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EXPOSURE TO ASBESTOS FIBRES DURING GASKET REMOVAL

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Abstract—In the chemical industry, asbestos gaskets have been used extensively to prevent leakage between solid surfaces. The purpose of this study was to assess the potential personal exposure to asbestos fibres during gasket removal and thus to determine what is reasonably required in terms of protective regime and work method. Two groups were studied: group A, who only removed gaskets if they could be removed easily and without breaking; and group B, who removed gaskets which were left by the first group. For both groups, the gasket was first made wet before removal. The samples were analysed using phase-contrast microscopy and transmission electron microscopy. The average exposure to fibres for group A, averaged over the work period, was 0.04–0.242 fibres ml^{-1} as determined by phase-contrast microscopy. On further analysis with transmission electron microscopy it was found that only four of the 11 samples contained asbestos in very low concentrations and that most of the fibres, which were identified using phase-contrast microscopy, probably originated from the glass fibre lagging around the pipes. For group B the average fibre concentration, averaged over the work period, as determined by phase-contrast microscopy, ranged between below the detection limit and 0.02 fibres ml^{-1}. The subsequent transmission electron microscopy analysis shows that the exposure to asbestos fibres ranged between below the limit of detection to 0.004 fibres ml^{-1}. This study shows that the exposure to asbestos fibres during gasket removal activities was well within the 8-h average exposure limit of 0.3 fibres ml^{-1}. Copyright © 1996 British Occupational Hygiene Society.

INTRODUCTION

In the chemical industry, asbestos gaskets have been used extensively to prevent leakage between solid surfaces. With time, the effectiveness of the seal may become compromised and therefore they are replaced periodically. Normally they are replaced on an *ad hoc* basis. However, during a major maintenance overhaul of a chemical facility, called a 'turnaround', hundreds or thousands of gaskets may have to be replaced over a period of a few days by maintenance teams. Typically, these activities are carried out by maintenance personnel from contracting companies who go from turnaround to turnaround performing similar jobs. Therefore, if there is a potential hazard through exposure to asbestos fibres, then it is these individuals who are at most risk.

Nowadays, the use of asbestos is limited by restrictions which are legislated in both European and North American countries. These restrictions are, naturally, due to the potential of asbestos to cause cancer. Eventually, it is expected that all existing gaskets will be replaced by non-asbestos substitutes. However, at present many chemical plants still use asbestos gaskets in their facilities and it will

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probably be years before all of them have been substituted with non-asbestos alternatives. Additionally, in developing countries, asbestos is still permitted and continues to be used for many applications, including gaskets. Therefore, it is important to determine whether there is a health risk associated with the removal of gaskets.

The three major types of gaskets used in the chemical industry are sheet or plate gaskets, spiral wound gaskets and metal jacketed gaskets. For the metal jacketed type, the gaskets are completely encapsulated by metal as the name suggests. These were not considered in this study. Spiral wound gaskets consist of a crysotile asbestos filler material compressed between stainless steel spiral windings. They typically fall out as soon as the pressure on the seating surfaces has been released. Plate gaskets are compressed sheets of crysotile asbestos bound together with nitryl or neoprene. When plate gaskets have been sitting in an installation for a long period under pressure and exposed to chemical agents, they may become damaged and fixed. In order to remove them, and leave a clean surface on which to put a new gasket, scraping may be required. This increases the chance of asbestos fibres becoming airborne and maintenance workers exposed.

There are not many studies in the literature which document the exposure to airborne asbestos during gasket removal. McKinnery and Moore (1992) looked at both removal of gaskets and packing material. For gaskets, the average monitoring period during removal for five samples was 31 min. On analysis using phase-contrast microscopy (PCM), the fibre concentration ranged between 0.049 and 0.44 fibres ml^{-1}. Further analysis was done using transmission electron microscopy (TEM). The concentrations found using TEM were higher, (0.86–18.55 structures ml^{-1}), however, for this study, the analysis method did not allow a direct comparison between PCM and TEM. Another study done by Millette and Mount (1993) looked at removal of dry packing material for three samples monitored over periods ranging between 25 and 33 min. They found fibre concentrations between 0.2 and 1.0 fibres ml^{-1} using PCM analysis. On analysing using TEM and converting to the PCM equivalent, fibre concentration was higher, ranging from 1.5 to 2.6 fibres ml^{-1}. These two studies by McKinnery and Moore (1992) and Millette and Mount (1993) both used a simulated work environment.

Cheng and McDermott (1991) looked at the difference between wet and dry removal of asbestos gaskets in a real work situation. The analysis method used was limited to PCM. They found that the average fibre concentration of four samples using dry removal was 0.11–0.23 fibres ml^{-1}. The sampling duration ranged between 19 and 55 min. For wet removal, fibre concentrations for two samples were below 0.06 fibres ml^{-1}. The sampling duration for the first and second sample was 15 and 30 min, respectively.

The purpose of this study was to assess the potential exposure to asbestos fibres during a real work situation and to determine what is reasonably required in terms of protective regime and work method. This second point was important in the light of legislation in The Netherlands covering asbestos activities (Ministry of Social and Work Affairs, 1993) which was valid at the time of the study.

In The Netherlands, at the time of this study, all asbestos activities were classified under one general rule which describes the protective measures to be taken during these activities.

(1) Workers must wear personal protective equipment (HEPA filter full-face mask respiratory protection, hooded coveralls, gloves and boots).
(2) The area must be cordoned off during removal activies.
(3) There must be a personal decontamination procedure in place.
(4) Individuals employed must be trained in the hazards of asbestos.
(5) Area monitoring must take place at the end of the job in order to declare the area asbestos-free.
(6) 'Asbestos removal activities must be reported beforehand to the authorities.

For gasket and packing removal, step (5) is not required and step (6) can be done once a year to a cover gasket removal for the whole year. This regime, when applied to gasket removal, is logistically challenging, conservative and expensive given the tight time schedule of a 'turnaround', and the number of concurrent activities which are carried out in the same location. A compromise position was adopted whereby two work methods were applied for the removal of asbestos gaskets.

METHOD

Group A

Group A was the 'first pass' group. In the course of the maintenance activity, when a gasket was to be removed, the individual wore a P3 disposable half mask, wet the gasket with a wetting agent, and then an attempt was made to remove it with little effort and with only a putty knife. If the gasket came out easily, it was placed in a plastic bag for special disposal. If the gasket proved difficult to remove or broke in the process, it was left for group B.

Employees from group A were working in sections of the plant where it was thought that asbestos gaskets would be encountered. However, it should be noted that there was no way of knowing for sure whether or not asbestos or substitutes would be encountered during the work activities. All the gaskets which were removed were saved for bulk analysis.

Group B

The gaskets which were left out during the first phase were removed by a team of trained individuals during the evening when there were limited personnel on site. For this group, the area was isolated, and a full personnel protective regime of P3 power pack respiratory protection (Protection Factor = 200), hooded overalls, boots and gloves was used. Full decontamination procedures were followed at the end of the shift. Again, the gaskets were saved for bulk analysis.

Personal exposure monitoring was performed for both groups according to NVN 2939 (1987). After sampling, the filters were divided into two. The first half was analysed using phase-contrast microscopy (PCM) according to NVN 2939 (1987). The second half of the filter was analysed using transmission electron microscopy (TEM) according to NIOSH 7402 (1989). TEM distinguishes between asbestos and non-asbestos fibres whereas PCM does not. It was felt that the additional analysis using TEM was necessary because other airborne fibres would likely be present since piping insulation (mainly fibre glass) was also removed in the same operation as gasket removal.

Owing to the expense associated with the TEM analysis, it was decided beforehand that those samples which had a concentration of less than 0.015 fibres ml^{-1} as determined by PCM, would not be analysed by TEM. (This figure was selected since this represents the total exemption value according to Dutch legislation.) This means that when an area measurement is found to have a concentration of less than 0.015 fibres ml^{-1}, the area is considered free of asbestos (Ministry of Social and Work Affairs, 1993).

RESULTS AND DISCUSSION

Table 1 shows the results for group A. Group A removed between two and 12 gaskets per shift. All gaskets were spiral wound. The average fibre concentration for work method A was 0.042–0.242 fibres ml^{-1}. When converted to exposure averaged over 8 h, it varied between 0.036 and 0.215 fibres ml^{-1}. On further analysis with TEM only four of the 11 samples contained asbestos in very low concentrations. This is not surprising since on bulk analysis of the gaskets, only five of the gaskets removed by group A contained asbestos. This is unfortunately the possible outcome when a real life situation is chosen rather than a simulated environment. These results are interesting, however, because of the relatively high concentration of fibres found by phase-contrast microscopy. These fibres probably came from the piping insulation which was removed prior to removal of gaskets. Had the TEM analysis not been carried out, there would have been erroneous over estimation of the airborne asbestos fibre concentration.

Table 2 shows the results for the second exposure group. All the gaskets removed by group B were asbestos plate gaskets. The work was intensive and represented a worse-case scenario since all the insulation was removed and the flange, or equipment piece was already open. This meant that full shift was spent only removing difficult to remove gaskets. Each worker removed between three and 13 gaskets. The average fibre concentration, as determined by PCM, ranged between below the detection limit and 0.02 fibres ml^{-1}. When this is converted to an 8-h limit, then the value ranges from below the detection limit to 0.005 fibres ml^{-1}. The TEM analysis shows that the exposure to asbestos fibres even in this worst-case scenario still remains well below both the limit value and the action limit even when looking at the statistics in terms of real time rather than averaging over 8 h. The only value obtained above the detection limit was 0.0037 asbestos fibres ml^{-1}.

CONCLUSIONS

The results of this study show that personal exposures to asbestos are kept well below the current limit values in The Netherlands. Using a suitable wetting agent provides adequate protection of the employee while limiting the cost and delay posed by unnecessary control measures. Secondly, phase-contrast microscopy, which has traditionally been used for this type of exposure monitoring situation, may not be applicable where there are mixed fibres present. This method overestimated the asbestos fibre concentration in this study.

It is interesting to note the legislative developments regarding asbestos in The Netherlands following the outcome of this study. The Labour Inspectorate has

Table 1. Exposure to airborne fibres for group A

Sample No	Number of gaskets	Time (min)	Total fibre concentration using PCM ($f\ ml^{-1}$)	Asbestos fibre concentration using TEM ($f\ ml^{-1}$)	Other inorganic fibres using TEM ($f\ ml^{-1}$)	Comments
1	2	432	0.068	Not detectable	0.043	One asbestos, one non-asbestos, both spiral wound
2	4	427	0.242	0.0012	0.0567	Two asbestos slightly damaged asbestos, all spiral wound
3	9	400	0.098	Not detectable	0.0203	Non-asbestos, spiral wound
4	2	421	0.042	Not detectable	0.0074	Non-asbestos, spiral wound
5	4	410	0.042	Not detectable	0.0258	Non-asbestos, spiral wound
6	4	400	0.093	Not detectable	0.025	Non-asbestos, spiral wound
7	2	430	0.051	0.0014	0.0157	Non-asbestos, spiral wound
8	5	416	0.056	0.0008	0.0169	Two asbestos, three non-asbestos, all spiral wound
9	5	425	0.052	0.0007	0.0151	Non-asbestos, spiral wound
10	4	435	0.051	Not detectable	0.032	One asbestos, three non-asbestos, all spiral wound
11	7	400	0.141	Not detectable	0.0289	Non-asbestos, spiral wound

Table 2. Exposure to airborne fibres for group B

Sample No.	Number of gaskets	Time (min)	Total fibre concentration using PCM ($f\ ml^{-1}$)	Asbestos fibre concentration using TEM ($f\ ml^{-1}$)	Other inorganic fibres using TEM ($f\ ml^{-1}$)	Comments
1	2	141	0.018	Not detectable	0.0144	All asbestos, plate type
2	2	141	0.02	0.0037	0.0237	All asbestos, plate type
3	3	71	Not detectable			All asbestos, plate type
4	3	71	0.025	Not detectable	0.0413	All asbestos, plate type
5	13	156	0.005			All asbestos, plate type
6	9	156	Not detectable			All asbestos, plate type
7	5	69	0.014			All asbestos, plate type
8	5	69	Not detectable			All asbestos, plate type
9	3	147	Not detectable			All asbestos, plate type
10	6	141	0.005			All asbestos, plate type

Black area indicates that the sample was not analysed by TEM.

recently published new draft guidelines which apply to removing asbestos gaskets. These allow, under certain conditions, for 'Work Method A' to be used for gasket removal activities (Ministry of Social and Work Affairs, 1994). For the employee, adequate protection and ease of compliance is assured while for the employer, the cost and complicated logistics associated with 'Work Method B' are avoided. This study shows another example of how it is possible for industry and legislative bodies to pull together on health and safety issues to study situations for mutual benefit.

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