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SCRUBBER DRIER HYGIENE

Research into the spread of microorganisms
by scrubber driers into the ambient air

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Research into the spread of microorganisms by scrubber driers into the ambient air

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SUMMARY

The Technical Committee of the Cleaning Research Association (VSR) has raised the question as to whether, during the use of scrubber driers, microorganisms that have been removed from the floor together with dirt can be spread through the air.

A purely theoretical consideration leads to the conclusion that the foregoing can indeed occur; the air stream leaving the machine may be contaminated with the vacuumed contaminated cleaning fluid (aerosol). In theory, this can contaminate the ambient air.

Because no known information is available for this phenomenon for the Dutch situation, the VSR has initiated research to preliminarily establish: whether, and to what extent, this phenomenon takes place in daily cleaning practice; whether the hygiene of the living environment can be affected; and whether health risks are plausible.

The research is divided into two series of experiments.
The first series of experiments investigated the extent to which the return liquid in the wastewater tank of a scrubber drier is contaminated with microorganisms after use in a practical situation.
In five hospitals (spread across the Netherlands), the contamination level of the liquid in the wastewater tank was investigated immediately after testing on two scrubber driers in use. Substantial numbers of microorganisms were found in all wastewater tanks of the scrubbing machines that were investigated. The average germ count measured per hospital varies from 4.4 to 7.1 Log TPC/ml.

The second series of research investigated whether and to what extent microorganisms in the vacuumed cleaning fluid are spread into the ambient air during scrubbing.
A series of scrubber drier tests were carried out using a medium-sized conventional single-disc scrubber drier. The cleaning fluid in the clean water tank of the machine was previously artificially contaminated with a model organism; (*Saccharomyces cerevisiae*). The contamination level was 6.9 Log CFU/ml: the same order of magnitude as the sampled wastewater tanks in the hospitals.

The air leaving the machine was sampled during scrubbing. The yeasts present in different air volumes were collected on growth media. After incubation, the yeast colonies were counted and the concentration of yeast germs in the air was calculated in CFU/m^3. The tests were carried out with and without the use of a HEPA filter in the scrubber drier.

In addition, the concentration of yeast germs in the ambient air was measured before and after the tests.

The measured concentration of yeast germs in the air, leaving the scrubber drier during use, appears to be no higher than in the air in the test room before and after the tests. The concentration of germs in the air, which is blown out of the scrubber drier with a HEPA filter during scrubbing and drying, is lower than the concentration in the air in the test room before and after the tests; the difference is statistically significant.

The result of the study implies that there is no indication that scrubbing and drying with a medium-sized conventional single-disc scrubber drier:

- spreads microorganisms removed from the floor into the ambient air and
- that users/residents of an area in which scrubbing takes place and/or the person operating the scrubber drier are exposed to a hygiene risk as a result.

CONTENT

CHAPTER 1 PREFACE

1.1 Research background

During regular meetings of the Technical Committee of the Association for Cleaning Research (VSR), the question was raised as to whether, during the use of scrubber driers, micro-organisms that have been removed from the floor together with dirt can be spread into the air. A purely theoretical consideration leads to the conclusion that the foregoing can indeed occur.

The reasoning behind this is as follows:
During the scrubbing and drying process, cleaning fluid is dispensed onto the floor surface (Figure 1). After scrubbing, this liquid, together with removed dirt, is vacuumed by a rapidly moving air stream. After the liquid has been separated from the air flow in the scrubber drier, the air is discharged externally. In view of the high air speed in the machine, it is plausible that during this process an aerosol is formed and enters the environment with the air leaving the machine. The aerosol particles consist of the cleaning liquid combined with removed dirt and microorganisms.

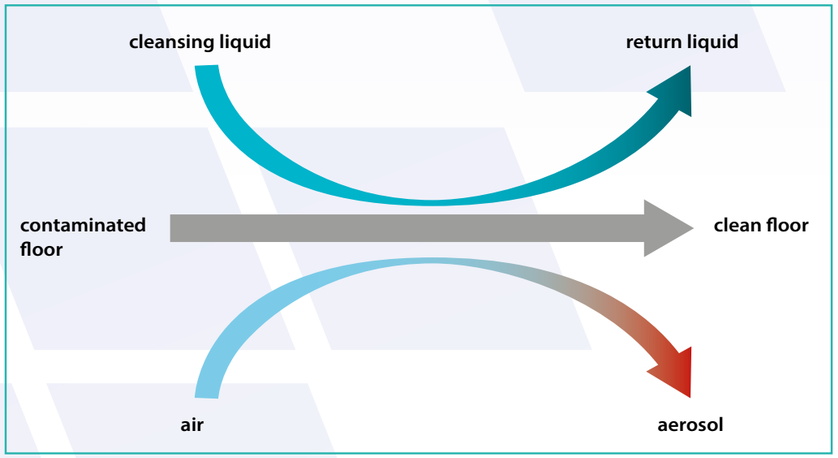

Figure 1: Scrubbing drying process

Because there is a need for more information about this subject and, to the knowledge of the VSR, no research has thus far been conducted into this phenomenon for the Dutch situation, it has been decided to conduct further research.

1.2 Purpose of the study

The aim of the study is to preliminarily determine whether and to what extent hygiene in daily cleaning practices is affected by the use of scrubber driers and whether this can introduce health risks.

Research questions

The research objective has been operationalised by answering the following research questions:

1. Do scrubber driers spread microorganisms removed from the floor into the ambient air during use?
2. And, if so, how does this contamination relate to the amount of germs already present in the air?
3. If germs are spread in the air by scrubber driers, is it to an extent that could cause health risks?

CHAPTER 2 MEASUREMENT METHODS AND MEANS

2.1 Overall setup of the research

The research is divided into two series of experiments.

The first series of experiments investigated the extent to which the return liquid in the wastewater tank of a scrubber drier is contaminated with microorganisms after use in a practical situation.

The second series of experiments investigated whether and to what extent microorganisms in the vacuumed cleaning fluid are spread in the ambient air during scrubbing. During these tests, the wastewater tank was artificially contaminated with germs at a concentration based on the results of the first series of experiments.

Finally, the emissions found were evaluated in an evaluation/interpretation. The results were compared with those from previous VSR research and a global health risk assessment was performed.

2.2 Preparatory measurements; contamination of wastewater tank in practice

The purpose of this section is to determine to what extent the return fluid, the fluid that is vacuumed into the dirty water tank after scrubbing, is contaminated with microorganisms. This is the liquid that can end up in the ambient air as an aerosol during scrubbing. The degree of contamination of this return fluid therefore determines the contamination of the aerosol that can end up in the ambient air.

Setup of the preparatory measurements

Two scrubber driers in use were sampled in 5 hospitals (spread across the Netherlands). The hospitals were approached in advance with a request to be allowed to sample and to inform them that the wastewater tank of the machines for sampling should not be emptied.

A sample of approximately 100 cm^3 per machine was taken from the liquid in the wastewater tank. In total, seven different machine types from four different manufacturers were sampled. The total germ count of these samples was then determined in the laboratory.

Determination of total germ count

An appropriate dilution series is splayed onto PCA mixing plate (Biotrading) and incubated at 30°C for 3 days. The colonies on the plates are counted and the colony count is calculated using the following formula.

$$N = \frac{\sum a}{(n_1 + 0.1n_2)d}$$

Whereby:
N = Colony count in dilution 0
∑a = Sum of the number of colonies counted
n_1 = Number of countable plates most diluted sample
n_1 = Number of countable plates least diluted sample
d = Dilution factor n_1

Contamination level of wastewater tank

The results of the germ determination are shown in Table 1. At all five hospitals visited, germs were found in the wastewater tank in all sampled machines. The degree of contamination varies from 3.9 to 7.6 Log TPC/ml.
There are no indications, based on the observed variance between measurements, of a systematic difference between the contamination of the wastewater tanks at the hospitals. The average number of germs found in the wastewater tanks at hospitals is 5.9 Log TPC/ml. The highest value measured is 7.1 Log TPC/ml.

Table 1: Contamination of the liquid in the wastewater tank

Hospital location	Manufacturer scrubber drier	Machine	Log TPC/ml	Average/location
Amsterdam	A -*	A_1 -	5.8 -	5.8
Dordrecht	B B	B_1 B_1	5.8 5.8	5.8
Rotterdam	C C	C_1 C_1	3.9 4.9	4.4
Almelo	D D	D_1 D_2	6.6 7.6	7.1
Geldrop	A A	A_2 A_3	5.9 7.2	6.5

* Only one machine had the wastewater tank unemptied.

2.3 Emission of germs from a scrubber drier

Set-up of the emission measurements

In a test room, the clean water tank of a scrubber drier was filled with water that had been artificially contaminated with a known micro-organism: the model organism. The contamination level of the liquid was of the same order as the contamination found in the wastewater tanks at the hospitals; not less than 5.9 log CFU/ml but not more than 7.1 Log CFU/ml.

After filling the clean water tank, the machine was used for scrubbing. During scrubbing, the air emitted from the scrubber drier was sampled using an air sampler. The microorganisms present in the sampled quantity of air were collected by the air sampler on a strip with a nutrient medium. Because the germ concentration in the exiting air was unknown in advance, germs were sampled from different air volumes. After sampling, the number of germs on the strips was determined. This data can be used to calculate the germ concentration of the model organism in the emitted air.
The original research plan was provided for the tests to be carried out with different types of scrubber driers. However, with many scrubber driers, the suction air is blown out in all directions at the bottom of the machine. The air flow on these machines is technically difficult or impossible to sample without affecting the scrubber-suction process or without mixing with the ambient air. It was therefore decided to perform the tests with a machine fitted with an HEPA filter (high-efficiency particulate air filter) that allows sampling directly behind the filter housing without substantially influencing the air flow. The tests with this scrubber drier machine were carried out with and without the use of a HEPA filter. This ensures that the effect of a HEPA filter was also included in the research.

The initial contamination of the air in the test room was determined prior to the tests with the scrubber driers: baseline measurement. And, after the tests with the scrubber drier were completed, the final contamination of the air in the test room was measured.

Testmachine

A medium-sized conventional single-disc scrubber drier was used for the tests.
The relevant technical data is listed in Table 2.

Table 2 Technical specifications test machine

Type	
Brush diameter	50 cm
Brush speed (rpm)	200 rpm
Brush pressure	0.63 N/cm²
Suction power	460 W (elektrisch)
Vacuum	155 mbar
Air flow	41 l/min
Suction mouth width	89 cm
Liquid flow	1.9 l/min (setting during the tests)
Filter system	HEPA (demonteerbaar)

Efficiency of the created airflow >
the airflow of 41 l/min causes a vacuum of 155 mbar (mbar = 100 N/m²)
155*100 N/m² at 41*10⁻³ m³ /60 s >> 155*100*41*10⁻³ / 60 N/m² * m³/s > 10.6Nm/s <> 10.6 Watt
Suction power (electric) motor: 460 W Power Airflow: 10.6 W > Efficiency: 2.3 %

Model organism and contamination clean water tank

The liquid in the clean water tank was artificially contaminated with the yeast *Saccharomyces cerevisiae* in the research. This yeast is a suitable model organism; it is better suited than a bacterium (e.g. *Micrococcus luteus*) from the perspective of safety, acceptance by researchers, easy to detect and easier to distinguish from the usual germs.
During the exploratory tests it was found that the number of germs in the dirty water tanks at the hospitals is on average 5.9 Log TPC/ml; with a highest value of 7.1 Log TCP/ml. The target value for the contamination of the liquid in the clean water tank during the investigation will therefore amount to a minimum of 5.9 Log CFU/ml, with a maximum of 7.1 Log CFU/ml. The (undiluted) yeast suspension contained $8.5x10^9$ colony-forming units (CFU) of yeasts per ml. A 0.12% solution of this suspension was used for the contaminated solution for the clean water tank.

A sample was taken from the clean water tank during the scrubber drier tests. The germ count for this has been determined. The measured concentration of yeasts in the clean water tank was 6.9 Log CFU/ml during the tests.

Air sampler

The tests used a Biotest Hycon RCS isolator to determine the number of germs (CFU) Saccharomyces cerevisiae in the ambient air. The inlet of the air sampler was positioned in the air stream 10 cm behind the filter housing.
The technical data of the air sampler is listed in Table 3. In the sampler, germs in the air were deposited on the surface of the test strip by means of centrifugal force (inertia).

Table 3 Technical data air sampler

Type	Biotest HYCON® RCS isolator
Producer	Biotest
Air flow	100 l/m
Impact speed	0.07 – 7 m/sec
Physical efficiency	Not specified

Sampling and determination of germ concentration in the air

To perform a measurement, the Biotest sampler was fitted with a test strip that had sterile Rose Bengal Agar (RBA) on it. RBA is a nutrient medium suitable for the determination of fungi and yeasts. The composition of the medium on the test strips is shown in Table 4.
After the measurement started, a predetermined number of litres (10, 20, 50, 100, 200 or 500 litres) of air was sucked in at a position directly next to the filter housing of the scrubber drier. The suction took place during scrubbing and drying. All measurements were performed in duplicate except for the final measurement of the ambient air. This was measured once.
After sampling, the strips were incubated for 3-5 days in an incubator at a temperature of 25ºC and the yeast colonies (large, white glossy) on the strips were counted. These counts were converted to CFU yeast per m^3 of air. Mould colonies were also present on the test strips (fluffy). These were not counted.

Table 4 Composition of test strips: HYCON® Agar Strips YM

Ingredients	g/l
Soytone	6
D(+) Dextrose	15
Malt extract	5
Magnesium Sulphate	0.5
Yeast extract	1
Agar	15
Selective Mix (Rose Bengal, Streptomicin, Chloramphenicol)	
Supplements and buffers	

Test room and environmental conditions

The measurements were carried out in a conference room with a linoleum floor in a commercial building. The dimensions of the room were: length 10 m, width 10 m and height 2.5 m. The floor space used in the room was 24 m^2 and the room volume was 250 m^3. Temperature and relative humidity were measured during the tests.

CHAPTER 3 RESULTS

3.1 Environmental conditions

The measured ambient temperature and relative humidity during the tests were 22°C ± 1.5°C and 55% ± 3% RH.

3.2 Measured germ concentrations

The concentrations of yeast germs measured in the study are listed in Table 4. Prior to the tests with the scrubber drier and after these tests were completed, the germ concentration in the ambient air in the test room was also measured. These results are also listed in Table 4.

Concentration Yeast Germs Log CFU/m^3	Measurement set 1	Measurement set 2	Average
Ambient air before the start of the scrubber drier tests	2.2	1.9	2.0
Scrubbing drying process without HEPA filter	1.9	1.7	1.8
Scrubbing drying process with HEPA filter	1.1	1.2	1.2
Ambient air after completion of the scrubber drier tests	2.1	-	2.1

Table 4: Germ Concentration in the Ambient Air and in the Emission Scrubber Dryer; Log CFU/m^3

The difference between the highest average concentration of yeast germs found and the lowest germ count found is 0.9 Log CFU/m^3. From a microbiological perspective this is a minor difference.
The difference between the mean concentration of yeast germs with and without the use of HEPA filter is small but statically significant, as is the difference between the mean concentration of yeast germs in the emitted air using a HEPA filter and the ambient air. The difference between the mean concentration of yeast germs in the outflowing air without the HEPA filter and the ambient air is not statistically significant.
There is no indication of a difference between the concentration of yeast germs in the air before and after the scrubber drier tests.

CHAPTER 4
DISCUSSION AND CONCLUSIONS

4.1 Germs in the ambient air

The concentrations of yeast germs in the ambient air measured in this study are not unexpected or exceptional. In VSR study 0100101 "*Hygiene of Hand Driers: Spread of Microorganisms in the Ambient Air by Drying Hands with Two Types of Hand Driers*[1]" the concentrations of yeast germs were comparable with the method used in this study. The concentrations of yeast germs during the tests with a conventional hand drier in a normal sanitary room were on average 2.1 Log CFU/m^3; which is consistent with what was found in this study.

Another reference can be found In VSR study 0130106; "*Hygiene of Feather Dusters; Exploratory Research into the Contamination Level of Used Feather Dusters and the Spread of Microorganisms through the Ambient Air and on Cleaned Surfaces when Cleaning with Feather Dusters*[2]". Using the methodology followed in this study the contamination (total germ count) of the ambient air in a busy area was measured in three hospitals. The measured values are 2.5, 2.8 and 2.8 Log TPC/m^3. These values are slightly higher, but they do relate to the total of bacteria, fungi and yeasts.

4.2 Germs in the outlet air from the scrubber drier

The measured concentrations of yeast germs in the air leaving the machine during scrubbing and drying are, contrary to expectation based on theoretical considerations, no higher than those in the ambient air. In other words, no indication has been found that a scrubber drier spreads germs from the floor surface into the air during scrubbing.
Rather, the opposite seems to be the case; the air emitted by a scrubber drier equipped with a HEPA filter is "cleaner" than the air sucked in. However, this difference is so small that it cannot be said that the machine (with an air displacement of 41 litres per minute) contributes to hygienically cleaner ambient air.

4.3 Test machine

The results in this study were obtained with a medium-sized conventional single-disc scrubber drier. It is to be expected that results with comparable machines, which work using the same operating principle, will be comparable. In other words, it is also to be expected that such machines will not spread removed germs into the ambient air.
This study does not make any assertions about machines in which the cleaning fluid is separated in a substantially different way than in the test machine.

4.4 Implications for institutional cleaning

During scrubbing and drying, the operating personnel remains in the immediate vicinity of the machine. Although the airflow is usually vented from the bottom of the machine, the operating personnel can still be exposed to this air flow. The results of this study make it clear that no hygiene risks are to be expected.

4.5 Conclusions

The results of the two series of experiments form a basis for answering the research questions.

Research questions:

1. Do scrubber driers spread microorganisms removed from the floor into the ambient air during use?
2. And, if so, how does this contamination relate to the amount of germs already present in the air?
3. If germs are spread in the air by scrubber driers, is it to an extent that could cause health risks?

The results of this study do not confirm the hypothesis that a scrubber drier spreads microorganisms removed from the floor through the ambient air during use.

Answer to research question 2:

The germ count of the emitted air is, on the test machine in this study, the same or, if a HEPA filter is used, lower than that of the air sucked in. The germ concentration in the ambient air is therefore not affected.

Answer to research question 3:

In view of the answers to research questions 1 and 2, it can be stated that the use of a scrubber drier as described in this study has no influence on air hygiene. This implies that health effects as a result of deteriorated air hygiene are not to be expected for people spending time in the environment or for employees who work with a scrubber drier.

CHAPTER 5 SUMMARY

The Technical Committee of the Cleaning Research Association (VSR) has raised the question as to whether, during the use of scrubber driers, microorganisms that have been removed from the floor together with the dirt can be spread through the air.

A purely theoretical consideration leads to the conclusion that the foregoing can indeed occur; the air stream leaving the machine may be contaminated with the vacuumed contaminated cleaning fluid (aerosol). In theory, this can contaminate the ambient air.

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A series of scrubber drier tests were carried out using a medium-sized conventional single-disc scrubber drier. The cleaning fluid in the clean water tank of the machine was previously artificially contaminated with a model organism; (Saccharomyces cerevisiae). The contamination level was 6.9 Log CFU/ml: the same order of magnitude as the sampled wastewater tanks in the hospitals.

The emitted air was sampled during scrubbing. The yeasts present in different air volumes were collected on growth media. After incubation, the yeast colonies were counted and the concentration of yeast germs in the air was calculated in CFU/m^3. The tests were carried out with and without the use of a HEPA filter in the scrubber drier.

In addition, the concentration of yeast germs in the ambient air was measured before and after the tests.

The measured concentration of yeast germs in the air, which exit the scrubber drier during use, appears to be no higher than the concentration in the air in the test room before and after the tests. The concentration of germs in the air, which is blown out of the scrubber drier with a HEPA filter during scrubbing, is lower than in the air in the test room before and after the tests; the difference is statistically significant.

The result of the study implies that there is no indication that scrubbing with a medium-sized conventional single-disc scrubber drier:

- spreads microorganisms removed from the floor into the ambient air and
- that users/residents of an area where scrubbing takes place and/or the employee operating the scrubber drier are exposed to a hygiene risk as a result.

CHAPTER 6
REFERENCES

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