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TO: Messrs. P. G. Dolan
J. F. Maclachlan
M. W. Oliver
W. S. Simpson
I. H. Weaver

March 1, 1974

SUBJECT: McGill Study of Asbestos Safety Garments

The final report on Phase I of the McGill study and comments by Dr. Gibbs in response to questions I raised are attached. Two sets of photographs, not reproducible by Xerox, are available. John Magenheimer has one set, I have the other.

I call your particular attention to the recommendations on pages 11 and 12. Engineering improvements are essential if the products are to be acceptable under the existing federal asbestos standard.

The management of Plant 2, referred to in Dr. Gibb's report, has been advised that airborne asbestos fiber concentrations in the breathing zones of men wearing asbestos garments in their plant exceeded the threshold limit value of 5 fibers per cc for an 8-hour work day and that concentrations over 10 fibers per cc, which exceed the excursion level of 10 fibers per cc permitted for a 15-minute period by the U.S. Occupational, Health and Safety Administration standard, were also observed.

Immediate action, in the form of engineering improvements, is necessary to insure that R/M products comply with OSHA standards.

John H. Marsh

Attachments
CC: Messrs. J. J. Magenheimer
J. T. Trainor

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DEPARTMENT OF EPIDEMIOLOGY AND HEALTH
[illegible] CANADA H2A 2B4
MCGILL UNIVERSITY
Telephone [illegible] Area Code 514

January 29, 1974

[illegible] Marsh
[illegible] Manhattan
[illegible] E. Street
[illegible], Conn.
06801

Dear Mr. Marsh,

Further to our discussions on Friday, January the 25th, I would like to clarify one or two points which you raised. The method used to count the membrane filters was that adopted by the British Occupational Hygiene Society. There are essentially two reasons for using this method. Firstly, we were transporting samples considerable distances before counting. The British method calls for treatment of the filter at the site with a "triacetin, amyl acetate, chloroform" solution which essentially fixes the fibres in place, reducing the risk of distortion of the particles before they reach the laboratory. Secondly, the American method calls for the preparation of a special solution containing dissolved membrane filter which must be fairly fresh when used, it requires some time for preparation and we have found that counts using the British and American methods are comparable.

With regard to the sub-micron diameter fibres, we chose scanning electron microscopy rather than transmission electron microscopy because virtually all techniques for examining airborne dust using transmission electron microscopy involve transfer of dust from the filter to the electron microscope grid. This can lead to serious loss of fibres under some circumstances and the fibre is unlikely to be observed in the same condition as it was collected. Because we were interested in the actual airborne fibre concentrations, we decided to eliminate the possibility of fibrillation etc. by collecting samples on nucleopore membrane filters and examining the samples directly.

The airborne fibre concentrations at Plant 2, raise a serious problem. There is no doubt in my mind that it should be impossible for a man to be unknowingly exposed to fibre concentrations exceeding those permitted in an asbestos industry. As you know, we agreed in our contract that the results of our studies would not be published until one year from submission of the final report to Raybestos-Manhattan. In the meantime, I would like

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to ensure that companies manufacturing asbestos safety garments are made aware that garments do exist which give rise to fairly high concentrations of asbestos in a man's breathing zone. I would appreciate any suggestions you might have.

There are probably two further investigations which are worthwhile

1) Tests of specially treated (eg coated inside and out) asbestos garments both in the laboratory and in the field. Although the dust concentrations released by the garments which we tested at plant 1 did not exceed the 5 fibre/cc standard, some of them would exceed the 2 fibre standard if the work practice adopted at a particular plant required men to wear them more frequently than at this plant.

2) Further investigation of the Novatex material. Exactly where to go with this material will be known in about 3 weeks when we have completed our tests.

If you have any further questions concerning the report on Phase I or would like to discuss follow up studies on asbestos garments, please do not hesitate to contact me.

Yours sincerely,

G.W. Gibbs, BSc, MSc, PhD
Assistant Professor

GWG/ssn

cc Dr. J. Nagenheimer

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Asbestos fibre release from asbestos safety garments

A report to Raybestos-Manhattan Inc.

By

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Introduction

On May 11, 1973 the writer (CMG) through the Office of Industrial Research of McGill University submitted to Mr. J. Marsh of Raybestos-Manhattan Inc. a proposal setting out work to achieve the following objectives...

Phase 1. To determine the exposure of men to asbestos fibre during the normal use of asbestos safety garments in industry.

Phase 2. To determine the fibre release into an ambient environment by garments manufactured from regularly processed asbestos cloth and to test asbestos cloth prepared by a new process.

Authorization to proceed with this research was given by Raybestos-Manhattan Inc. on May 24th and work started on this project within one month as planned. In accordance with the protocol this constitutes the final report on phase 1 of the investigation.

Materials and Methods

Populations for Study

Measurements of airborne fibre concentrations during the normal use of asbestos garments were made at two plants to be referred to as No. 1 and No. 2. Initial arrangements for surveys at plant 1 were made by Mr. J. Marsh and at plant 2 by the writer with the help of Mr. J. Lang of Safety Supply Company Limited, Montreal.

Plant 1

This was the blast furnace section of a large steel plant. Ore for reduction was fed continuously to four furnaces and five men were normally assigned to each furnace. In this investigation workers on two neighbouring furnaces (nos. 3 and 4) were chosen for study. The

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occupations of these men were Hot Blastman, Keeper, First Helper, Second Helper, and Third Helper. These men were responsible for preparing channels along which molten iron flowed from the furnaces to containers for transportation to another part of the plant. They were required to tap the furnace and keep all channels clear of slag during each cast. This involved the removal of solidified metal and slag from the channels using an iron bar and entailed intermittent rather than continuous heavy labour. Casts were held at approximately 4 hourly intervals and were of 1/2 to 1 1/4 hours duration. Men generally wore asbestos safety coats for the duration of a cast but hoods and gloves were worn for varying periods as considered necessary.

Plant 2

This was a small plant manufacturing elemental phosphorus. Four men were responsible for two furnaces which operated continuously. Slagging operations (i.e. tapping the furance) which were performed at approximately 1 - 1 1/2 hour intervals lasted 15-45 minutes. The men performed similar work to those at the Steel Works ensuring a free flow of the tapped materials. Asbestos safety coats and leggings were worn throughout the slagging operations but hoods and gloves were only worn when work made them necessary. Men on two shifts were studied.

Collection of airborne fibre samples

At plant 1 a preliminary survey was conducted on September 6, 1973 to determine whether graphite and other particles present in the air would interfere seriously with the fibre counts. Further tests were made at Plant 1 on October 2nd and 3rd, 1973. At plant 2, the survey was conducted on November 21, 1973. Airborne samples of dust were collected at both plants using the same methods. Personal monitors

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(MSA Monitaire) which had been calibrated for flow in the laboratory before each survey, were attached to each employee in such a way as not to interfere with his work. The pump was generally hooked over the worker's belt at the back and a plastic hose was passed over his shoulder to a 37 mm open filter in his breathing zone. The filter holder was attached in such a way as to be outside the asbestos coat but under the hood when worn. Due to the work practices it was not possible to observe the filter during the whole sampling period to ensure that the filter remained in this position. Samples for optical fibre counts were collected on Millipore 37 mm (Type AA) pore size (0.8 μm) and for scanning electron microscopic examination on Nucleopore (type GE-40 pore size 0.4 μm) filters. All samples collected on Millipore membrane filters were fixed with a solution of perspex (plexiglass) in chloroform as recommended in the method of the British Occupational Hygiene Society.[1] The sampling rates were approximately 2 litres per minute when using millipore filters and 1.0 litres per minute when using nucleopore filters. The sampling period was the total time from the start to finish of a cast or slagging operation. Although it would have been useful to have collected samples of ambient air in the work areas to determine background concentrations of fibre, safety regulations did not make this possible. We were assured by both companies that there were no other sources of fibrous materials in the work areas.

Counting of Airborne Fibre Samples

(a) Optical Counts

Segments of the fixed millipore membrane filters were mounted using the method of the British Occupational Hygiene Society,[1] and fibres greater than 5 μm in length and with length : breath ratios greater or equal to 3:1 were counted on a Zeiss ML Standard Research Microscope at a magnification of 500 X, using phase contrast. At least 20 fields were

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counted on each filter and the same observer made two counts for all samples taken at Plant one. Counts obtained by this observer have been shown to be in general agreement with other experienced observers in our laboratories.

(b) Scanning Electron Microscopy

Airborne samples of dust collected on nuclepore filters were examined by Scanning Electron Microscopy 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 6,000 X on a Cambridge Stereoscan Type 96113 Mark 2A scanning electron microscope. Scans were performed across the diameter of the spacement and photographs were taken at random. The field area ranged 257 to 265 μm^2 and the number of fields and fibres counted are shown in table 7. Both the total number of fibres and those with lengths greater than 5 μm were recorded. Bundles were counted as one fibre. Photographs of one sample (M160) which was taken on a man wearing a coat supplied by Raybestos Manhattan Inc. at plant I exhibited a very fine background of straight aligned fibres (Plate 1). These were not present on any of the other samples examined and as their nature and origin could not be ascertained this sample was not counted.

Asbestos Garments

Asbestos garments from at least three sources were studied.

(a) Samples at Plant 1

September 6, 1973 All men were the asbestos coats, gloves and hoods which are normally issued by the Steel Company. No leggings

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were worn. The coats and gloves were uncoated but the hood was aluminised on the outside but uncoated inside. Dr. J. Mogenheimer of Raybestos-Manhattan Inc. was unable to trace the manufacturer of these garments or to determine the origin of the cloth used in their manufacture. Estimates of the approximate ages of the garments were obtained from each man tested.

October 2, 1973 All men wore asbestos coats, gloves and hoods which were standard equipment for this plant. These were identical in appearance to those used on September 6, but it was impossible to trace the source of the materials used in their manufacture. Estimates of the ages of the garments were obtained from each man involved in the study.

October 3, 1973 Four men wore garments as described for September 6 and October 2. The other men tested were issued with new coats supplied by Raybestos-Manhattan Inc. and manufactured by Asbest Products of Cleveland, Ohio using material R/M L-71-1173 which is 10P-250 base cloth with a 2% acrylic finish. The hoods and sleeves were made of the same material with a 3 M aluminum film on the surface.

(b) Studies at Plant 2

Men at this plant wore uncoated asbestos coats purchased from Safety Supply or National Safety. It was not possible to determine the source of an individual coat and hence the source of material used in the safety garment manufacture is unknown. Men also wore leggings, gloves, and hoods, the hoods being coated on the outside with aluminum film. An estimate of the approximate age of each garment was obtained from the employees when tested.

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Results

The total number of airborne samples collected for optical fibre counts by garment source and age are shown in Table 1, and those for scanning electron microscopic observation in Table 2.

The pilot investigation at Plant 1 (September 6, 1973) was carried out in order to determine whether or not the high proportion of opaque dusts in the blast furnace area would render fibre counts impossible. Examination of these filters showed that fibres could be readily discerned against the dark background of graphite and magnetite particles, but did make the counting more difficult than when the high background was not present. Identification of fibres using crossed polarisers was much easier but for purposes of comparing results with standards, all counts were made using phase contrast microscopy. Examination of fibres under crossed Nichols demonstrated to both the satisfaction of Dr. John Nagenheimer of Raybestos Manhattan Inc. and ourselves that the fibres that we were observing were chrysotile. No attempt was made to distinguish different "types" of fibre and all fibres with length to breadth ratios greater than 3:1 were counted. The Environmental Health division of plant 1 and the Management of plant 2 informed us that there were no other possible sources of fibres in the viscinity of the casting or slagging processes. 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. The counts obtained for each sample are given in the Appendix (Tables A1 and A2).

Plant 1

The concentrations of fibres greater than 5 μm in length in the breathing zones of men wearing asbestos safety garments of various

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ages and from the two sources are summarised in Table 3. As only certain garments had been tested twice, the concentrations of fibre determined by the first test on all coats issued by plant 1 were plotted against the age of the garment (Fig. 1). The linear correlation for all results was 0.338. The concentration associated with the coat which was 12 weeks old was similar to that associated with the new coats. There were no coats which were more than 8 weeks old but less than 12. If the result for the 12 week old coat was excluded the linear correlation between age of coats and fibre concentration increased to 0.651. This shows that fibre release increases with age of garment up to 8 weeks, but the scatter is great and there are insufficient data and the correlation coefficient is not sufficiently high to reliably predict fibre release from garments of different ages. As the fibre release from relatively new garments was already sufficiently high to consider new methods of treating cloth, the garments issued by Raybestos-Manhattan Inc. were only tested when new.

The range and mean concentrations of airborne fibres in the breathing zones of men wearing asbestos garments at this plant are shown in Table 3. The mean concentration for 39 tests was 2.0 fibres/cc ± (s.e. = 0.15) for a mean exposure time of 52 minutes. With the new coats supplied by Raybestos-Manhattan Inc. the mean concentration was 2.4 fibres/cc (± s.e. = 0.4). The concentration in one case reached 5 fibres/cc for a mean exposure time of 54 minutes. The cumulative distribution of concentrations for all 39 tests is shown in Fig. 2. It can be seen that in 13 tests the concentration exceeded 2 fibres/cc. When the length of exposure for men wearing safety garments was calculated for an 8 hour work-day (assuming the usual work practice of 2 coats per day) the overall mean concentration to which they were exposed was 0.4 fibres/cc with concentrations ranging 0.1 - 1.1 fibres/cc

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(Table 4). In no case did the eight-hour weighted exposures exceed 2 fibres/cc, - the standard adopted by the British Occupational Hygiene Society[1]. The range of concentrations measured in the breathing zones of men with different occupations were similar (Table 5), indicating that no individual operation was giving rise to fibre release seriously different from the others. Photographs of the fibres seen in samples obtained at this plant are shown in plates 2-5.

Plant 2

The concentrations of fibres greater than 5 μm in length in the breathing zones of men wearing asbestos garments at this plant are shown in Table 6. The concentrations in all cases exceeded 5 fibres/cc and in all but 1 case exceeded 10 fibres/cc for exposure periods ranging 15 - 47 minutes. Technical staff present during these tests were certain that there was no interference with samples by workers and the results were too consistent to suggest such sabotage. Slagging operations at this plant were performed at 1 to 1 1/2 hour intervals and lasted 15 - 47 minutes. It was therefore possible for men to perform as many as 5 operations per shift and to wear these coats on average of 2 hours 45 minutes per day. Based on this exposure time, the 8 hour time-weighted average exposure would have been 4.7 fibres/cc. Typical fibres observed in samples collected at this plant are shown in plates 6 - 8..

Concentrations of Fibres Including Submicroscopic fibres

The numbers of fields and fibres counted for the six nuclepore samples examined by scanning electron microscopy are shown in Table 7. The total airborne concentrations of fibre and the concentrations of all fibres greater than 5 μm in length are shown in Table 6. The concentrations of airborne fibres > 5 μm in length as percentages of the total airborne fibre concentrations were 22%, 16.5%, 2.3%, 26%, 26% and 23% respectively.

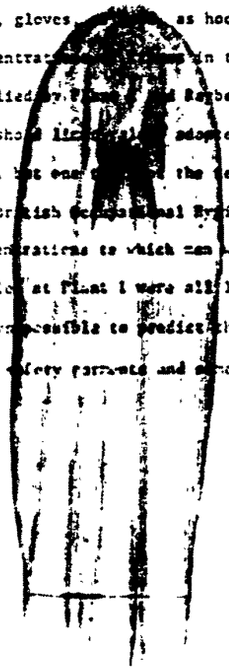
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In order to obtain an estimate of the percentage of fibres ≥ 5 μm in length which were not counted by the optical methods, the concentrations obtained by optical and electron microscopic methods were compared (Table 9). It must be noted that although samples were obtained on the same man wearing the same garments, they were not taken simultaneously. This comparison showed a wide fluctuation in the proportion of optically visible fibres ≥ 5 μm in length to total fibres ≥ 5 μm in length but suggested that in most cases there were a substantial number of fibres greater than 5 μm in length present in the airborne dust which were not visible by optical methods. Photomicrographs of samples from both plants are shown in plates 9-11.

Discussion

The mean concentration of airborne asbestos fibre measured in the breathing zones of workers wearing asbestos safety garments at plant I were similar to those reported by Lumley[2] for men wearing new fire fighting helmets with unlined asbestos cloth cover (2.3 fibres/cc) and lower than these reported by Bamber and Butterworth[3] who tested protective clothing in a laboratory study. In the study reported here it was not possible to determine whether the airborne fibres originated from the coat, gloves, [illegible] as hoods were worn only intermittently. The concentrations [illegible] in the breathing zones of all men wearing coats supplied by [illegible] Asbestos Manhattan Incorporated were below the threshold limit value adopted in the USA[4,5] (5 fibres/cc), in all but one case, but one [illegible] the tests exceeded 2 fibres/cc, the standard of the British Occupational Hygiene Society. The time-weighted average concentrations to which men were exposed for the particular operations studied at Plant I were all less than 2 fibres/cc. However, it is not always possible to predict the work practices of industries to be supplied with safety garments and the method of controlling exposures of new



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wearing safety garments should be sought. This might be done by ensuring that garments are not worn for periods exceeding 2 1/2 hours per shift as this would give a time-weighted exposure of less than 2 fibres/cc. More satisfactorily the fibre release of the garments should be reduced by a different manufacturing process. One such method, might be to aluminise both the inside and outside of the garments. Lumley[2] was unable to detect any fibre released from hoods which had been aluminised both inside and outside.

The concentrations in the breathing zones of men employed at Plant 2 were high, exceeding the excursion level of 10 fibres/cc permitted in the US standard[5]. The reason for the difference between the quantities of fibre released from these garments compared with those at Plant I is not known and the manufacturer and sources could not be ascertained. Such garments should not be used until a method of reducing their fibre release has been found.

The concentration of airborne fibre to which men wearing asbestos garments are exposed when submicron fibres were considered ranged from approx. 10 to 1,700 times the concentration measured by the standard optical microscopic methods. It is important that the submicroscopic component of exposure must be considered in spite of the fact that dust standards at present ignore them. Indeed recent evidence suggests that the fine fibres (< 3 μm in diameter) penetrate deeply into the respiratory system[6] and that fibres less than 0.5 μm in diameter and more than 5 μm in length play an important role in the production of primary malignant mesothelial tumours.[7]

Conclusions

1) The concentrations of optically visible airborne fibres (> 5 μm in length) in the breathing zones of men wearing asbestos safety

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garments at Plant I reached the threshold limit value of 5 fibres/cc in one out of 39 tests. One third of the measured concentrations exceeded the present British Standard of 2 fibres/cc.

2) There was some indication that fibre release increased with age of garment up to 8 weeks, but the correlations between age and fibre release were low.

3) The concentrations of optically visible airborne fibres (> 5 μm in length) in the breathing zones of men wearing safety garments at Plant 2 exceeded the 15 minute ceiling value of 10 fibres/cc published in the Federal Register in the USA.

4) The total fibre concentrations to which men wearing asbestos garments were exposed ranged approx. 10 to 1,700 times those observed by optical counts. In view of this wide variation, account must be taken of airborne concentrations of sub-micron fibres when new garments with potentially lower fibre release are developed.

Recommendations

1) There is a need to identify and decrease the fibre release from asbestos garments to prevent exposure of workmen to concentrations in excess of levels which existing and likely future US standards consider hazardous.

2) Airborne concentrations of fibre associated with the use of asbestos safety garments should be reduced by developing new processes for manufacture and treatment of asbestos cloths. Aluminising both the inside and outside of the garments might be one method. Garments for protection of workers employed in hot environments should be tested before release for sale to industries.

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3) Fine fibres (less than 0.5 μm in diameter) should be taken into consideration when tests of asbestos safety garments are conducted, and the release of fibres in the submicron sizes should be controlled.

Acknowledgments

Field surveys were conducted by Messrs. H. Hui BSc, and F. Schafer who also performed the fibre counts. Scanning electron microscopy was performed at the Pulp and Paper Institute, Pointe Claire, Quebec, by arrangement with Dr. A Rezanowich.

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Table 1

Number of airborne samples of dust collected for optical fibre counts for each source of garments

Plant	Source of Garment	Age (weeks)	No. of Garments	Number of Airborne Samples Collected
1	Normally issued by Plant 1	New	2	3
		1	2	5
		2	1	3
		3	1	1
		4	4	6
		8	3	3
		12	1	2
1	Provided by Raybestos-Manhattan Inc.	New	8	16
2	Normally issued by Plant 2 *	(New (0.2)	1	1
		(Coat (0.2) (Hood 4)	1	1
		(Coat 1) (Hood 4)	1	1
		(Coat 3) (Hood 8)	1	1
		(Coat 8) (Hood)	1	1
		(Coat 12) (Hood)	1	1
		Total	28	45

* In some cases articles of safety clothing were of different ages.

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Table 2

Airborne Dust Samples collected for Scanning Electron Microscopy

Plant	Source of Garments	Age of Garments (weeks)	Number of Garments	Number of Airborne Samples
1	Supplied by Plant 1	New	1	1
		1	2	2.*
		2	2	2
		3	1	1
		8	1	1
1	Supplied by Raybestos-Manhattan Inc.	New	3	3 *
2	Supplied by Plant 2	coat 3 hood 8	1	1
		8	1	1
		12	1	1
		Totals	13	13

* One sample invalidated because tubing came off filter.

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Concentrations of airborne asbestos fibres measured in the breathing zones of men wearing asbestos safety garments at plant I.

urce of rments	Age of garments weeks	Mean exposure* period (mins)	Number of samples	Concentration in fibres/cc Mean	Range
A	New (< 1 week)	49	3	1.1	0.7-1.3
	1 - 4 weeks	52	15	1.7	0.5-3.7
	> 4 weeks	51	5	2.0	0.6-2.6
B	New (< 2 days)	54	16	2.4	0.3-5.0
tal		52	39	2.0	0.3-5.0

A - Garments normally used by employees at plant I

B - Garments manufactured from materials supplied by Raybestos Manhattan

* Measurements were made for the total period required to complete a cast. Not all employees wore the hoods and coats for the duration of each cast.

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Table 4

Concentrations of airborne asbestos fibres to which men wearing asbestos garments would be exposed during a normal working day at plant I.

urce of arments	Age of garments weeks	Daily exposure* period (mins) Mean	Range	Number of samples	Concentration in fibres/cc Mean	Range
A	New (< 1 week)	98	82-114	3	0.3	0.1-0.3
	1 - 4 weeks	104	50-144	15	0.3	0.1-0.8
	> 4 weeks	102	70-130	5	0.4	0.1-0.6
B	New (< 7 days)	108	62-128	16	0.5	0.1-1.1
TOTAL		103	50-144	39	0.4	0.1-1.1

Estimated on the assumption that two castings are performed per 8 hour shift.

A - Garments issued by Plant I

B - Garments manufactured from cloth supplied by Raybestos Manhattan Inc.

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Table 5

Concentrations of airborne asbestos fibres in the breathing zones of men wearing asbestos garments by occupation

Occupation	Number of Samples	Concentration fibres/cc 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

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Table 6

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 in weeks	Mean Exposure period in mins	Number of Samples	Concentration in fibres/cc	
				Mean	Range
C	< 1 week	39	2	12.8	10.6-15.1
	1- 4 weeks	28	2	18.1	9.9-26.3
	> 4 weeks	38	2	112.3	10.6-14.0
		35	6	14.1	9.9-26.3

C - Source not determined - garments normally issued by Plant II

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Table 6

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 in weeks	Mean Exposure period in mins	Number of Samples	Concentration in fibres/cc	
				Mean	Range
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	112.3	10.6-14.0
		35	6	14.1	9.9-26.2

C - Source not determined - garments normally issued by Plant II

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Table 7

Number of fibres and fields counted for the Nucleopore samples examined by Scanning Electron Microscopy

Sample No.	Source of Garments	Number of Fields Examined	Total Number of Fibres Counted
N153	Supplied by Plant I	71	252
N161	Supplied by Plant I	70	248
N166	Supplied by Plant I	70	165
N164	Supplied by Raybestos-Manhattan	70	528
N172	Supplied by Plant 2	35	196
N170	Supplied by Plant 2	70	421

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Table 8

Airborne concentrations of asbestos fibre based on samples of dust collected on nuclepore filters and counted at approximately 6,000X magnification using scanning electron microscopy

Sample No.		Age of Garments (weeks)	Airborne fibre concentration (fibres/c Total Fibres	Fibres ≥ 5 μm in length
N153	Supplied by Plant I	8	100	32
N161	Supplied by Plant I	1	109	18
N166	Supplied by Plant I	3	869	20
N164	Supplied by Raybestos Manhattan Inc.	New	230	61
N172	Supplied by Plant 2	8	341	96
N170	Supplied by Plant 2	Coat 3 Hood 8	216	51

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Table 9

Concentrations of Airborne Fibres ≥ 5 μm in length measured from Scanning Electron Micrographs compared with concentrations measured by Optical Counts of Millipore Membrane Filter Samples.

Nucleopore Sample Number	Membrane Filter Sample Number	Concentration (fibres/cc) Nucleopore (N)	Millipore (M)	M/N %
N153	989	32	4.0	12.5
N161	-	18	-	—
N166	979	20	0.5	2.5
N164	976	61	2.9	4.7
N172	360	96	10.6	11.0
N170	739	51	26.2	51.3

* Samples were taken on the same man using the same garments but on different occasions.

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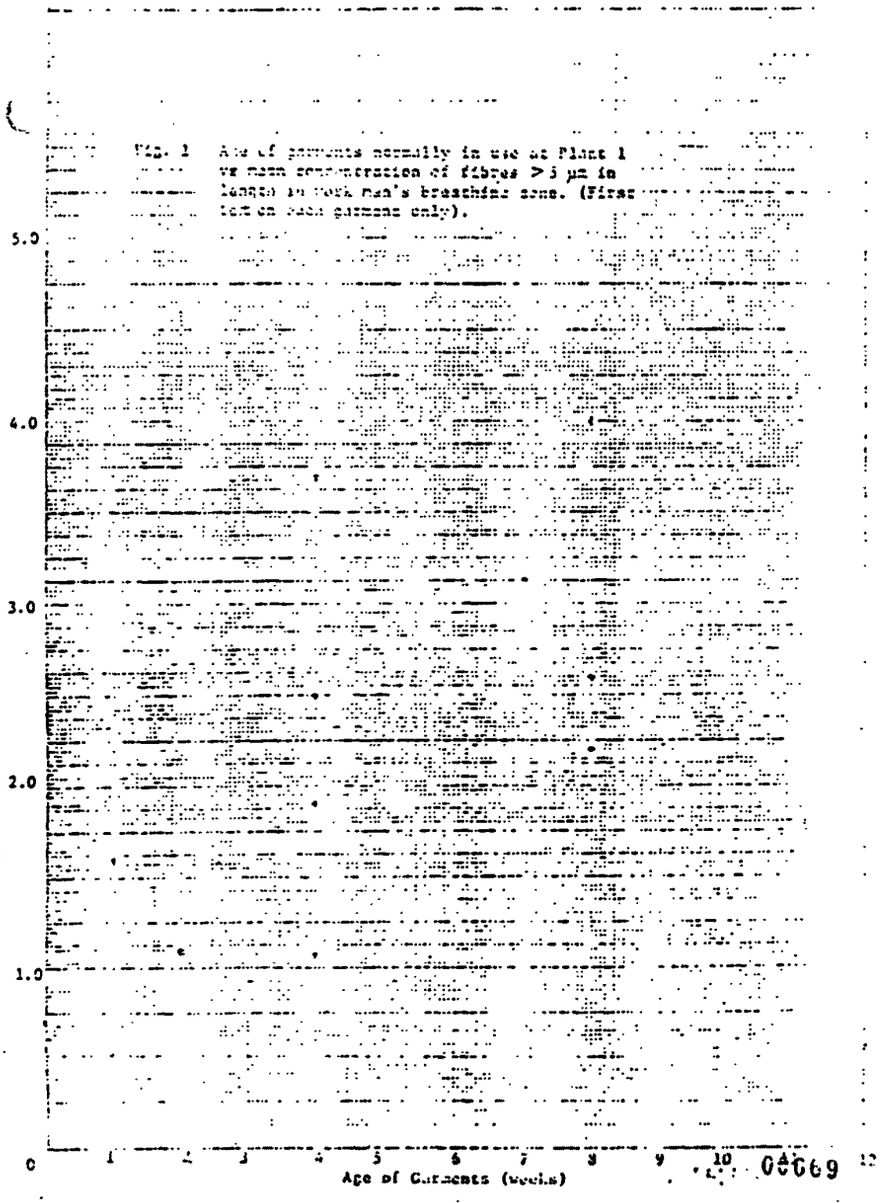
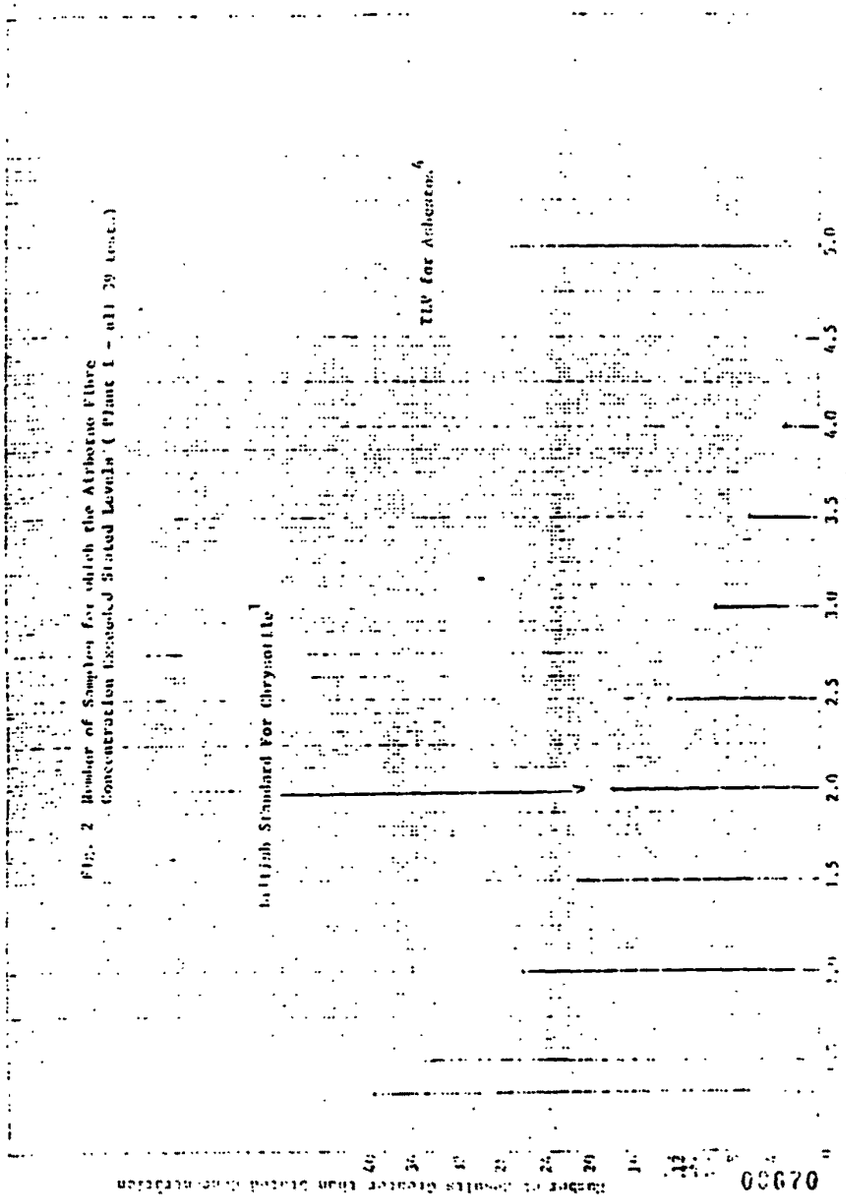


Fig. 1 Age of garments normally in use at Plant 1 vs mean concentration of fibres > 5 μm in length in work man's breathing zone. (First test on each garment only).

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Detailed results of study at plant 1.

d C_2 = concentrations calculated from independent counts of the same sample by the same observer).

No.	Employee No.	Occupation	Garment ID	Furnace No.	Coat No.	Age of Coat (weeks)	Sampling Time	Concentration in fibres/cc C_1 (i)	C_2 (ii)	C_3 Mean	Date of Survey
42	1	3rd Helper	A	3	1	8	60	2.4	1.6	2.2	6/9/
14	2	-	B	3	1	4	58	1.9	1.9	1.9	
77	3	-	C	3	1	8	55	2.6	2.8	2.6	
26	4	-	D	4	1	4	56	2.6	2.2	2.5	
71	7	2nd Helper	E	4	1	New	49	0.4	1.4	0.7	2/10.
56	7	2nd Helper	E	4	2	New	41	1.0	1.5	1.3	
91	3	-	F	4	1	4	50	1.0	0.7	0.8	
57	3	-	F	4	2	4	52	0.7	1.4	1.0	
15	8	-	G	4	1	4	57	3.9	3.6	3.7	
70	8	-	G	4	2	4	52	1.6	0.9	1.2	
60	9	Keeper	H	4	2	New	57	1.2	1.2	1.2	
87	10	-	I	4	2	1	52	0.5	0.5	0.5	
89	11	2nd Helper	J	3	2	8	35	4.3	3.7	4.0	
56	12	1st Helper	K	3	1	1	72	1.8	1.4	1.6	
81	12	1st Helper	K	3	2	1	25	3.4	3.8	3.7	
52	13	Keeper	L	3	1	12	65	0.6	0.7	0.6	
51	13	Keeper	L	3	2	12	39	0.5	0.7	0.6	
719	14	3rd Helper	M	3	1	2	63	0.9	1.4	1.1	
964	14	3rd Helper	M	3	2	2	25	1.2	1.4	1.3	
79	15	Hot Blaster	N	3	2	3	33	0.3	0.7	0.5	
955	12	1st Helper	K	3	1	1	53	2.4	2.2	2.3	3/10
973	12	1st Helper	K	3	2	1	63	4.2	1.9	3.0	
966	14	3rd Helper	M	3	2	2	63	0.7	0.9	0.8	
976	15	2nd Helper	R-1	4	2	New	51	3.4	2.3	2.9	
984	16	1st Helper	R-2	4	2	New	54	0.4	0.2	0.3	
975	17	Keeper	R-4	4	1	New	55	4.0	5.9	5.0	
971	17	Keeper	R-4	4	1	New	50	1.0	0.4	0.7	
	17	Keeper	R-4	4	2	New	53	0.4	0.5	0.5	
	17	Keeper	R-4	4	2	New	53	0.8	0.7	0.8	
961	18	3rd Helper	R-3	4	1	New	10	3.7	3.2	3.5	
955	18	3rd Helper	R-3	4	2	New	55	2.3	1.9	2.1	
972	19	-	R-5	4	1	New	31	0.4	0.8	0.6	
977	20	Hot Blaster	R-6	3	1	New	56	4.1	5.1	4.6	
982	20	Hot Blaster	R-6	3	2	New	51	3.1	2.9	3.0	
967	21	Keeper	R-7	3	1	New	56	3.8	4.4	4.1	
959	21	Keeper	R-7	3	2	New	62	2.3	1.4	1.9	
953	11	2nd Helper	R-5	3	1	New	57	1.8	2.4	2.1	
954	11	2nd Helper	R-5	3	2	New	64	2.7	3.5	3.1	
962	11	2nd Helper	R-5	3	2	New	64	4.0	2.7	3.4	

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Table A2

Detailed Results of Study at Plant 2

Sample No.	Employee No.	Garment ID	Age of Coat (weeks)	Age of Hood (weeks)	Sampling Time Minutes	Concentration in fibres/cc	Date of Survey
873	1	P	0.2	4	62*	10.6	21/11/73
847	2	Q	1	1	62*	9.9	
631	3	R	0.2	0.2	37	15.1	
360	4	S	8	8	47	10.6	
801	5	T	12	12	29.5	14.0	
759	6	U	3	8	15	26.2	

* Pumps were fitted 20 minutes before asbestos suits. Effective sampling time with asbestos suits 42 minutes.

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