Ann. occup. Hyg., Vol. 34, No. 6, pp. 547–552, 1990.
Printed in Great Britain.
0003–4878/90 $3.00+0.00
Pergamon Press plc

WORKPLACE PROTECTION FACTORS OF HSE APPROVED NEGATIVE PRESSURE FULL-FACEPIECE DUST RESPIRATORS DURING ASBESTOS STRIPPING: PRELIMINARY FINDINGS*

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(*Received 5 June 1990 and in final form 7 August 1990*)

Abstract—This research was designed to evaluate the workplace protection factors of Health and Safety Executive Approved, negative pressure full-facepiece dust respirators, during asbestos stripping.

A standard method to measure the concentration of asbestos fibres inside full-facepiece respirators has been developed and the workplace protection factors have been calculated from the data obtained. The respirators in this study are approved for use by the Health and Safety Executive in concentrations of up 900 times the Control Limit [HEALTH AND SAFETY EXECUTIVE, Guidance Note EH 41 (1985)] but the preliminary test results suggest that this level is inappropriately high for this type of respiratory protective equipment.

INTRODUCTION

THIS PAPER describes preliminary findings from field work which was carried out to determine the workplace protection factors (WPF) of Health and Safety Executive (HSE) Approved, negative pressure full-facepiece dust respirators during asbestos stripping.

The existing health and safety legislation contains specific requirements for respiratory protection whenever it is used by people at work to protect them from exposure to harmful substances including asbestos. Exposure to asbestos itself is covered by the Control of Asbestos at Work Regulations 1987 (HEALTH AND SAFETY EXECUTIVE, 1987). Regulation 8 states that where employees are exposed to levels of asbestos exceeding the control limit, after all other measures have been taken to reduce the level to the lowest level reasonably practicable, they have to be provided with approved respiratory protection. Such equipment is either 'approved' or 'type approved' by the HSE. Since no respirator is capable of providing complete protection against asbestos, it is important to know how much protection is likely to be provided by any given respirator. Hence each category of respirator has a 'nominal protection factor'. This is defined as the ratio of the concentration of contaminant present in the ambient atmosphere to the concentration within the facepiece, at maximum inward leakage, when the respirator is being worn (BS 4275, 1974). The respirators in this study are approved for use by the HSE in concentrations of up 900 times the control limit (HEALTH AND SAFETY EXECUTIVE, 1985). This is the level of protection which, in theory, should be achieved under normal working conditions.

Over the last decade, the performance of respiratory protective equipment against

*Presented at the BOHS Annual Conference, York, April 1990.

contaminants including lead, SO_2, nuisance dust and coal mine dust has been evaluated (EASTERN ASSOCIATED COAL CORPORATION, 1972; GRAUVOGEL, 1986; HARRIS *et al.*, 1974; HEE and LAWRENCE, 1983; LENHART and CAMPBELL, 1984; MYERS and PEACH, 1983; MYERS *et al.*, 1984; SHACKLETON *et al.*, 1985, unpublished; SMITH *et al.*, 1980; TONEY and BARNHART, 1976). These findings have demonstrated that the 'nominal protection factor' of the respirator is unlikely to be achieved in the workplace.

The purpose of this work was to develop a method for sampling asbestos fibres inside full-facepiece respirators and subsequently determine the workplace protection afforded by this category and type of respirator, against asbestos.

The air samples were collected during the course of various asbestos stripping operations, ranging from the removal of ceiling tiles known to contain asbestos, to the removal of asbestos lagging material.

METHODOLOGY

In order to calculate the workplace protection factor, two measurements are required. The fibre concentration outside the respirator (C_o) and the fibre concentration inside the respirator (C_i). C_o is divided by C_i to give the workplace protection factor. Samples for evaluating C_o and C_i are collected simultaneously.

In the United Kingdom, the recommended method for measuring the airborne fibre concentration of asbestos is the European Reference Version of the Membrane Filter Method (HEALTH AND SAFETY EXECUTIVE, 1988). Where the sampling method in this study deviated from the recommended method, full laboratory and in some cases workplace based investigations were conducted to ensure that the method used did not distort the results (TANNAHILL *et al.*, 1990). All sampling methods adopted were agreed in advance with the HSE.

Sampling technique

Challenge concentration. Samples were collected using a calibrated Rotheroe and Mitchell personal sampling pump, operating at 0.5 l. min^{-1}. The sampling head was fitted with an aluminium conducting cowl and was positioned on the wearer's lapel facing downwards. Air was drawn through Millipore 25 mm diameter, 0.8 μm pore size sampling filters. The filters were subsequently mounted using acetone vapour–triacetin and counted in triplicate using the criteria of the Reference Method (HEALTH AND SAFETY EXECUTIVE, 1988).

In-mask concentration. In-mask samples were collected using a calibrated Casella personal sampling pump, operating at 2 l. min^{-1}. The air was drawn onto a 13 mm diameter, 1.2 μm pore size Millipore sampling filter which was held in an open-faced, adapted Swinnex holder. This was placed to the inside of the perspex visor, in close proximity to the non-return valve on the ori-nasal cup. The filter holder was held in place by means of a purpose made brass nozzle which was securely bonded onto the visor (see Fig. 1). The filters were subsequently mounted using acetone vapour–triacetin and counted in triplicate using the criteria of the Reference Method (HEALTH AND SAFETY EXECUTIVE, 1988).

Originally, the in-mask air samples were collected onto 25 mm diameter, 0.8 μm pore size sampling filters at 4 l. min^{-1}. The resulting fibre densities were, however,

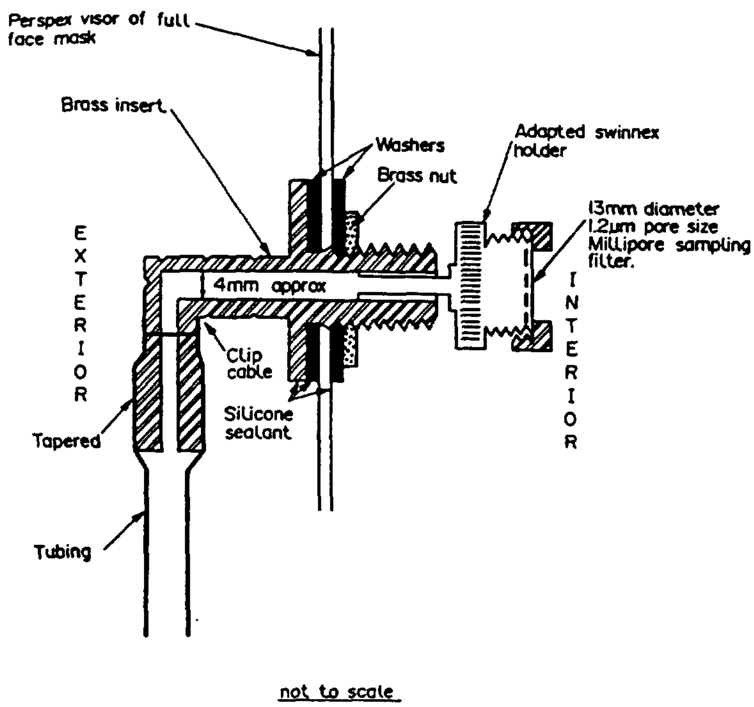

FIG. 1. Cross-sectional sketch of sampler adapted for use with full-face mask.

:xtremely low. After consultation with the HSE, 13 mm diameter 1.2 μm pore size ›ampling filters and a flow rate of 2 l. min^{-1} were adopted. Effectively this doubled the 'ibre density.

The modified respirators were tested at the Institute of Occupational Medicine in Edinburgh to verify that they continued to comply with BS 4555 (1970), and approval .o carry out the work was granted by the HSE.

Test group

Six pairs of in-mask and lapels samples were collected simultaneously from each ısbestos worker. Questionnaires were completed for each worker in which details :elating to his personal habits were noted and, in addition, the working conditions were ·ecorded during sampling (see Table 1). Also, the workers were kept under observation 'or the duration of sampling.

RESULTS

So far, three HSE Approved respirators have been tested in this study. All three acepieces were similar in design to each other, incorporating a panoramic visor and an nner cup. Each facepiece contained a five stap head harness. An example of the testing

TABLE 1. CONTENTS OF QUESTIONNAIRE

Personal details	Workplace conditions
Facial dimensions	Facial hair
Training	Exertion
Experience	Sweat
Perception of asbestos	Challenge concentration
Age	Wearing time
Smoker/non-smoker	
Marital status	

TABLE 2. EXAMPLE OF TESTING CONDITIONS

	Test volunteer X—sample 1 In-mask sample	Lapel sample
Flow rate	2 l. min^{-1}	0.5 l. min^{-1}
Sampling time	75 min	75 min
Filter diameter	13 mm	25 mm
Fibre count	20 fibres/100 fields	114 fibres/64 fields
	16 fibres/100 fields	100 fibres/61 fields
	21 fibres/106 fields	100 fibres/55 fields
Fibre concentration	0.012 f ml^{-1}	2.37 f ml^{-1}
Workplace protection factor = 197		

TABLE 3. WORKPLACE PROTECTION FACTORS

	Respirator A	Respirator B	Respirator C
Range	11–2090	26–3493	17–500
Geometric mean	200	577	120
Geometric SD	4.3	5.2	4.4
5th percentile	19	41	11

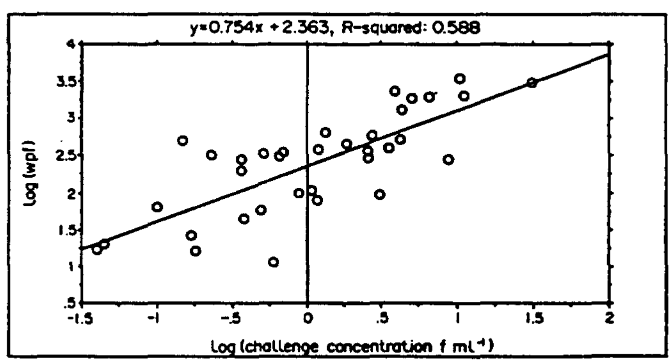

FIG. 2. Relationship between challenge concentration and workplace protection factor.

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conditions is summarized in Table 2. The workplace protection factors have been calculated from this data and are summarized in Table 3.

DISCUSSION AND CONCLUSIONS

Considerable differences were found, for all three respirators, between the protection factors afforded in the workplace and the protection implied by the literature from the HSE and the manufacturers' data.

The workplace protection factors achieved for respirator 'A' ranged from 11 to 2090 with a geometric mean of 200. Only 16% of the workplace protection factors were above 900. The workplace protection factors for respirator 'B' were generally higher than for respirator 'A' and ranged from 26 to 3493, with a geometric mean of 577. Forty per cent of the workplace protection factors for respirator 'B' exceeded 900. Limited data have been collected for respirator 'C', the workplace protection factors ranged from 17 to 500 with a geometric mean of 120, and none of the workplace protection factors exceeded 900 for this respirator.

The workplace protection factors were found to increase with increasing challenge concentrations (see Fig. 2), but the actual reason for this remains unclear. Other researchers have found a similar relationship in atmospheres of lead and of copper (MOORE and SMITH, 1976). Both researchers explained this relationship by the so-called 'behavioural effect'. It is thought that workers exercise more caution in areas of greater contamination, although this has not been apparent during the course of this work.

Despite this observed increase and the observed wide range of measured workplace protection factors, the mean values illustrate the need for the HSE and the manufacturers to come to terms with the fact that these respirators are not performing as well in the workplace, for whatever reasons, as they do under controlled laboratory conditions. However, no substantive conclusions can be made at this stage relating to the effect on the workplace protection factors by the other parameters listed in Table 1. We conclude that a nominal protection factor of 900 is inappropriately high for the negative pressure, full facepiece respirators evaluated in this study. On the basis of the calculated geometric mean, a nominal protection factor of 100 is suggested as more appropriate for this category of respiratory protective equipment.

Acknowledgements—The authors gratefully acknowledge the continued help and advice from Mr Robin M. Howie, Institute of Occupational Medicine, Edinburgh; Mr John Tickner, Health and Safety Executive, Bootle, and Mr Derek Longson, Health and Safety Executive, Sheffield.

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