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A Workplace Study of the Use and Maintenance of Respiratory Protective Equipment Against Vapour

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Abstract

A study, involving eleven companies, of user training and maintenance procedures for *respirators* has been carried out. From these companies a total of 45 Respiratory Protective Equipment (RPE) users were interviewed, of whom 26 used *respirators*. The participating organisations were volunteers and so their performance is likely to be better than the industry norm. Companies were heavily dependent upon RPE manufacturers and suppliers for the selection of suitable equipment. The user input to the evaluation and selection of suitable RPE was very poor and often non-existent, and training was generally unsatisfactory. Appropriate fit tests were not usually conducted, some users had facial hair, and RPE was removed for communication in known hazardous environments. Cleaning and maintenance were usually inadequate. The health and safety managers typically underestimated the duration of RPE usage and the user work rate. Some of the companies visited had good procedures for issue and maintenance but most did not have any record keeping facilities. The companies that had the best practice typically had a member of staff, such as a store-keeper, whose job was to monitor RPE issue, maintenance and record keeping.

Introduction

This paper describes a study of the issue, use and maintenance of *respirators* used against gas and vapour, and the training of wearers in industry. The work was commissioned to provide a base line for further activity in the field. It was carried out in conjunction with a study of the deposition pattern of adsorbate on the activated carbon filters from some of the *respirators* (Brown et al, 1997); both are concerned with the effect of working practices on *respirator* performance. Half-masks, some with non-replaceable filters, full facepiece masks and powered *respirators* are included in the study. Some users wore airline RPE. Although this was, strictly, outside the design of the study, information collected from

the companies on maintenance and training has been incorporated into the paper. Initially over 476 companies, identified from published registers of company information, were contacted within ten different industries, selected as significant vapour respirator users. The response rate to the questionnaire was 32%. Of the 58 companies who responded positively, 40 were approached, 14 volunteered and 11 actually took part in the study, with a RPE user sample of 45.

The aims of the study were to provide a general overview of the use of RPE within participating companies, to establish the quality of maintenance

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undertaken within the companies in comparison with requirements under the present British Standard BS4275 (1974), the Control of Substances Hazardous to the Health Regulations (COSHH), the associated Approved Code of Practice (ACOP) and manufacturers' recommendations, and to identify the extent, content, format and frequency of training and

instruction given to RPE end users. Information was gathered by structured interviews with health and safety representatives and RPE end users from each company. A visual inspection of the RPE was made at each site to assess the condition of equipment being used.

Companies Taking Part in the Study

Table 1 gives brief details of the companies who took part in the study. Within the companies RPE was worn by 28 paint sprayers (of whom 19 used airline RPE), 10 electroplaters and 7 glass fibre workers.

Company A

Four RPE users out of a total of five in a workforce of 20 at this electroplating company were interviewed. RPE in the form of half masks with inorganic vapour cartridges recommended by the distributors was used for maintenance tasks only. The users were exposed to acidic gases liberated during the electroplating process, but there was adequate ventilation according to the health and safety manager. Yearly checks on the level of exposure to hazardous substances were carried out but exposure measurements were not given to us. A health and safety policy was being developed, but no health checks were undertaken.

Company B

Five out of a total of nine RPE users were available for interview at this electroplating company. They wore either a half-mask with cartridges, a multitype or one of two types of full face RPE. The hazards were cyanide solutions and ammonia, at concentrations unknown to us. Extraction units were in place, and operators wore RPE during weekly cleaning out of the vats. The supervisor, in conjunction with the operators, was responsible for the day to day maintenance of the *respirators*. The managing director was responsible for the Personal Protective Equipment (PPE) budget, which was given high priority.

Company C

Two users were available for interview at this fibre-glass manufacturer. They wore half-mask *respirators* with organic cartridges and dust filters

which were not replaceable. These were issued to employees, including employees with beards. The hazards were styrene, at a level claimed to be below the Maximum Exposure Limit (MEL), along with resin and dust. Air quality was monitored monthly and records were kept. No health checks were undertaken.

Company D

Two users were available for interview at this fibre-glass manufacturer. These wore half-mask *respirators* with organic vapour cartridges during the manufacture and use of resins, at the company and at customers' premises. The employees were exposed to toluene and styrene at concentrations unknown to us. *Respirators* were normally used only when the employees were working in enclosed unventilated areas, usually on their customers' premises. At the company premises one employee was observed wearing a "Bandit face-scarf" (as worn by some cyclists) in preference to the *respirator* supplied, and most staff wore no protection. An extraction system was in place, but the smell of solvents was still apparent. Vapour levels were measured every three months within the company premises, but not on site, although the risk there was thought to be greater. Maintenance of the *respirators* was the responsibility of the end user. There was no formal health and safety procedure and health checks were not undertaken.

Company E

One worker was interviewed at this small fibre-glass works. Organic vapour *respirators* of a disposable type with non-replaceable cartridges were available and were required, by the company, to be worn if operators were working in enclosed areas, though operators used them only about once every three or four months. On a day to day basis they sometimes wore a nuisance dust mask, but no RPE. The workshop floor plan was open, without

Table 1. Details of companies participating in study.

Company	Industry	No. RPE users	Type of RPE	No. interviewed
A	Electroplaters	<5	Half mask with cartridges	4.00
B	Electroplaters	5-9	Half/full mask with cartridges	6.00
C	Glass Reinforced Plastic Manufacturers	<5	Disposable half mask with non-replaceable cartridges	2.00
D	Glass Reinforced Plastic Manufacturers	5-9	Half mask with cartridges	2.00
E	Glass Reinforced Plastic Manufacturers	5-9	Disposable	1.00
F	Glass Reinforced Plastic Manufacturers	<5	Powered helmet	1.00
G	Car Paint spraying	<5	Half mask with cartridges	2.00
H	Car Manufacturers	30-50	Disposable half mask with non-replaceable cartridges	8.00
I	Car Paint spraying	<5	Airline	1.00
J	Car Paint spraying	10-19	Airline	6.00
K	Car Manufacturers	20.00	Airline	12.00

extraction. Doors were kept open during warm weather periods. At the time of the visit there was a strong smell of resins and styrene vapour in and around the workshop.

There was no formal arrangement for maintenance or regular replacement of RPE. The managing director and the sales director were responsible for purchasing and keeping a stock of RPE. Operators were required to take responsibility for using the RPE. There were no health checks.

Company F

This small fibre-glass company had only four employees, of whom two were available for interview. One wore a nuisance dust mask. Large extraction units were situated where the resin spraying and finishing processes took place. Powered helmets were required to be worn if a process was carried out away from the extraction units or if the operator had to work closely over a task. The hazard was styrene, though there was not a strong

smell in the workshop. The Managing Director was responsible for purchasing RPE. It was the operator's responsibility to use and maintain it. There were no health checks.

Company G

Two RPE users were interviewed at this small car-spraying works. Each wore a half mask with an organic vapour and dust combination cartridge during paint spraying. The hazards were predominantly organic solvents, but isocyanates of unknown concentration were also used for up to two hours per week. There was no extraction system, and the normal procedure after paint spraying was to open the shutter doors and windows. However, we observed that when one member of staff had just finished spraying, all the doors and windows remained closed and the pungent smell of vapours persisted whilst the staff had a cup of tea in the work area. There was no formal health and safety policy. No health checks were undertaken and exposure levels were not measured.

Company H

This car manufacturer stated they had over 50 RPE users, and many of these used compressed-air-fed RPE. We interviewed eight workers, who wore half mask *respirators* with non-replaceable cartridges during paint spraying, in enclosed booths. The hazards and their concentrations were xylene at 100 ppm, n-butanol at 50 ppm and hydrocarbons at 50 ppm. The selection and maintenance of RPE was determined by the company health and safety policy, and individual users were responsible for the day to day maintenance and replacement of their *respirators*.

Company I

Only one end user from a total of five was available for interview at this firm of paint sprayers. He used airfed RPE against the hazard of isocyanates at unknown concentration. All paint spraying was carried out in a paint spraying booth with extraction. A visual check of the colour of spray deposited in the booth, and a check of the air pressure in the RPE supply was carried out daily. There was no formal health and safety procedure, but COSHH information was available. Health checks were not carried out within the company. The younger employees appeared to have a greater health and safety awareness because of their recent City and Guilds training.

Company J

Six users of airline RPE from a total of more than ten at this firm of car sprayers were interviewed. RPE was used during paint spraying in a spray booth with extraction to protect against isocyanates of unknown concentration. The paint storekeeper was responsible for keeping a record of all RPE and replacement RPE parts issued to users. Every four weeks the RPE was checked by him. In the interim period users checked their own equipment and reported any problems directly to the paint storekeeper. This system seemed to work very well and all RPE was well maintained. The maintenance policy was based on COSHH ACOP guidelines. The employees were very aware of the health risks and the need to take good care of their RPE in terms of maintenance and storage. There were disciplinary procedures in place for operators who were found negligent in their use of the issued RPE.

Company K

12 *respirator* users from a total of 20 were interviewed. RPE was used in paint spraying, both primary and repair. The repair paint spraying application involved the use of isocyanates. The primary paint spraying involved organic based paints. The concentrations of neither the organic vapours nor the isocyanates was known to us. Spraying was carried out in booths with extraction and every paint sprayer was issued with airline RPE. The maintenance was undertaken by the maintenance department every six months although formal records did not appear to be kept.

This company has a formal procedure which involves, first, a COSHH assessment. Then any new appliance is assessed for product type, compliance with British or European Standards, and the employees are asked to comment. Each of the three types of RPE used, the half-mask, the helmet and the air-fed visors, had a maintenance card specifying the type of checks, when they should be carried out and a pass or fail grade. These were not, however, used by the staff on the paint spraying lines. In addition a document card has been developed for the distribution of all PPE including RPE, identifying the date of issue and the make.

Selected employees within each section of the company undertake National Vocational Qualification (NVQ) training which includes correct use of

PPE and hygiene procedures applied to paint spraying. Airborne vapour levels are monitored every six months, and health checks on general paint sprayers

take place every two years. The paint sprayers who came into contact with isocyanates also had periodic medical assessments.

Findings of the Survey

The survey resulted in extensive findings, which are summarized below.

General Procedure

Only three of the eleven companies had a formal procedure relating to the COSHH ACOP for the selection, maintenance and use of RPE. Most companies relied on information from manufacturers or personal knowledge. In six companies responsibility for monitoring the state of the RPE rested with the users, who were required to exchange their RPE each month or to conduct a check on the equipment and report back any problems. In three of the companies a designated individual (e.g., supervisor or stores manager) conducted a monthly check. In two of the companies there was no monitoring of RPE because RPE with non-replaceable cartridges was used. The lack of a policy in the selection, use and maintenance of RPE could well account for the lack of formalised procedures to ensure safe and effective use of RPE.

Selection

None of the Health and Safety managers or personnel had received training in the selection of RPE. This could leave the health and safety personnel in a vulnerable position if they are not able to fully evaluate manufacturers' information. The end users were very seldom involved in the testing and selection of RPE. Ignoring this important source of information can lead to a mismatch in RPE to tasks and a lack of acceptance on behalf of the RPE users.

All the companies within this study were supplied with their RPE by local distributors. Advice on the selection of RPE was given by the manufacturers or distributors in seven of the 11 companies and was perceived by the Health and Safety managers to be helpful. The other companies relied on their own experience or chose equipment from a catalogue.

Three companies had a specific RPE budget, which was managed by the Managing Director or the Production Manager, who had freedom with regard to type or quantity of RPE. The other companies indicated that RPE was purchased 'as and when' needed, without financial restrictions. Three companies used airline RPE, all of the same model,

and 32% (6) of users stated that they had a choice in the type of RPE supplied.

Selection of the correct type of filter cartridge is important because different types of adsorbent are required for different hazards (HSE 1990, BS4275 1974). A cross tabulation of the filters and the gases or vapours to which the end users were exposed was carried out. It is possible that the RPE and filter type were issued without sufficient consideration of all vapours present. Of the nine RPE users who were exposed to more than one gas within a process, a third used incorrect filters for the second gas they were exposed to: organic and dust filters for acidic gas/vapours, or acid gas filters for ammonia. One of the smaller car paint spraying companies used half masks with organic filter cartridges for isocyanates, whereas air-supplied equipment should be used to protect against exposure to these or other sensitising agents.

Issue of RPE

In small companies the Managing Director or proprietor issued RPE. In larger companies it was the supervisor or equivalent. In one company a store manager was responsible for the issue and condition of the company's RPE. He kept full and accurate records of the equipment and his responsibilities for RPE were well recognised by all the users. However, this situation was not typical; most users were aware of who issued RPE but the whole system was relatively informal with little structure to the record-keeping. None of the RPE end users indicated a problem with the issue of RPE and collection of replacement parts.

According to BS4275 1974: each reusable device that is permanently allocated to an individual should be durably marked with his name, in a way that does not affect the performance, and the dates of issue should be recorded. In all companies RPE was allocated to a single user only, but in only 6 out of the 11 companies was the RPE marked. A record of the date of issue was kept in only three of the companies. In general terms, the distribution of RPE appears to lack structure in the majority of the companies who participated in this study.

Fit testing

HSE publication "RPE: A Practical Guide for Users" (HSE,1990) states that equipment should always be examined before it is put on, and should not be worn if it is found to be defective or if it has not been cleaned. If the RPE relies on a face seal then a fit check should be performed each time the RPE is put on. A recognized fit check prior to issue was not undertaken in any of the companies who participated in this study.

Health and safety personnel were asked whether fit checks were carried out on newly issued *respirators*. Two stated that such fit checks were carried out occasionally. Five never carried out initial fit checking and the remaining four used airline RPE .

Fit Checks were performed on only two of the *respirators* with non-replaceable filters and one of the half masks. All other RPE was distributed without an initial fit check. The only fit check used was an exhalation test to check the face seal.

96% (25) of *respirator* users said that a fit check had been carried out at the time of issue but this information was correct in only 12% (3) of cases. 77% (20) of *respirator* users said they conducted a fit check before each use of the *respirator*. However, the understanding of fit check by the majority of end users was that of adjusting the straps of the *respirator*. Only two 8% (2) of *respirator* end users were noted to have undertaken the positive pressure fit check prior to use, although 27% (7) of *respirator* users stated that they had received training on how to fit a *respirator*. 96% (25) of *respirator* users claimed they could, in their opinion, obtain a good fit with the one size of *respirator* available.

The 25 users who claimed a good fit included all 11 users who had some choice in the RPE selection and 14 of the 15 who did not. The reason for the *respirator* user thinking he had not achieved a good fit with the *respirator* was that movement affected the fit. The airline RPE users gave a number of reasons for concluding that they had not achieved a good fit with their RPE, such as deformation of the visor, the seal not being intact, and experiencing spray from the process whilst wearing the *respirator*.

RPE that incorporates any kind of face mask depends on a good seal between the skin and the mask for its effectiveness. Many face masks are available in one size only and cannot be expected to fit all the working population (HSE,1990). According

to the manufacturers' information only two of the *respirators* in the study were available in more than one size.

BS4275 (1974) explicitly states that facial hair will adversely affect fit. Any facial hair that comes between the skin and the respirator seating will compromise the seal of the respirator. This may take the form of a full beard, side burns or even cranial hair if the hair is long and casually groomed. Stubble is also a problem but a moustache is unlikely to cause problems since it can be completely contained within the respirator.

Hoods, visors, blouses, or positive pressure devices are often recommended as alternative to equipment relying on a face seal. We judged that 46% (12) of RPE users had sufficient facial hair to compromise the seal.

Spectacles with sides should not be worn if they can interfere with the seal of any facepiece. We observed that several air-fed RPE users wore spectacles, but with difficulty. They caused the foam around the visor to show signs of deformation which could potentially affect the performance of the RPE.

Comfort of the *respirators*

A total of 81% (21) of the users said the *respirator* they used was comfortable, irrespective of whether they had a choice of *respirator*. Four of those who had an option in the selection of the *respirator* felt it to be uncomfortable, even though they reported a good fit. In contrast 21% (4) of the airline RPE users, who did not have a choice of RPE, experienced discomfort. Reasons given for discomfort were that the *respirator* was bulky and unnatural, wearing the respirator caused the user to become too hot and wearing spectacles with the *respirator* caused discomfort.

Cleaning and storage

The HSE users' guide (1990) recommends that RPE should be cleaned and disinfected after each use following manufacturer's instructions, whilst BS4275 (1974) states that cleaning should be as frequent as necessary. It is recommended that rubber face-pieces be cleaned with soap and luke warm water, then thoroughly rinsed.

Despite the RPE manufacturers' recommendations to clean the equipment on a daily basis, this did not seem to be carried out. It appeared that the best

cleaning most items received was a wipe-over with a dry or moist tissue. Antiseptic cleaning was not undertaken. Whether this was due to facilities and materials not being supplied, a lack of training or the user simply not bothering was not clear.

The RPE storage locations were observed to be unsuitable in a number of companies. A typical problem was RPE stored where it could be exposed to workplace hazards. 46% (12) of the *respirator* users stored their RPE in a personal locker away from the work area when it was not in use. However, 23% (6) stored their *respirator* where it could be exposed to gas or vapour even when they were not using it, e.g. in the process booth, on top of a locker, in a tray near the process booth. The remaining 31% (8) stored their *respirators* in a box or locker, within the work area. In contrast, all but one of the airline RPE users stored their RPE in a personal locker away from the work area. The other user stored his RPE in the paint booth.

50% (13) of *respirator* users kept their *respirators* in the place designated by the health and safety representative. 12% (3) of those who stored their *respirators* inappropriately were given a personal choice of storage area by the health and safety representative. Of the RPE users who stored their *respirators* inappropriately, 31% (8) had been given appropriately designated storage.

Use of resealable storage bags

All the disposable *respirators* were manufactured by the same company and were supplied with resealable bags. Of the 11 disposable *respirator* users 55% (6) did not keep their RPE face piece in bag of any description. 27% (3) kept the disposable *respirator* in a resealable bag and the remaining 18% (2) used a box for storing the *respirator*. The half-mask/full-mask/powered *respirators* were stored in 50% (5) of cases in either a bag or a box, the other 50% did not use any type of covering. 84% (16) of airline *respirator* visors were not stored in either a box or a bag.

End of useful life of disposable *respirators* or cartridges

The identification of the end life of the cartridges or disposable *respirators* was the responsibility of the end user either individually or in conjunction with a supervisor. However, 15% (4) of *respirator* users were unaware of their responsibility.

The frequency with which the end life of the filters or disposable *respirators* are checked varies dramatically from daily (15% (4)) to never (38% (10)). Of the four *respirator* users who were trained in the detection of the end life of the filter, three checked their filter daily and one never. The methods used by the RPE users and the health and safety personnel for identifying the end life of the filters or disposable *respirators* are illustrated in Table 2.

Most health and safety managers believed, and recommended, that 'smell breakthrough' was the best way to identify the end life of the filters, though in fact this is a most unsuitable method. This was also the method adopted most frequently by the users. Only one health and safety manager used the recommended means of determining filter life, that is, by calculating a time frame for use. However, as previously noted, many of the health and safety managers underestimated the daily exposure time and the users' work rate. Thus, there are clear potential dangers if the time frame for safe use is based on flawed information. Once again the need for end user involvement is clear.

Type of maintenance

It is generally recommended that the following should be considered during routine checks: face pieces, hoods and blouses should not be cracked, punctured or otherwise distorted; harness stitching should be sound and elastic straps should have good elasticity; inlet and outlet valve mountings should be undamaged and have a perfect joint; filters, canisters and cartridges should be attached securely to the mask, and should be undamaged or undistorted with the colour coding of the gases clearly visible; metal and plastic components should be undistorted, free of damage and securely connected; hoses and airlines should be undamaged, with secure attachment. In addition, with powered RPE, the battery condition, air supply rate and pressure of the compressed air supply should be checked. According to the COSHH regulations (1996), a record must be kept of cleaning, inspection and maintenance.

The maintenance procedures carried out by either the RPE users or the individual responsible did not, in the majority of cases, comply with the manufacturers' recommendations. Only two of the companies who participated in the study followed a formalised procedure of maintenance checks. One of the larger companies also had maintenance

Table 2. The methods used to identify the end life of the filters by both the Health Safety managers and respirator users.

End life identification method	% of <i>respirator</i> users (frequency)	% of Health and Safety managers
Smell break through	38% (10)	63.6% (7)
Hygiene	4% (1)	
Visual check	12% (3)	27% (3)
Breathing resistance	15% (4)	—
Time frame	27% (7)	9.1% (1)
Not known	12% (3)	—

Note: Some *respirator* users used more than one method to identify endlife.

procedures, but, the investigators were told that these procedures were not carried out stringently.

The level and quality of record keeping varied greatly between user companies. Two of the car manufacturers had full and accurate records of RPE issue, maintenance and use. One of these companies had an enthusiastic person responsible for most aspects of RPE issue and use and it appeared that he was central to the success of the system. Other large companies had a recording system in place but those responsible for its completion and maintenance admitted that it was not always used. Generally the smaller companies did not have any formal system for the recording of the pertinent information.

Some of the smaller companies did not have full records of the concentrations of gas and vapour in the workplace. They tended to decide on the need for *respirator* use from knowledge of the materials present. Again, in general the larger companies had more complete details of the gas/vapour concentrations, but details were not made available to the investigators.

The wide variety in the type of maintenance undertaken within the companies is illustrated in Table 3. A cross tabulation between those RPE users who had received training and the type of maintenance they undertook did not indicate that maintenance of a higher standard was associated with training.

Work conditions

According to BS 4275 (1974), RPE use will be affected by work duration, activity of the wearer, vision, communication, temperature extremes and the necessity for eye protection. One of the particularly interesting findings from this study was the discrepancy between the health and safety managers' views of the duration of RPE use and the work effort and the statements provided by the users. Typically, the users wore the *respirators* for longer and worked more intensely than the health and safety managers thought. This goes to further reinforce the need for an active users' role in RPE selection at the workplace. Furthermore, the other factors listed above can only be properly considered by suitable user testing.

50% (23) of the interviewees said they had a maximum daily exposure to gas or vapour of seven or more hours. It may be unlikely that they would be exposed greatly for the whole working day but these responses implied that the RPE users were certainly in the vicinity of the process for most of a working day. Nine RPE users conducted a second process as part of their work. Of these, five said they had a maximum daily exposure to gas or vapours for eight or more hours.

The stated maximum weekly exposure to gas or vapours varied from one hour (7% (3) of RPE users)

Table 3. The type of maintenance undertaken by the RPE end users.

Type of maintenance	Disposable	Half-mask with cartridges	Full face- mask with cartridges	Powered	Air-line RPE
No maintenance	18% (2)	27% (3)	—	—	22% (4)
Replace dirty	18% (2)	—	—	—	—
Replace daily	18% (2)	—	—	—	—
General check	18% (2)	—	—	—	—
Clean only	27% (3)	9% (1)	—	—	11% (2)
Replace peel off	—	—	—	—	11% (2)
Clean, replace peel off visor	—	—	—	—	22% (4)
Clean and general check	—	9% (1)	—	—	—
Clean, check and change filter	—	55% (6)	—	—	5.5% (1)
Replace peel off and charge battery	—	—	—	100% (1)	—
Clean, replace peel off and check airline	—	—	—	—	28% (5)
Clean, full check and replace peel off	—	—	100% (3)	—	5.5% (1)*

* The filter in question was the airline filter, designed to remove oil and water from the air supply

to 45 hours (2% (1) of RPE users). The average weekly exposure was 20 hours.

Enclosed spaces. In this study enclosed spaces are defined by a subjective assessment on the part of the RPE users, i.e. any area that the RPE user felt was small, cramped or enclosed. 54% (14) of *respirator* users never worked in enclosed spaces, 42% (11) sometimes and 4% (1) always. For airline RPE users the figures are 79% (15), 21% (4) and 0.

Workrate. Workrate was classified by both RPE users and health and safety representatives as low, medium or high. 51% (23) of all RPE users stated their workrate to be of medium and 40% (18) high intensity. Agreement between the results from the

RPE users and their respective health and safety representatives, was found for 17% (8) of RPE users. 74% (34) of RPE users judged the workrate as being higher than their respective health and safety representatives estimated.

More than 60 % of the *respirator* wearers worked for four hours or less each day, at medium intensity. 53% (9) of airline RPE users who worked at medium intensity were also in an environment where they were exposed to gases or vapours for eight hours. None felt they had a high workrate. Whether this is in part due to the type of RPE used is unknown, but air-fed equipment may be less stressful than a *respirator* when worn for long periods.

Training

Training was deficient in nearly all companies visited. Where it had been undertaken it was clear that users had either forgotten it or chosen to ignore it. An illustration of this is the number who did not undertake a suitable fit check when donning the *respirator* and who did not clean it adequately, though it is likely that they would have been trained to do both. Much of the training referred to in this study was provided by in-house personnel. None of the companies retrained their staff in the use and maintenance of RPE even though this is recommended in the HSE's guide for users.

However, manufacturers of RPE often provide training for the users. One in particular has a comprehensive training service for medium to large scale users of their products.

Manufacturers are required to provide instructions for use with the RPE, but these were often ignored. This puts manufacturers and distributors in a very responsible position, and it means that for very many of the RPE user companies there could be a long and involved cascade training: RPE manufacturer, distributor, health and safety officer, supervisor, user. An example where such detailed information and direction appeared to be absent was in one of the companies using RPE in paint spraying. The RPE was always worn whilst spraying in the booth, with extraction, but was not worn when mixing the paint away from any form of extraction facility, where vapour would be present but no spray would be visible.

According to the users 88% (23) of the *respirator* users and 63% (12) of the airline RPE users received written instructions with the RPE on allocation. However, training was given to only 38% (10) *respirator* and 32% (6) airline RPE users.

Of 11 health and safety personnel questioned 36% (4) stated that RPE users are trained at the commencement of RPE use of which 27% (3) that users are given one-off training and 9% (1) that they receive ongoing training. No ongoing training was carried out at any of the companies who participated in this study.

Of the 16 RPE users who received training 19% (3) considered that training was the responsibility of the Stores manager, 19% (3) the Works manager, 13% (2) the NVQ trained or City and Guilds trained individuals, 6% (1) a health and safety consultant,

6% (1) the Manufacturer/distributor, and 6% (1) the Supervisor. In 31% (5) of cases the responsibility was not known. Neither the Stores Manager nor the Works Manager received formal training on the use and maintenance of RPE.

The presentation of the training was predominantly verbal. 56% (9) received training on the job, and 38% (6) from a formal lecture. One RPE user was trained using a video. Of the *respirator* users 27% (7) considered that the content of the training was how to fit the respirator, 15% (4) how to identify the end life of the filter, 27% (7), how to clean and maintain the *respirator*, and 11% (8) hazard identification and risk awareness.

Of the airline RPE users, 21% (4) considered that the content of the training was how to fit the *respirator*, 21% (4), how to identify the end life of the charcoal filter, 31% (6), how to clean and maintain the *respirator*, and 21% (4), hazard identification and risk awareness.

Perception of Respirator efficiency

92% (24) of the *respirator* users thought that the *respirator* did its job. The two who did not had no say in its selection nor did they conduct a fit check prior to its use. In contrast, 16% (3) of the airline RPE users who did not have a choice of RPE felt that it was not doing its job. The reasons given by the users for feeling the RPE was not fully efficient were vapour entering the mask (airline RPE only), that the *respirator* did not feel effective, and that their heavy workload reduced the efficiency of the *respirator*.

Risk perception

The RPE users were asked to consider whether their working environment was dangerous. 85% (22, of whom 14 had received training) of *respirator* users and 95% (18, of whom 6 had received training) of the airline RPE users stated that it was. The four *respirator* users who stated that the working environment was not dangerous were all from the same company, which had good extraction facilities and an in-house training programme.

A cross tabulation between the daily exposure to the hazard and the perceived danger demonstrated no relationship between the length of exposure to the hazard and the daily exposure for both *respirator* users or airline RPE. Similarly, there was no relationship between the weekly exposure and perceived danger.

54% (14) of *respirator* users and 42% (8) of airline RPE users who removed the RPE whilst in the working area stated that this action was dangerous. The reasons given for believing the removal of RPE in the work area was not dangerous are: that it was removed for a short period of time only, that it was removed only when the end user has stopped working, that extraction was present or that it was removed far from the immediate hazard.

Visual inspection of RPE by researchers

The RPE used within each company was examined. General cleanliness, perished or incorrectly assembled straps, and any obvious damage to the shape or structure of the RPE, the seal, the cartridges or the air lines of airline RPE was noted.

Only one of the airline RPE observed had damage to the foam around the visor. Whilst wearing glasses with this type of RPE had caused the finish of the foam to deteriorate slightly, there was no evidence that the seal had been compromised.

The overall cleanliness of the *respirators* with non-replaceable cartridges which were currently in use ranged from poor to acceptable. However, the half/full-masks and powered *respirators* in general appeared to be relatively clean. The overall cleanliness of the exterior of the airline RPE was, in general, good because the use of pull-off visor covers was common place, but there was often a film of particulate matter on the inside.

Conclusions

The difficulty of this type of investigation can be illustrated by the massive disinclination of companies to participate. Only 152 out of 476 companies responded, and 94 claimed that they did not use RPE. Since the companies contacted included paint spraying, fibre-glass production and electroplaters it seems improbable that such a large percentage of these either have no hazardous substances or provide excellent control at source and hence do not require the use of RPE. Only 11 allowed us access to the operators. Even clients for whom we have worked on previous occasions were reluctant to participate, possibly owing to the sensitive nature of the study, or because the work was funded by the HSE.

Cooperating companies probably felt that their policy and action in this area of RPE was correct. It is unlikely that conditions at firms who declined were better than at cooperating firms. Very few of the companies in the study had formed health and safety procedures and not all of these implemented them fully.

Companies are very reliant on external sources (manufacturers and suppliers) when selecting RPE. Information supplied by an RPE manufacturer is limited and there is a danger that user companies could rely too heavily on this and fail in their duty to the user. Generally, detailed risk assessments are not considered when selecting RPE. Health and safety personnel generally underestimated the duration of exposure and work rate, important considerations in RPE selection.

A number of RPE users within the study experienced some degree of discomfort, heat, bad vision with spectacles and problems with communication. Some workers removed their RPE even though they considered the environment to be hazardous. There is a need for close user involvement in testing and selection of suitable RPE. This process might involve testing of RPE under true working conditions for several days by a representative sample of users. Some form of structured feedback to the person responsible for purchase should be provided. There should be an ongoing monitoring of the suitability of RPE for the work being done.

All participants, health and safety officers, users, issue and maintenance personnel, should be aware of their responsibilities for ensuring the quality of equipment at issue and throughout its life cycle. Responsibility for some day-to-day user training could also be given to issue personnel. A recognised fit check should be carried out upon issue and subsequently at regular intervals, and it should be acted on if poor fit is revealed.

Manufacturers' instructions for cleaning should be followed. In addition to training all end users in simple maintenance tasks, for effective maintenance of RPE it is important to have a dedicated individual who is responsible for the issue and upkeep of the RPE as part of their job description. The designation of a person to be responsible for the issue and maintenance of RPE was seen to result in good

practice and record keeping. In the companies who participated in this study, maintenance was usually the responsibility of the end user, though some were not aware of this.

Few companies undertook training, and in those who did it was generally ineffective. The training provided should be practical, targeted and regularly updated and it should be part of a system which encompasses all levels of staff within the company. As HSE's guidance document states 'Managers and supervisors must also be aware of why RPE is being worn and how it should be worn properly'. None of the health and safety managers had received training on the selection of RPE and only one had received any training on its maintenance and use. This is despite the fact that they play a central role in the

selection and use of the appropriate RPE for their company. The training should also include some basic Health and Safety Legislation and responsibilities. This should cover the responsibilities that employees have in using equipment provided for their own protection and their duty of care.

Employers should recognise that their duty of care extends beyond simple provision and maintenance of RPE to the extent that mandatory use of RPE, where identified, must be enforced. The end user should be aware of the useful life of filter cartridges and should leave the contaminated area well before the cartridges become saturated. The absence of smell breakthrough should never be relied upon to indicate protection.

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