

Review of occupational hygiene reports on suitability of respiratory protective equipment (RPE)

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This report presents an overview of evidence on RPE and user behaviour drawn from a number of sources, including published material; IOM reports; and the expertise and experience of IOM staff. It provides an evidence-base for factors influencing the use (or non-use) of RPE in the workplace and on how well RPE programmes are currently implemented.

Although the remit was RPE, the study adopted a wider remit of personal protective equipment (PPE), on the basis that, although there will be equipment specific issues, the underlying principles influencing the use of any PPE will be essentially the same as those specifically relating to RPE.

From the reviews, it is clear that the first steps in any RPE programme start with management. Managers at all levels need to:

- recognise the need for RPE;
- accept their role in an effective programme;
- ensure that appropriate RPE is selected;
- ensure that sufficient RPE is provided;
- ensure that information and training needs are met;
- play their part in enforcement and supervision, including leading by example where appropriate;
- make suitable provision for cleaning, maintenance and storage (as appropriate).

Many of these functions have parallels within the workforce where the following issues were identified:

- hazard awareness and risk perception;
- behaviour;
- worker involvement;
- comfort and disability;
- compatibility.

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1 INTRODUCTION

The Health and Safety Executive (HSE) is undertaking a cross-cutting project under the Disease Reduction Programme (DRP) to help reduce respiratory disease by promoting good practice in the selection, maintenance, supervision and training for use of respiratory protective equipment (RPE). To achieve this aim, the project requires sound research evidence on RPE and user behaviour to support interventions and to embed the advice with employers and employees.

This report presents the findings of a review of such evidence drawn from a number of sources and aimed collectively at providing a clear evidence-base for the factors influencing the use (or non-use) of RPE in the workplace. Although the emphasis of the overall project is on respiratory protection, the study reported here adopted a wider remit of personal protective equipment (PPE) in general, on the basis that, although there will be equipment specific issues, the underlying principles influencing the use of any PPE will be essentially the same as those specifically relating to RPE.

2 BACKGROUND

HSE Analysis of the 2005 HSE FIT 3 workplace survey (Thompson & Wake, 2007) suggests about 5.5 million employees in around 224,000 workplaces could be at risk of respiratory disease. Of the employers specifically asked about the use of respirators nearly half reported that they have workers using RPE and that the majority of these had received some level of training.

However, according to the same source, a recent HSL investigation of seven companies, together with information gathered from the welding and poultry industries, concluded that:

- There was a lack of specific training for employees on the use of RPE;
- Selection, storage and use of respirators was often incorrect;
- There was a low overall awareness of and concern for the risks posed by fumes and gases;
- There was a lack of enforcement of RPE use by employers.

The HSE believe that these failings are likely to be caused by:

- Incorrect equipment being selected;
- Badly fitted equipment;
- Incorrect usage of RPE;
- Lack of training in correct use of RPE;
- Incorrect storage of RPE.

In addition, other factors may also play a role, including the nature of the hazard, the type of RPE, level of comfort, and the enforcement of use within the company.

A very recent report (Easterbrook, 2009) included aspects of RPE use in a survey of exposures to and control of Respirable Crystalline Silica (RCS). Covering four sectors (brickmaking, construction, stonemasonry, quarrying) it provided further evidence of the general inadequacy of RPE programmes. As part of the project, "RPE Competency Descriptors" were developed, using verbal descriptors to categorise sites on a scale ranging from 1 (no evidence of use or provision of suitable RPE) to 5 (evidence of exemplary RPE programme with only minor deviations from agreed practices and policies). The majority of sites visited for the survey were rated at 2 or less on this scale.

3 AIMS AND OBJECTIVES

The overall aim of the project was to collate information from various sources on investigations of RPE use to provide information on how well RPE programmes were currently implemented.

Against this overall aim, a series of specific objectives were drawn up:

- Provide an overview of the peer-reviewed literature on determinants for and barriers against proper RPE use;
- Review occupational hygiene consultancy and research reports undertaken by the IOM from 2005 onwards and extract information on RPE use;
- Interview occupational hygienists and other relevant staff at IOM to gather information on RPE use and their experience in reasons for inappropriate use of RPE;
- Hold an Internal Workshop with IOM occupational hygienists and other key scientists to determine the relative importance of the barriers to appropriate RPE use and suggest solutions;
- Prepare a report to the HSE and a paper for submission to the Annals of Occupational Hygiene for publication

In order to achieve these objectives the remit for the reviews and interviews was extended to encompass all forms of PPE.

4 OVERVIEW OF THE PEER-REVIEWED LITERATURE

4.1 INTRODUCTION

The aim of this overview was to explore the published scientific literature for papers which provided an overview of the factors (determinants for and barriers against) relating to proper RPE use to protect against exposure to respiratory hazards. It was not intended to conduct an exhaustive evidence-based review, such as might be conducted to establish the efficacy of an intervention. However, the intention was for the search strategy and subsequent selection of papers to provide sufficiently comprehensive coverage of the literature to give confidence that all relevant issues had been identified and documented.

4.2 LITERATURE SEARCH CRITERIA

In keeping with the overall philosophy outlined earlier, the search was widened to encompass papers on PPE in general. The following search terms were therefore included:

- Personal protective equipment;
- PPE;
- Respiratory protective equipment;
- RPE;
- Respirator.

and one of the following terms at a time:

- Behaviour;
- Attitudes;
- Awareness;
- Risk perception;
- Knowledge (of risks or hazard);
- Problem;
- Barrier;
- Safety culture;
- Comfort;
- Non-use;
- Wear;
- Heat;
- Communication.

Those articles which focussed on factors affecting the effectiveness of the PPE but which did not relate this to the use/non-use of RPE were excluded. The search was also extended to those relevant articles cited in the selected articles.

The databases searched were: PubMed, ISI Web of knowledge, British Library (BL), Barbour Index and Google Scholar.

The search terms in ISI Web of Knowledge were entered as topics. This resulted in retrieval of the same papers when entering PPE/RPE/respirator & other search terms. Therefore, searches in PubMed, and BL were performed by entering PPE/RPE/respirator in the title and the other search terms as topic/descriptor words. The search in Google Scholar was restricted to respiratory protective equipment, since a Boolean search of personal protective equipment and awareness, behaviour, etc, retrieved around 6,000 documents.

Before requesting the full papers for review a two-stage screening was carried out. The first stage was a filter process examining the titles of the papers obtained. Those outside the topic for review were eliminated. The second stage of the screening process was to screen abstracts against the inclusion and exclusion criteria. Where it was unclear whether the paper should be included or excluded, a conservative approach was taken and the full paper obtained.

One recently published report (Easterbrook, 2009) provided evidence for the general inadequacy of RPE programmes in the sectors investigated. However, it provided little specific evidence regarding the attitudes to or awareness of RPE usage, or of barriers to that usage, and was not therefore included in the main review.

4.3 LITERATURE OVERVIEW

4.3.1 Industrial sector

Five studies were identified which reported information on the determinants and barriers of use of PPE among industrial workers, four in the US and one in New Zealand. The same factors identified in studies in the 1990s were reported in later studies. Detail on the type of RPE used is given where available.

Akbar-Kahnazadeh (1998), in a study in a metal refining plant in the US, reported that workers identified discomfort as the main reason for not using PPE: glasses limited vision; hard hats were too heavy; respirators (full-face and half-mask, silicon and rubber) irritated the skin; hearing protection was hard to wear; gloves interfered with work; shoes were too heavy; and harnesses interfered with work. The belief that PPE was not needed was strongest for hard hat wearing.

White et al. (1988), in a survey of industrial spray painters who used chemical cartridge respirators, also found discomfort as the main reason for non-use. However, beliefs about the efficiency of the respirator, or of the health consequences of being exposed were also correlated with respirator use, although less strongly.

Similar results were reported by Laird et al. (1993), in a survey of use of RPE by industrial workers in New Zealand. Feeling too hot, difficulty in breathing and lack of vision were the most common barriers against respirator use. Despite improvements in respirator fitting (Campbell et al., 2001), more recent studies have identified the same factors as barriers for RPE use (Salazar et al., 2001).

Salazar et al. (2001) examined different attitudes towards the use of respirators according to type of respirator, frequency of use and health symptoms. The authors interviewed 255 employees in a weapon facility in Washington State. Eighteen factors were identified as affecting the use of RPE. The main negative barriers identified by the authors were: lack of communication and vision when wearing the RPE; poor comfort; the "structural environment" (e.g. space constraints in the workplace) and fatigue (defined as "the mental and physical state related to concern about exposure and to the burden associated with respirator use").

The results were analysed according to the type of RPE used and, separately, the frequency of such use. The substances they could potentially be exposed to was considered the most important determinant for respirator use amongst air-purifying respirator (filter respirator) users whilst training (information and knowledge about its use) was considered to be most important for users of supplied-air respirators

(breathing apparatus). However, these two and fit-testing were the top three factors in both categories.

The results were divided into those from employees who wore RPE less than once per month and those who wore it once a month or more. For all RPE types taken together, the substances they could potentially be exposed to was considered the most important determinant for respirator use by both groups. Fit-testing and training made up the top three for both usage groups although the relative order was reversed such that those using RPE more frequently rated fit-testing more highly whilst training featured more strongly in the group of less frequent users.

It is interesting to note that factors such as organisational culture and pressures from peers or supervisors did not feature as strong influence on RPE use.

Similar factors were identified for non-use of PPE for dermal exposure amongst industrial workers in the US (Geer et al. 2007). Risk of exposure, as in Salazar's study, and efficacy of the PPE, were identified as the major determinants of use. The fact that workers had never had a health problem was identified as a barrier for PPE use. Neboit et al. (2000) highlighted that an important factor influencing risk perception for chemical hazards is the lag between exposure and any health effect (short or long term): long term health effects may be perceived as hypothetical and produce a negative reaction for PPE wearing.

4.3.2 Agricultural sector

Vaughan et al. (1993), in a study of the relationship between risk perceptions and self-protective behaviour in immigrant farm workers in the US (who were chronically exposed to pesticides), concluded that information to the workers about the risk, their belief in the efficacy of the PPE and confidence about their own ability to control exposure were determinants of PPE use.

MacFarlane et al. (2007) interviewed 1102 farmers recruited from the most common agricultural activities in Victoria, Australia. The study indicated that farm chemical training and schooling were positively associated with wearing of PPE (gloves, boots, clothing, half-face cartridge respirators). Older farmers were more inclined not to use PPE, possibly because they were less likely to have had such training (MacFarlane et al. 2007). The use of respirators was generally very low. Respirators were mostly used during mixing of pesticides but not during application. MacFarlane et al. suggested that this could be due to the farmers' awareness of the higher exposure during mixing compared to application. Similar behaviours were previously observed by Avory et al. (1994), Murphy et al (1996); Mandel et al. (2000) and Hwang et al. (2000).

When farmers believed that the risk health was low they were less inclined to wear respirators (Nieuwenhuijsen et al., 1996; Mitchell et al., 2008). For example, in a longitudinal study of 4500 farmers in California from 1993 to 2004, 50% of farmers reported wearing respirators most of the time when exposed to pesticides. However, fewer than 10% of farmers wore a respirator most of the time when exposed to dust.(Mitchell et al., 2008). These authors observed that dust was perceived as a nuisance rather than as a hazard. In this study, education and age were not associated with respirator use.

Other barriers to agricultural workers wearing RPE included discomfort, safety hazard of wearing the equipment while performing tasks requiring exertion; and the lack of education in their use (Ehlers and Palermo, 2005; as stated by Mitchell et al.,

2008).

4.3.3 Health care sector

More studies were found which focused on health workers than related to other working sectors. The main barriers reported in this sector were lack of time, especially in emergency situations, (Kelen et al., 1990); interference of the PPE device with the care of the patient; and personal discomfort (Kelen et al., 1990; Linn et al., 1990; Hammond et al., 1990; Willy et al., 1990; Hoffman-Terry, 1992; Gershon et al., 1995; Helfgott et al., 1998; Akdumman et al., 1999, Preston et al., 2002; Nickell et al., 2004; Tan et al., 2006; Mathews et al., 2008). Lack of knowledge about the consequence of exposure has not been found to be a barrier to the use of RPE amongst health workers (Gershon et al., 1995; Helfgott et al., 1998; Bryce et al., 2008).

Linn et al. (1990), in a study of glove-wearing in response to risk of HIV infection, observed a positive association between risk perception and glove-wearing. Akduman et al. (1999) observed a higher usage of double gloves by staff working in higher-risk surgical rooms compared to other surgical rooms where exposure to sharps was lower. A recent study in 2007 of surgical nurse's behaviour in Poland reported similar results (Ganczak et al., 2007). Those nurses who were more afraid of acquiring an infection were more likely to comply with PPE regulations. This study showed that nurses trained on infectious diseases were also more likely to wear PPE. Other reasons for non compliance were non-availability of the PPE (37%); wearing interfered with good patient care (32%); lack of time (19%); and the perception that the PPE provided was ineffective (9.8%).

It has been suggested that these barriers would probably be more influential during emergency situations such as an influenza pandemic. Phin et al. (2009), in a study of a simulated influenza pandemic exercise in a hospital in the UK, reported that the main barriers to PPE use were: patients being uncomfortable because they could not see the face of their carers; and tasks took longer to complete when wearing PPE. However, it should be noted that the issue of the discomfort of patients was the perception of the carers and did not necessarily reflect the views of the patients. For example, in a separate field, the perception of patient dislike as a barrier to the use of patient hoists was shown to be misguided (McGuire et al, 1996; Moody et al, 1996) and it is possible that similar misguided perceptions may be occurring with respect to RPE use.

Nickell et al. (2004), in a study in a hospital in Toronto during the severe acute respiratory syndrome (SARS) outbreak in 2003, cited physical discomfort as the main barrier for non-use of masks, followed by difficulty in communicating; difficulty in identifying people; and a sense of isolation.

In Singapore, Tan et al. (2006), in an examination of the factors influencing non-use of RPE by family physicians during a SARS outbreak, reported that lack of initial information about the severity of the disease and the lack of belief in the efficacy of the equipment influenced health care behaviour.

In health environments with a lower risk of infection, for example in dental clinics, risk perception was found to be a barrier against use of PPE such as gloves, masks, and eye wear (Lange et al., 1995). The authors argued that possible reasons arose from a lack of knowledge, a belief of being able to assess the risk from the medical history of the patient or a naive belief that "it won't happen to me". Discomfort when treating the patient (decreased sensation/restricted movement) was also found to be a

barrier, which could reflect the fact that most of the dentists surveyed were educated at a time when glove wearing was not compulsory (Lange et al. 1995).

4.4 LITERATURE OVERVIEW SUMMARY

Most of the studies on the use of PPE have focused on compliance and some on the effect of intervention programmes. Fewer papers have been published on the attitudes and behaviours of workers related to the use and non-use of PPE. Specific studies on attitudes towards RPE were scarce in the literature. Therefore, this overview includes studies on attitudes towards the use of general PPE (gowns, masks, eyewear, gloves, etc) as information gathered in these studies can usually be translated to RPE.

The factors that influence a workers decision whether or not to wear a respirator are complex and they are not homogenous between and within work environments. The major determinants for the use of PPE reported in the literature review included risk of exposure and knowledge of the consequence of the exposure. The major barriers to their use included physical discomfort, lack of time, perception of low risk and negative belief in their efficacy.

The relative importance of these factors varies with the work environment and sometimes with the specific PPE. In the case of RPE, usage factors are also possibly influenced by the type of RPE. However, the type of respirator used was not always indicated in the reported studies, which makes it difficult to properly evaluate this factor.

In the industrial sector physical discomfort (such as thermal problems and breathing difficulty) was identified as the main barrier for non-use of PPE, especially in those jobs which demanded high physical activity. The frequency with which it was necessary to wear respirators, respirator type and individual worker's experiences (e.g. health symptoms) were also found to influence workers behaviour towards the use of respirators (Salazar et al. 2001).

The main determinant for the use of PPE amongst agricultural and healthcare workers was perception of risk. Perception of risk can become a barrier when workers perceive the risk as low as, in such circumstances, they are less convinced of the value of wearing PPE (Dejoy et al. 2000).

Use of PPE has been positively associated with younger workers in the agricultural sector (McFarlane et al. 2007) and the health care sector (Helfgott et al. 1998) possibly signifying an age-related change in attitudes to risks. However, it is not clear from this study whether this is due to younger people being more risk-averse or older workers being more reluctant to wear PPE for some reason.

Results from the studies reviewed suggest that an effective intervention should focus on several determinants and be specific to each workplace. The review studies agreed that propaganda itself it is not enough to promote wearing of PPE.

Table 1 summarises the studies that have examined the attitudes of workers towards the use and non-use of PPE.

Table 1: Summary of studies examining determinants and barriers on PPE use

Reference	Work environment	PPE	Reasons for non-use of PPE	Reasons for use of PPE
Industrial workers				
White et al. 1988	Industrial painters (US).	Respirators (unspecified)	Personal comfort; Respirator availability; Cigarette smoking; Social influences (the attitudes of the entire workforce).	
Akbar-Kanzadeh et al. 1995	Workers in metal alloy & ceramic plant (US).	Respirators (full-face and half-mask); Face masks; Gloves; Safety glasses; Safety boots; Harnesses.	Was not needed; Created a new hazard; Interfered with work; Discomfort (too heavy, hard to wear, restricted breathing or communication, irritated skin, incorrect type or model).	
Laird, 1993	Industrial workers (New Zealand).	RPE (unspecified).	Personal comfort (felt too hot, difficulty in breathing, not seeing adequately).	Risk perception
Salazar et al. 2001	Hazardous waste workers (Washington, USA).	RPE (air purifying & air-supplied).	Communication & vision problems; Personal comfort (fatigue); "Structural environment" (e.g. space constraints).	Air purifying respirators: Risk perception; Fit-testing; Training. Air-supplied respirators: Training; Risk perception; Fit-testing.

Geer et al. 2007	Industrial workers (Baltimore & Lancaster, USA).	Dermal PE.	No previous health problems.	Confidence on knowing how to use the PPE; Confidence on the efficiency of the PPE.
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Farmers

McFarlane et al. 2007	Farmers (Victoria, Australia).	Respirators (half-mask); Face masks; Gloves; Safety glasses; Protective clothing.	Lack of knowledge (non-use of PPE associated with older, less trained workers).	Risk perception.
Mitchell et al. 2008	Farmers (California, USA).	Respirators (unspecified) for pesticides & dust.	Long periods of usage.	Risk perception (higher use of respirators for pesticide handling than dust).

Health care workers

Akduman et al. 1999	Surgical workers (St Louis, Missouri, USA) Exposed to blood & body fluids.	Eye wear; Gloves; Gowns.		Younger workers associated with higher use of PPE.
Preston et al. 2002	Nurses (Pennsylvania & New York, USA).	Gloves; Gowns; Face masks.	Knowing patients were not HIV positive.	Risk perception.
Linn et al. 1990	Physicians (California, USA). Exposed to blood & body fluids.	Gloves.	Low likelihood of disease transmission; Fear of offending patients; Compromise care.	Younger workers showed higher risk perception.

Hammond et al. 1990	Surgical residents in trauma room resuscitations (USA)	Gloves; Gowns; Eye wear protection; Clothing protection.	Lack of time; Forgot; Perception of low risk; Perception PPE was unnecessary.	
Kelen et al. 1990	Residents in emergency department (USA)	Gloves; Gowns; Eye wear; Face masks.	Lack of time; Interferences with skill; Personal comfort; Perception of low risk; Perception PPE doesn't work; Lack of availability.	
Willy et al. 1990	Mid-wives (USA).	Gloves; Gowns; Eye wear; Face masks.	Interferences with patient relationship; Decreases dexterity; Perception PPE was unnecessary; Lack of availability; High cost of PPE; Ignorance of PPE use.	Perception of risk.
Hoffman & Terry, 1992	Surgical & medical resident physicians (USA)	Gloves; Gowns; Eye wear; Face masks.	Lack of time; Lack of availability; Affect the relationship with the patient; Perception PPE doesn't work.	Perception of risk
Gershot et al. 1995	Health care workers (USA)	Gloves; Gowns; Eye wear; Face masks.	Lack of availability.	Perception of risk; Have received training.

Helgott et al. 1998	Students on deliveries and surgical rooms (US).	Gloves; Gowns; Eye wear; Face masks.	Lack of time; Personal comfort; Perception of low risk; Ignorance of PPE use.	
Bryce et al. 2008	Intensive care unit workers (Vancouver, Canada).	Respirators (half-mask).	Lack of knowledge was NOT identified as a barrier.	
Ganczak et al. 2007	Surgical nurses (Poland)	Eye wear; Gloves; Gowns.	Non-availability of the PPE; Belief patient was not infected; Wearing interfered with good patient care; Lack of time; Belief equipment was ineffective.	Fear of acquiring HIV; Trained nurses showed higher wear of PPE.
Lange et al. 2005	Dentists in Brisbane private clinics (Australia).	Respirators (half-mask); Gloves; Gowns; Face masks; Eye protection.	Perception of low risk.	
Phin et al. 2009	Nurses (UK) (simulation influenza pandemic exercise).		Interferences with skill; Patients felt uncomfortable;	

5 OVERVIEW OF IOM RESEARCH REPORTS

5.1 INTRODUCTION

As part of the review of existing knowledge on factors affecting the use of RPE, previous IOM research reports (Technical Memoranda and HSE Contract Research Reports) were scanned for information of interest. As with the overview of the mainstream published literature, the focus was not limited to RPE but extended to encompass other forms of PPE for which the principles could be regarded as transferable. From this material the following overview was prepared. Not all of the reports identified have been summarised here, to avoid unnecessary duplication of the points made.

5.2 SUMMARY OF STUDIES AND OF RELEVANT FACTORS IDENTIFIED

As early as 1984, IOM studies were identifying aspects of PPE selection and use which remain relevant to this day. Coleman et al. (1984) studied various aspects of communication in noisy environments, including the use of hearing protection and its influence on communication. In summarising the factors influencing the use of such protection, the authors referred to concerns regarding over-protection. One of the reasons for that was the observation that the factors most associated with higher performance tended to be those which were most likely to lead to adverse subjective responses. In the case of hearing defenders these included defender weight and clamping force (to the side of the head). Similar arguments can be applied to RPE. Although clearly there are differences between types of RPE, higher performance RPE tends to need to fit more closely (and probably firmly) to the face; is likely to be heavier; and may well also have a higher respiratory (inhalation) resistance. However, in recent months, direct examples have been encountered during site visits of employers taking the line that it is convenient to provide all employees with a consistent product and therefore issuing them all with Type 3 RPE (P3), even where a risk assessment indicates a need for a lower performing product. This may well result in an unnecessary load on the wearer with a concomitant reduction in willingness to wear the RPE or a tendency not to wear it correctly (e.g. to reduce the tightness of fit).

Coleman et al (1984) also highlighted maintenance and cleaning requirements in relation to hearing protection which are probably of greater relevance to reusable RPE, as poor cleaning is not just a question of personal hygiene but can also adversely affect exposure. Again, examples have been encountered in recent years during site visits by IOM consultants of inadequate procedures in place for cleaning and maintaining RPE, a factor which undoubtedly contributed to employees receiving measurable exposure to contamination.

A further issue raised by Coleman et al (1984) was that of unwanted 'side effects'. With the hearing defenders it was impaired communication and diminished sound location. Interestingly, impaired communication was also identified in respect of RPE in a later IOM study of powered helmet respirators (PHR). In this instance (Howie et al, 1987) it was not primarily the sound levels at the ears which were affected (although some forms of powered helmet respirator incorporating the fan in the helmet could have this problem). In the case of PHRs the main impact was due to the visor impairing the audibility of speech leading to the commonly reported habit of lifting the visor (and therefore losing all respiratory protection) in order to talk to colleagues. Again, although reported in the 1980's, this issue remains relevant today and more recent reports of observations of such actions have been received.

Perhaps the most prevalent potential side-effect with RPE is that of respiratory resistance, particularly on inspiration rather than expiration with the wide-spread (but not universal) inclusion of exhalation valves. Again, this has long been recognised as a concern, with seminal work by IOM staff, such as Bentley et al. (1973), establishing acceptable levels of such resistance. However, reports continue to be received of complaints by workers of excessive breathing resistance, although the possibility that this was simply a convenient focus for other problems must be considered. In some forms of RPE and contaminant this could however possibly be an indication that such devices are being worn for too long and filters are becoming clogged.

Rushworth et al (1986) reported on ergonomic aspects of fall-arrest harness use in vertical storage bunkers. Although the connection to RPE might not seem immediately obvious there were a variety of issues identified for which parallels can be drawn with RPE (and other PPE) use. The first of these was the issue of risk perception. Potential wearers had been doing the work for some time, and regarded themselves as somehow less at risk ('I've been doing this job for years and I haven't fallen yet'). Similar issues can arise with RPE when recognition of new risks results in a requirement for protection where none was considered necessary before. Past examples of this include benzene and mercury exposures, as well as (at one time) asbestos.

The second issue was the perception that the effort of obtaining and donning a harness was 'not worth the hassle' where only a brief exposure was anticipated. Clearly, whilst the exposure to a fall situation needs only to be fleeting, making this a particularly acute issue with harnesses, some acute respiratory hazards can result in a biologically significant exposure with only a relatively brief exposure. Clearly, if such attitudes can apply to the severe consequences of not wearing fall-arrest equipment, then reliance on risk awareness to promote RPE use is unlikely to be wholly successful.

Another issue, which has resonances with others mentioned earlier, was the discomfort or disability experienced through harness use. Earlier references to problems with discomfort and disability associated with different forms of RPE illustrate the parallels here.

In some instances, perception of the perceived effectiveness of the PPE can be an issue. That was identified by IOM work aimed at developing improved hearing protection (Best et al, 1989) which addressed the concerns about communication whilst wearing hearing defenders. The study developed a 'flat response' defender which offered the advantages of avoiding distortion of wanted sounds penetrating the defender (and enhanced audibility as a result). This electronic defender also provided the added advantage of reduced attenuation at low noise levels (again enhancing communication). Unfortunately these efforts had the unexpected side effect of being too good at their target aims, with the result that prospective wearers did not like them as they did not believe that they could be providing them with adequate protection. Although not formally documented, it is understood that similar issues arose within the mining industry with the initial introduction of the eminently less uncomfortable disposable (paper) face masks. With a target audience accustomed to heavy, intrusive, rubber half-masks it proved difficult initially to convince them that these new forms of RPE were equally effective. Although such respirators are now widely accepted this nevertheless does illustrate the importance of the workforce 'trusting' the protection provided.

Howie et al (1996) reported on the 'at work' effectiveness of RPE in asbestos stripping. The work examined full-facepiece positive pressure respirators. Quantitative assessments indicated that RPE performance was not as good as the nominal protection assumed of 200 or 2000 and recommended an assumed protection factor of 40 for these devices. The study explored a variety of possible contributory factors.

The first of these was inadequate systems in place for the maintenance and/or replacement of respirators. Although the workers were issued with well-maintained devices for the purposes of this study it was observed that their own respirators were generally not in good condition. Specifically it was noted that a substantial proportion of these respirators were not capable of sustaining the minimum required flow rate for the minimum required duration. In use this could result in negative pressures within the RPE and a consequent increased risk of inward leakage. Clearly, with multiple use RPE, it is essential that a good system of cleaning and maintenance is in place and that clear criteria for replacement are established. This is less likely to be the case with self-employed or peripatetic workers who are expected to supply and maintain their own RPE.

A second issue directly influencing RPE performance is the quality of fit. The study suggested that a significant proportion of the workers had facial dimensions which fell outside the range defined by the 'Los Alamos Grid' – used to define sizing for respirator design (Hack & McConville, 1978). It was also shown that these individuals tended to demonstrate poorer protection factors.

One good aspect of this study was that the workers generally demonstrated a good level of awareness of the risks of asbestos exposure with adequate protection levels being recorded. Possibly associated with this was the observation that the training given to the various groups of workers appeared to have been adequate and that no re-fitting of respirators (a possible sign of initially poor fit) was observed.

High work rates were observed during the study. These had a number of potential consequences. The first was that the increased energy demands might lead to high respiration rates, which could potentially increase the risk of negative intra-facepiece pressures, increasing the risk of inward leakage. Work demands, in particular working overhead or in other adverse postures, could result in a risk of facepiece fit being compromised as facepieces tend to hang away from the face in any head-down posture. It was also suggested that high workloads, coupled in some instances with high ambient temperatures could increase the risk of mask movement and inward leakage.

This study was carried out before the current requirement for face-fit testing was introduced and it was noted that such testing was only performed at one site. It should also be acknowledged that, at the time of this study, general awareness of the hazards posed by asbestos was high and that this might well have influenced the generally good performance etc recorded during this study.

Key issues from this study would therefore include:

- ensuring adequate systems for maintenance and replacement;
- ensuring appropriate sizing and fitting (presumably now covered by adequate face-fit testing procedures);
- considering the work activities to be carried out and the possible impact of environmental conditions in selecting appropriate RPE.

Pilkington et al (2000) reported on the findings from a field study of workers involved in sheep-dipping. Although the study did not specifically examine RPE there were a number of informative findings relating to the use of other forms of PPE.

A key finding was that the type of work being performed was the main predictor of hazardous exposures. This reinforces the long-held view that reduction of any hazard at source is likely to be most effective in controlling risk. Although there were signs that hazard awareness and risk perception were factors in influencing behaviour in terms of the use and care of PPE; generally uniformly high levels of background awareness of such hazards associated with sheep dipping made it difficult to identify any covariance with behaviour. Attitudes towards personal risk appeared to be a more important variable.

This study suggests that attention in training to enhance personal risk perception (and not just hazard awareness) might be of value in influencing RPE use.

The issues of hazard awareness and the role of training were examined in a further IOM study (Hughson et al, 2002). Again, this study did not specifically examine RPE use although there are no reasons to suppose that the findings would be specific to the mode of protection (hearing).

One key issue was the general observation from a number of industrial sites that protection appeared more likely to be worn where the risk was more apparent (i.e. higher noise levels) and exposure continuous. Intermittent or lower exposures tended to result in less reliable PPE use. Although it could be argued that protection was less necessary under such conditions it became apparent that adverse exposures were occurring with potentially significant noise doses. Coupled with this was the observation that PPE was more likely to be worn intermittently where rules (and signage) were unclear or where such rules were not always enforced, a possible reflection of management attitudes to the risk. A related factor was the observation that the designation of PPE zones was based, in part, on convenience rather than need. The unnecessary prescription of protection was seen as undermining the need for PPE. This is clearly more difficult where the hazard is sporadic or intermittent and is more likely to be a problem with some forms of hazard where the risk is less apparent (i.e. respiratory hazards with a low threshold in comparison to perceptible levels through odour or visual cues).

Such management attitudes were identified as a potential influence on the use of PPE. In part, this was reflected in the familiar issue of management staff not wearing protection when visiting workplaces. Although the necessity for protection in such circumstances might be questioned on the grounds of limited exposure duration it does suggest an adverse safety culture and can clearly give an adverse negative message to those workers affected.

Different modes of intervention were examined during the study, including training based upon the principals of behavioural safety. This approach was not generally well-received by management or workers and the view was expressed that, in what were organisations with largely traditional management approaches, workers were more accustomed to (and responded better to) conventional direct instructions. This was reflected in the finding that conventional hazard awareness training was more effective in influenced the consequent use of PPE.

The other key finding of possible relevance was the observation that ensuring that the PPE provided was the most appropriate for the work in question was one of the more effective means of positively influencing PPE use.

Again, a number of key findings can be summarised from this work, of potential relevance to RPE use.

- appropriate designation of areas where protection is necessary;
- clear management reinforcement of such areas;
- selection of most appropriate form of PPE;
- use of training methods best suited to the workforce and management styles.

This latter issue, with the selection of appropriate training methods, or rather that a given training approach might not be universally equally effective, was touched upon in the work by Creely et al, 2003, in reporting the development of a multimedia Safety Data Sheet (mmSDS). Compared to a conventional Safety Data Sheet (SDS) the mmSDS appeared to be more effective in improving the level of knowledge and awareness of chemical hazards, together with risk perception. However, in the more experienced group the impact in terms of PPE use and other safety behaviour was minimal, although the authors do indicate that level of compliance with good practice was already high so there was limited scope for improvement. In contrast, the novice group, starting from a lower base-line, demonstrated both the expected increase in knowledge and awareness but also a marked improvement in safety behaviour, including the use of PPE. To some extent, the lower impact with experienced workers might be attributable to their reluctance to change, or a degree of complacency amongst them. Both are commonly encountered in industry. Whatever the reason it would seem plausible that a different approach might be appropriate for experienced workers, compared to those just commencing employment.

Cowie et al (2005) reported a two stage study of isocyanate use which included a series of observational and exposure monitoring studies at more than 20 manufacturing facilities. This far-reaching study included consideration of RPE use as well as other forms of PPE. It is interesting to note that although where direct exposure to isocyanates was involved RPE usage was considered good, usage, in particular the type of RPE used, was less good where incidental exposure could occur. Many of the workplaces visited made extensive use of engineering controls. However, there was a small minority where this was not the case and a high degree of reliance was placed on RPE. Although the RPE observed at these sites was good, the authors expressed concerns that this placed undue reliance on RPE as the primary form of protection. A further issue, which might be seen as incidental to the main thrust of this overview but is nevertheless of potential value, was the observation that, at a number of sites, although RPE use was generally good, there were opportunities for contamination via other channels (e.g. skin contact and absorption) and that the use of other forms of PPE to combat these risks was less satisfactory. Clearly, although not of immediate relevance specifically to any RPE programme, this is of importance in respect of the overall dose of isocyanates (or whatever the chemical in use) received by exposed individuals.

5.3 SYNOPSIS OF MAIN ISSUES OF RELEVANCE

A number of key themes can be identified from this overview. Some of these relate directly to the effectiveness of RPE programmes in persuading employees to wear RPE, others can be related more to its effectiveness once worn. Nevertheless, all seem to be of potential importance in achieving the overall aim of improved workplace protection.

Some of the factors are clearly interrelated and, to a certain extent, can be seen as different aspects of the same issue. It is important to recognise however that these

factors have been largely identified from studies where RPE or PPE usage was not necessarily the main focus. The absence of any reference to other specific issues (e.g. management systems or the effectiveness of training) should not be construed as suggesting that these are of lesser importance.

The first group can be related to the willingness of the employees to wear RPE in the first place. These include:

- hazard awareness;
- risk perception;
- perceived effectiveness of protection;
- management attitudes and example;
- time and/or hassle involved with donning

Once worn, a second series of factors, mainly relating to comfort and disability issues can be identified:

- respiratory resistance;
- discomfort (e.g. pressure and/or chafing);
- thermal discomfort;
- impaired communication;
- other interactions/interference with work activities.

Many of these can be exacerbated by over-prescription, given that many of the factors likely to adversely affect wearability (weight, pressure against face, size/bulk) are, to some extent, correlated with functional performance.

Although not directly contributing to wearability; inadequate maintenance, cleaning or replacement programmes can also influence overall effectiveness and, indirectly through factors such as increased respiratory resistance or reduced airflow, can influence acceptability.

6 OVERVIEW OF IOM CONSULTANCY REPORTS

6.1 INTRODUCTION AND METHOD

As part of the information-gathering process, IOM occupational hygiene consultancy reports from the preceding two years (2006-2008) were examined by an experienced occupational hygienist. Selection was on the basis of their having been some material relating to the need for protection from respiratory hazards and some focus on the use of RPE as a part of that protection. The purpose was to identify those elements of these reports which related to the effectiveness (or otherwise) of RPE programmes.

A total of 32 occupational hygiene reports were identified from that period as containing material of relevance. The information was abstracted against a standardised proforma which took account of the following:

- nature and size of the organisation;
- nature of hazard;
- airborne concentrations in relation to exposure limits;
- type of RPE in use;
- face fit testing;
- other control measures; and
- information, instruction and training provided.

In the main, the surveys had been requested either because the organisation was concerned about the level of exposure to its operators to a particular material or as a routine monitoring exercise.

All of the surveys had been commissioned to measure total inhalable dust and or respirable dust although a small number also included measurement of vapours. The most common hazardous material measured was respirable crystalline silica (RCS), although surveys for metals and wood dust were also identified.

The information gleaned from these reports is summarised below.

6.2 OVERVIEW OF FINDINGS

6.2.1 Sectors

The reports identified were derived from employers in what can be summarised under five sectors:

Construction/ Stonemasons/ Quarries	- 8 reports
Education/ Council	- 4 reports
Agriculture	- 3 reports
Manufacturing/ Recycling plant/ Pharmaceutical	- 12 reports
Fuel Supply/ Power Stations	- 5 reports

The sizes of the companies were rated as small, medium or large defined as: small <10 employees, medium 10-50 employees and large as >50 employees.

Table 2: Number of companies covered, by size

Sector	Size		
	Small	Medium	Large
Construction			1
Stone masons	1	1	
Quarries	2	3	
Education			3
Council		1	
Agriculture		3	
Manufacturing	2	3	5
Recycling		1	
Pharmaceutical			1
Fuel Supply/ Power Station			4

6.2.2 Type of RPE

Amongst the 31 companies for whom relevant reports (32) had been prepared, 20 made disposable respirators only available, with a further 11 providing both disposable and ori-nasal cartridge respirators.

FFP1 disposable masks were being used in four organisations; one to provide protection against general dust; one where wood dust was being generated; one where coal was being handled and one where the airborne dust contained metals and Respirable Crystalline Silica.

Two companies provided air-fed hoods; one manufacturing organisation, where a variety of solvents and chemicals were used, and a pharmaceutical company which also provided airline-fed suits.

No specific details are available as to how the RPE had been selected but, other than those chosen by a suppliers' representative, the specific types had been chosen and ordered through catalogue browsing.

In all but two instances the RPE in use on the day of the survey was considered by the consultant to be suitable for protection against the hazardous materials and the airborne concentrations measured. In the two cases where the RPE was not appropriate, recommendations were made to assess the tasks and circumstances in question and to use this information for the selection for the appropriate RPE.

In 18 of the surveys the airborne dust/ vapour concentrations were found not to exceed the relevant WEL or guideline limits and the RPE was being used to further reduce any exposure risk.

In the other surveys, at least one of the hazardous materials being monitored exceeded the exposure limit. In all but one of these, FFP2 respirators were being used as a minimum with many companies supplying FFP3's.

Nine of the companies surveyed provided no other form of control other than the RPE; this included many of the larger organisations. Where other means of control were in use these comprised of various local exhaust ventilations systems, use of vacuum cleaning systems and water suppression.

6.2.3 Face-Fit Testing

Across the 31 companies, of the 43 different types of respirators provided which relied on an effective face seal, employees reported having been face-fit tested for only 14 of these types. The organisations who had provided face-fit test included; four of the five large manufacturing companies; the two small manufacturing companies; two of the medium sized agricultural companies; a medium sized quarry and one of the small and one of the medium sized stonemasons. These data suggest a more favourable picture than that recently reported by Easterbrook (2009) who indicated that a considerable majority of employers surveyed in the stonemasonry and quarrying sectors did not have face-fit testing in place.

The exact nature of the face-fit tests which were provided is not always known from the report but most would appear to have been quantitative rather than qualitative.

6.2.4 Information, Instruction and Training

A total of 20 companies provided Information, Instruction and Training to their employees in some form. Of these, 17 took the form of tool box talks and three involved sessions delivered by the company Health and Safety Advisor.

In addition to the monitoring carried out during the surveys observations were made as to work methods and in particular use of control measures, including RPE. The general awareness of those employees who had received advice through these II&T sessions, regarding the nature of the hazard and the requirement to make full and proper use of any RPE provided, was apparent from the actions observed and recorded during the surveys carried out.

6.2.5 Storage and Maintenance

Only eight of the companies provided storage facilities for employee's RPE; five had a system in place for cleaning respirators and five had established maintenance procedures.

Those companies which had no storage facilities in place allowed disposable masks to be temporarily stored in the open, where they were at risk from some form of contamination prior to operator use.

6.2.6 Record Keeping

Amongst the 32 reports examined, the detail about record-keeping provided was limited. It appears that 13 of the companies kept no records regarding RPE, 12 companies had no information regarding record keeping, five kept records on RPE training and two kept records of RPE issue. However, the companies that had no information available on record keeping were all part of a larger group and had no direct control regarding issue and selection of RPE.

6.2.3 Recommendations made

Not surprisingly, the shortcomings identified above formed the focus for many of the recommendations regarding RPE protection and protective programmes made in the reports by IOM consultants. Thus, recommendations were made to 17 companies to institute face-fit testing; 25 reports had recommendations given regarding

information, instruction and training; and, in 21 reports, recommendations were made for improvements to record keeping.

In three instances, recommendations were also made concerning the introduction of health surveillance. In two cases it was considered that the RPE provided by the companies was inappropriate and recommendations were made change to change to an alternative type.

In a broader context reflecting the hierarchy of protection, in 11 instances recommendations were made regarding Local Exhaust Ventilation systems, either that such a system should be installed or that an existing system should be reviewed and improved.

6.2.7 Discussion

On a positive note it appears that most employers had made an appropriate selection of RPE in respect of the risks involved (the basis of that selection is not known). However, there are clear indications that, in many instances, significant management input stopped there and that many elements of a good RPE management programme were not in place in the majority of companies. These results must be considered in the context that the companies in question had, for whatever reason, sought professional occupational hygiene advice. Two interpretations can be placed on this. The first is that they had issues which were bad enough to warrant seeking such advice. The second is that they were arguably more enlightened than many. This contextual information might impact on the extent to which the findings from this limited survey reflect the broader National picture. It is not possible to determine which of these provides the more accurate picture and, indeed, the two issues are not mutually exclusive. On balance however it would seem likely that, if anything, this sample underestimates any shortcomings within employers in general, suggesting considerable scope for improvement.

7 OUTCOMES FROM INTERVIEWS

7.1 GENERAL

In addition to the examination of written reports, summarised above, interviews were carried out with a number of IOM employees who worked with RPE in some context. These included PPE Testing Laboratory staff, Occupational Hygiene specialists and those involved in asbestos working who observe the implementation of RPE requirements on a regular basis.

7.2 PPE TEST STAFF OBSERVATIONS AND COMMENTS

PPE testing laboratory staff have had exposure to RPE issues in two main ways. Firstly, until relatively recently, the laboratory was a certified test house for RPE performance testing. Secondly, the laboratory has the unique status of having UKAS (United Kingdom Accreditation Service) accreditation for face fit testing and provides this service to client companies on a commercial basis.

As with the occupational hygiene reports, the fact that the employers had seen fit to utilise this face fit testing service indicates a certain mindset which might well not be representative of the broader pool of employers. In addition, the impressions and recollections outlined below are not based on any systematic collection or recording of such details.

Against this background it was apparent on a number of occasions that the employees attending had received little or no training or information before attending. It was not unusual, for example, for employees to attend for face fit testing without any experience of fitting their RPE or for any effort having been made by their employer to ensure that reasonably correctly fitting RPE had been provided. Coupled with this, in a minority of instances there were ethnic issues, where language difficulties made understanding instructions a problem or clothing created potential difficulties in obtaining an appropriate fit.

Significant problems in obtaining a correct fit were observed with a small but sizeable minority of those tested. In some instances this was because of individual facial characteristics although, in a number of instances it was inadequate fitting. There was a tendency observed for employees to fit their masks as tightly as possible in the belief that this was the best way to ensure an adequate fit that would ensure that they “passed” the test. Where the mask was too large for the face of the wearer this could result in the mask distorting on the face, resulting in an inadequate seal.

In a number of instances it was apparent that the mask was not being worn in the manner it would usually be fitted in the workplace. On some occasions this became apparent from comments made by test subjects, for example men who said that they had shaved their beard off specifically for the testing where it was apparent that they would regrow this immediately afterwards. Clearly comments such as this create reservations about the quality of any training received; the perception of the risk involved; and the level of supervision and reinforcement that might be anticipated.

Despite these reservations the Test Laboratory staff indicated that they were aware of a general improvement in recent years in attitudes towards wearing RPE, especially (but not exclusively) amongst younger employees.

Although not a systematic appraisal the information gathered reinforces the need identified from the review of IOM occupational hygiene reports that there was scope

for improvement in information and training of both employers and employees as part of any RPE control programme.

7.3 ASBESTOS STAFF

Informal Interviews were conducted with a number of staff involved in providing asbestos-related services to clients. Despite the established risks from asbestos exposure, many of the comments reflected poor attitudes to RPE use, with RPE not being worn correctly or being temporarily removed within enclosures.

In many instances this reflected general attitudes and a relative absence of management influence. Well managed sites were described as those where management staff would visit sites and reinforce the need to wear RPE. However, the mobile nature of the industry means that, in many instances, sites function without such managerial influence and reliance is placed more directly on the members of the work team. Although not formally studied, there was an impression that, whilst hazard awareness might have been reasonable, personal risk perception was often deficient. In particular, an age-related differentiation was suggested with a proportion of older, more experienced workers not considering the risk to be sufficiently serious. The absence of obvious immediate (acute) effects of asbestos exposure; the long latency of any response; and the fact that some employees who anecdotally have been exposed to relatively high levels of asbestos do not go on to develop asbestosis (suggesting an apparent immunity) were all factors which contributed to this.

Whilst peer support or pressure can, in some circumstances, be of positive effect, the impression was that, in general, peer influences were negative. Older workers were seen as dismissing the training and information received by (usually) younger workers entering the industry and undermining the messages received. Parallels of apparent immunity can be drawn with cigarette smoking ('my uncle smoked 60 a day and lived into his 80's').

As a further overlay, the issue of attitudinal influences was also seen to make a significant contribution. The prevailing 'macho' culture mitigated against the wearing of RPE, further undermining any individual who might wish to do so.

Whilst the industry can perhaps be regarded as somewhat extreme it is likely that such perceptions, attitudes and beliefs prevail to some extent elsewhere and should be accounted for in any strategy. It emphasises a need for strong policies and procedures and reinforcement of those by supervisors and other managers. There can be a tendency, in this and other industries, for management to feel that they have discharged their duties by the act of telling employees to wear RPE, and that any subsequent failure to do so is solely the responsibility of the individuals concerned.

7.4 OCCUPATIONAL HYGIENE STAFF

Occupational hygiene staff endorsed much of which has been said and written previously, which will not therefore be repeated here. However, a potentially important additional factor was for any programme for RPE should be presented in the context of any other measures which have been introduced or at least considered. The concern was expressed that use of RPE might be seen as a cheap way of dealing with a problem; which is easy for 'them' but places the burden on 'us' the workers. Clearly, in any risk management programme for an airborne hazard, RPE would be seen as the last resort (or possibly a temporary expedient whilst

longer term measures are devised and introduced). However, there is an impression that, in some workplaces, the thinking behind this is not communicated to the workforce, which only sees the final solution. This comment has resonances with experiences in relation to other hazards (e.g. ergonomic hazards) where workers resented introduced measures because they were not aware of the extensive 'back room' efforts to identify better alternatives.

This can be seen as a specific example of the benefits of an inclusive organisational culture where employees are more actively involved in the risk reduction process and are therefore more likely to sign up to the eventual solution.

As a further practical issue the relative pros and cons of the use of prescriptive zones for compliance within a workplace were discussed. Whilst such zones have the merit of being easier to manage (and avoid any ambiguity as to where and when RPE is required) they can have the disadvantage of requiring RPE to be worn where it might well be apparent to all that it is not necessary (possibly in more peripheral parts of the zone). There is historical evidence from IOM studies (Edlin et al, 1974) that some individuals at least are quite efficient in identifying when RPE is necessary and taking appropriate action. In some industries/workplaces enabling individuals by giving them such control might offer an appropriate alternative to more prescriptive measures, although clearly this would require a higher level of knowledge and awareness to be effective.

8 WORKSHOP OUTCOMES

8.1 INTRODUCTION

As planned, a workshop was held to discuss the findings of the reviews. The purposes of this workshop were to:

- Review the information gathered from these reviews;
- Identify any other issues which participants might be aware of;
- Discuss the relative importance of the issues raised;
- Identify 'avenues for amelioration' – i.e. what can be done about improving RPE use by employees?

The workshop was attended by nine IOM staff and a representative from the client. IOM staff were drawn from a wide variety of backgrounds including both research and consultancy/service staff from occupational hygiene, ergonomics/human factors, and asbestos services.

The workshop commenced with brief presentations of the findings of the three strands of investigation: published literature; IOM research reports; and occupational hygiene consultancy reports. In each instance, opportunity was provided to review and comment upon the findings.

There was broad consensus and agreement on the issues identified, although it was clear that different experiences in various industries with differing hazards and risk resulted in some varying perspectives and perceived priorities. No substantively different issues were identified with a number of examples being brought forward which reinforced those issues already detailed.

8.2 RELATIVE IMPORTANCE OF ISSUES

The consensus view which emerged during the workshop was that promoting the right attitude amongst managerial and supervising staff (including senior peers) was essential. Unless management and supervising support, reinforcement and enforcement was in place there was little or no real value in addressing issues such as wearability.

Whilst bearing in mind that none of the IOM studies which touched on PPE issues were formulated to study this specific issue there was no evidence that failure to provide RPE in some form was a commonly encountered problem, which seems to reflect HSE experience as documented earlier (section 2). Although, in some instances, technically inappropriate RPE might be provided (or RPE which was unsuitable for other reasons) some protection was usually available.

As the HSE guidance, published in HSG 53 (HSE, 2005), illustrates, a degree of knowledge and understanding is necessary to select the current RPE for a particular hazard and job. Clearly this is an important issue and one which should not be neglected. Nevertheless, unless rigorous implementation of an RPE programme is accepted and acted upon at all levels by managers and supervisors, which RPE is selected will be largely immaterial.

Beyond this, it was difficult to single out specific issues above others, especially in context-free circumstances. It would seem from the literature, as well as personal experience, that there were marked differences between different sectors of work in the factors which assumed greater importance. Clearly the issue of the perceived

importance of non-verbal communication with patients amongst health-care staff provides a good illustration of this.

8.3 AVENUES FOR AMELIORATION

It follows from this reluctance to single out specific individual issues for attention, that the consensus was for a need for a holistic approach to addressing the issue, once that of ensuring management commitment and contribution was addressed. Clearly there is a certain circularity in that selecting the correct RPE for the job is of limited value if workers are reluctant to wear it (despite management and supervisory pressures) because it interferes with their ability to carry out their job; or is disproportionately uncomfortable for the associated risk. Although workshop members were reluctant to endorse the view, they were reminded of the suggestion of a previous IOM employee that it could be better for a worker to wear poorer protection more reliably than to have the correct level of protection but to be reluctant to wear it. Certainly, given that, in many instances, high performance relies heavily on correct fit, any tendency not to wear such RPE correctly could well reduce the effective protection received below that of lesser devices.

To avoid unnecessary duplication, the views expressed during the workshop and more detail surrounding this outcome will be incorporated into the following more general discussion and conclusions.

9 DISCUSSION AND RECOMMENDATIONS

9.1 THE ISSUES INVOLVED

In carrying out the searches and surveys and, to a lesser extent, in exploring personal experiences, the assumption was made that information and experience gained in respect of other forms of PPE is applicable to RPE. Although hazard specific issues will clearly only be of relevance to protection against that hazard it became apparent during the project that this appeared to be a valid assumption. Cross-references and parallels were frequently drawn between different types of PPE and examples of particular issues relating to other forms of PPE were often matched by similar examples relating to RPE.

The various overviews and explorations carried out as part of this project have identified a clear pattern in the factors influencing RPE usage, albeit one modified by the circumstances surrounding a particular industry or workplace. The key identified factors in influencing such usage were:

- Hazard awareness;
- Risk perception;
- Perceived effectiveness of protection;
- Management/supervisory attitudes (including leading by example);
- Safety culture (e.g. attitudes of co-workers);
- Time and/or hassle involved with donning equipment.

Other factors can be considered to be 'nested' within these. For example, personal health problems might serve to heighten risk awareness.

The importance of management factors was illustrated in the results of the survey of RCS by Easterbrook (2009) in which the majority of sites visited were rated 2 for RPE competence, largely on the grounds of the absence of any fit-testing. Ensuring the provision of correctly fitted RPE is clearly essential before any concerns regarding the comfort and/or disability imposed by the RPE in question. Unfortunately, although the RPE competence rating scales includes issues such as training and operator awareness, detailed results are not provided on these other issues.

Once worn, a second series of factors can be identified, mainly relating to comfort and disability issues, which might impact on the correctness of wearing or the willingness to continue to wear the equipment:

- Lack of instruction and training;
- Respiratory resistance imposed by the device;
- Discomfort (e.g. pressure and/or chafing);
- Thermal discomfort;
- Impaired communication;
- Other interactions/interference with work activities.

There would appear to be broad consensus, using information from a variety of sources, of what the issues are regarding effective RPE protection and programmes.

It is clear that organisational/management issues are fundamental factors in any successful programme. To a certain extent this is self-evident in that, unless the need for RPE has been recognised and accepted, then there is no value in

addressing individual levels such as attitudes to the RPE or the wearability of any RPE provided.

This is perhaps most problematic where a respirable hazard is newly recognised where this was not previously the case or where the risks associated with that hazard are not apparent (at least in the short-term). There are many workers for example who can recall using substances such as mercury or benzene with a relatively relaxed regime in force who perhaps find the more recently identified hazards associated with these substances difficult to appreciate.

Coupled with this issue is that of the apparently “immune” workers. There has been a long tradition of seeking to protect those in any workforce who are potentially most susceptible. However, establishing, for example, a 5% at risk level means that, by definition, 95% of the workforce can safely be exposed to that level (and most exposed to higher levels) without apparent risk. Such inter-individual variability means that, almost inevitably, any hazard in any industry will spawn apparent survivors. Overcoming the consequent attitudes and beliefs that this engenders is one of the challenges to be faced.

Any form of PPE (and RPE is no exception), imposes some form of barrier between the wearer and their environment and creates some degree of additional load on them. The extent of that barrier and loading depends to a large extent on the nature of the RPE selected which, in turn, will depend to some extent at least on the risk in question. Tolerance of those barriers and loads will also depend to a large extent on the nature of the risk, or probably more specifically the perceived risk. At one extreme, the loads and barriers imposed by self-contained breathing apparatus (BA) are far in excess of those associated with a simple limited use (disposable) half-mask and yet those loads are frequently accepted by those required to wear the equipment because of the potential hazards and risks they face. Even here however, there are still many who are regularly required to wear BA, such as in the fire services, who recall when wearing BA was seen as ‘soft’.

It is difficult to predict the outcome of the complex interactions between perceived risk and tolerance of discomfort and disability. What is clear however is that if these loads or barriers are perceived as unacceptable then problems can occur. Such problems are most likely to arise where there is a mismatch between actual risk (which determines the type of RPE and therefore, in general terms, the associated loads) and perceived risk (which will be a strong determinant of attitude and consequent acceptance). Selecting inappropriately protective RPE could be a further factor in particular instances of RPE wearing, disturbing the balance between the level of RPE load perceived as acceptable and that actually imposed.

A case-study, published by the US Environmental Protection Agency provides an excellent illustration of the key role for management and supervision (EPA, 2001). The strategy described had three ‘key components’ of awareness of hazard; use of PPE and employee training. A shop manager was dedicated to ensuring that the workers knew the risks and how to protect themselves. Having made sure that the workers knew the dangers he then worked with them to select and purchase equipment that was ‘right for them, effective and comfortable’. The workers receive periodic refresher courses and instruction on how to wear RPE correctly. However, despite all these elements being in place the manager is quoted as saying: “I do have to keep reminding the guys, especially some of them...”.

9.2 AN IDEAL PROGRAMME

Implementing an RPE programme is of course only part of the bigger picture of risk management and control. For the purpose of this discussion, it will be assumed that the stages which precede introducing such a programme leading up to the decision that RPE is an appropriate element of any risk control programme have already been addressed.

The following programme is not derived from any one source. The elements of it are based on a combination of knowledge and information drawn from all of the types of source examined during the study: peer-reviewed literature; IOM research and consultancy reports; and the expertise of those interviewed or making other contributions. Examples of each element or the equivalent failure (e.g. not recognising the need for RPE/PPE), have been raised within the written literature and have been observed in specific instances by IOM staff.

9.2.1 Management issues

As indicated above, it is clear that the first steps in any RPE programme start with management. Managers at all levels need to:

- Recognise the need for RPE;

Hazard awareness and risk perception are key elements at all levels. It is important that those with management or supervisory responsibilities are aware of the hazards involved; know of the possible consequences of exposure and recognise and accept the role which correctly selected and worn RPE can play in controlling such risks. The overviews have identified the potential negative influence of older workers who perhaps have a different perspective framed by prior experience. Such workers are more likely to be those who either have formal supervisory/managerial responsibilities or have an informal role as 'senior workers', which might present particular problems in developing an effective programme.

- Accept their role in an effective programme;

As with other workplace health and safety issues there is a clear need for all employees, especially managers, to recognise that they have a role to play in health and safety and that their attitudes and behaviour can be a major positive (or negative) influence. Encouraging an inclusive health and safety culture where such issues are the responsibility of all, not just a designated person, will make a valuable contribution to the subsequent effectiveness of any programme.

- Ensure that appropriate RPE is selected;

Clearly any RPE must be technically appropriate for the hazard in question. As stated earlier, systems offering greater protection are often more intrusive and/or uncomfortable to wear and any tendency therefore to over-protect should be discouraged.

However, it is also important that the RPE is compatible with work activities (and with other forms of PPE) and is reasonably comfortable and acceptable to the workforce. There are many indications that involving the workers in the selection process and, where possible, providing them with a degree of personal choice, helps to ensure better acceptance and compliance.

- Ensure that sufficient RPE is provided;

RPE (and other PPE) must be readily available. Whether disposable or re-usable systems are used then replacement supplies must be readily and easily available or any efforts to ensure compliance will be undermined.

- Ensure that information and training needs are met;

Intuitively it is important that employees are made aware of the hazard and consequent risks associated with the substances being protected against. However, there is some evidence that, in some industries at least, an almost authoritarian approach is more effective with people responding better to just being told what to do. Parallels can be drawn with the introduction of seat belt legislation – where a legal imposition proved effective where information and exhortation had failed. Nevertheless, some at least in the workforce are likely to respond better to a more informed approach. Properly conducted, such training should provide an opportunity to identify and address the entrenched attitudes which engender a disproportionately low risk perception.

- Play their part in enforcement and supervision, including leading by example where appropriate;

The managerial and supervisory role is ongoing – as illustrated by the case study cited earlier. Whilst technically the risk associated with a brief exposure during a short visit to a work area might well be negligible, failure to wear RPE in such circumstances will undermine any efforts to maximise compliance. ‘Leading by example’ might sound trite, but it is likely to be far better than ‘do what I say, not what I do’.

- Make suitable provision for cleaning, maintenance and storage (as appropriate).

Some types of RPE, most notably those which are powered in some way, have higher cleaning and maintenance requirements than others and may well require centralised provision. Examples have been encountered where, for example, powered respirators have been provided without this ancillary provision (with predictable consequences). However, even less demanding types of RPE might nevertheless require some provisions to be made. For example, RPE which is only worn intermittently is often seen lying on workbenches or otherwise exposed to contamination when not being worn and provision should be made for temporary storage facilities close at hand.

Such provision should also include allowing time within the working day for such activities. If it left until after the end of the shift it is less likely to be carried out correctly, if at all.

9.2.2 Workforce issues

So far, the elements have focussed primarily on the role of those in management or supervisory positions. Many of the functions have parallels within the workforce where the following issues can be identified:

- Hazard awareness and risk perception

As stated above, it is important that employees are made aware of the hazard and consequent risks associated with the substances being protected against. However, it is clear that this should focus on the needs of the individuals concerned and, especially where a requirement for RPE is introduced where there has not been one previously, care should be taken to identify and counter the possible reluctance to recognise the risk, particularly amongst older workers.

In some instances, such attitudes can possibly stem from a reluctance to admit that the individual has been at risk, perhaps for many years (a concern which can also influence management attitudes).

- Behaviour

Properly conducted, training in hazard awareness and risk perception should provide an opportunity to identify and address the entrenched attitudes which engender a disproportionately low risk perception and consequent antagonism to wearing RPE. It must be recognised that there is often a considerable gulf between getting people to recognise/acknowledge a risk and getting them to change their behaviour as a result. There can be many contributory factors at play here, including the 'macho' culture described earlier. It is also important to recognise that the real reason for a failure to change might not be that put forward by the employees, for example someone who 'blames' the physical characteristics of the RPE rather than admitting to just not wanting to wear it, or an individual not wanting to admit to experiencing feelings of claustrophobia when wearing a full-face respirator.

- Worker involvement

As stated above, there is evidence to suggest that involvement of the workforce in the selection of RPE is likely to encourage subsequent use. Where practicable, this is also likely to extend to providing a degree of choice as this effectively involves every individual in the selection process.

- Comfort and disability

Where the need for RPE has been recognised and accepted there can still be a reluctance to wear such equipment if it is seen to be uncomfortable or intrusive. Although worker involvement in selection will help to offset this, the possibility remains that some employees will find the level of discomfort from a particular form of RPE unacceptable. In some instances (e.g. need to use a heavier, bulkier, class 3 gas/vapour filter) this might be unavoidable. If this is the case then this should be explained to the employees so that they can appreciate that these characteristics are a necessary part of providing the required level of protection. In other instances however, using class 1 equipment but replacing it more frequently might be an option.

Where verbal or non-verbal communication is seen as important one option might be to use a fan-assisted hood which would mask the mouth less and the thin visor material of some such hoods is likely to be less disruptive of speech.

Although these are very specific examples they illustrate how adverse side-effects of specific types of RPE can possibly be overcome.

It is important to recognise that this is not 'just' a comfort issue. If RPE is either not worn or not worn correctly then health and ultimately life expectancy can possibly be adversely affected.

- □ Compatibility

Issues relating to interactions between different types of PPE have long been recognised and are entrenched within the PPE 'Manufacture' and 'Use' regulations and the EU Directives which engendered them. It is important to recognise that RPE might interfere with other forms of PPE (especially eye protection but also possibly any other head-borne PPE) and might therefore either not be worn correctly or not worn at all as a result. No RPE programme should be introduced in isolation of other workplace risks or the protective requirements they engender.

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Review of occupational hygiene reports on suitability of respiratory protective equipment (RPE)

This report presents an overview of evidence on RPE and user behaviour drawn from a number of sources, including published material; IOM reports; and the expertise and experience of IOM staff. It provides an evidence-base for factors influencing the use (or non-use) of RPE in the workplace and on how well RPE programmes are currently implemented.

Although the remit was RPE, the study adopted a wider remit of personal protective equipment (PPE), on the basis that, although there will be equipment specific issues, the underlying principles influencing the use of any PPE will be essentially the same as those specifically relating to RPE.

From the reviews, it is clear that the first steps in any RPE programme start with management. Managers at all levels need to:

- recognise the need for RPE;
- accept their role in an effective programme;
- ensure that appropriate RPE is selected;
- ensure that sufficient RPE is provided;
- ensure that information and training needs are met;
- play their part in enforcement and supervision, including leading by example where appropriate;
- make suitable provision for cleaning, maintenance and storage (as appropriate).

Many of these functions have parallels within the workforce where the following issues were identified:

- hazard awareness and risk perception;
- behaviour;
- worker involvement;
- comfort and disability;
- compatibility.

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