

Harpur Hill, Buxton
Derbyshire, SK17 9JN
T: +44 (0)1298 218000
F: +44 (0)1298 218590
W: www.hsl.gov.uk



Testing of RPE mercury filters used in the chlor-alkali industry

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Project Leader: **N Vaughan**

Author(s): **S Frost**

Science Group: **Human Factors**

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EXECUTIVE SUMMARY

Objectives

To carry out tests on RPE filters which had been used in the chlor-alkali industry to provide protection against mercury vapour. The filters are designed to provide protection against mercury vapour and are CE marked accordingly. Instructions as to how they may be safely used are ambiguous and the typical use pattern within this industry was questioned by an HSE Inspector. Tests were requested to establish if mercury vapour collected on the filters over several shifts could be released and breathed in by the RPE wearer on a subsequent occasion of wear.

Main Findings

No significant mercury vapour could be detected in the effluent from the filters whilst being challenged with clean air. Two different measuring techniques were used; the most sensitive had a detection limit of $2 \mu\text{gm}^{-3}$. Although there is currently no published exposure standard for workplace mercury vapour, until 2005 the occupational exposure level was $25 \mu\text{gm}^{-3}$ (eight hour time weighted average). Currently the European Commission is considering adopting $20 \mu\text{gm}^{-3}$ as an exposure standard. Therefore, a concentration of less than $2 \mu\text{gm}^{-3}$ is not considered a significant hazard to health.

It is of concern that persons responsible for RPE selection and use are failing to carry this out correctly. Examples of both incorrect selection of filters and misunderstanding of the levels of hazardous substances within the workplace came to light during the course of this work. These failures could have serious consequences for RPE wearers if as a result of these failures they are inadequately protected.

Recommendations

The results of this work do not indicate that the way in which properly selected RPE filters are currently being used in the chlor-alkali industry is a cause for concern.

However these tests are limited and in order to establish that workers are definitely not being exposed to hazardous substances, as a consequence of the way in which these filters are used, further work would be required. Ideally the filters would need to be challenged with typical workplace contaminants at typical concentrations. The effluent would need to be tested for the challenge contaminants and also for other substances which may be given off as a result of a reaction of the contaminants with each other and/or the filtering material.

HSE should carry out further work, across all industries, to establish the extent of, and reasons for, incorrect estimation of workplace airborne hazardous substances and incorrect selection of RPE. Appropriate remedial action should be taken.

1 INTRODUCTION

The European Standards BS EN 141:2000 and BS EN 14387:2004 for Respiratory Protective Equipment gas filters and combined gas filters, requires that they be marked with certain information. In the case of filters which are designed to provide the wearer with protection against mercury vapour this includes a requirement for them to be marked with the statement “maximum use time 50 hours” (at least in the official language of the country of destination, or an appropriate pictogram; BS EN 14387 only).

This statement could be interpreted in a number of ways ranging from:

- The filter may be used, as part of RPE, to give protection against an atmosphere known to be contaminated with mercury vapour, provided that no longer than 50 hours has elapsed since opening the manufacturers’ sealed packaging, and that the manufacturer’s use by date has not been exceeded.

For example, if the filter packaging is opened on a Monday at 9am the filter may not be used beyond the Wednesday of the same week at 11am.

to:

- The filter may be used, as part of RPE, to give protection against hazardous atmospheres, as indicated by the manufacturer. The total accumulated time of use, against an atmosphere that is contaminated with mercury vapour, should be no greater than 50 hours, provided that the manufacturer’s use by date has not been exceeded.

For example: If a filter is used against mercury vapour once a week, for 2 hours, the same filter could continued to be used for 25 weeks (giving a total use time against mercury vapour of 50 hours) before it should be replaced. During those 25 weeks that filter may be used at other times against other contaminants, for which it is suitable, in line with the manufacturer’s recommendation.

The advice given in HSE guidance document HSG 53, regarding use of RPE filters, is to ‘seek clear instruction from the manufacturer’. However, manufacturers seem as unclear as users as to how to interpret the statement “maximum use time 50 hours”. Different manufacturers, when asked, provided both of the above interpretations.

1.1 EUROPEAN STANDARD TESTS

All RPE, including gas filters, is required to be CE marked before it can be used for personal protection in the workplace in the UK. Before filters can be CE marked, laboratory tests are required to be carried out as directed in the appropriate European Standard. The filter will be subjected to a challenge test gas at a prescribed concentration and flow rate. The time taken for the challenge gas to be detected at the breakthrough concentration, downstream of the filter, should be less than the minimum breakthrough time given in the standard. For combined filters several tests are performed using each of the appropriate gases, a new filter being used for each test gas.

Achieving the requirement for the standard tests does not give any guarantee of how the filter will perform in practice in the workplace. It may be that there is more than one contaminant present and a combined filter is selected as being the most suitable. Other controls in the workplace may have reduced the contaminant concentration(s) of the gas(es) to a level which is very much lower than that used as the challenge in the standard test. The length of time for

which the RPE is required may be short and it may be required infrequently, and stored between uses. Given these considerations it may be difficult to know for how long the filter will give adequate protection to the RPE wearer.

The standard test for a mercury filter requires that it be challenged with mercury vapour at a concentration of 13mg (13000 μg) m^{-3} . Testing is at two flow rates of 30 l min^{-1} and 95 l min^{-1} respectively. The minimum breakthrough time is 100 hours, the breakthrough concentration being 0.1 mg (100 μg) m^{-3} .

1.2 WORKPLACE CONSIDERATIONS

Mercury vapour is not listed in EH40/2005 as having a workplace exposure limit (WEL). However it is listed in the superseded EH40/2000; the 8-hour TWA OES is given as 25 $\mu\text{g m}^{-3}$. The European Commission is currently considering a recommendation that the OEL be set at 20 $\mu\text{g m}^{-3}$ (SCOEL, 2003).

In the chlor-alkali industry the concentration of mercury vapour in the workplace can exceed 25 $\mu\text{g m}^{-3}$. Measurements up to 180 $\mu\text{g m}^{-3}$ (TWA) have been recorded by HSL scientists. However, such concentrations are considerably lower than that required to be used as the challenge for testing the filters in the European Standard test (section 1.1). They are in fact, similar to the breakthrough concentration.

Filtering respirators are selected as the most suitable control to prevent exposure of workers. Typically the same filters are used on several occasions over several days with a total accumulated use time against mercury vapour not exceeding 50 hours.

1.3 TESTS

The performance of filters, as used in the chlor-alkali industry, was questioned by an HSE Inspector. He discussed (with HSL PPE section) the possibility of testing mercury filters. It is known that some types of RPE filter may 'gas off' if used on more than one occasion; that is contaminant collected within the filter material during one occasion of use may be subsequently released when the device is used again, providing the wearer with contaminated air. Enquiries with manufacturers suggested that this may have happened, a number of decades ago, with mercury vapour filters. However, no supporting documentation could be found.

It was agreed to obtain filters which had been used in the chlor-alkali industry, and test them by passing clean air through them and testing the effluent air for the presence of mercury vapour.

2 TEST METHOD

2.1 USED FILTERS

At the time of the tests there were several chlor-alkali plants in operation in the UK. Three different companies were contacted in order to obtain used RPE filters. That is, filters which had been used within their workplace to provide protection for their workers against mercury vapour, and were considered by the company, to be at the end of their usable life. The companies were initially asked to provide information as to how the filters would typically be used. A copy of the questionnaire can be found in Appendix A.

They were then asked to record the actual use of an individually identified filter or set of filters from opening the packaging to removing them from service. A copy of the form can be found in Appendix B. As requested, the user then sealed the filters, using the original manufacturer's seals, and over-wrapped them in ziplock bags. They were collected from the site by HSL officers, together with the recorded history.

A total of 10 individual filters were tested.

2.2 PREPARATION OF FILTERS FOR TESTING

The filters had been wrapped in two or three layers of zip-lock transparent plastic bag, as well as being sealed by the manufacturer's sealing caps. Each layer of packaging was opened in a fume cupboard in the presence of one of the Mercury Vapour Indicator (MVI) units described below in section 2.5.1. The MVI was connected to the calibrated chart recorder providing a continuous readout recording. The digital readout was handwritten on the pen chart.

After removal of all of the packaging the exterior of the filter was cleaned with damp paper towel and allowed to dry in the fume cupboard. The filter was then placed inside a new labelled zip-lock bag and the mass of the bag and contents, as measured using a calibrated balance, was recorded. After each test run the filter was returned to the same bag and the total mass was again recorded.

2.3 AIR FLOW RATES

The filters which were tested are used as part of a powered RPE device. The manufacturer specifies that three such filters must be attached to the blower unit at one time. The flow rate, which the blower unit supplies, was established by testing as being approximately 180 l/min. As three filters are in use at one time it was assumed that 60 l/min would be flowing through each filter and this was therefore used as the flow rate for testing each filter individually.

2.4 DURATION OF TEST RUN

Each filter was challenged with the clean laboratory airflow of 60 l/min (supplied from calibrated equipment) for approximately five hours. This length of time was chosen as a typical maximum day's use and in order allow for collection of a detectable mass of mercury vapour on the sample tubes.

2.5 MEASUREMENT OF MERCURY VAPOUR LEVELS

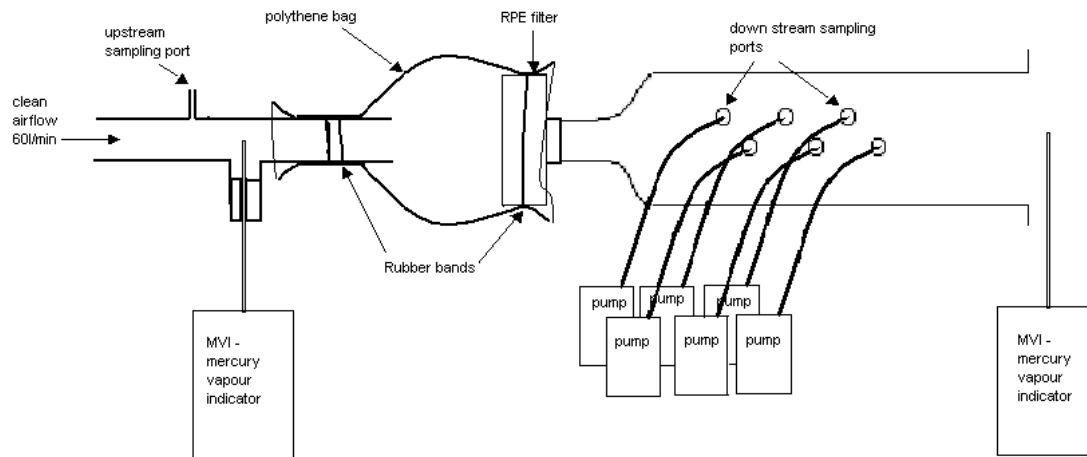


Figure 1 Diagram of the test set-up

2.5.1 Mercury Vapour Indicator (MVI) Units

Two calibrated mercury vapour indicator units were used to record the level of mercury vapour. One sampled the clean air supplied to the filter and the other sampled the effluent air downstream of the filter (see figure 1). The devices were supplied by Shawcity Ltd. and were borrowed from field measurement section at HSL. They are capable of indicating the presence of very low levels of mercury vapour (down to 0.1 microgram per cubic metre) however, the instructions indicate that they are affected by other substances, for example water vapour.

The units are designed for taking real time measurements in the workplace and have a direct reading digital display. For these tests they were connected to a chart recorder in order to give a continuous record of the deflection over the time of each test. Before each test run the chart recorder was calibrated against the digital display.

The first test run showed a small deflection on the downstream side of the filter. Consultation with Shawcity revealed that the device could give such a deflection if substances other than mercury vapour were present. In order to be certain that of the presence of mercury vapour, it was decided that a detection method specific to mercury would be needed.

2.5.2 Pumped sample tubes

SKC Hydrar sample tubes were used to collect mercury vapour which had been driven off of the filter by the applied clean airflow. One was placed upstream of the RPE filter as a check on the clean air supplied to the filter and several were placed downstream of the filter (see figure 1).

Samples were drawn through the tubes using sampling pumps operating at approximately 200 ml/min. The pumps were calibrated before and after each test run.

The upstream sample tube was sampling for the entire test run time of five hours. The sample tubes downstream of the filter were left in place for different lengths of time. All six were set sampling from the beginning of each test run. One was removed and sealed after 30 minutes. The remainder were removed and sealed after 1,2,3,4 and 5 hours respectively.

The samples were analysed in two batches. The first batch were analysed by Mr D Musgrove at HSL using Inductively Coupled Plasma – Mass Spectroscopy (ICP-MS) the detection limit applied was 100 ng. The second batch were analysed by Harwell Scientifics using ICP-MS; the detection limit applied was 50 ng.

3 RESULTS AND DISCUSSION

3.1 RPE FILTERS

The filters requested for testing were of a type that is recommended by the manufacturer for use to protect against inhalation of mercury vapour within the workplace. Two different companies provided used filters but obtaining them was not without difficulty. One of the companies had collected filters, which had been used for protection against mercury vapour, only to subsequently discover that they were not intended for such use (these filters were not included in our tests). This is indicative of insufficient care having been taken in the filter selection process. The other company experienced significant staff changes at management level, which resulted in different information being supplied with the filters (discussed in section 3.2).

3.2 FILTER USE INFORMATION

Table 1 was compiled from the information given by the companies who provided the used filters. It shows the number of hours for which the filter was used per day, from the day of first use (day 1). The maximum number of days over which a filter was used is 12. The final column gives the total accumulated use time, which was either 31 or 34 hours.

Table 1 Record of filter use against mercury vapour (from information supplied by the users)

| Filter | Filter use per day (hours) | | | | | | | | | | | | Total hours used |
|--------|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|------------------|
| | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 | Day 9 | Day 10 | Day 11 | Day 12 | |
| A1 | 5 | 5 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 31 |
| A3 | 5 | 5 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 31 |
| A2 | 5 | 5 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 31 |
| B1 | 5 | 5 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 31 |
| B3 | 5 | 5 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 31 |
| B2 | 5 | 5 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 31 |
| C1 | 3 | 7 | 7 | 0 | 0 | 7 | 7 | 3 | | | | | 34 |
| C2 | 3 | 7 | 7 | 0 | 0 | 7 | 7 | 3 | | | | | 34 |
| D1 | 6 | 7 | 7 | 7 | 4 | | | | | | | | 31 |
| D2 | 6 | 7 | 7 | 7 | 4 | | | | | | | | 31 |

Information on the ambient mercury vapour concentrations in the workplace, in which the filters had been used, is vague. One company suggests up to $50 \mu\text{gm}^{-3}$, another gave actual levels on 3 different days as 22, 21 and $40 \mu\text{gm}^{-3}$, respectively, but no information for other days. However measurements taken by HSL field scientists using personal samplers indicate that time weighted average (TWA) mercury vapour levels, at these same sites, may be as high as $180 \mu\text{gm}^{-3}$. This level is high compared with the $20 \mu\text{gm}^{-3}$ present within the workplace of the chlor-alkali industry in Sweden in 1988 (Sallsten et al, 1990).

Other hazardous substances, which the companies indicated as being present in the workplace air with the mercury vapour, were chlorine and dust. The level of chlorine gas was described as “small” by one employee and as a maximum of 1000 ppm by another employee working for the same company. The 8 hour TWA WEL for chlorine is 0.5 ppm (EH40/2005). Therefore a quoted level of 1000 ppm indicates a significant misunderstanding on the part of the company of the ambient working conditions.

3.3 RECEIVED CONDITION OF FILTERS

The filters that were collected from the sites had all had their manufacturer’s end seal caps replaced and had all been individually wrapped in clear polythene bags. There was no indication of physical damage to any of the filters. The outside of the filters (labelled R) from one of the sites was contaminated with a brick red colour dust. The other filters were relatively clean in appearance.

3.4 OPENING OF FILTER PACKAGING

The peak mercury vapour levels as measured (by an MVI unit) as each layer of packaging was first opened are given in Table 2. The inner bag contained a volume of air of approximately one litre maximum. The middle layer packaging refers to a bag large enough to contain three filters in individual bags. The middle layer packaging contained a volume of air of approximately 2.5 l maximum. Some of the filters had been wrapped in an outer layer bag of identical size to the middle layer bag. This was tightly fitting over the middle layer packaging and therefore contained only a small volume of air.

Table 2 Peak mercury vapour levels on opening filter packaging

| filter | packaging opening peak mercury vapour μgm^{-3} | | |
|--------|--|--------------|-------------|
| | outer layer | middle layer | inner layer |
| A1 | N/A | 0 | 99 |
| A3 | N/A | 0 | 300 |
| A2 | N/A | 0 | 23 |
| B1 | N/A | 22 | 55 |
| B3 | N/A | 0 | 19 |
| B2 | N/A | 0 | 27 |
| C1 | 8 | 87 | 170 |
| C2 | 17 | 80 | 280 |
| D1 | 80 | 300 | 80 |
| D2 | 17 | 34 | 89 |

The concentration of mercury vapour within the layers of packaging within which the used mercury filters were received ranged from 0 to 300 μgm^{-3} .

The filters had been stored in the bags for varying lengths of time, which would have allowed time for vaporisation of mercury contained within the packaging. Some of these measurements of mercury vapour concentration are well above acceptable workplace levels. However, given the small volume of air contained within the packaging the actual amount of mercury vapour present inside the packaging was small. The highest measured mercury vapour concentration was $300 \mu\text{gm}^{-3}$ contained within an estimated volume of 2.5 l. A typical fume cupboard size is 1.5m x 2.0m x 1.0m, containing a volume of 3m^3 or 3000 litres. Opening the bag within such a *non-operating* fume cupboard, diffusion of the contents to homogeneous distribution would have resulted in a vapour concentration within the fume cupboard of only $0.25 \mu\text{gm}^{-3}$; a concentration considerably less than the $20 \mu\text{gm}^{-3}$ presently being considered as an occupational exposure limit by the European Commission Scientific Committee for Occupational Exposure Limits (SCOEL).

3.5 TEST RUNS

3.5.1 MVI results

Table 3 Summary of deflection recorded by MVI unit positioned upstream of filter

| Filter | Mercury vapour level upstream of the filter as recorded by an MVI μgm^{-3} | | | | |
|--------|---|------|--|-------|--------------|
| | max | min | comments | mean | standard dev |
| A1 | 0 | -1.4 | initially 0, gradual decrease to -0.2 throughout test | -0.7 | 0.6 |
| A3 | 0 | -1.2 | gradual variation throughout test | -0.6 | 0.5 |
| A2 | 1 | -0.7 | gradual variation throughout test | 0.15 | 0.7 |
| B1 | 0 | -1 | gradual variation throughout test | -0.5 | 0.4 |
| B3 | 0 | -1.8 | initially 0, gradual decreased throughout test | -0.9 | 0.7 |
| B2 | 0.3 | -2.4 | varying throughout test | -1.05 | 1.1 |
| C1 | 2 | -1.4 | for 4.5 hours deflection < 0; final 30 mins increased to 2.0 | 0.3 | 1.4 |
| C2 | 0.2 | -0.8 | zero for 3 hours; varying gradually thereafter | -0.3 | 0.4 |
| D1 | 0 | -0.2 | initially 0, gradual decreased to -0.2 throughout test | -0.1 | 0.1 |
| D2 | 0 | -0.2 | initially 0, gradual decreased to -0.2 throughout test | -0.1 | 0.1 |
| | | | mean standard deviation | | 0.6 |
| | | | detection limit (3 x standard deviation) | | 1.8 |

The deflection levels detected by the MVI unit upstream of the filter are given in Table 3. The MVI unit had been zeroed using the same laboratory air source as used for the test run. This table shows the variation in the deflection. This information was used to calculate a detection limit for the measuring technique of $1.8 \mu\text{gm}^{-3}$, as well as providing a base deflection for each test run which should be deducted from measurements downstream of the filter.

Table 4 Summary of deflection recorded by MVI unit positioned downstream of filter

| filter | Mercury vapour level upstream of the filter as recorded by an MVI | | | | filter loss in mass during test g |
|--------|---|-----|------|--|-----------------------------------|
| | initial | max | min | 5hour test- effluent vapour level MVI unit | |
| A1 | 5 | 5 | 0 | 2 for first 20 mins; varying between zero and 0.4 for 4.6 hours | 25.6 |
| A3 | 0 | 0 | -2 | gradual variation between 0 and -2.0 throughout test time | 5.3 |
| A2 | -2 | 3 | -2 | negative (-2.0 for approx 30 minutes; zero for 2.5 hours gradual increase to 3.0 for remainder of test time | -1.3 |
| B1 | 1 | 1 | 0 | 1.0 for first 2 mins; 0.6 decreasing to 0 by 1.5 hrs; thereafter zero | 13.94 |
| B3 | 4.4 | 4.4 | 1 | some dips to 1 during first hour, but continuing 3-4 for 5 hours | 28.7 |
| B2 | 2 | 4 | 1.5 | variable 1.5 to 4.0 | 6.7 |
| C1 | 6.6 (reducing to 4 after 3 minutes) | 6.6 | 3 | approx 4.0 throughout test run (varying between 3.0 and 5.0) | 52.25 |
| C2 | 5.5 | 5.8 | 2 | initial 40 mins varying between 2.0 and 5.8; 5 for 3.5 hours, reducing to 3 for final hour | 22.4 |
| D1 | 5 | 5 | 3.5 | 5.0 for first, thereafter hour gradual reduction to 3.5 | 27.841 |
| D2 | 0 | 0.4 | -1.4 | varying between -1.4 and 0.4 throughout test time | 13.8 |

Table 4 gives information on the deflection recorded by the MVI positioned downstream of the filter. Several of the test runs indicate that mercury vapour may have been given off from the filter. The data presented is the raw data, no correction has been applied to take in to account the deflection recorded upstream of the filter. The maximum concentration detected for a significant part of the test run was $5.5 \mu\text{gm}^{-3}$ subtracting the mean upstream deflection for this test run gives a value of $5.8 \mu\text{gm}^{-3}$.

The suppliers of the MVI unit consider that the units cannot be relied upon to definitely detect the presence of low levels of mercury vapour unless other interferences can be eliminated. According to the equipment supplier, a value of up to $5 \mu\text{gm}^{-3}$ could be attributed to the presence of high concentrations of water vapour. Both MVI units were zeroed before each test run in the challenge air stream. This air was of low humidity, sourced from the warm dry laboratory, typically 34% relative humidity at 21°C. The filters under test had probably been used in conditions of lower temperature and higher humidity and under such conditions would have adsorbed water vapour during use. Table 4 gives the loss of mass of the filter during testing. Some of the filters experienced significant loss of mass (5 filters losing in excess of 30g) during the test run and it was during these same test runs that the downstream MVI unit

indicated the highest levels. It is reasonable to assume therefore that the indicated deflections are probably due to the presence of water vapour in the effluent air, which has been driven off from the filter material by the dry laboratory air.

Assuming the maximum ambient mercury vapour concentration (recorded by HSL scientists) of $180 \mu\text{g m}^{-3}$ had been present for the total use time of the filter of 34 hours. The filter subjected to a flow rate of 60 l min^{-1} could have collected a maximum of 22 mg of mercury during use.

Calculation of the overall detection limit for the measuring technique for the presence of mercury vapour needs to take into account the deflection caused by the presence of water vapour which can be as much as $5 \mu\text{g m}^{-3}$. This needs to be added to the detection limit calculated from the measured variation in the upstream measurement of $1.8 \mu\text{g m}^{-3}$. The total detection limit for the presence of mercury vapour using this measurement technique becomes $6.8 \mu\text{g m}^{-3}$ a value which is higher than any recorded corrected downstream deflection. Therefore it cannot be concluded with any certainty that any mercury vapour was given off from any of the filters during testing.

3.5.2 SKC Hydrar sample tubes

The results of the analysis of the sample tubes for the presence of mercury revealed that no detectable mass of mercury had been collected on any of them.

Given the detection limit of the analysis method, there is a minimum concentration of mercury vapour, which would lead to collection of a detectable mass of mercury. For the longest sampling time of 5 hours, at sample flow rate of 0.2 l min^{-1} the presence of $2 \mu\text{g m}^{-3}$ of mercury vapour in the effluent air would allow 120ng of mercury to be collected on a sample tube. This is above the detection limit of 100ng for the analysis method of either Harwell Scientific or HSL. In other words if a mercury vapour concentration of 2 micrograms per cubic metre or greater had been present in the effluent air, it should have been detected. Harwell Scientific claim a detection limit for their analysis method such that only $1 \mu\text{g m}^{-3}$ of mercury vapour in the effluent air could be detected.

The OEL for mercury vapour, prior to 2005 was $25 \mu\text{g m}^{-3}$ (EH40;2000). There is currently no WEL but the European Commission is currently discussing an exposure limit of $20 \mu\text{g m}^{-3}$ which, if agreed, will probably be adopted in this country. The presence of less than 2 micrograms per cubic metre of mercury vapour in inhaled air would represent an exposure 10 times less than that not presently considered to be potentially harmful.

4 FURTHER DISCUSSION AND CONCLUSIONS

The presence of mercury vapour within the filter packaging clearly indicates that the filters had been externally contaminated with mercury or had been packaged in an environment in which there was a high concentration of mercury vapour, well above the pre-2005 OEL.

No significant amount of mercury vapour was given off from the filters on testing with clean air. Continuing to use these combined filters as part of RPE for another 5 hours within a mercury clean workplace should not have exposed the RPE wearer to a detectable mercury vapour concentration, unless another workplace contaminant was acting on the filter material in such a way as to cause release of mercury vapour.

No conclusions can be drawn as to whether these filters would continue to provide protection in a mercury vapour contaminated environment. In order to ascertain this, further testing would be necessary, challenging the filters with mercury vapour. Other work has been carried out on mercury RPE filters after they had been used to provide protection for workers in mercury mines (Vouk et al, 1951). The ambient concentrations of vapour in the mines then studied were very high averaging $1200 \mu\text{gm}^{-3}$ with up to $2000 \mu\text{gm}^{-3}$ at the working place of some of the workers. Laboratory testing of the filters after 60 hours use over up to 20 days showed that they were still impermeable to mercury vapour (detection limit appears to be $10 \mu\text{gm}^{-3}$).

In order to definitely state that no significant exposure to hazardous substances would occur when this type of filter continues to be used, further tests would be necessary, ideally challenging the filters with the specific mix of hazardous substances which are known to be present in a particular workplace. (In the case of the chlor-alkali industry a significant concentration of chlorine gas as well as mercury vapour may be present in the workplace.) Testing the effluent air for a range of contaminants would be necessary, although there would be significant technical difficulties in conducting this work.

There is evidence of selection of filters that are unsuitable for the conditions and underestimation of the ambient concentrations of mercury vapour concentrations in these workplaces. HSL scientists have measured mercury vapour concentrations at these same workplaces and found them to be much higher than those measured in the same industry in Sweden. It is also of concern that there appears to be misunderstanding of the concentrations of other airborne hazardous substances, such as chlorine gas, which may be present in the workplace.

5 APPENDICES

5.1 APPENDIX A

HSE Study: Mercury Vapour Filters for Respiratory Protective Equipment Preliminary questionnaire

Company name:

Contact name:

1. Approximately how many of your employees require respiratory protection against mercury vapour?
2. Please give details of RPE and filters which you currently use for protection against mercury vapour.

| RPE | | | Filters | | |
|------|------|-------|---------|---------------------|--------------------|
| Type | Make | Model | Type | Manufacturer's Code | Number of filters* |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

*Please give the number of filters which are fitted simultaneously to this type of RPE.

3. How many mercury vapour filters would you replace in a month?
4. What is the maximum number of days, from the day of opening, for which each mercury vapour filter is in use?
5. What is the maximum total number of hours for which a mercury vapour filter is worn to give respiratory protection against mercury vapour?
6. What is the maximum number of wearing occasions for which the same filter would be used?
7. What substance(s), if any, other than mercury vapour, do you expect the filters are filtering from the working environment?

| Substance | Concentration |
|-----------|---------------|
| | |
| | |
| | |
| | |

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