0% MRE, with the broom only method having MRE values of approximately 95% to %. No noticeable performance difference related to bag loading was observed.

JMMARY

arpet

1) The portable residential vacuum cleaner gave low MRE's with the plain tool and moderate MRE's with the mechanical agitator. - Table 1

2) The more powerful HEPA and central vacuums gave moderate MRE's with both plain tools and mechanical agitators. - Table 1

3) Experimental errors prevented accurate measurements using the low (0.7 g) dust loading.

4) The initial cleaning gave the highest incremental dust removal with subsequent cleaning cycles producing diminishing returns. With the case of the agitator head, MRE's approaching 100% are possible with long cleaning cycles. - Figure 1

5) The professional dry/wet cleaning did not produce MRE's above those obtained by the residential units with the agitator tool. - Table 1

Vinyl floor covering

1) All methods gave very high MRE's, however the broom alone left a visible dust residue.

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RESIDUES OF LUBRICANT OILS AS A SOURCE OF IMPURITIES IN VENTILATION DUCTS

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ABSTRACT

Contamination of ventilation system may originate from the debris left in the ducts during the time of construction of the building, or from the dust accumulated during the normal use of HVAC system. Lubricant oil residues from the manufacture of the ducts contribute to the deposition of dust on the ducts. In this study, hygienic characteristics of two lubricant oil emulsions used in manufacture of the ducts were investigated. One of the oil was based on mineral oil and the other on vegetable oil. The tests were made by treating galvanized surfaces with diluted emulsions, 3 and 5% (same as in manufacturing use). Evaporation of the oils from surfaces of new galvanized steel sheets were followed for five months. The potential of lubricants to act as a growth substrate for microbes was tested with Penicillium brevi-compactum in the laboratory. After the five months evaporation time, the oil residues were 60 and 84%, respectively, on the galvanized steel surface. In the inhibition tests the oils did not have significant inhibition effect on fungal growth. The surfaces treated with lubricant emulsions were found to offer a sufficient medium for fungus. The fungal growth potential was similar on the both media. Thus, the residues of viscous oil on the inner surface of ventilation ducts promotes accumulation of dust and may also promote fungal growth if water is available.

INTRODUCTION

Main purpose of a ventilation system is to deliver sufficient amount of fresh, clean air to occupied rooms. The supply air in the ventilation system can be contaminated by an active source, such as a microbial colony on the inner surface of the system, or by passive sources, such as disengagement from construction and insulation materials or dust settled during use (1). Part of the debris in the ducts also originates from the time of construction of the building. In several cases, ventilation has been claimed to deliver stuffy, odorous air. Fanger and his group (2) found that ventilation system itself was a major source of odorous pollutants of indoor air. The odour emissions has been observed to be at highest after nocturnal breaks on the mornings, especially on Mondays (3). Pejtersen et al. (4) detected that porous materials, such as ventilation filters and noise reducer units with mineral wool had the highest odour emissions. Air ducts were not studied in the study. The dust accumulation rate onto supply air ducts has evaluated to be from 0.7 g/m^2*year (5) to 2.3 g/m^2*year (1). Design features and filtration affected mostly dust accumulation rate, but, in addition, the viscous residues of lubricant oils were observed to collect dust from air stream.

The first aim of this study was to determine the evaporation rates of two lubricant oils, the first of which was based on mineral oil and, the second on vegetable oil, which are used in the manufacture of ventilation ducts. The second aim was to study whether the lubricant oils have a potential to act as a growth substrate for micro fungi. It was also investigated whether the biocides used in oils are effective to prevent fungal growth on a metal sheet containing a thin layer film of lubricant residue.

MATERIALS AND METHODS

The mineral oil based lubricant (A) contained 70% of mineral oil and 30% of additional components, such as surface active compounds. The vegetable based lubricant (B) contained 70% turnip rape oil and 25% additional compounds. Both the oils contained biocides to prevent the microbial growth in diluted solutions. Together oils represent about one 65% of the lubricants used in manufacture of air ducts in Finland.

Determination of the oil residues

Both oils were diluted in distilled water to a concentration equal to the emulsion used in the manufacture; oil A to 3% and oil B to 5%. One gramme of each dilution was weighted and spread on ten pieces of cleaned galvanized metal sheets (56 mm * 56 mm) used for ventilation ducts. The sheets were weighted immediately after adding the emulsions and later on, twice a week for one month. The sheets were stored open face in an air conditioned room (T 20±0.5°C, RH 50±5%). This gravimetric follow-up of residues was continued occasionally for five months.

Microbial activity on oily metal surface

In order to study microbial activity on oily metal surface, both lubricant oil emulsions were spread on three metal sheets as in evaporation study. Water from the emulsion was allowed to evaporate by keeping the sheets open in clean room. Clean galvanized metal sheets were used as controls. A fungal species commonly found in ventilation ducts, Penicillium brevi-compactum, was chosen to the activity test. A half millilitre of P. brevi-compactum suspension was inoculated on the oily metal surfaces. The inoculated metal sheets were incubated in two litre glass chambers at room temperature, and relative humidity in chambers was regulated by saturated K_2SO_4 solution to 96%. Microbial activity was followed as CO_2 production by an IR-analyzer daily during the first three weeks, and twice during the next two weeks.

Disinfection properties of lubricant oils

Both lubricant oils contained biocides to prevent microbial growth in a diluted emulsion. The biocidic efficiency was determined on malt extract agar (6) with Penicillium brevi-compactum, Cladosporium cladosporioides and Aureobasidium pullulans, which are common fungi in outdoor and indoor environments in a subarctic climate (7, 8). One millilitre of fresh suspension of each fungus was inoculated on to 15 Petri plates. On five of the plates 0.2 ml of sterilized water was added as controls; on the next five plates 0.2 ml of emulsion A, and to the rest five emulsion B was added. The plates were incubated for 4 days at 25°C. The diameters of inhibition zones were measured crosswice which resulted the mean average diameter.

RESULTS

Water evaporated within a few days from lubricant oil emulsion of both products studied. Evaporation of the oils continued then along the curves shown in Fig. 1. The final residue was 60% for emulsion A and 84% for emulsion B after 155 days. Residues of both oils were very viscous on the metal sheet.

Carbon dioxide production of P. brevi-compactum on oily metal surfaces followed the normal shape of growth curve, which indicates that the lubricant oils can act as a growth substrate for fungi. The growth rates were similar on both oily substrates (Fig. 2). Activity of the test fungus did not occur on the control sheets.

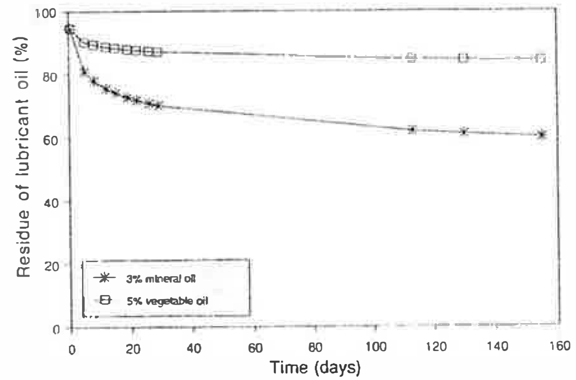

Fig. 1. Evaporation of the lubricant oils; 100% indicates the amount of pure oil in the emulsion.

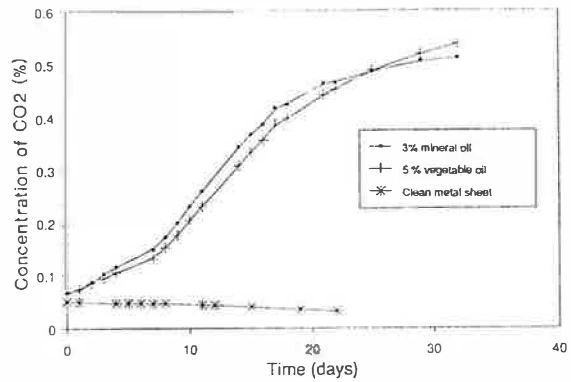

Fig. 2. Carbon dioxide production of Penicillium brevi-compactum on galvanized metal surface containing residues of mineral oil and vegetable oil based lubricants.

The lubricant oils did not inhibit growth of Aureobasidium pullulans and Cladosporium cladosporioides, but they had a slight effect on growth of Penicillium brevi-compactum (Table 1). In the inhibition tests, all three fungal species grew over the control plates without inhibition effects.

Table 1. The effect of lubricant oils A and B on microbial the growth; sterilized water was used as a control. The diameter of inhibition zone is presented in millimetres, and indicates that the liquid added on the plate had no effect on fungal growth during 4 day incubation at 25°C and RH 96% conditions.

Fungal strain	Inhibition zone caused by emulsion tested		
	A mm	B mm	Control mm
Aureobasidium pullulans	-	-	-
Cladosporium cladosporioides	-	-	-
Penicillium brevi-compactum	1-2	1-5	-

DISCUSSION

The use of lubricant oil emulsions in the manufacture of circular air ducts is necessary to decrease friction. Lubricant oil emulsions based both on mineral oil and on vegetable oil turnip rape oil are used for this purpose. The evaporation rate of the mineral oil was found to be higher than the rate of the vegetable oil emulsion. Mineral oil based lubricant left a thinner layer of viscous oil for dust to accumulate. However, 60% of the mineral oil used in manufacture of ducts was still left on the metal surface after five months. As much as 84% of the vegetable oil based product remained after the same period. Therefore, lubricant oil residues may contribute to indoor air impurities originating from the duct system.

In the laboratory tests, both the lubricants proved to be suitable growth substrates for the fungus Penicillium brevi-compactum. The metabolic activity of the fungus was similar on both lubricant oils tested. Thus, nutrients are not a restricting factor for fungal growth even in new air ducts if they contain lubricant oil residues. Antimicrobial tests showed that the biocides used in the oils do not inhibit the growth of common fungi.

As a summary, this study indicated that manufacturers should pay more attention to develop more volatile lubricant oils, or the lubricant should be washable from the duct surface.

CONCLUSIONS

The residues of lubricant oils used in manufacture of circulated air ducts promotes dust accumulation in recently assembled air ducts. The evaporation of the lubricant oil emulsions from the inner surface of the ducts gives an additional load of volatile organic compounds indoors decreasing the indoor air quality. The oil residues may act as a nutrient for fungi if enough moisture is available.

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