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The conditions and perception of work during painting behind screening

by Spee T, Boeckhout CI, van Ginkel T, Terwoert J

Affiliation: Arbouw Foundation, PO Box 8114, NL-1005 AC Amsterdam, The Netherlands. spee@arbouw.nl

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The conditions and perception of work during painting behind screening

by Ton Spee, PhD,[1] Con I Boeckhout,[2] Ton van Ginkel, MSc,[3] Jeroen Terwoert[4]

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Objective This study attempted to reveal whether airborne solvent concentrations during painting behind screening are comparable to solvent concentrations during painting indoors, what factors potentially influence work conditions during painting behind screens, both positively and negatively, and what can be done to eliminate the disadvantages of screening.

Methods Measurements of volatile organic compounds (VOC), climate, light, and noise were made at three sites during 1 day each. VOC were measured at another 10 sites, again during 1 day each. Questionnaires were sent to painters working in 305 firms.

Results The results of the first series of measurements (exposure to VOC) ranged from 3.4 to 22.9 mg/m^3 with a geometric mean of 11.7 and a geometric standard deviation of 2.1. This range was less than the level expected in well-ventilated rooms. In the second series of measurements, with a few exceptions, the concentrations of the individual compounds were below 1 mg/m^3. In both series, the exposure index was generally ≤0.05. The advantages of working behind screening were more certainty of work during the winter months, better temperature conditions, better quality of work, less draft, and less temperature fluctuation.

Conclusions Painting behind screening, as studied in this project, results in low exposure to VOC when compared with indoor situations. The main factors that need to be improved are temperature, lighting, view from the workplace, and ventilation.

Key terms climate; light; noise; seasonal influence; solvent exposure; ventilation; work conditions.

The amount of work in the outdoor painting trade fluctuates greatly depending on the season. During the summer, there is plenty of work, but it dries up during the winter months. As a result, painters suffer from seasonal unemployment during the winter. In The Netherlands the painting trade puts a lot of effort into preventing seasonal unemployment. Outdoor painting behind screening during the winter is supported (eg, by grants) to compensate for the time taken to set up and dismantle the screening. Major changes in Dutch social security legislation will make it more difficult to lay off workers during the winter months and thus make it imperative to create a more continuous flow of work. Terwoert and Van Niftrik (1) have estimated that the amount of work behind screening will grow to a maximum of 26% of the total amount of outdoor painting. Figure 1 shows an example of work behind screening.

There is no doubt that work behind screening is beneficial in preventing seasonal unemployment, but it also has some disadvantages in that screening diminishes natural light and can cause a feeling of confinement and draft. Neither a search of literature databases on psychosociology nor requests for information among colleagues abroad have yielded any information on the subject, however.

Figure 1. Working behind screening.

1 Arbouw Foundation, Amsterdam, The Netherlands.
2 Tauw bv, Deventer, The Netherlands.
3 P2 Research and Consultancy, Utrecht, The Netherlands.
4 IVAM Research and Consultancy on Sustainability, Amsterdam, The Netherlands.

Correspondence to: Dr T Spee, Arbouw Foundation, PO Box 8114, NL-1005 AC Amsterdam, The Netherlands. [E-mail: spee@arbouw.nl]

Since about 1980, the health effects of exposure to relatively low concentrations of organic solvents, chronic toxic encephalopathy has been of concern (2). Much research has subsequently been done on exposure to volatile organic compounds (VOC) during outdoor and indoor painting (3). Outdoor painting does not generally result in high exposure to VOC. Occupational exposure limits are occasionally exceeded during indoor painting. In The Netherlands, apart from a few exceptions, the professional indoor use of solvent-based paints and adhesives has been banned since 1 January 2000.

Concern also exists about whether painting behind screening should be considered an indoor situation. If so, it would be necessary to reconsider the use of solvent-based paints behind screening. In 1984 Riala et al (4) reported exposure of 132 ppm (corresponding to 739 mg/m^3, an average of 77 samples) to the solvent naphtha during indoor painting using paints with a 30–50% concentration of the solvent naphtha. In well-ventilated rooms, the average exposure was 38 ppm (218 mg/m^3, 31 samples), as against 197 ppm with poor ventilation (1132 mg/m^3, 46 samples). In 1997, Wieslander et al (5) estimated exposure to the solvent naphtha in indoor situations at 600 mg/m^3. Burstyn & Kromhout (6) have recently reported a strong trend towards lower solvent exposures among Dutch painters. Taking toluene as a marker, they reported a 12% annual decrease in exposure, corresponding to a halving of exposure every 5.5 years, over 1980–2000.

On the basis of these considerations, we formulated the following three questions: (i) are airborne solvent concentrations during painting behind screening comparable with solvent concentrations during painting indoors, (ii) what factors potentially affect work conditions during painting behind screens, both positively and negatively, and (iii) what can be done to eliminate the disadvantages and what would be the best design of screening?

Materials and methods

Information was collected in the following two ways: (i) by measuring the chemical and physical factors that may be an influence and (ii) by investigating the effect of screening on painters' perception of work conditions.

Perception of work conditions

A questionnaire was developed containing the following items: (i) characteristics of the respondents, the firm and the materials in use (eg, worker age, number of years on the job, size of firm); (ii) specific questions about working behind screening; and (iii) three open questions. The questionnaire was validated by discussing it with several painters. Part 3 of the questionnaire was concerned with whether working behind screening was felt to be better or worse than working without screening, taking into account items such as posture, dust, and climate.

A multistage sample was taken. Each firm that had applied for a grant for painting behind screening received five questionnaires and was asked to hand them out to their employees. The questionnaires were thus sent to painters working in 305 firms, 8.5% of the total of 3570 painting firms operating in The Netherlands (7). A total 64.6% of all painting firms had five employees or fewer. In addition, as most employees did not come to the office every day, an employer could easily forget to hand out the questionnaire. By comparing the respondents' characteristics (age, size of firm, and region) with those of the entire painter population, we were able to assess whether the respondents were a representative sample. Statistical analyses were carried out using SPSS 10.0 (SPSS Inc, Chicago. IL, USA). The differences between the group means were tested using t-tests ($P<0.05$).

Chemical and physical factors

The measurements of chemical and physical factors (VOC, climate, light, and noise) were made at three sites during 1 day each (on 5, 6 and 7 March 1998). A second series of measurements of VOC was carried out from 24 January 2003 until 10 March 2003.

Volatile organic compounds

First series (1998). Personal air sampling (PAS) was carried out on two painters at each site using personal air samplers by Dupont USA (type P4LC). Each painter was given two runs of about 2 to 4 hours. (At one site there was only one run of about 5 hours.) The sampling method was active sampling using active charcoal in accordance with NVN 2947 (8). This series consisted of 10 samples taken from six painters at three sites. Two samples taken from one person on the same day were treated as one full-shift sample by calculating the time-weighted average of the two samples. Thus four full-shift samples and one 5-hour sample were obtained. The samples were analyzed using gas chromatography-mass spectrometry (GC-MS).

Second series (2003). Personal samples were taken by means of passive sampling using 3M 3500 organic vapor monitors. The sampling time ranged from 225 to 520 minutes. These samples were also analyzed using GC-MS. This series consisted of 33 samples from 33 painters at 10 sites. Exposure indices were calculated from the measured exposure levels and the maximum accepted concentrations (MAC) in The Netherlands. The measured exposure levels were compared with those found in indoor situations in other studies.

Climate

The climate conditions were sampled at least four times during the workday. Temperature, relative humidity, and air velocity were determined using a Testo 451 with 0636.9760 and 0635.1049 sensors (Testo GmbH & Co, Germany). The radiation temperature was measured using a black sphere thermometer. The results were evaluated in accordance with NVN-ISO/TR 11079 (9).

Light

The light intensity was measured with a lux meter (Pantac Carlo Gavazzi digital lux meter, type LM-20) at least four times during the workday. The results were evaluated in accordance with NEN 3087 (10).

Noise

Exposure to noise was determined using a real time analyzer (Bruel & Kjaer, type 2260) with a B&K type 4189 microphone at least four times during the workday in accordance with NEN 3418 (11), a Dutch standard that states how to calculate exposure levels from short-time task-based measurements. The measurements lasted 10 minutes. The noise levels were compared with the level considered to be harmless. The results were also evaluated in accordance with NEN 3438 (12), taking into consideration the effects on both concentration and communication.

Results

Response to the questionnaire

Altogether 362 questionnaires were returned. The characteristics of the respondents were compared with the characteristics of the entire painter population, as found by the Economic Institute for the Construction Industry (5). This comparison produced the following results: (i) the proportion of people under 25 years of age was just below that of the entire painter population and that of people aged 45 years and over was slightly higher, (ii) the proportion of people working in firms with 1–10 employees was just below that in the entire population, and (iii) there were relatively more respondents from the north and fewer from the south. Although it was not possible to calculate the response rate, the respondents' characteristics were considered representative of the entire painter population.

Perception of work conditions

Painters' perception of the advantages of painting behind screening is shown in figure 2, in order of diminishing frequency. The painters mentioned the following advantages of painting behind screening (in order of frequency): (i) more certainty of work during the winter months, (ii) better temperature conditions, (iii) better work quality, (iv) less draft, and (v) less fluctuation in temperature. The painters mentioned the following disadvantages of painting behind screening (in order of frequency): (i) impaired view from the workplace, (ii) negative reactions by the occupants of the building, (iii) less ventilation, (iv) more stench, smoke, fog, and vapor, and (v) more draft.

When asked about the effectiveness of the screening, 75% of the respondents stated that the screening was effective against rain and other precipitation, 47% considered it effective against wind, and 31% said it protected against cold.

Types of screening

The painters' opinions of the types of screening were canvased in open questions. The answers are summarized in table 1. The respondents stated that the different materials had different advantages and disadvantages. Tarpaulin gave the best protection against wind, rain, and cold. Netting was preferred for ventilation.

Chemical and physical measurements

Conditions during the measurements. Painting was done using alkyd-based paints containing 300–350 g/l of solvent. The paint was applied with brushes.

In the first series at site I, the screening consisted of tarpaulin. At site II it was plastic sheeting, and at site III it was netting. There was no additional lighting, heating, or mechanical ventilation behind the screening. The ambient temperatures were high in relation to the season, the temperatures ranging from 6°C to 13°C.

In the second series, the screening consisted of polythene sheeting, 90% netting, or a combination of the two (appendix 1). There was no additional lighting behind the screens (except at site 5), and no heating (except at site 4, where a hot air blower was used). The ambient temperature ranged from –3°C to +10°C, normal daytime temperatures for the Dutch winter months.

Volatile organic compounds. In the first series of measurements, exposure to VOC ranged from 3.4 to 22.9 mg/m^3, with a geometric mean of 11.7 and a geometric standard deviation of 2.1. The exposure index ranged from 0.01 to 0.05.

The exposure measurements in the second series yielded low results. With a few exceptions the concentrations of individual compounds were below 1 mg/m^3. Below this value, the laboratory does not report concentrations, only the identity of the compound. As a result, 31 out of the 33 exposure indices could only be expressed

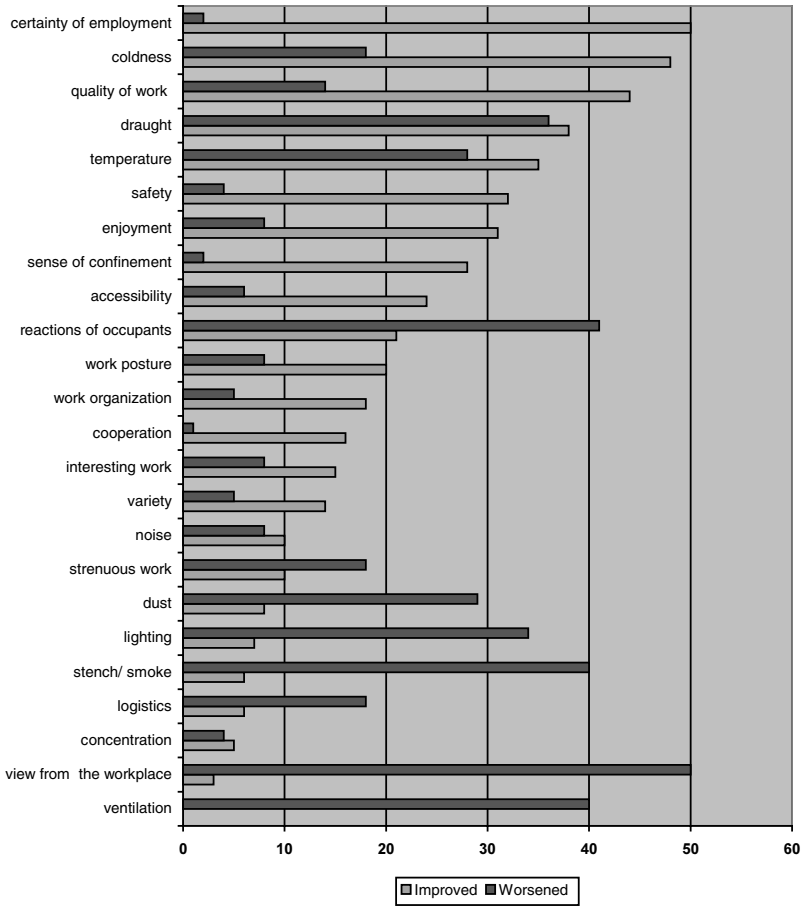

Figure 2. Perception of advantages of working behind screening, in order of diminishing frequency.

Table 1. The main advantages and disadvantages of the various types of screening.

Type of screening	Preferred (%)	Not preferred (%)	Main advantage	Main disadvantages
Tarpaulin	52	26	Protection against wind	Poor ventilation, poor lighting, flapping
Wooden board	21	22	Protection against wind	Difficult to handle
Netting	19	42	Ventilation	Draft, loss of heat
Plastic sheeting	11	12	Easy to handle	Poor ventilation, flapping

as being below the detection limit, which is determined by the sampling time and the compounds present. All the exposure indices in series II were ≤0.05, with two exceptions, one measurement at site 3 (exposure index 0.11) and possibly one measurement at site 9 (exposure index <0.08). At site 3 the result was attributed to the presence of trimethylbenzene. At site 9 the exposure index was reported as a maximum value, owing to the low concentrations of many compounds. The results of the measurements of exposure to VOC and details of the types of buildings, types of screening, and exposure are summarized in the appendix.

Climate, lighting and noise. The results of the measurements of the climate parameters (lighting level and noise) are summarized in table 2.

Even under the relatively mild conditions prevailing during the measurements, the climate was "chilly" to "very chilly" in several cases. In 6 out of 18 measurements (33%) the lighting level was below 200 lux, the lower limit for this work being under the NEN 3087 limit (10). All of the noise levels were well below 80 dB(A); therefore no harmful noise levels were found. They occasionally exceeded 70 dB(A), the level considered a nuisance affecting concentration and communication according to NVN 3438 (12).

Comparison of the perception and measurements

Table 3 summarizes the results of the perception of the work conditions and the measurements. It only includes items that were investigated in more than one way.

Discussion

The multistage design of the questionnaire study had a major drawback. As most of the painting firms employed

Table 2. Results of the measurements of the climate parameters, lighting, and noise. (T = air temperature, T_g = globe temperature, RH = relative humidity, v = air velocity, WCI = wind chill index, T_{ch} = wind chill equivalent temperature, E = strength of lighting, LAeq= A-weighted equivalent sound level)

Series	Site	T (°C)	T_g (°C)	RH (%)	v (m/s)	WCI (W/m²)	T_{ch} (°C)	Evaluation WCI	E (lx) (range)	LAeq [dB(A)] (range)
I	1	9.7–12.0	10.4–11.1	88–90	0.3–0.6	381–443	13–16	Chilly	75–410	57–68
I	2	12.3–16.0	11.6–15.8	52–88	0.8–1.9	394–481	13–16	Chilly	20–480	62–75
I	3	5.6–9.0	4.7–9.7	82–95	0.3–1.0	437–598	6–14	Chilly/very chilly	100–1350	61–68

fewer than five employees, the response to the questionnaire would always be below 100%. Altogether 24% of the questionnaires were returned, but, as we do not know how many questionnaires actually reached a painting employee, we could not state a response rate of 24%, and the actual response is unknown. The respondents' characteristics match those of the general painter population, however, and, therefore, the response can be considered representative of that general population.

Two alternative sampling designs were considered. One was to send questionnaires to all of the painters at random. The addresses of all Dutch painters can, in certain circumstances, be supplied by the Social Security Fund, but which of them usually work behind screening is not known. Only 8.5% of the 3750 painting firms operating in The Netherlands have applied for grants for work behind screening, however. The proportion of painters working behind screening was likely to be under 50%, probably far below that figure. Another possibility was to contact the 305 firms that had applied for grants and ask them for the addresses of their employees. As the response to queries of this kind is usually around 60% in our experience, we would have lost almost half of our respondents before having even sent out the questionnaires. The multistage design was therefore considered the best, although the results must be interpreted with care.

The measurements of the physical parameters did not produce any surprises, and, therefore, it was decided not to repeat them.

The main reason for undertaking this project was to ascertain whether exposure to solvents during painting behind screening was comparable to indoor situations. If so, it would make sense to apply the ban on solvent-containing paints to painting behind screening as well.

Exposure to VOC was found to be low in the first series of measurements and was in fact much lower than expected. [We had expected it to be comparable to a well-ventilated indoor situation.] According to the results of Riala et al (4) and the calculation by Burstyn & Kromhout (6), we would expect an average exposure of 40–50 mg/m^3 to VOC in manual house painting in well-ventilated rooms. On the basis of the solvent content of paints, which declined from 30–50% in 1984 (4) via 28% in 1994 (13) to 15% in 1999 (13), we would expect a decline in exposure from 218 mg/m^3 to about 80 mg/m^3. In fact, the average exposure was 12 mg/m^3 (geometric mean). This expectation raised the question of whether these few measurements could be considered representative of average exposures, and, therefore, it was decided to set up a larger measurement program, with 33 samples at 10 sites. As in the first series, the average exposure was low. Evidently, exposure to VOC during painting behind screening is lower than during painting indoors in well-ventilated rooms.

Table 3. Comparison of the perception of the workers and the measurements of the work situation. (VOC = volatile organic compounds)

Parameter	Perception of effect of screening		Results of measurements
	Better (%)	Worse (%)	
Temperature	45	5	"Chilly" to "very chilly"
Lighting	10	35	About 33% below limit
Noise	10	10	No problem
VOC, stench, smoke, vapor	5	40	No problem

When we combined the results of the measurements with those of the questionnaires, we found that the workers perceived the situation regarding VOC, stench, smoke, fog, and vapor to be worse, whereas the measurements did not show this to be a problem. There is no explanation for this result, although the unpleasant smell of VOC may play a part. Lighting requires attention, on the basis of both the perception of work conditions and the measurements.

Concluding remarks

Painting behind screening, as practiced in this study, resulted in low exposure to VOC in comparison with indoor situations. Screening affected the work conditions both positively and negatively, the certainty of work during the winter months being the predominant positive factor and a feeling of confinement, on the part of both the painters and the occupants of the building, being the predominant negative factor. The work was felt to be less interesting, and the view was impaired (as one would expect). Some attention paid to this aspect during the design of screening conditions could improve this problem. Attention needs to be paid to the physical

work conditions in that, in many cases, additional heating or lighting is required. The most important factors to improve are the temperature, lighting, view from the workplace, and ventilation.

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