FILE NAME: Asbestos Textile Product Use (ATPU)

DATE: 1975

DOC#: ATPU009

DOCUMENT DESCRIPTION: Journal Article - Fibre Release from Asbestos Garments

Annals Occup. Hygiene Vol 18, pp 143–149, 1975

Ann. occup. Hyg. Vol. 18, pp. 143–149. Pergamon Press 1975. Printed in Great Britain

FIBRE RELEASE FROM ASBESTOS GARMENTS

G. W. Gibbs

Dept. of Epidemiology and Health and Occupational Health and Safety Unit, McGill University, Montreal, Canada

Abstract—The concentrations of airborne fibres (5 µm) in the breathing zones of workers wearing asbestos safety garments were measured using the membrane filter method. At plant 1 where men wore asbestos coats, hoods and mittens, concentrations of fibres ranged from 0·3 to 5·0 fibres/cm^3 and the 8 hr time-weighted concentrations from 0·1 to 1·1 fibres/cm^3. At plant 2 where hoods, coats, mittens and leggings were worn, concentrations of airborne fibres ranged from 9·9 to 26·2 fibres/cm^3 and the 8 hr time-weighted average concentration was 4·7 fibres/cm^3. Counts of fibres collected on Nuclepore filters and examined by scanning electron microscopy showed that the concentrations of fibres 5 µm in length represented 2·3 32 per cent of the total airborne fibre. The difference between the quantities of fibre released from the garments at the different plants was probably related to the methods or materials used in garment manufacture. The results showed that there is a need to identify and to reduce the release of fibre from asbestos safety garments currently supplied to protect persons working in hot environments.

INTRODUCTION

Tests of industrial-type asbestos aprons and gauntlets in the laboratory (Bamber and Butterworth, 1970) have shown that concentrations of asbestos near the breathing zone of a worker can exceed the current British (British Occupational Hygiene Society, 1968) and proposed US standard (Occ. Safety and Health Administration, 1972) of 2 fibres/cm^3 for chrysotile and amosite asbestos. Fibre concentrations associated with the wearing of new unlined asbestos cloth fire-fighting helmets have also been shown to exceed 2 fibres/cm^3 (Lumley, 1971). The concentrations of asbestos to which industrial workers wearing asbestos safety garments at their place of work are exposed, and hence the potential hazard for such workers, have not been previously reported. The objective of the present study was to provide such information.

MATERIALS AND METHODS

Population for study

The study involved men employed at two ore reduction plants where asbestos safety garments were worn routinely. The first survey was conducted in the blast furnace section of a large steel plant (plant 1) where ore for reduction was fed continuously to four furnaces. Five men were normally assigned to each furnace and all workers on two neighbouring furnaces were chosen for study. As the work on each furnace was fundamentally the same, neighbouring furnaces were chosen for convenience. The men working on these furnaces prepared channels along which molten iron flowed, tapped the furnaces and kept channels clear of slag during casting. Castings were held at approximately 4-hr intervals and lasted $\frac{1}{2}$–1$\frac{1}{4}$ hr. Men generally wore asbestos safety coats for the duration of a casting but hoods and gloves were worn for varying periods as necessary.

Address for reprints: Dr G. W. Gibbs, 3775 University St., Montreal, Quebec, Canada

The second survey was conducted at a small plant manufacturing elemental phosphorus (plant 2). Four men were responsible for two furnaces which operated continuously. Slagging operations (i.e. tapping the furnace) were performed at approximately 1–1½-hr intervals and lasted 15–45 min. The work was similar to that at the steel works. Asbestos safety coats and leggings were worn throughout the slagging operations but hoods and gloves were worn only when necessary. Men employed on two shifts were studied.

Asbestos garments

The asbestos garments worn by men in this study, as far as could be ascertained, were from three sources. Information and properties of the cloths from which garments were manufactured are summarized in Table 1. In spite of extensive inquiries, it was not possible to obtain full details of the cloths from which garments were manufactured in all cases. This was due to the fact that manufacturers bought cloth from more than one supplier and it was not always possible to identify the individual coats used by the companies. Estimates of the age of the garments were obtained from each man tested.

TABLE 1. MATERIALS USED FOR MANUFACTURE OF ASBESTOS GARMENTS

		Plant 1 Garments—Source A	Plant 1 Garments—Source B	Plant 2 Garments—Source C
Coats	Weight	2·5 lb/yd²	2·5 lb/yd²	2·25–2·50 lb/yd²
	Grade	Underwriters*	Underwriters	Underwriters
	Weave	Plain	Plain	Plain and herring-bone
	Treatment	Nil	½% Acrylic resin based on weight of cloth	Nil
Hoods	Weight	1·2 lb/yd²	1·2 lb/yd²	2·25 lb/yd²
	Grade	Underwriters	Underwriters	Underwriters
	Weave	Herringbone	Herringbone	Basket
	Treatment	Aluminized outside	Aluminized outside	Dust suppressed† Aluminized outside
Mittens	Weight	2·50 lb/yd²	2·50 lb/yd²	2·25–2·50 lb/yd²
	Grade	Commercial	Underwriters	Underwriters
	Weave	Plain	Plain	Plain and herring-bone
	Treatment	Nil	½% Acrylic resin based on weight of cloth	Nil
	Comments	Knit flame proof cuff, chrome leather, green tanning—palm and thumb		
Leggings	Weight	Not worn	Not worn	2·50 lb/yd²
	Grade			Underwriters
	Weave			Basket
	Treatment			Dust suppressed

* Underwriters—80–85% asbestos.

† These hoods were manufactured from heavier cloth than normally encountered in industry and the aluminized layer had a different appearance.

Collection of airborne fibre samples

Airborne samples of dust were collected using calibrated personal monitors which were attached to the employee in such a way as not to interfere with his work. The open-faced filter was located in the employee's breathing zone, outside the asbestos coat but under the hood when worn. Samples for optical fibre counts were collected on Millipore 37 mm (type AA, pore size 0·8 μm) and a number of samples for scanning electron microscopic examination were collected on Nuclepore (type GE-40 pore size 0·4 μm) filters. Sampling rates were approximately 2 l./min. The sampling period was the total time from the start to finish of a slagging operation. It was not possible to collect samples of ambient air in the work areas as safety regulations at both plants did not permit persons other than the employees in the work area during a cast. However, we were assured by management and research departments that there were no other sources of fibrous dusts.

Counting of airborne fibre samples

(a) *Optical counts.* Millipore membrane filters were mounted and counted using the method of the British Occupational Hygiene Society (1968). Fibres greater than or equal to 5 μm in length and with length:breadth ratios greater or equal to 3:1 were counted on a Zeiss WL standard research microscope at a magnification of 400× using phase contrast. At least 20 fields were counted on each filter and the same observer counted each sample twice.

(b) *Scanning electron microscopy.* Airborne samples of dust collected on Nuclepore filters were examined by scanning electron microscopy (SEM) as follows. Circular segments (13 mm in diameter) were cut with radii touching the centre of the 37 mm filter and were attached by adhesive tape to standard 13 mm SEM mounts. Samples were coated with 150 Å layers of Au–Pd and scanned at a magnification of approximately 6000× on a Cambridge Stereoscan type 96113 Mark 2A scanning microscope. Scans were performed across the diameter of the spacement and photographs of random fields were taken. The field area ranged 257–265 μm². Both the total number of fibres and those with lengths greater than or equal to 5 μm were counted.

Surveys

(a) *Studies at plant* 1. *Day* 1 (Pilot study)—All men wore asbestos coats, gloves and hoods issued by the Steel Company (Source A). No leggings were worn. Details of the garments are shown in Table 1.

Day 2—All men wore asbestos coats, gloves and hoods issued by the Company and these were identical in appearance to those used during the previous survey.

Day 3—Four men wore garments as described for Day 1 and Day 2. The other employees were issued with new coats, hoods and mittens (Source B). The specifications are shown in Table 1.

(b) *Studies at plant* 2. Men at this plant wore asbestos coats, leggings, gloves and hoods supplied by Source C, shown in Table 1.

RESULTS

Optical counts

The pilot investigation at plant 1 showed that fibres could be discerned against the dark background of graphite and magnetite particles present in the work area.

This background made counting more difficult than when it was not present but the asbestos fibres could still be identified and counted. As there was no obvious reason why counts obtained on samples collected in the pilot investigation at plant 1 should be different from those obtained in subsequent surveys at the same plant, the results were combined.

At plant 1, the concentrations of fibres ⩾ 5 μm in length in the breathing zones of men wearing asbestos safety garments of various ages and sources are shown in Table 2. The mean concentration for 39 tests was 2·0 fibres/cm³ (S.E. = 0·4). The concentration in one case reached 5 fibres/cm³ for a mean exposure time of 54 min.

TABLE 2. MEASURED CONCENTRATIONS AND TIME-WEIGHTED CONCENTRATIONS OF AIRBORNE FIBRES TO WHICH MEN WEARING ASBESTOS SAFETY GARMENTS AT PLANT 1 WERE EXPOSED

Source of garment	Age of garments (weeks)	Mean exposure period for slagging operation (min)	Number of samples	Measured concentration (fibres/cm³)		Daily exposure period (min)		8-hr weighted concentration (fibres/cm³)	
				Mean	Range	Mean	Range	Mean	Range
A	New (< 1 week)	49	3	1·1	0·7–1·3	98	82–114	0·3	0·1–0·3
	1–4 weeks	52	15	1·7	0·5–3·7	104	50–144	0·3	0·1–0·8
	4 weeks	51	5	2·0	0·6–2·6	102	70–130	0·4	0·1–0·6
B	New (< 2 days)	54	16	2·4	0·3–5·0	108	62–128	0·5	0·1–1·1
Total		52	39	2·0	0·3–5·0	103	50–144	0·4	0·1–1·1

To investigate the effect of age on fibre release, the results of the first test on all coats issued by plant 1 were plotted against the age of the garment. The linear correlation for all results was 0·4. When the result for the 12-week-old coat, which was similar to that for new coats, was discarded the linear correlation between age and fibre concentration increased to 0·68. This suggested that the fibre release increased with age of garment up to 8 weeks. However, the scatter was great, the number of measurements was small and the correlation coefficient too low to reliably predict fibre release from garments of different ages.

In 13 tests, the concentration exceeded 2 fibres/cm³. When the length of exposure for men wearing safety garments was calculated for an 8 hr work-day (assuming the usual work practice of two casts per day) the overall mean concentration to which they were exposed was 0·4 fibres/cm³ with concentrations ranging 0·1–1·1 fibres/cm³ (Table 2). In no case did the 8-hr weighted exposure exceed 2 fibres/cm³—the standard adopted by the BRITISH OCCUPATIONAL HYGIENE SOCIETY (1968). Breathing zone concentrations were similar for men with different occupations (Table 3), indicating that no individual operation was giving rise to fibre release seriously different from the others.

At plant 2, the breathing zone concentrations of fibres (⩾ 5 μm in length) exceeded 5 fibres/cm³ in all cases and in all but one case exceeded 10 fibres/cm³ for exposure periods ranging 15–47 min (Table 4). Slagging operations at this plant were performed at 1–1½-hr intervals and lasted 15–47 min. It was therefore

TABLE 3. CONCENTRATIONS OF AIRBORNE ASBESTOS FIBRES IN THE BREATHING ZONES OF MEN WEARING ASBESTOS GARMENTS BY OCCUPATION. PLANT 1

Occupation	Number of samples	Concentration (fibres/cm³) Mean	Range
Keeper	9	1·7	0·5–5·0
Hot blastman	3	2·7	0·5–4·6
First helper	5	2·2	0·3–3·7
Second helper	7	2·5	0·7–4·0
Third helper	6	1·9	0·8–3·5
Miscellaneous	9	1·6	0·5–3·7
Total	39	2·0	0·3–5·0

possible for men to perform as many as five operations per shift and to wear these coats an average of 2 hr 45 min per day. Based on this exposure time, the 8 hr time-weighted average exposure would have been 4·7 fibres/cm³.

TABLE 4. CONCENTRATIONS OF AIRBORNE ASBESTOS FIBRES MEASURED IN THE BREATHING ZONES OF MEN WEARING ASBESTOS SAFETY GARMENTS AT PLANT 2

Source of garments	Age of garments (weeks)	Mean exposure period (min)	Number of samples	Concentration (fibres/cm³) Mean	Range
Source C	< 1 week	39	2	12·8	10·6–15·1
	1–4 weeks	28	2	18·1	9·9–26·2
	> 4 weeks	38	2	12·3	10·6–14·0
Total		35	6	14·1	9·9–26·2

Concentration of fibres including submicroscopic fibres

The total airborne concentrations of fibres greater or equal to 5 μm in length counted from scanning electron micrographs are shown in Table 5. The concentrations of airborne fibres ≥5 μm in length as percentages of the total airborne fibre concentrations were 32, 16·5, 2·3, 26, 28 and 23% respectively. In order to estimate the percentage of fibres ≥5 μm in length which were not counted by optical methods (due to narrow diameters), the concentrations obtained by optical and electron microscopic methods were compared (Table 5). It must be noted that,

TABLE 5. CONCENTRATION OF AIRBORNE ASBESTOS FIBRE AS DETERMINED BY SCANNING ELECTRON-MICROSCOPIC EXAMINATION OF NUCLEPORE MEMBRANE FILTERS (N) AT 6000× MAGN. AND OPTICAL EXAMINATION OF MILLIPORE MEMBRANE FILTERS (M) AT 400×

Source of garment	Age (weeks)	Airborne fibre concentrations (fibre/cm³): SEM count on Nuclepore filter (N) Total fibre	Fibres ≥ 5 μm length	Optical count on Millipore filter (M) Fibres ≥ 5 μm	M/N %
A	8	100	32	4·0	12·5
A	1	109	18	—*	—*
A	3	869	20	0·5	2·5
B	New	230	61	2·9	4·7
C	8	341	96	10·6	11·0
C	Coat 3 Hood 8	216	51	26·2	51·0

* Sample for comparison lost.

although the samples which were compared were obtained on the same man wearing the same garments, they were not taken simultaneously. This probably explains the large variation in the ratios of optical counts to electron microscopic counts of fibres ≥ 5 µm. Nevertheless, the electron microscope counts indicated that substantial numbers of fibres ≥ 5 µm in length were present in the airborne dust which were not visible by optical methods.

DISCUSSION

The mean concentrations of airborne asbestos fibres measured in the breathing zones of workers wearing asbestos safety garments at plant 1 were similar to those reported by LUMLEY (1971) for men wearing new firefighting helmets with unlined asbestos cloth covers (2·3 fibres/cm^3) but lower than those reported by BAMBER and BUTTERWORTH (1970) (mean 3·5 fibres/cm^3) who tested an undefined type of protective clothing in a laboratory study. In this present study, it was not possible to determine whether the airborne fibres originated from the coat, gloves, or hood, as hoods were worn only intermittently. In all but one case, the concentrations of fibres in the breathing zones of men wearing coats from sources A and B were below the threshold limit value of 5 fibres/cm^3, currently adopted in the U.S.A. (OCC. SAFETY AND HEALTH ADMINISTRATION, 1972), but one third of the tests exceeded the standard of the BRITISH OCCUPATIONAL HYGIENE SOCIETY (1968) (2 fibres/cm^3). The time-weighted average concentrations to which men were exposed for the particular operations studied at plant 1 were all less than 2 fibres/cm^3.

The concentrations of fibre in the breathing zones of men employed at plant 2 were high, exceeding the excursion level of 10 fibres/cm^3 permitted in the U.S. Standard. The reason for the difference between the quantities of fibre released from these garments compared with those at plant 1 is not known. However, both coats and mittens at plant 2 were untreated and leggings were also worn. The coats were observed to leave asbestos on the men's clothes when removed. It would seem advisable that garments which release fibres readily should not be used until a method of reducing their fibre release has been found.

CONCLUSION

In conclusion, there is a need to identify and decrease the fibre release from asbestos garments to prevent exposure of workmen to concentrations which may be considered hazardous to health or exceed present and likely future standards. This should be done by developing new processes for manufacturing and treating (or coating) asbestos cloths and by testing garments for fibre release before distribution for sale to industry. Such tests should take into consideration the release of sub-microscopic fibre.

Acknowledgements—I acknowledge with thanks the assistance of Messrs H. Hui, M.Sc., A. Corsillo and F. Schafer, who conducted the field surveys and performed the fibre counts, Mr C. Y. Hwang, M.Sc., who was responsible for the electron miscoscopic studies, the companies who provided access to their plants to conduct the study and the workers who participated. This research was supported by a grant from Raybestos Manhattan Inc.

REFERENCES

BAMBER, H. A. and BUTTERWORTH, R. (1970). *Ann. occup. Hyg.* **13**, 77–80.

BRITISH OCCUPATIONAL HYGIENE SOCIETY (1968). *Ann. occup. Hyg.* **11**, 47–49.

LUMLEY, K. P. S. (1971) *Ann. occup. Hyg.* **14**, 285–286.

OCC. SAFETY AND HEALTH ADMINISTRATION (1972) Occupational Safety and Health Standards. Standard for Exposure to Asbestos Dust. *Fed. Reg.* **37**, Title 29, CFR part 1910, 11318–11322.