PLAINTIFF'S EXHIBIT KM-390

EVALUATION OF EXPOSURE TO ASBESTOS DURING MIXING AND SANDING OF JOINT COMPOUNDS

GYPSUM ASSOCIATION
Denver, Colorado

November 19, 1973



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INTRODUCTION

The Gypsum Association retained George D. Clayton and Associates to conduct an industrial hygiene survey at a test site located in Denver, Colorado. The purpose of the survey was to determine the concentrations of airborne asbestos to which workers were exposed during mixing and sanding of joint cement compounds and to interpret the results in terms of potential health hazards with particular reference to regulations promulgated under authority of the Occupational Safety and Health Act of 1970. This study was conducted on November 19, 1973 by Mr. Robert D. Soule of Clayton and Associates. Results of that study are reported herein.

BACKGROUND

The Gypsum Association, located at 1603 Orrington Avenue in Evanston, Illinois is a trade association which represents ten to fifteen industrial companies which are engaged in the manufacture of products incorporating gypsum or gypsum-like materials. As with most industrial concerns, the activities of the Gypsum Association have become more broad with the passage and implementation of federal regulations such as the Metal and Non-Metallic Mine Safety Act and the Occupational Safety and Health Act. Technical committees composed of personnel from companies comprising the Gypsum Association have been established with particular interest in the occupational safety and health field. Of particular concern in this respect was the potential hazard associated with exposure of workers to airborne asbestos during mixing and sanding of compounds used to seal cracks and joints formed during installation of wallboard material. Although the specific formulations used by the various companies manufacturing and supplying the joint compound vary, it is understood that essentially all of them incorporate asbestos in the product whether as a dry compound or a ready-mix product.

In order to evaluate the exposure of workers to asbestos during handling and use of the joint compound products, the Gypsum Association decided to undertake a test program during which several products would be mixed and sanded. George D. Clayton and Associates was retained to collect and analyze samples which would represent the exposure of workers engaged in the study. The tests were performed on November 19, 1973 in a development of townhouses known as King's Mill Townhouses, which were under construction in a suburban area north of Denver, Colorado.

POTENTIAL HEALTH HAZARD ASSOCIATED WITH EXPOSURE TO ASBESTOS

Asbestos is a generic term referring to various mineral silicates. The types used most widely in industrial applications include chrysotile, or "white asbestos" (a hydrated magnesium silicate), amosite,

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or "gray asbestos" (an iron magnesium silicate), crocidolite, or "blue asbestos" (a sodium iron silicate), tremolite (a calcium magnesium silicate), and anthophyllite (another iron magnesium silicate). Of these, chrysotile accounts for over 90 percent of the total usage of asbestos in this country, with amosite and crocidolite being the only other types used to any significant extent.

Asbestos exists naturally in bundles of extremely fine fibers which can be subdivided easily into many smaller fibers. The potential health hazard associated with exposure to asbestos is that of inhalation of airborne fibers resulting in a type of pneumoconiosis referred to as "asbestosis." Small asbestos fibers can pass readily through the upper respiratory tract and be deposited in the terminal bronchioles of the lung. There, they produce a local irritation which the body attempts to overcome by initiating a tissue response resulting in the encapsulation of the fibers and consequent formation of "asbestos bodies." If sufficient quantities of fibers are inhaled over an extended period of time, a generalized diffuse peribronchiolar fibrosis can develop. This pulmonary fibrosis can impair the transfer of oxygen across the aveolar membranes and result in respiratory insufficiencies, or even cardiac failure. It has been determined, through toxicological and epidemiological studies, that long fibers, 20 to 50 micrometers in length, are most active in the production of the fibrosis. Fibers shorter than about two micrometers in length, are practically without an irritating effect. There is some evidence that other minerals having fibrous characteristics can produce similar reactions.

Many recent studies have indicated an association between exposure to asbestos in both industrial and urban atmospheres and an increase in a relatively rare type of lung cancer known as mesothalioma. Although it has not been possible to establish a connection with asbestos in all cases of this disease, there is a strong correlation between exposure to crocidolite and occurrence of mesotheliomas. Other types of asbestos have been implicated to a much lesser extent. However, this "new hazard" has received much public attention because it has been suggested that very minimal, non-occupational exposure can be sufficient to produce the disease in some individuals.

For many years the American Conference of Governmental Industrial Hygienists has recommended a threshold limit value (TLV) of five million particles per cubic foot of air (mppcf) for all types of asbestos-bearing dusts containing less than one percent crystalline silica. The threshold limit value is defined as the concentration of an airborne contaminant to which it is believed that nearly all workers can be exposed for continuous and repeated work days without experiencing adverse effects. The TLV of five mppcf was based on the impinger sampling technique which was selected as the standard method in the early epidemiological studies of occupational exposure to asbestos. With this method, air is drawn through an impinger containing water and the total particles (both grains and fibers) in an aliquot of the sample, are counted using light-field microscopic techniques.

Within recent years, because of the increasing concern about asbestos in the environment and the resulting need for a more relevant sampling method, the American Conference of Governmental Industrial

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Hygienists has proposed a TLV of five fibers (greater than five micrometers in length) per cubic centimeter of air. This standard is based on the membrane filter technique with actual microscopic fiber counting at 400-450X magnification using phase contrast illumination.

The Occupational Safety and Health Administration (OSHA) has established the above concentration (five fibers, greater than five micrometers in length, per cubic centimeter of air) as an emergency standard and have announced that, effective July 1, 1976, the acceptable limit for an eight-hour, time-weighted average exposure will be reduced to two fibers cc. In addition, OSHA has established the concentration of ten fibers (greater than five micrometers in length) per cubic centimeter of air as an acceptable ceiling concentration. Workers shall not be exposed to concentrations of asbestos in excess of this value, regardless of duration of exposure.

SAMPLING AND ANALYTICAL METHODS

The air sampling conducted to evaluate exposures of workers to asbestos was all of the "breathing zone" type. These samples were collected by drawing air through 37-mm diameter membrane filters (Millipore Type AA) at a rate of about two liters per minute using small, battery-operated pumps (Mine Safety Appliances Company, Model G). The sampling units were worn by the workers engaged in either mixing or sanding the joint compound; the pump was attached to the belt and the sampler head fastened on the outside of the worker's shirt at approximate breathing zone height. Thus, these samples were representative of the time-weighted average conditions to which the men were exposed during the sampling period. The sampling head consisted of a three piece cassette (Millipore); during sampling the face cap was removed and the filter was used in an "open face" mode with the filter positioned slightly downward so as to minimize dust falling directly onto the filter.

Sampling was conducted for the entire duration of the mixing operations but because of the higher anticipated concentrations associated with sanding of the joint compounds it was decided to change filters approximately every ten minutes. Sampling during the sanding on the various joint compounds was conducted over a total period of sixty minutes. Therefore six consecutive ten-minute samples were obtained for each sanding test. In addition to the ten-minute tests, samples were collected over thirty-minute periods as well, i.e., two consecutive 30-minute samples for each sanding test. After collection of each sample the filter cap was replaced and the cassette, or sampler head, was sealed immediately and prepared for transfer to the analytical laboratory.

The method of counting asbestos fibers was essentially the same as that used by the U.S. Public Health Service for the enumeration of asbestos dust on membrane filters. The description of this method first appeared in an article written by C.H. Edwards and J.R. Lynch and appeared in the Annals of Occupational Hygiene, Volume 2, pages 1-6 (1968).

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In summary, the method consisted of the following steps.

A pie-shaped section of each sample was mounted on a standard microscope slide using a high viscosity solution of membrane filter in a 1:1 mixture of diethyl oxalate and dimethyl phthalate to render the filter transparent. The asbestos fibers which were on the surface of the filter were then counted using a 10X eyepiece and a 40X objective with phase contrast illumination.

A number of fields, selected at random across the sample, sufficient to reveal a minimum of 100 fibers were examined and fibers greater than five micrometers in length were counted. Any particle having an aspect ratio of three or greater was considered to be a fiber. Although it was conceivable that there would be fibers of paper or other materials present on the filters which would have been dislodged from the wallboard during the sanding operation it did not appear that these were of any adverse consequence during the analysis of the samples. Although it is realized that the counting technique is not specific in terms of being able to identify the chemical nature of the fibers present in the sample, all of the fibers observed in these samples appeared to have physical features characteristic of asbestos fibers.

For those samples collected over a thirty-minute period, and which were too heavily loaded to evaluate directly under the microscope, the collected material on the filters was dislodged in a highly purified distilled water bath using an ultrasonic unit (Dynasonic Corporation, Model G6 generator and Model T6 tank) and diluted to one liter. An aliquot of the resulting suspension was drawn, passed through a membrane filter (Millipore Type HA) and was then analyzed according to the procedure described above.

PRESENTATION OF RESULTS

A total of four joint compound products were used during this study. These products (two dry mix and two "ready mix") were supplied by two manufacturers whose identities were not known to the investigator. The products were identified by code (2D, 2R, 4D and 4R), a number referring to the supplier and the letter indicating whether the product was a "dry" or "ready-mix" compound.

The results of the sampling program conducted during the mixing of the two dry mix products and sanding tests on all four joint compounds are presented in Tables I through IV. Examination of these data reveals the following:

1. During mixing of Joint Compound 2D, the worker was exposed to a concentration of ~~3.4~~ fibers, greater than five micrometers in length, per cubic centimeter of air.

2. The amount of total particulate generated during the sanding operation on Joint Compound 2D was so great that direct

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analysis of the ten-minute samples was not possible. Analysis of the thirty-minute samples, which were redeposited, indicated an average concentration of 39.4 fibers, greater than five micrometers in length, per cubic centimeter of air.

3. The results of analyzing four of the six ten-minute samples collected during sanding on Joint Compound 2R indicated an average concentration of 4.2 fibers per cubic centimeter; two of the samples were too heavily loaded to analyze directly. Results of analysis of the two thirty-minute samples collected during the sanding on Joint Compound 2R indicated an average concentration of 11.1 fibers per cubic centimeter, a factor of over 2.5 times as high as the average obtained from analysis of the ten-minute samples.

4. The sample obtained during the mixing of Joint Compound 4D indicated a concentration of 7.6 fibers, greater than five micrometers in length, per cubic centimeter of air.

5. Results of analyzing four of the six ten-minute samples collected during the sanding on Joint Compound 4D indicated an average concentration of 4.4 fibers per cubic centimeter. Analysis of the two thirty-minute samples, which were subjected to the redepositing procedure, indicated an average concentration of 14.8 fibers per cubic centimeter, a factor of 3.4 times as high as results obtained from the ten-minute samples.

6. The results of analysis of five of the six samples obtained during the sanding on Joint Compound 4R indicated an average concentration of 10.8 fibers per cubic centimeter. Results of analysis of the two thirty-minute samples indicated an average concentration of 9.7 fibers per cubic centimeter, a value essentially the same as that obtained from analysis of the ten-minute samples.

7. Six of the thirteen ten-minute samples obtained during sanding on the four joint compounds indicated concentrations in excess of five fibers per cubic centimeter. Both mixing operations generated asbestos concentrations in excess of five fibers per cubic centimeter.

8. Two of the thirteen ten-minute samples collected during the sanding tests indicated concentrations in excess of ten fibers per cubic centimeter, the acceptable ceiling concentration. One of the two mixing operations generated an asbestos-in-air concentration in excess of ten fibers per cubic centimeter.

9. Of the four products tested, sanding on 2R and 4D resulted in concentrations less than, but approaching, the current acceptable limit for continuous exposure of workers, five fibers per cubic centimeter. Product 4R consistently produced very high concentrations of total dust which obscured the asbestos fibers on the samples.

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CONCLUSIONS

The following conclusions are presented on the basis of observations and measurements made during the study reported herein.

1. Based on the results of the ten-minute samples, it is apparent that the exposures of workers engaged in mixing and sanding of the various joint compounds used during this test would be to concentrations approaching or exceeding five fibers, greater than five micrometers in length, per cubic centimeter of air.

2. It is clear that persons engaged in the mixing and sanding of joint compounds similar to those used during this test would be exposed to concentrations of airborne asbestos in excess of two fibers per cubic centimeter during the entire course of their work. This value is the proposed acceptable limit for an eight-hour time-weighted average exposure to asbestos which is scheduled to become effective July 1, 1976.

3. With the exception of the tests conducted during sanding on joint compound 4R the results of analysis of the thirty-minute samples, using the redeposition technique, were consistently higher than those obtained by direct analysis of the ten-minute samples by a factor of 2-1/2 to 3-1/2. Therefore, it appears that use of the redeposition technique would result in the apparent concentrations of asbestos in air being higher than actually present and would therefore err on the "conservative" side.

4. Discounting the results obtained by analysis of the thirty-minute samples, for which the redeposition technique was used, three of the samples collected (mixing of 2D and sanding on 4R) indicated concentrations in excess of ten fibers per cubic centimeter and are therefore a concern as peak exposures. With those exceptions, the problem is one of controlling the time-weighted average exposures of workers to asbestos. In that respect, it must be pointed out that the sampling results reported herein are indicative of the exposures of workers during the mixing or sanding operations and not their time-weighted average exposure for a full workday.

RECOMMENDATIONS

1. The results of sampling reported herein should be analyzed in conjunction with a study of the work practices and routine of persons engaged in mixing, sanding or otherwise being exposed to joint compounds similar to those used in this study. In this way a true evaluation of the time-weighted average exposure of such workers to asbestos can be made. If it is true that, as reported by workers used during this test, it would be unlikely for an individual to mix or sand on the joint compounds for greater than two hours per workday, then the time-weighted average exposure of such workers to asbestos likely would be within acceptable limits. Of course, the problem of controlling any

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exposures to below ten fibers per cubic centimeter would still have to be contended with.

2. From the standpoint of being able to eliminate or minimize the problem of excessive concentrations of asbestos being generated by handling and use of the joint compounds, consideration should be given to the following aspects.

   a. The most effective means of eliminating the asbestos problem obviously would be to eliminate asbestos from the joint compound formulations if this is feasible. Although the specific role that asbestos plays in the joint compound formulations is not clear it is understood that manufacturers of joint compounds consider it necessary that asbestos be in the formulations.

   b. From an engineering standpoint, it may be necessary to implement the following measures in conjunction with mixing and sanding of the joint compounds containing asbestos.

      i. Mixing of the joint compounds could be done in such a way that the material is more effectively wetted as it is removed from the containers or could be done within an enclosure, with or without mechanical ventilation, so as to minimize the amount of asbestos fibers released into the breathing zone of the workers.

      ii. Although the results of the air sampling reported herein indicate concentrations of asbestos fibers in excess of acceptable limits, either those currently enforced or those proposed to be made effective in July, 1976, it was obvious during the study that the sanding process in general has associated with it exposure of the worker to tremendously high concentrations of total dust. Therefore, if means were implemented to maintain the exposure of the workers to total particulate to within acceptable limits there would be an inherant control of the asbestos problem as well. Although more extensive in nature, engineering control of the total dust generated by the sanding operations is feasible. Such control techniques would include, but not be limited to, the use of a wet sanding technique and/or use of a portable local exhaust ventilation system incorporating, as the air moving device, a unit similar to common industrial vacuum cleaners and bag collectors.

The next phase of the testing program to control workers' exposures to asbestos during use of the joint cement compounds logically would be evaluations of the various potential engineering control concepts indicated or inferred above.

Report prepared by: Robert D. Soule

Robert D. Soule, P.E.
Vice-President, Industrial Hygiene Services

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GEORGE D. CLAYTON & ASSOCIATES
INDUSTRIAL HYGIENE SAMPLING SUMMARY

Client Gypsum Association — Material Asbestos

1973 Date	Sample No.	JOINT COMPOUND 2D Description (a)	Sampling Period Start	Sampling Period Stop	Sample Weight	Sample Volume Liters	Concentration Fibers >5µm/cc		
11/19	2D-M	Mixing of compound(b)	09:28	09:34		13	31.4		
11/19	2D-S-1	Sanding on compound(c)	11:57	12:27		60	35.2**		
11/19	2D-S-2	Sanding on compound(c)	11:57	12:07		-	*		
11/19	2D-S-3	Sanding on compound(c)	12:07	12:17		-	*		
11/19	2D-S-4	Sanding on compound(c)	12:17	12:27		-	*		
11/19	2D-S-5	Sanding on compound(c)	12:27	12:57		60	43.6**		
11/19	2D-S-6	Sanding on compound(c)	12:27	12:37		-	*		
11/19	2D-S-7	Sanding on compound(c)	12:37	12:47		-	*		
11/19	2D-S-8	Sanding on compound(c)	12:47	12:57		-	*		

(a) All samples were obtained in the breathing zone of the workers.
(b) Mixing of Compound 2D was done by Mr. Harold McDowell in King's Mill Townhouse Unit U-81.
(c) Sanding of Compound 2D was done by Mr. James Pasquariello in King's Mill Townhouse Unit U-77. Psychrometric conditions in U-77 at 11:45 were 56°F dry bulb, 41°F wet bulb (22% relative humidity)

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too heavily loaded for direct analysis
material on filter was taken into suspension and an aliquot redeposited for analysis

GEORGE D. CLAYTON & ASSOCIATES
INDUSTRIAL HYGIENE SAMPLING SUMMARY

Client Gypsum Association Material Asbestos

1973 Date	Sample No.	JOINT COMPOUND 2R Description (a)	Sampling Period Start	Sampling Period Stop	Sample Weight	Sample Volume Liters	Concentration Fibers >5μm/cc		
11/19	2R-S-1	Sanding compound (b)	15:48	16:18		60	12.3**		
11/19	2R-S-2	Sanding compound (b)	15:48	15:58		20	4.5		
11/19	2R-S-3	Sanding compound (b)	15:58	16:08		20	4.2		
11/19	2R-S-4	Sanding compound (b)	16:08	16:18		20	4.1		
11/19	2R-S-5	Sanding compound (b)	16:18	16:48		60	9.9**		
11/19	2R-S-6	Sanding compound (b)	16:18	16:28		20	*		
11/19	2R-S-7	Sanding compound (b)	16:28	16:38		20	3.8		
11/19	2R-S-8	Sanding compound (b)	16:38	16:48		20	*		

(a) All samples were obtained in the breathing zone of the workers.
(b) Sanding of Compound 2R was done by Mr. David Potter in King's Mill Townhouse Unit U-79. Psychrometric conditions in U-79 at 15:45 were 39°F dry bulb, 35°F wet bulb (66% relative humidity).

* too heavily loaded for direct analysis
** material on filter was taken into suspension and an aliquot redeposited for analysis

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GEORGE D. CLAYTON & ASSOCIATES

INDUSTRIAL HYGIENE SAMPLING SUMMARY

Client Gypsum Association — Material Asbestos

1973 Date	Sample No.	JOINT COMPOUND 4D Description (a)	Sampling Period Start	Sampling Period Stop	Sample Weight	Sample Volume Liters	Concentration Fibers >5µm/cc		
11/19	4D-M	Mixing compound(b)	09:09	09:17		14.4	7.6		
11/19	4D-S-1	Sanding compound(c)	10:20	10:50		60.0	15.5**		
11/19	4D-S-2	Sanding compound(c)	10:20	10:29		18.0	5.2		
11/19	4D-S-3	Sanding compound(c)	10:29	10:40		22.0	*		
11/19	4D-S-4	Sanding compound(c)	10:40	10:50		20.0	3.7		
11/19	4D-S-5	Sanding compound(c)	10:50	11:00		20.0	4.1		
11/19	4D-S-6	Sanding compound(c)	10:50	11:20		60.0	14.1**		
11/19	4D-S-7	Sanding compound(c)	11:00	11:10		20.0	*		
11/19	4D-S-8	Sanding compound(c)	11:10	11:20		20.0	4.7		

(a) All samples were obtained in the breathing zone of the workers.
(b) Mixing of Compound 4D was done by Mr. Harold McDowell in King's Mill Townhouse Unit U-80.
(c) Sanding of Compound 4D was done by Mr. James Pasquariello in King's Mill Townhouse Unit U-76. Psychrometric conditions (dry and wet bulb temperatures) were not recorded.

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* too heavily loaded for direct analysis
** material on filter was taken into suspension and an aliquot redeposited for analysis

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INDUSTRIAL HYGIENE SAMPLING SUMMARY

Client Gypsum Association — Material Asbestos

1973 Date	Sample No.	JOINT COMPOUND 4R Description (a)	Sampling Period Start	Sampling Period Stop	Sample Weight	Sample Volume Liters	Concentration Fibers >5μm/cc		
11/19	4R-S-1	Sanding compound (b)	14:31	15:01		60.0	11.3**		
11/19	4R-S-2	Sanding compound (b)	14:31	14:41		20.0	6.3		
11/19	4R-S-3	Sanding compound (b)	14:41	14:51		20.0	7.5		
11/19	4R-S-4	Sanding compound (b)	14:51	15:01		20.0	19.9		
11/19	4R-S-5	Sanding compound (b)	15:01	15:31		60.0	8.1**		
11/19	4R-S-6	Sanding compound (b)	15:01	15:11		20.0	5.3		
11/19	4R-S-7	Sanding compound (b)	15:11	VOID		-	-		
11/19	4R-S-8	Sanding compound (b)	15:18	15:31		26.0	15.0		

(a) All samples were obtained in the breathing zone of the workers.
(b) Sanding of Compound 4R was done by Mr. David Potter in King's Hill Townhouse Unit U-78. Psychrometric conditions in U-78 at 14:45 were 44°F dry bulb, 38°F wet bulb (68% relative humidity).

** material on filter was taken into suspension and an aliquot redeposited for analysis

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