning	Frequency	1–5 times a week	1–5 times a week
	Methods	Mainly dry	Mainly damp-wet
Maintenance	Application of restorer	–	Wax supplied during cleaning with wax containing detergent
	Spray-buffing	1 time per month	2–4 times per month
Complete scrubbing and re-establishing	Frequency	Every 5–10 years	–
	Method	Deep scrubbing with dark scrubbing pad, low speed scrubbing machine and alkaline solution	–

Table 2 Cleaning and maintenance costs in NOK per year for linoleum floors maintained with wax- and polish-based systems

Maintenance system	Floor cleaned 5 days per week	Floor cleaned 2 days per week
Wax based	100.84	50.39
Polish based	86.04	45.76

Table 3 Results from measurements of friction and gloss on linoleum floors maintained with wax- and polish-based systems

Building and maintenance system	Status	Floor	Friction μ	Gloss, units
Building 9, polish	Non-problem	Fourth	0.47	70
	Tendency to powdering	Second	0.37	50
	Non-problem	First	0.51	66
Building 6, polish	Powdering	Third	0.34	28
	Powdering	Second	0.32	30
	Powdering	First	0.31	33
Building 10, wax	Non-problem	First	0.36	8
	Non-problem	Basement, middle	0.46	11
	Non-problem	Basement, south	0.52	9
	Non-problem	Basement, north	0.73	8

DISCUSSION

The procedures used for establishing polish-based maintenance system on linoleum floors is more time consuming than procedures for establishing wax-based systems. In addition, more care must be taken during the process to keep the right climatic conditions when polish is applied. The process includes the use of VOC-containing chemicals (Nilsen *et al.*, 2003). Polish-based systems are on the other hand easier to clean and maintain due to their harder surface. This gives a considerably (10–20%) lower overall cleaning and maintenance cost for the polish-based system. These costs can increase if powdering problems occur. A study performed by a Swedish cleaning company (Franzén, 1995) revealed 20% increase in cleaning costs in a building with powdering problems. Such problems may also affect the indoor environment (Malmberg and Flodin, 1995; Nyman, 1995).

Waxed linoleum floors have a very low gloss compared to floors with polish, and they can in some cases show a high floor friction. The higher friction and the need for damp or wet cleaning methods can make waxed floors heavy to clean, increasing the physical work load for the cleaners. Floors with polish and powdering problems have a lower floor friction than non-problem floors, resulting in increased risk of skid accidents. The interNordic standard NS INSTA 800 (Norwegian Standards Association, 2000; Nilsen *et al.*, 2000) recommends floor friction of minimum 0.4 in order to assure good slip resistance on floors with high traffic.

CONCLUSIONS

Wax-based maintenance systems have higher cleaning and maintenance costs, lower gloss and higher friction than polish systems, but no risk of powdering problems when used on linoleum floors. Polish-based systems can have powdering problems, resulting in increased cleaning costs, reduced slip resistance, and reduced indoor air quality. The pros and cons of the two systems are summarized below.

Polish-based system

+ Surface that is easy to clean
+ Suitable for dry cleaning methods
+ Easy to maintain, can be burnished with super-high-speed machines
+ Good resistance against scuff marks
+ Good water resistance
+ God slip resistance
+ Good durability, min. 5 years without scrubbing
+ Gloss can be adjusted by choosing the right product
– High demands for right conditions during application and drying
– Not adapted to the binder in the linoleum
– More time-consuming to establish
– Difficult to remove without damaging the linoleum surface
– Polish and strippers containing volatile organic compounds have to be used
– Small mistakes in cleaning and maintenance procedures can cause powdering problems

Wax-based system

+ Powdering safe surface
+ Gloss near to the original gloss of the linoleum
+ Little resources needed to establish the system
+ Small risks involved in the establishing process
+ No need for chemicals that can damage the linoleum
+ No products containing VOCs are needed
+ Adapted to the binder in the linoleum, gives deeper impregnation
– Dirt can build up in the soft coating
– Need for frequent burnishing (2–4 times more often than for polish)
– Burnishing with slower moving machines (need more time)
– Need for wetter and more time consuming cleaning methods
– Increased physical workload for cleaners
– Less water resistant surface
– Risk for build up thick layer of wax, can give discoloration
– Higher cleaning costs

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