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**Efficacy of gloves used in printing:
A volunteer study**

HSL/2006/02

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ACKNOWLEDGEMENTS

The authors would like to thank:

Joanna Ryan, Paul Jones and David Noble of Field Boxmore Ltd, Leicester, who helped with this study, provided information and materials, and allowed their work to be videoed.

The volunteers who participated in the exposure study.

HSL Visual Presentation Section for making the workplace video.

Kama Cachaele Latex GmbH, who performed glove permeation tests.

Glen McConnachie of Organic Measurement Section for developing a method for analysing Permeatec pads, and for analysing same.

Neil Plant of Organic Measurement Section for analysing passive Tenax vapour monitors.

Paul Cocker for assisting with the experiments.

This study was conducted under the supervision of the HSE Research Ethics Committee.

Use of trade names and products in this report does not imply endorsement or approval by HSL or HSE.

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EXECUTIVE SUMMARY

Background

There is a high incidence of skin problems among printers and dermatitis and skin problems are a priority area for HSE. Printers are exposed to a wide range of substances with potential for exposure by both inhalation and skin contact. This range of substances coupled to the need for flexibility and touch-sensitivity poses difficulties in the selection of appropriate gloves. In addition, there is a concern that gloves will behave differently and perform less well in use than in standard laboratory permeation tests. Research Project R51.253 'Chemicals in the Printing Industry' included factory visits to observe work practices. One of the solvents used by the printers was 1-methoxy-2-propanol and this was found in printers' urine at one workplace. This raised the questions of whether it had been absorbed via the dermal or inhalation routes. It was impractical to investigate this by eliminating the inhalation route at the print works itself, so a volunteer study in the laboratory was proposed (this study) where conditions could be tightly controlled.

Objectives

To investigate the efficacy of gloves used by printers during an ink-mixing task and subsequent clean-up.

Method

Video recordings of printers cleaning ink mixing bowls were used to train volunteers (n = 7). They were also trained in the technique of glove removal (to prevent cross-contamination) and wore Permeatec absorbent pads on fingers and palm under the gloves to monitor solvent levels inside the gloves. Volunteers wore one of the two types of gloves used by printers and air-fed high efficiency respiratory protection to prevent inhalation of vapours. Cleaning tasks lasted for 30 minutes and volunteers collected urine samples before the simulation and for 24 hours afterwards. Samples were analysed for volume, the concentration of 1-methoxy-2-propanol and creatinine to assess the effectiveness of the gloves and to compare with the levels found in real workplaces. To monitor the spread of solvent and to check for any leakage into the glove through holes or around the cuffs, the solvent contained a fluorescent marker. Photographs of the hands were taken under ultraviolet UVA light before and after the simulated cleaning.

Main findings

Exposed skin was contaminated with droplet splashes of solvent (and not ink) on the forearms, and smeared with a mixture of solvent and ink at the cuff of the glove. This suggests that the glove was too short for this particular task of cleaning inside a narrow bowl, which prevented free movement. Clothing was contaminated with widespread ink smears and solvent droplets.

There was a strong link between air levels of 1-methoxy-2-propanol around the volunteers and levels found in the Permeatec under-glove monitors, suggesting that the under-glove exposures were caused by air movements rather than by glove permeation. This was confirmed by sealing the cuffs of one of the pairs of gloves, which reduced the under-glove measurements to 1% of their previous value.

Eighty seven urine samples from 14 volunteer exposures were collected and analysed for 1-methoxy-2-propanol. Three samples had detectable levels of 1-methoxy-2-propanol but these were too low to quantify. The remaining 84 samples had no detectable 1-methoxy-2-propanol.

Conclusions

The gloves protected the hands adequately but were too short to protect the forearms. Dermal exposure to solvent was low during the simulated cleaning task with the gloves, being limited to splashes on the outer clothing or exposed skin of the arms, and airborne dermal exposure to solvent vapours.

Inhalation exposure was eliminated for the volunteers, but could be present in the workplace.

Direct contact of the gloves with the chemicals was common, with the glove being used as the only protection. Reducing the frequency of contact would reduce the risk of inadvertent contact.

The Permeatec pads were shown to be useful samplers for volatile compounds, but when they are used as potential dermal exposure samplers, they cannot distinguish liquid splashes from vapours absorbed directly from the air. Results from previous occupational exposure studies that have used cotton-carbon cloth as potential dermal pad samplers for volatiles will need to be interpreted carefully. The cotton-carbon cloth is only a useful medium for monitoring actual dermal exposure if it is occluded (to prevent vapour absorption from the air).

Recommendations

- Conduct further occupational studies to investigate the real-world use of gloves in printing and possible causes of dermatitis. An example would be to recover discarded gloves or commandeer half-used gloves, to find the levels of known irritant chemicals inside.
- Publish an article warning occupational hygienists that cotton-carbon cloth absorbs vapours from the air that could be mistaken for dermal exposure by splash or glove permeation. Glove permeation can only be confirmed if the insides of the gloves are isolated from the external air.
- Suggest to the print works that the solvent be substituted if possible for a less volatile one.
- Develop tools to reduce direct hand contact with inks or solvents in the printing industry.

1 INTRODUCTION

There is a high incidence of skin problems among printers and dermatitis and skin problems are a priority area for HSE. Printers are exposed to a wide range of substances with potential for exposure by both inhalation and skin contact. This range of substances coupled to the need for flexibility and sensitivity poses difficulties in the selection of appropriate gloves.

Advice and guidance on glove selection is often based on laboratory tests of the permeation of single substances. The penetration of mixtures of substances is less well understood and there is suspicion that some components in mixtures will enhance the penetration of others. In addition, there is a concern that gloves will behave differently in use and perform less well than in laboratory tests. Reasons proposed for this are that flexing, stretching and elevated skin temperatures act to reduce breakthrough times below that of the test conditions (unstretched, unflexed, 23°C). The effect of flexing and temperature has been found to reduce breakthrough times to as little as one third (Oppl, 2001).

HSE is looking at the solvents, gloves and exposure controls used by printers in an attempt to help reduce exposure and risk of ill-health. Field studies are being conducted to determine what solvents and gloves are commonly used and whether there are more appropriate gloves. Other investigations involve laboratory studies of the standard permeation rates of solvent mixtures through gloves. To complete the picture HSE also needed to look at the effectiveness of gloves when worn and used.

This volunteer study sought to simulate the 'real-world' and took as its model the activities, gloves and cleaning solution used in the ink mixing room at one of the co-operating print works of a good general standard of cleanliness, that had been visited by HSE and HSL as part of the field studies of Research Project R51.253 "Chemicals in the Printing Industry".

One way of assessing exposure and the effectiveness of gloves (and PPE in general) is biological monitoring. Analysing a substance or its metabolite in urine can give a guide to the amount of substance that has evaded the exposure controls and been absorbed by a worker. Using biological monitoring in the assessment of printers' exposure in the workplace will give a guide to their overall level of exposure but it will not be able to distinguish between what is inhaled and what has been absorbed through the skin. If the gloves are working properly the contribution of dermal absorption to the total should be negligible and inhalation should be the dominant route of uptake. If the gloves are not working as intended then, at the relatively low airborne concentrations in the workplace, the dermal route could be significant. It is not practical to give printers the type of air-fed respiratory protective equipment that would completely remove the possibility of inhalation of substances and allow the study of dermal absorption only. However, this type of study could be done in a controlled laboratory environment and this is the basis for the study reported here.

1.1 AIM

The study sought to use the solvents and gloves used by lithographic printers and simulate their activities in a controlled environment where inhalation could be prevented and the effectiveness of their gloves studied. The information gathered will contribute to HSE's policy and advice to the printing industry on the correct selection and use of chemical protective gloves. Although this project deals with lithographic printing, ultimately all sectors of the printing industry will be studied in a rolling programme.

1.2 OBJECTIVES

- To simulate the activities where printers use gloves to protect against solvents
- To collect urine samples and analyse for solvent/metabolites
- To sample beneath gloves to detect presence of solvent indicating that breakthrough or leakage could have occurred.
- To track the spread of liquid solvent to indicate whether penetration (leakage) had occurred, and thus confirm the permeation route.
- To determine from the results whether the gloves are suitable for use for the task studied.

2 METHODS

2.1 SELECTION OF SOLVENT

HSL's occupational hygienists visited several print works and sought information of the solvent mixtures used in various processes. The safety data sheets were obtained and samples of the solvents themselves were analysed for components whose exposure could be assessed by analysis of the solvent or its metabolites in urine. The most suitable solvent was UltraKing wash-up fluid comprising over 99% of 1-methoxy-2-propanol. Devanthery *et al*, (2002) showed that 2% of the 1-methoxy-2-propanol absorbed is excreted unchanged in urine and this has been proposed as a basis for biological monitoring (Jones et al 1997). Section 2.12 discusses the health risks of 1-methoxy-2-propanol. During analysis of several of the other solvents, known skin sensitisers were identified as present in relatively high concentrations. These were not listed on the safety data sheets because they were not a high enough concentration to warrant inclusion.

2.2 SELECTION OF GLOVES

During the visits to the print works the hygienists noted the types of gloves used for various tasks. Two of the most common ones were Superglove Nitritech II (Glove 1), and Ansell-Edmont Solvex 37-675 (Glove 2), both flock-lined, 0.4mm thick nitrile with a short cuff, and these were both used in the volunteer study. At the time of the study, the standard (EN374-3) glove permeation times for the solvent were not known. They were later shown to be 90 minutes for one brand and two hours for the other (Kächele-Cama Latex, 2004). This was in excess of the volunteers' planned single-use exercise (30 minutes), although the effect of flexing and temperature has been found to reduce breakthrough times to as little as one third (Oppl, 2001). The professional printers took only 4 or 5 minutes to clean a bowl before removing the gloves, but they re-used the gloves during the day and for several days at a time.

2.3 SELECTION AND TRAINING OF VOLUNTEERS

The study had the approval of HSE's Research Ethics Committee (ETHCOM/REG/04/03). Appendix 1 contains the application to the Ethics Committee, and Sections 2.11 and 2.12 contain statistical and risk assessment arguments that supported the application. Volunteers were sought from HSL staff and female volunteers were asked to be sure they were not pregnant. Before the exercise, volunteers watched a video of a printer cleaning an ink-mixing bowl using a spatula to remove excess ink and then a combination of cloths and solvent squirted into the bowl from a wash-bottle (Fig 1). Volunteers were trained in the technique of glove removal (to prevent contamination of ink and solvent not caused by the exercise itself).



Fig 1. A sequence of pictures from the video used to train volunteers.

2.4 TEST CHAMBER

A perspex chamber (approximately 3m wide, 2m wide, 2m high) was used to conduct the study. Air and vapours could be recirculated by a fan inside the chamber, or extracted to outside to remove the vapours. The maximum extraction rate was measured by recirculating sulphur hexafluoride gas (SF_6) inside the chamber, and then switching to full extraction. The decay of SF_6 is shown in Fig 2 on a logarithmic scale. The slope of the graph indicates that the air exchange rate (the time for the air concentration to fall by a factor of $1/e$) inside the chamber was a maximum of 0.42 air changes per minute. It takes approximately six minutes to fall by a factor of ten.

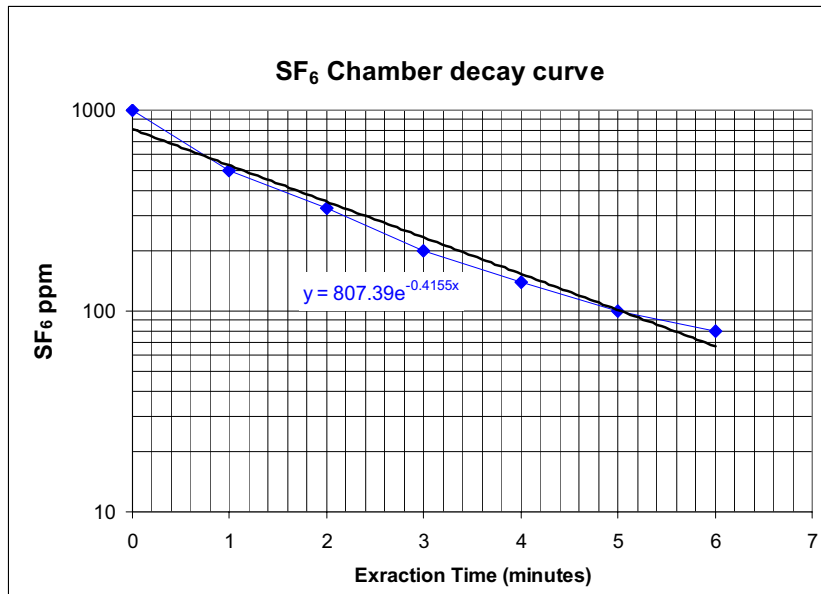


Fig 2. Extraction rate from the chamber

The chamber was used in an extraction mode with the fans at reduced flow to maintain the atmosphere at or around the OES of 100 ppm for 1-methoxy-2-propanol. The flow was adjusted as the tests progressed. For comparison, air concentrations in the ink mixing room in the workplace was measured at 50 – 75 ppm using passive and pumped Tenax samplers.

2.5 AIR MEASUREMENTS

Volunteers (n=7) wore a loose fitting air-fed helmet and hose; the Protector Tornado T-5 polycarbonate visor helmet when inside the chamber to prevent inhalation of solvent vapours (Fig 3). This is a light duty device with an Assigned Protection Factor of 20. Air monitoring was carried out using pumped Photo-Ionisation Detectors (PIDs) (MultiRAE Plus manufactured by Rae Systems Inc.) mounted at the waist with the sampling points both inside the air-fed helmet at the mouth and outside at the forehead. These recorded instantaneous vapour levels during the exercise, and gave added value to the study as a measure of the effective protection factor of the helmet.

From test 5 onwards, a Tenax passive sampler was taped to the outside of the helmet at the forehead for comparison with the PID. From test 4 onwards, a Permeatec pad (described later) was taped to the chamber wall as an air monitor for comparison with underglove samplers (not shown in Fig 3).

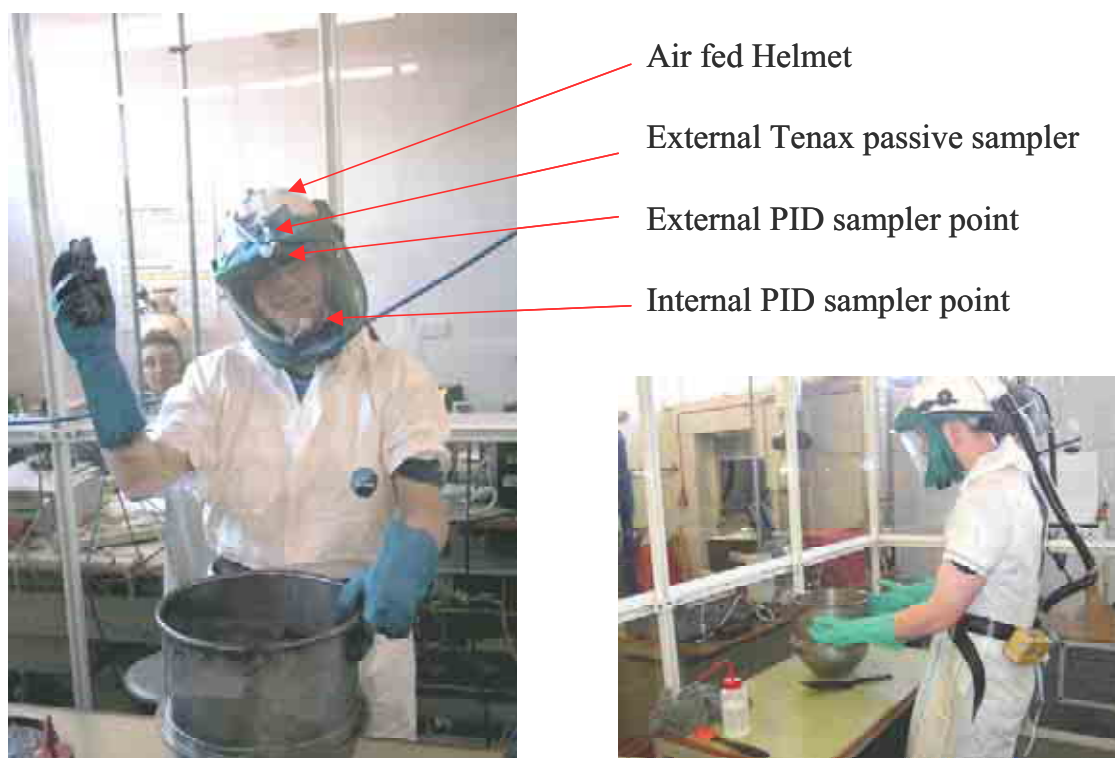


Fig 3. Subjects inside the chamber showing air monitoring equipment.

2.6 HAND MEASUREMENTS

Permeatec “solvent” pads (CLI Inc) have a cotton-carbon cloth square with a strip in the middle that changes colour when in contact with polar solvents (Fig 4, left). Unfortunately, 1-methoxy-2-propanol is non-polar and does not trigger the colour change, therefore a method was developed by the Organic Analysis Section to extract it from the cotton-carbon cloth. This has been done before by Mattorano et al (2004) to detect methyl ethyl ketone.

Permeatec pads were placed on the thumbs and forefingers of the volunteers' hands as shown in Fig 4 (left). From test 6 onwards, extra pads were placed on the palms of the preferred (dominant) hands, and also on the second knuckles (not shown) as a likely flexing point.



Fig 4. Locations of the Permeatec pads under the gloves.

2.7 FLUORESCENT TRACER IN THE SOLVENT

A non-toxic fluorescent dye (Tinopal SWN) was added to the solvent to act as a record of the splash locations. The dye stained the skin and the non-fluorescent oversuit, and remained behind when the solvent had evaporated. This dye could not be used to detect permeation of the solvent through intact glove material, but it acted as a check that liquid splashes had not crept down the glove cuff or penetrated the material through holes, cuts or manufacturing defects.

2.8 PHOTOGRAPHIC RECORDS

The work practices of the volunteers were recorded with a stills camera, and occasionally a video camera. After the exercise, photographs were taken in daylight of the spread of ink over their arms and gloves (Fig 4 left), and also of the oversuit in general. The volunteers then stood inside a shell of ultraviolet (UVA) lights to show the spread of the solvent splashes (Fig 5).



Fig 5. Oversuit under normal and UVA light showing heaviest spread of solvent and also the presence of flock on the hands

Further photographs of the hands were taken under UVA light before (Fig 6 left) and after (Fig 6 right) washing hands in water to remove glove-lining flock fragments on the hands that fluoresced strongly and could be mistaken for penetration of solvent. The dominant (preferred) hand retained more flock than the lesser (non-preferred).

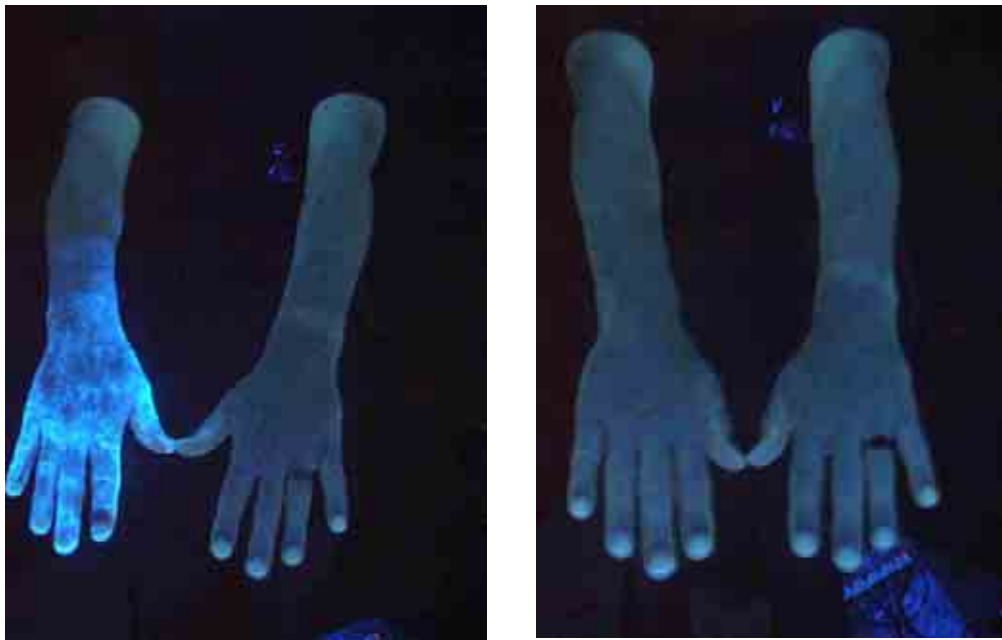


Fig 6. Hands and arms under UVA light showing spread of solvent on the arms and also the presence of flock on the hands (left) removed by washing (right)

Further photographs were taken using the monochrome FIVES fluorescence monitor to reveal the presence of fluorescent dye (Fig 7 below). The FIVES system is more sensitive than the colour camera and shows smaller masses of dye. It was not used to quantitatively measure the mass of dye.

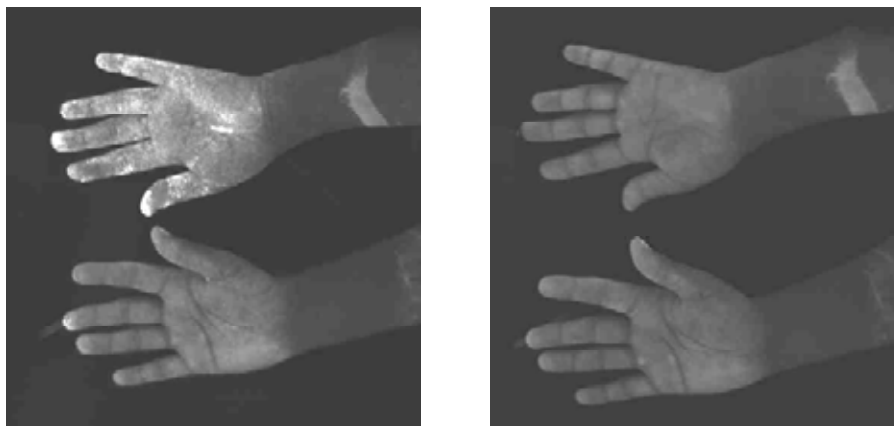


Fig 7. FIVES photographs of hands and arms under UVA light showing spread of solvent on the arms. It also shows presence of flock on the hands (left) removed by washing (right).

2.9 EXPERIMENTAL PROTOCOL SUMMARY

After training, the volunteers provided a specimen of urine to act as a background level. They donned a Tyvek overall to protect their outer clothing. The sleeves of the coverall were removed so as not to interfere with the cleaning process (Fig 3). They wore a plastic apron on top (tests 1-6), but the oversuit used alone showed up the contamination better, and it was omitted. Permeatec pads were placed on the forefinger, palm and back of each hand (Fig 4). The gloves were carefully donned so as not to displace the Permeatec pads. Volunteers wore an air-fed hood to prevent inhalation of any vapours (Fig 3). PID air monitoring recorders were fitted to the belt loop (Fig 3, right). No solvent vapours were present inside the chamber before the volunteers entered. Simulated cleaning took place inside the exposure chamber. During the simulation the volunteers first used a spatula to spread some dark purple ink inside the bowl. They then cleaned both the inside and outside of the bowl and any ink contamination from the bench with rags and solvent. They finished each cleaning cycle by wiping down the table top and the tools, ready to start again. The volunteers repeated several cleaning cycles in one session to make a total of at least 20 minutes from first use of the solvent in a single use of the gloves. They used approximately ten rags each in the exercise, and between 300 and 700 ml of solvent. Heaviest use of solvent was in the first cycle, as they rapidly learned to use it to better effect later. Vapours were cleared from the chamber before the doors were opened at the end of the exposure period.

Attendant staff removed the volunteers' air-fed hoods to prevent cross-contamination of ink. Gloves were carefully removed to prevent further transfer of ink or solvent onto the arms. The Permeatec patches were removed and placed in labelled bottles of solvent for analysis. Tenax tubes were sealed with blanking caps and stored for analysis. The volunteers were escorted to the darkroom ensuring that they touched nothing. Photographs of the hands were taken under UV light before and after the simulated cleaning, and after a handwash to remove glove flock (Figs 6 and 7).

The volunteers collected their total urine at 4 hourly intervals and one overnight sample afterwards. The urine samples were analysed for volume, concentration of 1-methoxy-2-propanol and creatinine. The total amount of 1-methoxy-2-propanol excreted was used to assess the effectiveness of the gloves.

2.10 ANALYTICAL METHODS

2.10.1 Analysis of 1-methoxy 2-propanol in Permeatec pads

Cotton-carbon cloth readily absorbs vapours. Extracting it again efficiently is difficult and a reduced extraction efficiency has to be accepted. Matterano *et al* (2004) used carbon disulphide to extract acetone, hexane, xylene, toluene and methyl-ethyl ketone, achieving 91-93% extraction efficiency with the last mentioned. Carbon disulphide was found not to be effective for 1-methoxy-2-propanol, but HSL's Organic Measurement Section developed an efficient extraction method using dichloromethane.

Permeatec pads were stored in individual airtight bottles until analysed. The cotton carbon cloth pad was separated from the plaster backing and the colour change strip removed and discarded. 1-methoxy-2-propanol was extracted from the cloth by desorption in dichloromethane. Analysis was by capillary gas chromatography with mass selective detection. A mass spectra library was used to identify the 1-methoxy-2-propanol, and compared with laboratory standards in the range of approximately 10 to 1700 µg per pad. Analytical recovery was estimated at 91% (90-100%) by dosing (spiking) pads. Results are corrected for 91% recovery efficiency in this report. The limit of quantification was estimated as 2 µg per pad.

2.10.2 Analysis of 1-methoxy 2-propanol in Tenax tubes

Exposed Chromosorb106 passive sampling tubes were sealed until analysis. Adsorbed Volatile Organic Compounds (VOC's) were recovered by two-stage thermal desorption: primary thermal desorption under helium flow with cryofocussing into a low volume sorbent trap, followed by secondary desorption from the trap through a capillary gas chromatography column to a flame ionisation detector. Identification and mass quantification of recovered analyte was according to UKAS accredited method OMS-001, using a specific gravimetric standard of 1-methoxy-2-propanol in methanol loaded to Cr 106 tubes at approximately 20 µg, equivalent to 44 ppm for a 240 minute exposure period. The air concentration was determined from the effective uptake rate 1.88 ng/ppm/min, (partial validation according to EN 838 level 1B, including some field test data), and from the reported sample times (sampling times are not covered under the accredited method). The Limit of Detection was estimated as 0.1 ppm for a 240 minute sampling period. By the elected method recovery efficiency was 100%. Second analyses of some of the tubes yielded no further detectable analyte, so full recovery on the first pass was confirmed.

The sampling times were not 240 minutes, so the equivalent standard rescales from 44 ppm to 300 ppm, but this estimate is not according to the accredited method. The detection limit also rescales to approximately 0.5 ppm for a 30 minute sample.

2.10.3 Analysis of skin and clothing contamination

Video and photographic records were made of the areas visibly contaminated areas with ink on the apron (when worn) and oversuit, and on the exposed skin of the neck, arms and hands. Notes were made at the time of ink spots that might be difficult to photograph. Photographs were taken of the oversuit and skin under UV light to record

the locations of solvent. Although the FIVES apparatus is capable of quantitative analysis on skin if a suitable calibration is made, no quantitative analyses for solvent were made. The presence of coloured ink combined with the solvent on the skin made it impossible to quantify.

2.10.4 Analysis of the continuous vapour concentrations air monitoring

Photo-Ionisation detectors (PIDs) mounted inside and outside the air-fed helmet were zeroed against clean breathable air and calibrated by exposing them to a bottled certified standard organic vapour. The PIDs recorded information every second creating a large amount of data which was downloaded onto a PC. The data was used to assess the performance of the RPE and to calculate the mean solvent vapour concentration outside of the RPE visor during each test run. This mean was calculated over the same time during which the Tenax tubes were open.

2.10.5 Analysis of 1-methoxy 2-propanol in urine

The analytical method for 1-methoxy-2-propanol was based on Jones *et al* (1997), with a hydrolysis stage from Devanthery *et al* (2002). It involved the extraction of 1-methoxy-2-propanol from urine, derivatisation with trimethylsilyl imidazole, followed by capillary gas chromatography with GCMS detection. The detection limit was <1 µmol/l and the coefficient of variation at 100 µmol/l was 5% for within-day and 9% for day-to-day measurements.

2.11 STATISTICAL ANALYSIS

The following calculations were performed prior to the study to assess whether the study would achieve its aim to assess whether the gloves used in printing to prevent exposure to solvents actually reduce exposure. If the gloves prevented any dermal exposure then there would be no urinary excretion of 1-methoxy-2-propanol. If the gloves were not worn both hands would be exposed to the solvent for up to 1 hour. An estimate of urinary excretion of 1-methoxy-2-propanol can be made based on the following:

- A volunteer study involving inhalation of the occupational exposure standard of 100 ppm (375 mg/m³) for 8h found levels of up to 110 µmol/l in end-of-exposure urine samples. This acts as a comparator for the significance of dermal uptake.
- 2% of the solvent absorbed is excreted unchanged as 1-methoxy-2-propanol in urine (Devanthery *et al*, 2002)
- The rate of penetration of (liquid) solvent through skin is 1.2 mg/cm²/h (Dugard *et al* 1984)
- The surface area of one hand is 400 cm²
- The systemic dose after 1 hour's hand immersion in liquid would be 1.2 x 400 x 2 = 960 mg and of this 2% would be excreted as 1-methoxy-2-propanol in urine = 19.2 mg (213 µmol) in approx 1 litre of urine in 24 hours.

2.11.1 Power calculation

A null hypothesis that the gloves afford *no* reduction in systemic exposure corresponds to the median total urinary excretion of 1-methoxy-2-propanol being approximately 213µmol (this is 26% of systemic dose following an 8 hour inhalation exposure at the exposure limit –see section 2.12.1 on toxic hazard for further details). This hypothesis may be tested against the alternative that the gloves offer a significant reduction in exposure (and hence no urinary excretion of 1-methoxy-2-propanol). If an acceptable level of control is that the gloves actually reduce

exposure to 10% of the dose that would follow from inhalation exposure at the exposure limit for 8 hours OES then 8 volunteers will give 98% power to detect a statistically significant reduction in exposure (significance level 0.05, 1 sided test). Furthermore a sample size of 8 will also give a 90% power to detect an approximately 3-fold difference in performance of the two glove types. Both these calculations (determined using the power and sample size option within S-PLUS) assume a log normal distribution for urinary excretions of total 1-methoxy-2-propanol with a geometric standard deviation of 1.88 - this being the higher of two GSDs for the urinary excretion of another solvent in a similar experimental study of wiping and mopping with N-methyl pyrrolidone (ETHCOM/REG/99/09). The comparison between gloves has not been made on the basis of each subject forming their own control as it was expected that the within person variability (due to biological variations in metabolism and absorption) would be a modest component of total variability (which includes variation in external exposure and in the performance of the gloves).

2.12 RISK ASSESSMENT

2.12.1 Toxic hazard

Methoxy-2-propanol was reviewed by HSE's WATCH committee when proposing an occupational exposure limit in 2002. The lead health effect and basis for setting the limit was eye irritation and was based on a no observed effect level after exposure to 150 ppm for 2.5 hours in a volunteer study. WATCH agreed a health-based airborne limit of 100 ppm. The 8 hour OES (now a WEL) is 100ppm with a 10 minute STEL of 150 ppm (HSE EH40, 2002). Since then there have been two further published volunteer studies involving inhalation exposure to 1-methoxy-2-propanol at up to 100 ppm (Jones *et al*, 1997 and Devanthery, 2002).

The HSE review noted that there was significant absorption of 1-methoxy-2-propanol through the skin and this could make a substantial contribution to body burden and a 'skin notation' was agreed. The toxicity review noted that 1-methoxy-2-propanol was of low acute oral and dermal toxicity with no concerns for reproductive toxicity but could give rise to slight eye and skin irritation in humans.

The study proposed here will be conducted in an exposure chamber that will be used as a fume hood to reduce the concentration of vapours generated by wiping activities. Even in the absence of this control it is very unlikely that exposure would exceed the limit. However, because we want to be sure that if there is any absorption of 1-methoxy-2-propanol it has entered the body by absorption through the skin we will ask the volunteers to also wear an air-fed hood to remove the possibility of inhalation of vapours or contact of the vapour with eyes. As a consequence the risk from inhalation of 1-methoxy-2-propoanol is considered negligible.

Dermal contact with liquid 1-methoxy-2-propanol will be prevented by the gloves worn by the volunteers. The gloves will be selected based on their suitability to prevent exposure to 1-methoxy-2-propanol and on their common use by the printing industry. If the gloves work as expected then there should be no exposure or risk from skin contact with 1-methoxy-2-propanol. If the gloves were to be punctured or tear it is most likely that the volunteer would notice contact with solvent and the exposure would be stopped. In the unlikely event that the glove failed without the volunteer noticing there is the potential for dermal contact to liquid 1-methoxy-2-propanol for up to 1 hour. Based on an in-vitro absorption rate of 1.2mg/cm²/h through isolated human skin (Dugard *et al*, 1984) and a surface area of one hand of 400 cm² the maximum systemic absorption from continuous skin contact would be 480 mg. This can be compared with an inhalation dose at the exposure limit of 375 mg/m³ x 10m³ (for 8 hour exposure) or 3750 mg. Thus the worst-case dermal exposure would be 13% of an acceptable inhalation exposure intended to prevent irritancy. The slight narcotic effects seen in rats were

after exposure to 1-methoxy-2-propanol, and were seen at concentrations 2 to 3 times higher than those causing irritancy. The worst-case dermal dose is less than 10% of that which might cause slight narcotic effects and thus considered negligible.

2.12.2 Radiation Hazard

Fluorescence monitoring involved exposures to low levels (less than 0.5 mW/cm^2) of long-wavelength ultra-violet (UVA) radiation for about two minutes. The UVA radiation was well below the limit level at which eye protection is a requirement (2.0 mW/cm^2 for 8 hours). The UVA tubes also emitted dark blue light, which may have caused slight disorientation if the eye looked directly at them, because it has difficulty focusing on them. No harm is caused by this exposure, and dark glasses were offered to remove the blue light and in case of discomfort.

3 RESULTS

3.1 SUMMARY OF RESULTS

Results for the air and dermal measurements are shown in Table 1a. The air measurements are in ppm and are averages over the exposure time. The Permeatec pad results are in µg and are the total mass over the sampling time. As the sampling times differed from subject to subject, the Permeatec masses are consistent within a subject, but subjects cannot be compared directly. Assuming that the absorption rates of the Permeatecs were constant throughout the sampling periods, the masses have been rescaled (time adjusted) to 30 minutes in Table 1b.

Table 1 Complete set of results: a) as gathered, and b) time adjusted

a Permeatec exposures scaled to 30 minutes

Exposure				CHAMBER AIR			UNDER-GLOVE				UNDER-GLOVE				URINE	
Subj.	Test	Glove	mins	PID	Tenax	P-tec	Permeatecs Preferred Hand µg				Permeatecs Non-preferred hand µg				Sum 24hr	
				ppm	ppm	µg	Thumb	Forefinger	Palm	Knuckle	Thumb	Forefinger	Palm	Knuckle	µmol/litre	
1	1	Glove 1	10	26	x	x	242	22	x	x	221	224	x	x	nd	
2	2	Glove 1	22	99	x	x	835	802	x	x	822	593	x	x	nd	
3	3	Glove 1	36	168	x	x	229	220	x	x	142	105	x	x	nd	
4	4	Glove 1	27	180	x	x	754	89	x	x	67	47	x	x	nd	
5	5	Glove 1	33	133	x	849	1408	565	x	x	259	326	x	x	nd	
1	6	Glove 1	22	165	215	771	393	114	3480	1629	82	58	x	x	nd	
7	7	Glove 1	24	97	125	642	30	31	879	182	35	35	x	x	nd	
8	8	Glove 1	26	164	170	1753	645	135	5175	3849	90	45	x	x	nd	
Average				Glove 1	27	144	170	1004	3178	1887	613	279	214	173		
Std Dev				Glove 1	5	34	45	507	2164	1847	454	290	278	212		
9	9	Glove 2	28	138	222	990	119	104	1720	1362	13	20	x	x	nd	
7	10	Glove 2	26	69	79	648	23	23	1720	315	11	19	x	x	nd	
1	11	Glove 2	28	147	203	1466	319	329	3630	3156	152	122	x	x	nd	
2	12	Glove 2	24.5	76	128	796	35	40	534	370	35	19	x	x	nd	
5	13	Glove 2	30	127	167		607	174	1659	2027	60	29	x	x	nd	
8	14	Glove 2	35	199	312	2070	510	311	5755	4267	96	109	x	x	6	
Average				Glove 2	29	126	185	1194	2503	1916	269	163	61	53	x	x
Std Dev				Glove 2	4	48	81	579	1879	1571	250	132	55	49	x	x
9	15	Glove 2	21	83	x	1132	5	5	23	22	4	4	x	x	Missing	
Printer 1	Glove 2	14		x	50.5	x	x	19	x	350	x	x	x	x	Workplace	
Printer 2	Glove 2	11		x	70	x	x	356	x	267	x	x	x	x	Workplace	

b Permeatec exposures scaled to 30 minutes

Corrected Exposure				CHAMBER AIR			UNDER-GLOVE				UNDER-GLOVE					
Subj.	Test	Glove	mins	PID	Tenax	P-tec	Permeatecs Preferred Hand µg				Permeatecs Non-preferred hand µg					
				ppm	ppm	µg	Thumb	Forefinger	Palm	Knuckle	Thumb	Forefinger	Palm	Knuckle		
1	1	Glove 1	30	26	x	x	725	66	x	x	663	673	x	x	pilot run	
2	2	Glove 1	30	99	x	x	1139	1094	x	x	1121	809	x	x		
3	3	Glove 1	30	168	x	x	190	183	x	x	118	88	x	x		
4	4	Glove 1	30	180	x	x	838	99	x	x	74	53	x	x		
5	5	Glove 1	30	133	x	772	1280	513	x	x	236	297	x	x		
1	6	Glove 1	30	165	215	1052	536	156	4746	2221	112	79	x	x		
7	7	Glove 1	30	97	125	802	37	38	1099	228	44	44	x	x		
8	8	Glove 1	30	164	170	2022	744	156	5971	4442	104	52	x	x		
Average				Glove 1	30	144	170	1162	3938	2297	681	320	259	203	x	x
Std Dev				Glove 1	0	34	45	587	2534	2108	461	374	385	282	x	x
9	9	Glove 2	30	138	222	1061	127	112	1843	1459	14	21	x	x		
7	10	Glove 2	30	69	79	748	27	27	1984	364	13	22	x	x		
1	11	Glove 2	30	147	203	1571	341	352	3889	3381	162	131	x	x		
2	12	Glove 2	30	76	128	974	43	48	654	453	43	23	x	x		
5	13	Glove 2	30	127	167		607	174	1659	2027	60	29	x	x		
8	14	Glove 2	30	199	312	1775	437	267	4933	3657	82	93	x	x		
Average				Glove 2	30	126	185	1226	2494	1890	264	163	62	53	x	x
Std Dev				Glove 2	0	48	81	430	1591	1410	235	127	56	47	x	x
9	15	Glove 2	30	83	x	1617	6	7	32	31	6	6	x	x	taped gloves	

Key:

- Pilot run. Exercise was shorter than the others. Results are included here for completeness. Not counted in glove Average.
- Calibration was only as far as 1000µg. Result is extrapolated. All Permeatec corrected for 91% recovery.
- Pumped Tenax. All other measurements are using passive (not pumped) Tenax.
- Subject 2 (tests 2 and 12) was left-handed. Data adjusted to show preferred and non-preferred rather than left and right.
- Tests 1-4 Chamber fans run low for exercise. Tests 5-15 Chamber fans run higher to keep atmosphere below OES.
- x No sample taken.
- Taped gloves. Not counted in glove Average.
- Plaster rolled up inside glove. Particularly low results. Test 7 included in average.

A complete set of photographs for each of the volunteer exercises and the subsequent contamination is available, including DV digital video (tests 2 and 5 only) on DVD, and jpeg colour stills and bmp monochrome stills (FIVES) on CD-ROM.

A selection of the set of photographs of the contamination of the subjects is given for each glove type in Appendices 2 and 3. Appendix 4 shows photographs from the last test run under different conditions (discussed later). Appendix 5 gives details of skin and clothing contamination and general observations from each test run.

3.2 SKIN CONTAMINATION – INK AND DYE

There were no differences between the skin contamination patterns from the two glove types, so further discussion refers to both types.

3.2.1 Forearms

Ink: Preferred forearm: The forearms were contaminated with ring stains of ink just above the cuff on the preferred forearm (9 out of 15 subjects, Appendix 5), which held the cloth inside the bowl. Only one subject escaped ink stains completely.

Ink: Lesser forearm: There were no similar rings on the lesser (non-preferred) forearm (0 out of 15 subjects), which held the bowl on the outside, however there were spots and stains above the cuffs that did not form a ring. 10 subjects escaped ink stains completely.

Solvent: Exposed forearms were also contaminated with ring, stain and droplet splashes of solvent, in many cases mixed with the ink. Only six out of the thirty forearms were free of solvent.

The above suggests that the glove was too short for this particular task of cleaning inside a narrow bowl, which prevented free movement. The printers themselves used wider-necked bowls on our workplace visits and were free of ink stains, but splashes of droplets of solvent may have occurred.

3.2.2 Hands underneath gloves

There was no visible contamination of the hands inside gloves arising from ink, solvent splash or drip (i.e. not arising via permeation of the intact material). This finding was after handwashing to remove flock (Figs 6 and 7). Two instances of visible finger contamination of ink and solvent were through careless removal of gloves (Subjects 1 and 10) and were observed at the time.

3.2.3 Faces

The subjects' faces were covered by the helmet visor, so remained clear of contamination during the tasks. However, one subject showed spots of dye on the face and one showed a stain on the chin. In both cases, the contamination appeared *after* the handwashing procedure. The spots were assumed to have arisen from splashes from a contaminated sink during the handwashing. The stain was from flock particles caught in chin-stubble, which transferred from the back of a flock-covered hand used to scratch the chin just before handwashing.

3.3 CLOTHING CONTAMINATION – INK AND DYE

There were no differences between the clothing contamination patterns from the two glove types, so further description refers to both types.

The gloves were almost all contaminated up to the cuffs with ink and solvent. The aprons (if worn) or the fronts of the oversuits (if not) were contaminated with widespread ink smears and solvent droplets. Four subjects had no ink stains on their fronts, and three subjects had no solvent splashes on their fronts. These figures include one subject who managed to keep free of both. Fig 5 shows one of the more contaminated oversuits. A horizontal line of ink/solvent at the waist shows where the rim of the bowl was held upright against the body to clean inside. A diagonal line lower down shows where the rim of the bowl was held tilted against the body to clean inside. A horizontal line below that at the top of the legs shows where the contaminated tabletop touched the clothing. Smears on the sides of the clothing at the top of the legs show where contaminated gloved hands touched the clothing.

3.4 VAPOURS IN THE CHAMBER (EXTERNAL TO THE GLOVES)

The Tenax and PID personal samplers were both mounted on the helmet. Results (Table 1) correlated extremely well (Fig 8 blue symbols and line, right hand scale, Pearson's $R^2=0.82$). However, the Tenax's gave readings approximately 35% higher than the PIDs ($p<0.003$ by paired t-test). The reason for this is not known but (if the PID is assumed to be correctly calibrated) may possibly relate to the short sampling period and the particular uptake rate value ($U_{eff} = 1.56$ ng/ppm/min) used to determine the air concentration from the recovered mass of PGME. Although Chromosorb 106 is the preferred sorbent for sampling PGME use of Tenax TA is acceptable. The value of U_{eff} available is an 8 hour value, partially validated according to BS EN 838:1996 level 1b which includes field tests. Values of U_{eff} are known to decrease with increased sampling period and therefore the 20 – 30 minute value (applicable to these samples) will be greater than the value actually used. It is unlikely that this would account for 35 %.

The air concentrations exceeded the 8hr WEL of 100 ppm inside the chamber from time to time (depending on which air sampler is taken to be "correct"). However, the subject was protected by the RPE at all times inside the chamber, and the chamber was flushed to well below the WEL before it was opened. Workplace measurements by pumped (not passive) Tenax (Table 1) were 50 - 70 ppm.

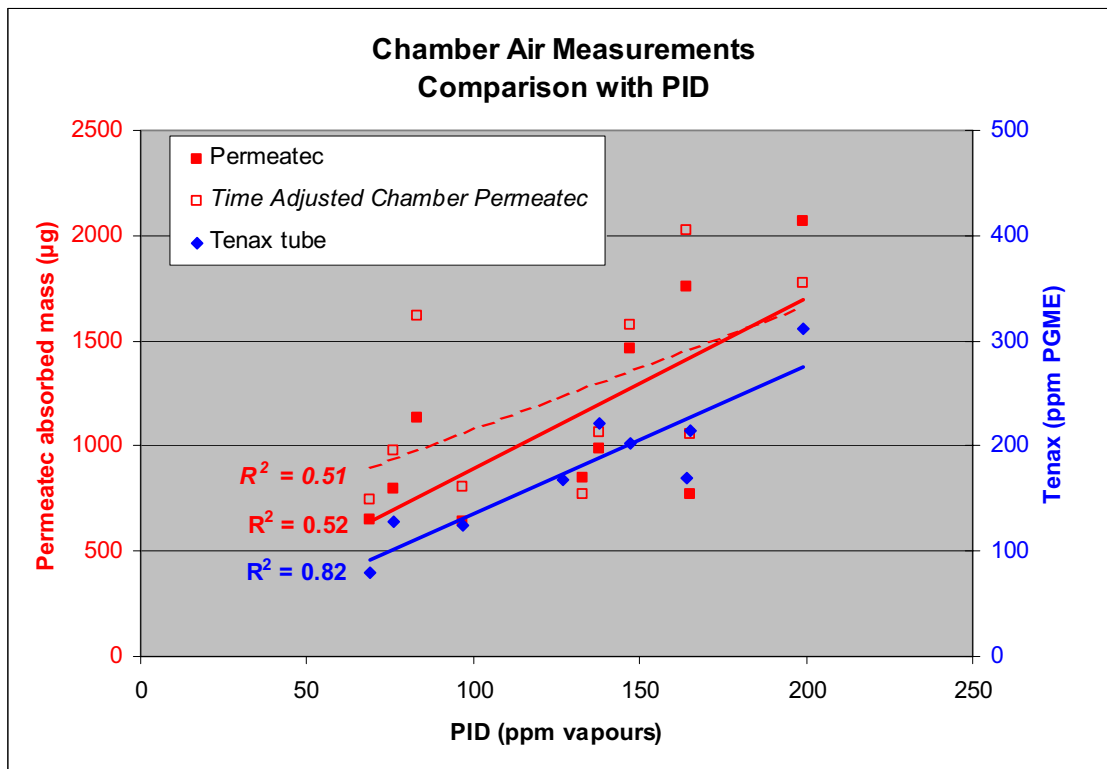


Fig 8. Air measurements in the Chamber

Correlations are less good between the Permeatec pads static chamber samplers and the personal PID and Tenax samplers (Table 2). Surprisingly, the correlations were worse when the Permeatecs were adjusted for time. Correlation was worst between the Tenax and the time adjusted Permeatec. The pilot run is excluded from these correlations.

Table 2 Correlations of air measurements

Pearson's Correlation Coefficient R²

	TENAX	PID	Permeatec
PID	0.82		
Permeatec	0.51	0.52	
Time Adj. Permeatec	0.35	0.30	0.82

The PID recorded sharp increases in vapour concentrations whenever the table was wiped with solvent during clean-up. Heaviest use of solvent did not always coincide with the highest air concentrations although no formal correlation was carried out because no accurate measurement of solvent use was kept. For example, it was noted that Tests 8 and 12 involved particularly heavy use of solvent, but the air concentrations were among the lowest for Test 12.

3.5 EFFICACY OF THE RESPIRATORY PROTECTIVE EQUIPMENT

The RPE provided the test subjects with a very high level of protection against inhalation of the solvent vapour. The in-facepiece concentration was below 0.6ppm for the majority of the test time and always below 1ppm. The PID data collected was used to calculate the protection factor using the data selection method devised by Vaughan and Bailey (2003). The performance of the RPE is the subject of a separate report (Frost and Mogridge, 2005).

3.6 VAPOURS INSIDE THE GLOVES

Means and standard deviations of the glove and air measurements using Permeatec pads are shown in fig 9.

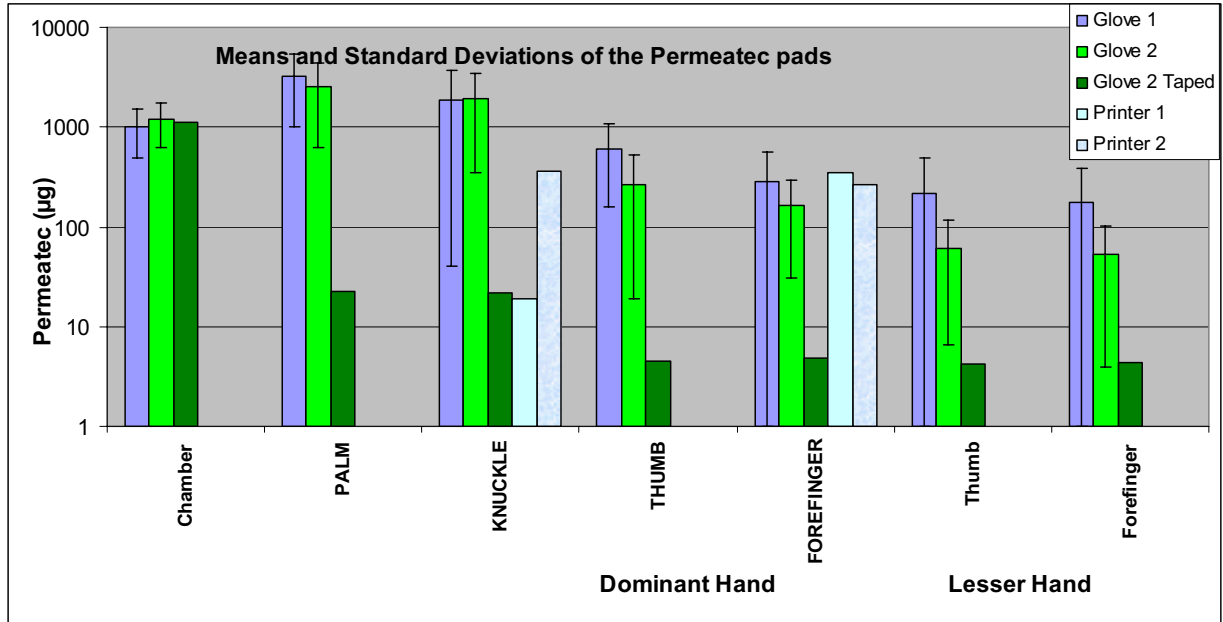


Fig 9 Arithmetical means and standard deviations of Permeatec hand and chamber air measurements.

The leftmost group of columns in Fig 9 shows that there were no differences in the average air concentrations in the chamber (outside the gloves) for each glove type, and that it was therefore a fair comparison. The rest of the groups of columns also show no differences between the Permeatecs inside the gloves for the two glove types. The knuckle and forefinger groups also show that three out of four workplace measurements at of similar levels to the volunteer study. The palms and knuckles were consistently much higher than the thumbs and forefingers (further inside glove) of the same (dominant) hands. The thumbs and forefingers of the dominant hands were consistently a little higher than those of the lesser hands.

Correlations of glove and air measurements are shown in Table 3.

Table 3 Correlations of Permeatecs with air (left section), within-gloves (right section in yellow), and between glove pairs (right right section in white)

	Chamber			Pearson's Correlation Coefficient R ²				
	Tenax	PID	Permeatec	Dominant Palm	Dominant Knuckle	Dominant Thumb	Dominant Finger	Lesser Thumb
Dominant Palm	0.49	0.76	0.79					
Dominant Knuckle	0.54	0.77	0.93	0.86				
Dominant Thumb	0.28	0.10	0.06	0.53	0.69			
Dominant Finger	0.58	0.00	0.12	0.49	0.71	0.48		
Lesser Thumb	0.27	0.02	0.05	0.49	0.59	0.25	0.82	
Lesser Finger	0.45	0.01	0.01	0.51	0.53	0.38	0.92	0.94

The right section of Table 3 shows within-glove correlations in yellow (excluding the pilot run and the taped glove). Within the dominant hand glove, the palm and knuckle results correlated

very well ($R^2 = 0.86$); the thumbs and fingers correlated less well, both between themselves and with the palms and knuckles ($R^2 = 0.71$ to 0.49). Within the lesser hand glove, the finger and thumb correlated extremely well ($R^2 = 0.94$).

The right section of Table 3 shows the “between-glove but within-pair” correlations in white (excluding the pilot run and the taped glove). Between the glove pairs, the lesser hand finger and thumb correlations were a mixed bag, and no consistent pattern emerges ($R^2 = 0.92$ to 0.25). The dominant palms and knuckles (left two columns of right section) correlated to a similar extent with the thumb and finger in the same glove as with the pair ($R^2 = 0.71$ to 0.49 in the last four rows of table). These results include the knuckle Permeatec from Test 7 that fell off inside the glove. If this result is excluded, correlations for the knuckle do not improve.

The left section of Table 3 shows correlations of the air measurements with the glove measurements (excluding the pilot run and the taped glove). The Chamber Permeatec is probably the best measure to choose to compare with the gloves, because no adjustment for exposure time is required. The air measurements correlated well with the palm and knuckle pads ($R^2 = 0.93$ to 0.49), but poorly with all of the finger and thumb measurements further inside the gloves ($R^2 = 0.58$ to 0.00).

The good correlations with air concentrations suggested that the Permeatec pads were not responding to permeation at all, but to air movements inside the glove. The nearer to the cuff that the pad was located, the better the correlation with air. This was tested by taping the cuffs to the hands (Test 15, Table 1 and Appendix 5). The results are very clear and are shown in dark green in Fig 9: the levels dropped to 1% of their previous values. The taped glove confirmed that all exposure to the hands was caused from air movements inside the gloves.

It was not possible to determine exact significance levels for the correlations because multiple comparisons are being made, some with different sample numbers. The correlation matrix was ill-conditioned and therefore impossible to invert to obtain significance values.

3.7 BIOLOGICAL MONITORING

Eighty-seven urine samples from 14 volunteer tests were analysed for 1-methoxy-2-propanol. All were below the detection limit of $<1 \mu\text{mol/l}$ apart from those in test 14, where traces of up to $3 \mu\text{mol/l}$ were found in three of the five post-exercise samples. This is at or below the limit of quantification, so the summed value in mg shown in Table 1 is above the detection level but is not an accurate figure. The biological monitoring results confirm that the volunteers had no significant systemic exposure by either the dermal or inhalation routes.

4 DISCUSSION

The volunteers used much more solvent and splashed it around more liberally than was observed at the print works. Being inexperienced, the volunteers took longer to carry out one cleaning cycle than the professionals. The method of working of using a solvent soaked rag in one gloved hand took longer for the volunteers than the printers, so the opportunity for the 1-methoxy-2-propanol to permeate the glove was greater. The printers take just a few minutes for a single cycle, however they also clean the mixer blade at the same time, so a realistic cleaning cycle takes approximately 10 minutes from their first use of solvent as recorded on video during the field visits.

The volunteers' oversuits under UV light showed splashes of dye from solvent, and under visible light showed ink stains arising from self-contamination - repeatedly touching their own clothes with their inky, solvent-soaked gloves.

Their forearms were smeared with a mixture of solvent and ink at the cuff of the glove. This suggests that the glove was too short for this particular task of cleaning inside a narrow bowl, which prevented free movement. During our field visits, the printers themselves used wider-necked bowls and were free of ink stains, but splashes of droplets of solvent still may have occurred. As the narrow bowl used in the volunteer study was also supplied by the printers, it would be reasonable to expect that they also cleaned narrow bowls using the same gloves.

The gloves were almost all contaminated up to the cuffs with ink and solvent, indicating that they were too short for the task. The rings and stains on the forearms above the gloves cuffs may have been caused by mobile liquids running down the cuffs onto the skin, which a longer glove may not prevent. None of the subjects turned the ends of the gloves back to catch such runs. Turning back the cuffs would however, have encouraged transfer to the inner surface of the glove.

The absence of visible traces of fluorescent dye or ink stains on the hands underneath the gloves showed that there was no solvent or ink contamination on the hands inside the gloves arising from penetration of the gloves through cuts and tears or by runs down the cuff.

The Permeatec pads underneath the gloves with sealed cuffs showed levels only 1% of those with unsealed cuffs, so we can estimate that 99% of the solvent vapour caught by the Permeatecs was from external air vapours, and that any contribution from permeation of the glove would be negligible compared to this.

Solvent vapour was detected inside the gloves but no detectable levels in the volunteers' urine, therefore there was no significant uptake from the dermal vapour exposure. We can conclude that if printers wear their 0.4mm nitrile gloves properly, they will be protected for more than 20 minutes. Their uptake exposure, as identified by urinary traces at the workplace, could arise from inhalation over the whole working day rather than from dermal absorption. There would have to be considerable permeation to match the amount inhaled, although the hazard might be in the form of local dermatitis rather than body burden.

The air concentrations measured in the volunteer study were slightly higher than those found at the print works. The air concentrations measured at the print works during use of the solvent, as measured by short term pumped samplers, were 50-70ppm, below the 8-hour WEL of 100ppm and the 10-minute WEL of 150ppm. The chamber concentrations were 70 – 300 ppm (Fig 8).

5 CONCLUSIONS

The gloves were sufficient to protect the hands of the workers against solvent for the duration of the multiple bowl-cleaning task (20 minutes from first use of solvent).

The gloves were too short for this particular task of cleaning inside a narrow bowl, which prevented free movement. They may be acceptable for wider bowls.

Dermal exposure to solvent was low during the simulated cleaning task with the gloves, being limited to stains and splashes on the outer clothing or exposed skin of the arms, and airborne dermal exposure to solvent vapours.

Inhalation exposure was eliminated for the volunteers, but could be present in the workplace. Any contribution to body burden from permeation of the glove in that time is negligible compared to the contribution from air vapours.

Direct contact of the gloves with the chemicals was common, with the glove being used as the only protection. Reducing the frequency of contact with the gloves would reduce the risk of inadvertent contact.

The Permeatec pads were shown to be useful samplers for volatile compounds, but when they are used as potential dermal exposure samplers, they cannot distinguish liquid splashes from vapours absorbed directly from the air. Results from previous occupational exposure studies that have used cotton-carbon cloth as potential dermal pad samplers for volatiles will need to be interpreted carefully. The cotton-carbon cloth is only a useful medium for monitoring actual dermal exposure if it is occluded (to prevent vapour absorption from the air).

5.1 RECOMMENDATIONS

Conduct further occupational studies to investigate the real-world use of gloves in printing and possible causes of dermatitis. An example would be to recover discarded gloves or commandeer half-used gloves, to find the levels of known irritant chemicals inside.

Suggest to the print works that the solvent be substituted if possible for a less volatile one.

Develop tools to reduce direct hand contact with inks or solvents in the printing industry.

Publish an article warning occupational hygienists that cotton-carbon cloth absorbs vapours from the air that could be mistaken for dermal exposure by splash or glove permeation. Glove permeation can only be confirmed if the insides of the gloves are isolated from the external air.

6 REFERENCES

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7 APPENDICES

APPENDIX 1 VOLUNTEER INFORMATION SHEET January 2004

Efficacy of gloves in printing

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Purpose of study

This study will investigate whether the two most commonly used gloves in the printing industry actually work as well as expected. The study is part of work by HSE to reduce the high incidence of skin problems among printers. The mixtures of solvents used and requirement for flexibility and touch-sensitivity pose difficulties in the selection of appropriate gloves. HSE is conducting laboratory studies of the permeation rates of solvents through the gloves commonly used. To complete the picture HSE also needs to look at how well the gloves perform when worn and used.

Selection criteria

Pregnant women or women who might be pregnant will not be accepted for this study and should not volunteer. Anyone else may volunteer for the study.

Withdrawing during study

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this Information Sheet to keep and be asked to sign a consent form. However, even if you sign the consent form you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect your employment.

Complaints procedure

If taking part in this research project harms you, there are no special compensation arrangements. If you are harmed due to someone's negligence, then you may have grounds for a legal action but you may have to pay for it. Regardless of this, if you wish to complain, or have any concerns about any aspect of the way you have been approached or treated during the course of this study, then you may approach the HSE Research Ethics Committee through its secretariat at 0151 951 4555.

Study details

You will take part in 2 cleaning tasks using a cloth and solvent to simulating the cleaning of an ink mixing bowl or roller. Each task will last approximately 1 hour, and will involve wearing an air-fed hood and gloves to reduce exposure to solvent vapours. The tasks will be carried out with a minimum of 1 week between them. You will be asked to give a urine sample before each task, and to collect all your urine for approximately 24 hours after the task. Urine samples will only be analysed for the solvent or its metabolites, and will not be analysed for alcohol or drugs of abuse. The exercise will take place in the exposure chamber used by Personal Protective Equipment Section to further reduce the possibility of you inhaling any of the solvent vapours. You will be provided with a disposable overall to protect your clothing and you can wear any other (preferably old) clothing you choose under the overall. To check that there has been no

leakage through holes in the gloves or around the glove cuff we will add a fluorescent marker to the solvent and take pictures of your hands under UV light before and after the task.

Confidentiality

All data will be anonymised at the start. You will be given an identification number that will only be known by you and by those working on the study. Names will not be used on any paperwork, other than the consent form. Photos and video may be recorded during the study. Whilst every effort will be made to preserve your anonymity, this cannot be guaranteed.

Research results

The results of the study will be published and available in the public domain. You will not be identified by name in any published documents.

Resulting benefits

This short duration study will allow HSE to have a better understanding of how gloves used to protect printers from solvents actually work in practice and whether it needs to revise its advice and guidance.

Associated risks

The solvent chosen for the study is one commonly used by printers for cleaning ink from equipment. The lead health effect of the major component (1-methoxy-2-propanol) is irritancy of the eyes and upper respiratory tract. It is not a carcinogen, mutagen or sensitiser and the no observed effect level for developmental toxicity was at least 15 times the occupational exposure limit. This substance has a health-based exposure limit of 100ppm for 8h. The levels you will be exposed to will be well below the occupational exposure limit and will be further reduced by the air-fed hood you will be wearing. In addition the task will last no longer than 1 hour.

The gloves you will be wearing are also commonly used by printers and will be chosen to be suitable for the task. The gloves should prevent direct contact with the solvent but if they tear or leak we will stop the task to prevent further exposure.

Volunteers are reminded that they may withdraw from the study at any time with no reason.

Funding

The research is being funded by Chemical Risk Assessment Control (CSD3) of the Field Operations Directorate (FOD) at HSE.

Research approval

The study has been approved to proceed by the HSE Research Ethics Committee.

Honorarium

In recognition of the commitment required of volunteers to give multiple urine samples they will be given a small honorarium in the form of book or record tokens to the value of £20 on completion of the study.

Contacts

Please contact any of the staff named below for further information or if you have any questions. You can contact us by email or telephone.

John Cocker extn 2691
Martin Roff extn. 2498

Thank-you for agreeing to take part in this study.

Volunteers should note that HSE has no legal liability to pay compensation for damage, loss or injury resulting from participation in this study in circumstances where there has been no negligence on the part of HSE.

I, **agree to participate in the study entitled:**
(name in block capitals)

Efficacy of gloves in printing

I confirm that I have read and understand the information sheet dated for the above study, have had the opportunity to ask questions, and understand what I am expected to do as a volunteer.

..... **(initial here)**

I have been promised that any information obtained in this study that can be identified with me will remain confidential, or only disclosed with my permission. I am in agreement that any information not identifiable with me may be presented at meetings and published so that it can be useful to others.

..... **(initial here)**

I do/do not agree that photographs and video material recorded during the study may be used for illustration purposes in reports and any subsequent journal articles. This is on the understanding that, while every effort will be made to preserve my anonymity, this cannot be guaranteed.

..... **(delete and initial here)**

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason and without my rights being affected

..... **(initial here)**

This project has been cleared to proceed by the HSE Research Ethics Committee. If you have any concerns about the conduct of this study you may contact the medical secretary of the Research Ethics Committee directly on 0151 951 4555.

Signed(Dr D Snashall, Chair to the HSE Research Ethics Committee)

Date

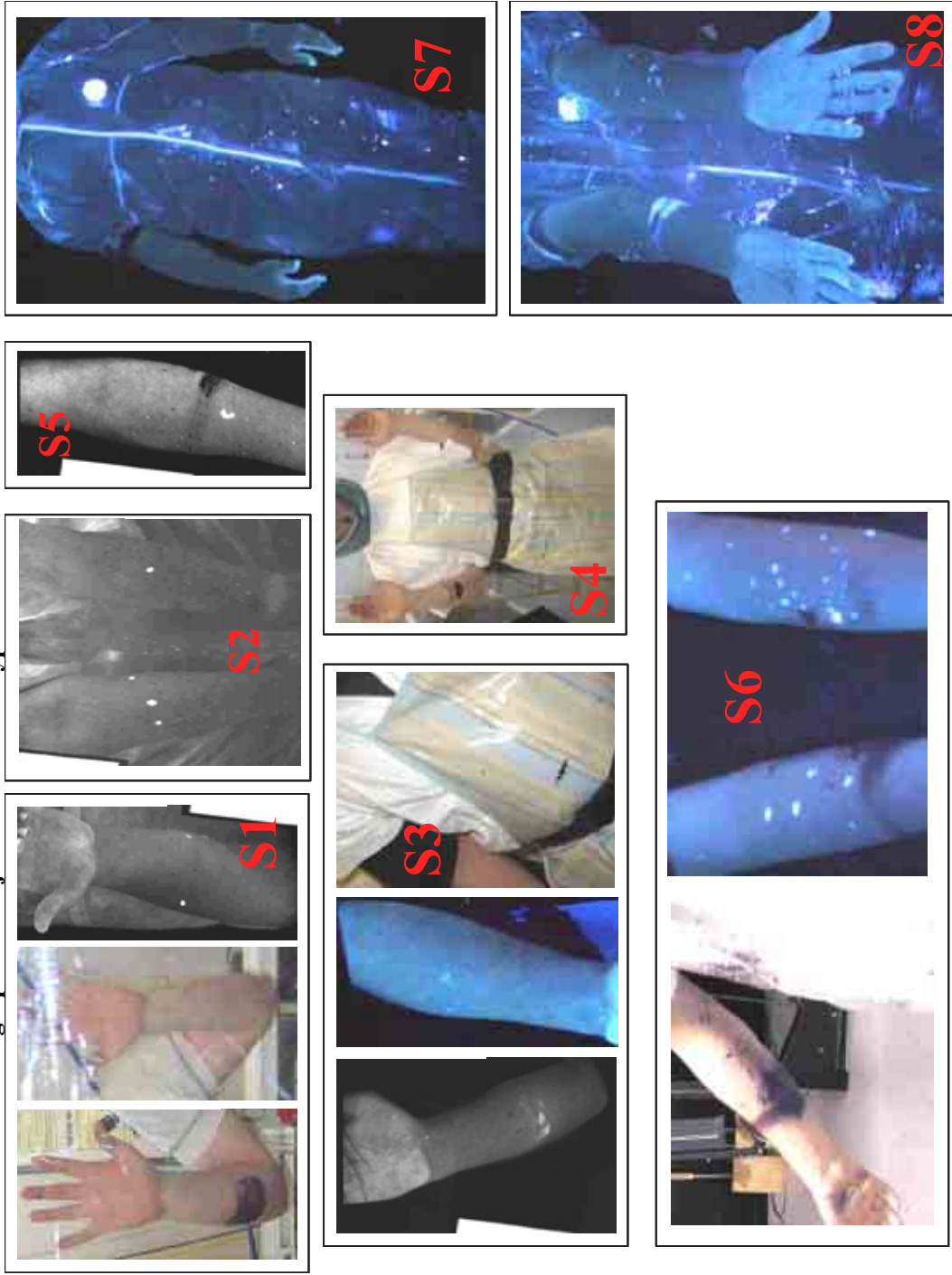
SIGNATURE

DATE

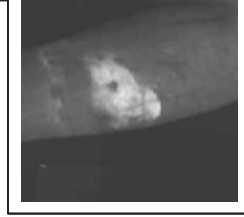
PERSONAL REFERENCE CODE ALLOCATED

Signature of Project Officer (Dr J Cocker)

APPENDIX 2 Photographs of subjects from Glove Type 1



APPENDIX 3 Photographs of subjects from Glove Type 2



APPENDIX 4 Notes on each test run

Test No.	Lesser Forearm		Preferred Forearm		Oversuit	Solvent	Remarks
	solvent splashes	ink splashes	solvent splashes	ink splashes			
1	Few spots			ink splashes stain		Approx. Use* 100 ml	One cycle. Dom. Forefinger Permeatec detached inside glove. 2 ink stains on fingers from touching oversuit after handwash.
2	Few spots		Few spots	Ring	Slight	200 ml	DV video? Heavy solvent use on first cycle. Removed gloves inside chamber at end of test during flush-out.
3	Few spots		stain	Ring	Yes/		
4	A few			Ring+stain	Yes	200 ml	
5	pinpricks		stain	stain	Yes/	100 ml	DV video? Spots on face and arms appeared AFTER washing – contaminated sink?
6	Many spots	Stains	Many spots	Heavy Ring+stain	Heavy	150 ml	Splat of ink on table transferred to apron and oversuit. Right hand stained during glove removal.
7	One spot		Faint stain		Light spots		Very careful and methodical. Knuckle Permeatec carbon cloth was found to be detached and rolled up when glove removed.
8	Spots + stains		Spots + Rings	2 Rings	Heavy	350 ml	Solvent bottle topped up and passed into chamber.
9			Faint rings	Ring+stain	Yes/Yes		
10	2 small spots	No	Ring + stains	No	No/Yes	150 ml	Very careful and methodical. Stains on arms and finger AFTER handwashing, transferred by touching oversuit.
11	Spots+ stains	Large Spots	spots	Spots	Yes/Yes		Small spots of dye on hands and face BEFORE starting. No more thereafter. Worked quickly but cleanly. Right Palm Permeatec detached inside glove early on in test run.
12				spots	No/Yes	200 ml	Spots on forearm BEFORE starting (not dye). Check b/gs.
13			stain	Ring	No/slight		
14	Spots+ stains	Spots+ stains	Heavy Ring+stain	Ring+stain	Yes/Heavy	300 ml	Solvent bottle topped up and passed into chamber. Heaviest suit contamination.
15	Stains	Stains	Stains + spots	Ring+stain	Yes/Yes	350 ml	Sealed gloves. Table placed differently in chamber. Solvent bottle topped up and passed into chamber.

A full wash bottle of solvent is estimated to contain 250 ml. All subjects started with a full wash bottle. Solvent use was inferred from the amounts left in the bottle.

APPENDIX 5 Photographs of subject 15 from Taped Glove Type 2

