Studies of airborne asbestos fiber concentrations associated with various operations of the drywall taping process have been undertaken in the province of Alberta, Canada. The results show that mixing, sanding and sweeping created high levels of airborne asbestos dust. The measured concentrations were frequently in excess of occupational health standards. Sanding in particular was assessed the most hazardous operation. The results are discussed in light of present and proposed Occupational Health Standards, and in terms of its implications for other workers, household contacts, and consumer's risk. Measures to reduce and control the health hazards associated with the process are described.

Occupational exposure to asbestos in the drywall taping process

DAVE K. VERMA[A] and CHARLES G. MIDDLETON[B]
[A]Occupational Health Program, McMaster University, Hamilton, Ontario, Canada L8N 3Z5;
[B]Occupational Health & Safety Division, Alberta Worker's Health Safety & Compensation, Edmonton, Alberta, Canada T5K 2J6

PLAINTIFF'S EXHIBIT
tabbies
SoA 5651

introduction

Occupational exposure to asbestos is associated with a risk of asbestosis, mesothelioma, an excess risk of cancer of the lung and possible cancers at other sites.[1-4] These asbestos related diseases have been found in mines and mills,[5] in manufacturing industries,[6] and in the use of asbestos products such as insulation in construction industries.[7] The magnitude of the occupational health problem associated with asbestos exposure is enormous. The relative risk of lung cancer among asbestos workers has been demonstrated from epidemiological studies to range between 1.4 and 3.3 for miners and millers, 1.0 to 13.7 for production and manufacturing industry workers and 5.1 to 8.3 for insulators.[4] The risk due to cigarette smoking and asbestos exposure has been recognized to be multiplicative rather than additive so that an asbestos worker who smokes has an extremely high risk of lung cancers. An asbestos worker who smokes has a 92 times greater risk than a worker who neither smokes nor works with asbestos.[3]

Very little has been reported in the literature about the potential occupational health risk to drywall taping workers. A review of the literature revealed only two independent studies dealing with the occupational exposure to asbestos in the taping process. In the first study results of thirty-nine air samples taken at the various operations of the process were discussed.[8] Generally high (mean values of 2.6 to 47.2 fibers/cc for specific operations) airborne asbestos levels were noted. This earlier report has recently been published in an expanded version.[9] In the second study, conducted on a similar sample size, much lower (mostly between 0.5 and 3.5 fibers/cc) exposure levels were reported.[10] The latter authors inferred that the results of the first study may not be indicative of typical occupational exposure of the drywall taping process.

Data is also lacking on the health status of this group of workers exposed to asbestos. One published report of medical examinations conducted on a group of 69 tapers showed X-ray abnormalities characteristic of asbestos exposure in 37 out of 69 films.[11] Two thirds of this group had an exposure of 10 years duration or longer, and 61 were smokers or ex-smokers. A recent clinical report[9] on the same group of drywall workers, but with an expanded cohort (114), showed radiological evidence for pulmonary asbestosis in 40.9% of the cases examined. This compares to 48.5% among insulators.[9] Consequently drywall tapers appear to have similar exposure as insulators. In light of this it is interesting to note that tapers in Alberta are not under medical surveillance whilst insulators, who are considered asbestos workers, are. To our knowledge this lack of medical surveillance for tapers as asbestos workers exists in other provinces of Canada and most parts of the U. S.

Because of the above mentioned concerns we initiated, in 1975, an investigation in the province of Alberta of the drywall taping process. This operation was known to involve the use of an asbestos containing compound. Specifically the aim of this study was to assess quantitatively the occupational exposure to asbestos in this group of workers. Our findings are summarized in this report.

the drywall taping process

In the construction of a commercial building, wallboards are fixed to metal studs with screws, while in residential houses the gypsum wallboards are nailed onto the wooden studs. The resulting joints, as well as screw and nail indentations, are finished by taping.

The opinions and suggestions contained in this report are the private views of the authors and are not to be construed as official or representing the views of Alberta Worker's Health Safety and Compensation.

mixing

The dry joint compound powder is normally contained in paper bags. The bag is slit open by a knife and the powder dumped into a container. Water is then added according to the manufacturer's directions and the compound mixed by means of a portable electric drill equipped with a mud and paint mixer. Some joint compound is sold as a paste (referred to as "premix") and only a small amount of water is required. The prepared mixture in its putty like form after wetting is referred to as mud. The time spent mixing in a working day is short. It usually takes 5 to 10 min. to mix a batch and in most instances one to three batches are required daily.

application

The joint compound (mud) is placed on the bottom side of a paper tape and is applied to cover the joints between the gypsum boards and allowed to dry. Subsequently, this compound is also applied on the front side of the tape and to screw and nail indentations. A major portion (65-70%) of the working day is spent in this operation.

sanding

The joints and indentations are sanded between each application of mud, with the major amount of sanding being carried out after the final coat. Three to four coats of mud are usually applied. Sanding operations normally involve either hand sanding or pole sanding. Hand sanding is carried out with a hand-held, abrasive paper, covered sanding block. In pole sanding, the sanding block is at the end of a long pole. Generally speaking most of the sanding is carried out by pole sanding. We estimate that 25-30% of total time is spent in this operation.

sweeping and cleanup

The debris and the dust accumulated on the floor resulting from the mixing, application and sanding operations is generally cleaned up by dry sweeping. In many instances, especially in cases of commercial building and large projects, this operation is carried out by general laborers. However, it was generally found to be part of the work schedule of employees of small companies working on residential construction projects.

the composition of joint compounds

The composition of joint compounds varies from manufacturer to manufacturer. During the study period most joint compounds were said to contain between 3 - 6% of chrysotile asbestos by weight. The remainder was composed of limestone or dolomite, talc, clay, mica, starch and fungicide. A typical joint compound formulation, based on the information obtained from the manufacturers, was:

Limestone	80 - 85%
Clay, talc, mica	5 - 10%
Asbestos (as chrysotile)	3 - 6%
Fungicide (Organic material)	Less than 1%
Poly-vinyl alcohol, Poly-vinyl acetate, starch, potassium tri-polyphosphate, etc.	2 - 3%

Although most joint compounds at present contain 3 - 6% of asbestos (chrysotile), in the past they have contained much higher proportions of asbestos.[9] Three types of joint compounds are available: taping, topping, and all purpose, all of which contain asbestos. Taping joint compound is applied in one or two coats and is designed for strength. The topping or finishing variety is generally applied in the final coat and has better finishing qualities. The all purpose compound is a compromise formula that can be used for both taping and finishing purposes. Asbestos is used in these joint compounds because it serves several functions including controlling shrinkage and cracking when the mud dries, and providing good workability in troweling and sanding.

materials and methods

site description

During 1975 to 1977 several work-sites were visited throughout the province and eight of them were evaluated by air sampling. Work schedules and the time spent at various operations at worksites differed widely. In small companies, the owner often worked out of his home and undertook all the work himself. Companies with larger workforces of 15-20 employees had individual workers performing specific tasks such as sanding on a full-time basis.

Following these initial surveys we conducted a more detailed study over a three-month period at a downtown site in Edmonton where a multi-storied hotel was under construction. This survey of a large commercial site was begun in January, 1978.

Both the residential and commercial site studies concentrated on the evaluation of worker's exposure to airborne asbestos dust. The potentially hazardous effects of other components of dust such as nuisance particulates, crystalline silica, chemicals, etc., were not examined in the same detail. It was felt that asbestos posed the most significant hazard and control measures applied for asbestos exposure would be equally effective against other hazardous particulates.

methodology

1. Airborne asbestos dust samples were taken by using open-face filter cassettes, loaded with 37 mm 0.8 micron pore size Millipore, Type AA membrane filters. Air was drawn through the filter papers by a portable pump at a flow rate of 2.0 liters/min. The sampling period was guided by two factors — concentrations expected and duration of operations. Most sampling assemblies were attached to the worker's lapels. To obtain area or location samples assemblies were attached to portable stands. The pump was calibrated before each use by a soap bubble meter. The flow rate was checked frequently during sampling.
2. To determine the concentration of airborne asbestos, analysis of the samples was effected by the NIOSH reference Membrane filter method.[12] For consistency, most of the asbestos counting was done by one of us (C.M.) A very limited number of

TABLE I
Summary of Airborne Asbestos Fiber Concentrations (in fibers > 5 μ/cc) Encountered in the Drywall Taping Process

Operations[A]	Number of Samples	Sampling Time (Min)		Concentrations		
		Range	Mean	Range	Mean	Median
Application[B] (2)	10	39 - 65	54.4	0.4 - 1.3	0.9	0.9
Mixing[B] (1) (Dry Powder)	3	10 - 12	10.6	9.0 - 12.4	11:2	12.2
Mixing[B] (2) (Pre-mix)	7	4 - 5	4.6	1.2 - 3.2	2.4	2.3
Mixing Area[C] (2) (Pre-mix)	7	3 - 5	4.0	1.2 - 2.7	2.0	2.0
Hand Sanding[B] (1)	22	10 - 80	15.0	2.1 - 24.2	11.5	11.5
Pole Sanding[B] (1)	20	10 - 38	18.5	1.2 - 10.1	4.3	4.0
Pole Sanding[B] (2)	32	4 - 21	13.9	1.2 - 10.0	4.6	3.8
Pole Sanding[B] (3)	52	4 - 38	15.7	1.2 - 10.1	4.9	3.8
Sanding Area[C] (3)	10 (8 from set 1)	10 - 58	22.0	0.3 - 7.0	3.2	2.3
Sweeping[B] (1)	6	9 - 30	20.7	4.0 - 26.5	12.1	7.7
Sweeping[B] (2)	4	10 - 20	14.2	14.5 - 25.4	19.6	19.4
Sweeping[B] (3)	10	9 - 30	18.1	4.0 - 26.5	15.1	15.5
All operations (1)	59	9 - 80	17.5	0.3 - 26.5	8.0	5.9
All operations (2)	62	3 - 65	18.5	0.4 - 25.4	4.3	2.7
All operations (3)	121	3 - 80	18.0	0.3 - 26.5	6.1	3.7

[A]The numbers in parentheses refer to the following collection schedules:
(1) air samples taken at several residential sites throughout the Province of Alberta during 1975-77;
(2) air samples taken at the Edmonton multi-storied hotel site during 1978;
(3) air samples taken during 1975-1977 and 1978 combined.
[B]Personal samples were collected.
[C]Area samples were collected.

samples (10) were either analyzed by X-ray diffraction or were subjected to scanning electron microscopy for asbestos fiber identification.

3. The data analysis involved the computation of simple descriptive statistics.

results and discussions

In Table I, the number of samples collected for various operations are given along with range and mean of sampling time and range, mean and median of the observed fiber counts. The data obtained during 1975-77 are designated in this table as set (1) and those obtained in 1978 are identified as set (2). This distinction between the two sets of data was made because, as already mentioned, set (1) was primarily from the residential taping operations and set (2) from large commercial building taping operations. However, since the joint compound used was similar and the exposure level comparable, to strengthen the data base they have been combined as set (3). In addition, the Low Value (L), the Lower Quartile (1Q), the Median (M), the Upper Quartile (3Q) and the High Value (H) for the measured fiber concentration were evaluated. The results are depicted in Figure 1 and for the taping process as a whole, appear to follow a log normal distribution.

The results summarized in Table I and Figure 1 are conveniently discussed in detail in relation to each of the four operations of the process: mixing, application, sanding and cleanup.

mixing

Although the exposure duration of this operation was short, concentrations as high as 12.4 fibers/cc were found in the limited number of samples (3) taken during mixing of the dry joint compound powder. Concentrations as high as 59.0 fibers/cc have been reported earlier.[8]

The mixing of the pre-mix compound on the other hand resulted in much lower exposure of only 1.2 to 3.2 fibers/cc. Considering the short duration of mixing and low exposure encountered, the use of pre-mix should not create any significant hazard in this operation.

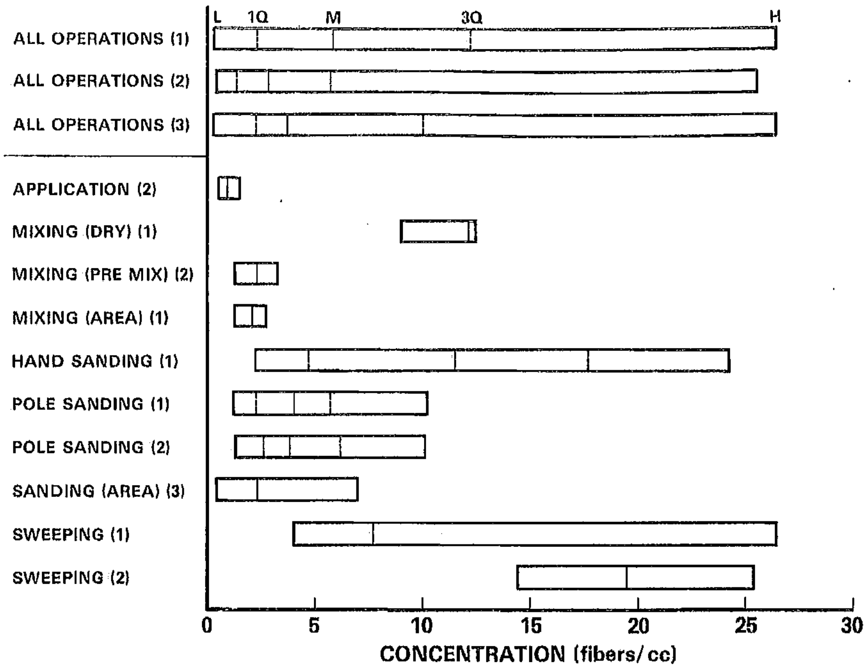

Figure 1 — Observed fiber counts for the various operations in the taping process. The numbers in parentheses (ordinate labelling) refer to the collection time and place as explained in footnote *a* of Table I. L, 1Q, M, 3Q and H represent Low value, the Lower Quartile, the Median, the Upper Quartile and the High value respectively.

application

During application, the compound is in the form of a paste and virtually no dust should be generated. Air samples taken, however, indicated concentrations ranging from 0.4 to 1.3 fibers/cc. Other studies[8,10] have not reported fiber levels during this operation. The airborne fibers found were most likely the residual fibers that were generated in other operations, e.g. mixing or sanding that were carried out earlier.

sanding

It can be seen from the data in Table I and Figure 1 that airborne asbestos fiber levels encountered during hand sanding ranged from 2.1 to 24.2 fibers/cc and during pole sanding (which is the more prevalent means of sanding) ranged from 1.2 to 10.1 fibers/cc. There was good agreement between the median concentrations encountered during sanding in both the data for 1975-77 and for 1978 (see Figure 1).

Our results which show high concentrations during sanding are in general agreement with the results of one of the earlier studies.[8,9] Levels of 1.2 to 19.3 fibers/cc were reported for pole sanding (number of samples - 10) and 1.3 to 16.9 fibers/cc during hand sanding (number of samples - 11).[8] These and our own results are considerably higher than those (0.3 to 3.5 fibers/cc, 29 samples composed of 24 pole sandings and 5 hand sandings) reported in the only other study.[10] Although our results show hand sanding to produce higher fiber concentrations than pole sanding, other studies have shown the opposite.[8,9] The reason for this difference is not obvious but could be due to different work practices.

No mechanical control measure e.g. local exhaust at the sander was employed. The only practical available measure is the use of appropriate respiratory protection. Unfortunately, the use of respirators by this group of workers was not widespread.

sweeping and cleanup

In cases where it was possible to obtain samples, concentrations of 4 to 26.5 fibers/cc were measured.

relation of findings to occupational health standards

To facilitate the interpretation of exposure experienced by tapers, a brief discussion of the present and proposed occupational health standards follows. Our own results are subsequently discussed in the light of these levels.

The asbestos standards and recommendations in the U.S. and Canada are constantly being revised. OSHA has a present standard of an 8 hour time weighted average (TWA) of 2 fibers/cc that are greater than 5 microns in length, with a ceiling of 10 fibers/cc and it has a proposal to reduce it to 0.5 fibers/cc as a TWA.[1,2] NIOSH has recommended the adoption of a TWA of 0.1 fibers/cc with a ceiling of 0.5 fibers/cc.[2] ACGIH has also published in its intended changes list of 1978 new TLV's for various forms of asbestos that range from 0.2 fibers/cc to 2 fibers/cc.[13]

In the Province of Alberta, the asbestos standard since 1975 has been a TWA of 2 fibers/cc with a ceiling of 10 fibers/cc. Some provinces (e.g. Alberta and Ontario) in Canada are considering adoption of asbestos standards similar to those proposed by ACGIH in its intended changes list of 1978.

To determine the time weighted average (TWA) concentrations to which tapers were exposed the following formula was employed:

$$TWA = \frac{\sum_{i}^{n} C_i t_i}{\sum_{i}^{n} t_i} = \frac{\sum_{i=1}^{4} C_i t_i}{\sum_{i=1}^{4} t_i \ (=40)}$$

Where C_i is the exposure encountered at job i during the time (t_i) employed at this operation. A typical taper's work week of 40 h could be broken down into the following exposures.

(i) 2 h (t_1) during mixing with an exposure concentration of C_1

(ii) 27 h (t_2) during application with an exposure concentration of C_2

(iii) 10 h (t_3) during sanding with an exposure concentration of C_3

(iv) 1 h (t_4) during cleaning with an exposure concentration of C_4

The calculated TWA values differ greatly depending upon the type of operations used in the above formula. Let us consider two situations: case (1) where mixing was done by employing dry mixing and sanding effected by hand sanding. Case (2) where a pre-mix compound was employed and the finishing achieved by pole sanding. Using the median values given in Table I and Figure 1 of 12.2 fibers/cc, 2.3 fibers/cc, 11.5 fibers/cc, 3.8 fibers/cc, 0.9 fibers/cc and 15.5 fibers/cc for dry mixing, mixing pre-mix, hand sanding, pole sanding, application and sweeping respectively, the calculated TWA values are 4.5 fibers/cc for case (1) and 2.1 fibers/cc for case (2).

It is clear that the TWA values calculated in the above manner are generally in excess of the present occupational limit and are far in excess of the newly proposed criteria. Such assessments for the taping process may not be very adequate in all cases since various factors affect the final result. These include:

(I) Time periods allocated to various operations are only approximates and may vary significantly.

(II) Operations may be performed solely by one individual (e.g. a person doing sanding full-time which was the case in some instances).

(III) Dry-joint compound produces a much higher dust concentration than pre-mix compound during mixing.

(IV) The percentage of asbestos found in the compounds may vary depending upon the manufacturers.

(V) Some operations (e.g. cleaning and sweeping) may not be performed by all tapers.

Because of these limitations a single TWA value for all drywall taping processes, cannot be accurately assessed. Consequently, it is our opinion that the exposure data is most meaningful when expressed, as in Table I and Figure 1, as the concentrations encountered in specific operations (mixing, application, sanding and cleanup) of the taping process from which the TWA for any situation could be derived.

In the U.S. the Consumer Product Safety Commission (CPSC) in 1978 banned the sale of asbestos containing compounds to the consumer, on the grounds of possible asbestos related health risks.[14-15] This ban, however, does not apply to the products made for commercial and industrial use where most of the occupational exposure to tapers occurs. In Canada, the Department of Consumer and Corporate Affairs of the Federal Government currently has under consideration a similar ban.[16,17] This Canadian proposal differs from the U.S. Consumer Product Safety Commission's in that it may apply to products made both for consumer and industrial/commercial markets.

conclusions and recommendations

We believe that our results constitute a realistic and comprehensive assessment of typical exposure experienced by tapers. The data should be useful in planning suitable health protection programs and in the assessment of past exposure for such purposes as adjudication of compensation claims, and design of epidemiological studies. The essentials of our findings may be summarized as follows:

(1) The tapers are occupationally exposed to potentially hazardous asbestos dust concentrations in their work. The asbestos hazard can be eliminated by the use of asbestos free joint compound. Although asbestos free joint compound is available and most manufacturers are actively working towards the reduction and/or elimination of asbestos in their material, most of the taping compounds used still contain asbestos. The use of asbestos free compound is the only feasible method of total control of asbestos exposure and is therefore strongly recommended. However, a person engaged in mixing, sanding, and sweeping, of asbestos containing compound should wear an approved respiratory protective device.

(2) The use of pre-mix compound is preferable over dry powder joint compound, because it eliminates high exposure during mixing. It is recommended that the amount of joint compound used should be the minimum necessary for the job.

(3) Sanding is the most hazardous operation of the taping process because the concentrations of asbestos encountered are high and a large portion of total time is spent in this operation. To reduce the exposure various control measures should be considered, including the effective use of respirators and rotation of workers.

(4) The short term hazard associated with sweeping and cleanup operations could be reduced by employing an industrial type vacuum cleaner. If a broom must

be employed, a dust suppressant compound should be used.

(5) Tapers who work with asbestos containing compound should be included in the medical surveillance program for asbestos workers. Additional epidemiological studies of this group of workers are also recommended. Furthermore, tapers should be familiarized with the potential health hazards, especially the greatly elevated lung cancer risks for asbestos workers who smoke.

(6) The unnecessary exposure of tradesmen not directly involved in taping, can be avoided by proper job scheduling and restricting the entry to exposure areas. Contamination of the home environment can be minimized by careful handling of workclothes and good personal hygiene.

Acknowledgement

The authors wish to thank Mr. David E. Gibson, Director, Occupational Hygiene Branch, Alberta Worker's Health Safety & Compensation for his help and encouragement during the study. Thanks are also due to Mr. Gerry Wunderlich of Alpine Drywall Company and to those drywall tapers who participated in the study.

We are grateful to Mr. Jim Julian, Dr. David Muir and Dr. Evert Nieboer of McMaster University for their help in the preparation of this report.

References

1. **National Institute for Occupational Safety and Health:** Criteria for a Recommended Standard . . . Occupational Exposure to Asbestos. U. S. DHEW, Cincinnati (1972).
2. **National Institute for Occupational Safety and Health:** Revised Recommended Asbestos Standard. U.S. DHEW, Cincinnati (1976).
3. **Selikoff, I. J., E. C. Hammond and J. Churg:** Asbestos Exposure, Smoking and Neoplasia. *J. Am. Med. Assoc. 204*:104-110 (1968).
4. **Becklake, M. R.:** Asbestos Related Diseases of the Lung and Other Organs: Their Epidemiology and Implications for Clinical Practices. *Am. Rev. Resp. Dis. 114*:187-227 (1976).
5. **McDonald, J. C., M. R. Becklake, G. W. Gibbs, A. D. McDonald and C. E. Rossiter:** The Health of Chrysotile Asbestos Mine and Mill Workers. *Arch. Env. Health. 28*:61-68 (1974).
6. **Knox, J. F., S. Holmes, R. Doll and I. D. Hill:** Mortality From Lung Cancers and Other Causes Among Workers in an Asbestos Textile Factory. *Br. J. Ind. Med. 25*:293-303 (1968).
7. **Selikoff, I. J.:** Asbestos Disease in the United States (1918-1975). *Rev. Jr. Mal. Resp. Suppl.* 1 au Tome 4:7-24 (1976).
8. **Rohl, A. N., A. M. Langer, I. J. Selikoff and W. J. Nicholson:** Exposure to Asbestos in the Use of Consumer Spackling, Patching and Taping Compounds. *Science. 189*:551-553 (1975).
9. **Fischbein, A., A. N. Rohl, A. M. Langer and I. J. Selikoff:** Drywall Construction and Asbestos Exposure. *Am. Ind. Hyg. Assoc. J. 40*:402-407 (1979).
10. **Rhodes, H. B. and B. L. Ingalls:** Asbestos and Silica Dust in the Drywall Industry. Part 1 and Part 2. G.D.C.I. (Gypsum Drywall Contractors International) *Drywall. 21*:6-8 (1975). *22*:1-6 (1976).
11. **Anon.:** Asbestos Risk Exists From Use of Taping Compound. *Insulation Hyg. Progress Rep. 7*:2-4 (1975).
12. **National Institute for Occupational Safety and Health:** Sampling and Evaluating Airborne Asbestos Dust. U. S. DHEW, Cincinnati (1974).
13. **(TLVs):** *Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1978.* ACGIH, Cincinnati (1978).
14. **Ray, D. R.:** Personal Communication, Consumer Product Safety Commission, Washington, DC 20207 (December, 1978).
15. **U. S. Federal Register:** 42:63354-63365 (December, 1977).
16. **Brownstein, M.:** Personal Communication, Consumer and Corporate Affairs, Gov't of Canada, Ottawa, Canada (May, 1979).
17. **Consumer and Corporate Affairs Canada, Product Safety Branch:** Trade Communique - *Asbestos Containing Products.* Issue No. 1. (April, 1979).