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Evaluation of Asbestos Exposure from Asbestos-Roofing Removal Operations

Joseph W. Aherne
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Professor Lester Levin
Industrial Hygiene

Submitted as partial fulfillment of requirements for Master of Science degree in Occupational Health.

Introduction

In the past few decades, the marvelous advantages of an inflammable, resistant, fibrous mineral which inspired the Greeks to call it "asbesta", meaning inextinguishable or unquenchable, have paled in comparison to the impact it has had on thousands of workers and their families. The magnitude of the asbestos problem is only now being realized. Studies have been completed on the working environments of several occupations and also on the workers families. In addition, monitoring studies have been completed on the environments of buildings within which asbestos materials have been used in construction[1]. Asbestos fiber exposures have been evaluated in the mining and milling of asbestos[2], insulation trades[3], and in the drywall construction industry[4]. The synergistic effect when a cigarette smoker is also exposed to asbestos fibers results in an extremely higher probability of carcinoma[3]. It has been estimated that an asbestos worker who smokes has approximately 90 times greater probability of contracting cancer than the non-smoker.

The occupational risk due to asbestos exposure to roofers has not been investigated to any great extent to this date. A complete survey of the literature discovered only a few references which demonstrated only a minimal exposure[5,6]. However, most of the monitoring performed for these studies was during the application of new roofing material. It is more reasonable to assume that fiber release would occur during tear-off operations, as when

weathered roofing materials are being removed.

The life of a roof ranges between 10-25 years[5,7]. Over this life time the materials are weathered, thereby becoming brittle and worn. As the weathering process continues the asbestos fibers, which originally had been fixed into an asphalt matrix may become loosened. When the shingles and roofing felts are removed these fugitive fibers will become airborne, resulting in a health hazard to the worker and to the populace in the neighboring community.

The "Tear-Off" Process

When a roof is replaced the shingles and felts or the built up roofing materials are pulled off the roof and discarded to a trash bin on the ground. This procedure causes the destruction of the shingles, roofing felts and other materials. During the process a significant amount of dust is produced in which the asbestos content is directly dependent on the amount in the roofing materials.

Shingle roofs are, for the most part, installed on residential structures; therefore, the asbestos fibers released during removal create a greater potential for exposure to the general public than do those released from commercial or ~~residential~~ industrial buildings.

Shingles are removed completely by hand, tearing the shingles off with the hands or with the aid of small hand tools, claw hammer and crowbar.

Built up roofing is generally installed on commercial or industrial structures. These are composed of a layer of insulation, covered

by a couple layers of roofing felt with hot asphalt spread on top and slag stones placed in the molten tar. The removal of these is accomplished by a combination of mechanical and manual tasks. The slag stones are removed with an industrial vacuum or swept up with brooms. Gasoline powered roof cutters are employed to section the roof in small pieces(2'x3'). These sections are then stacked on wheelbarrows and transported to the edge of the roof where they are discarded to the ground. The sectioning process creates a great amount of dust and since it usually continues simultaneously with the removal the potential for asbestos fiber exposure is great when the roofing felts or insulation contain asbestos.

The workers were generally not supplied with any type of respirators or masks for protection. However some did wear kerchiefs for their own protection.

Composition of Roofing Materials[5,8]

The asbestos content of roofing materials varies with the manufacturer and also with the type of product, i.e. felt, shingle, insulation. The basic material used to manufacture most roofing products is asbestos paper. The asbestos content varies from 5-100%(?). The type of asbestos is chrysotile in all instances. This results from the fact that this type is mined in Canada and, therefore, is inexpensive compared to the other types. This paper is then impregnated with asphalt to prepare it suitably for roofing felts and shingles. Asbestos content in the final product is 15-25% for shingles and 45-65% for the felts.[5]

Flashing cement and roof coating also contain asbestos fibers, 15-45% and 3-25% respectively.[8] However, these products remain semi-viscous throughout their life and therefore fiber release is unlikely.

Asbestos fibers are used in roofing materials to improve their longevity and the durability of the products. It increases the tensile strength, heightens resistance to corrosion and rot, and it greatly improves the insulation value and fire resistance potential.

Materials and Methods

Site Description

Most roofing contractors are small businesses with only a few employees. In these cases, the roofers usually work out of their homes with one or two trucks depending on the size of the particular job. Companies with larger work forces also exist but these companies generally do larger commercial and industrial roofing. Nevertheless, whether the company is large or small most employees arrive at the site ready for work and return home directly. These work practices create the potential for asbestos exposure to the workers' family.

This report contains an evaluation of the latter type of operation on industrial sites. The number of men needed for each job depends directly on its size and the estimated time for completion. Two sites were selected after a considerable amount of difficulty due to the lack of activity in the roofing industry during the

period of the research project.

The sites were of the commercial type, each with a builtup roof covered with slag stones. The roof in each case was removed as describe above.

Sampling

Airborne asbestos dust samples were collected in accordance with the NIOSH/OSHA recommended method[9,10]. Samples are collected using a portable sampling pump to draw air through a 37 mm 0.8 micron pore size Millipore, Type AA membrane filter. Air is pumped through the filters at a rate of 2 liters/min. Personal samples were collected by attaching the filter to workers collar by means of a clothing clip. Area samples were collected 4-6 feet off the ground to determine general environmental exposures. The flow rate was checked frequently during sampling. The pumps were calibrated before each use with the Kurz Flow Calibrator.

Fiber Determination

The filters were analyzed using the NIOSH approved membrane filter method[9]. The opaque filters are chemically treated to render them tranparent. The asbestos fibers are then sized and counted. Fibers >5 microns are counted and fibers/cc are calculated from the sampling time and flow rate. The asbestos fiber count was performed by an ACGIH accredited laboratory and the fiber/cc calculations were completed by the researcher.

Results and Discussion

The fiber exposures are tabulated in Table I and summarized in Table II. The results show a trend in exposure from very little

TABLE I

Airborne Asbestos Exposure to Roofers

	Position of Sample	Sample I.D. Number	Sampling Time (Min)	Sample Volume (Liters)	Concentration fibers >5 microns per cc.
Site I					
	Personal-loader	IMR-9-1	55	110	0.18
	"	-2	40	80	- 0 -
	"	-3	55	110	0.08
	-barrow	-4	45	90	0.13
	"	-5	50	100	0.23
	-operator	-6	35	70	0.29
	Area-down wind	-7	37	74	0.08
	"	-8	53	106	0.03
	-up wind	-9	95	190	0.05
Site II	Personal-loader	1-BV-5-1	50	100	too heavy to count
	-barrow	-2	50	100	0.06
	"	-3	50	100	0.09
	Area-up wind	-4	60	120	- 0 -
	-down wind	-5	55	110	0.05
Site III	Personal-barrow	2-BV-12-1	22	44	0.13
	"	-2	24	48	0.18
	"	-3	13	26	0.11
	"	-4	20	40	0.21
	"	-5	24	48	0.06
	"	-6	13	26	0.22
	-loader	-7	24	48	0.12
	"	-8	18	36	0.16
	"	-9	13	26	0.11
	Area-down wind	-10	60	120	- 0 -
	-up wind	-11	41	82	- 0 -
	-down wind	-12	21	42	0.07
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Loader- these workers stacked the sections onto the wheelbarrow
Barrow man- pushed the wheelbarrow and discarded the sections to the dumpster on the ground
Operator- manned the roof cutter which sectioned the roof

for the background readings to a significant exposure for some of the workers. The up-wind area samples which determined the background levels ranged from 0-0.05 fibers/cc with an average of less than 0.02 fibers/cc. The down-wind samples were also quite low ranging from 0-0.08 fibers with an average 0.05 fibers/cc.

TABLE II

Summary of Airborne Asbestos Exposure

Position of Sample	Number of Samples	Sample Time (Min) Range	Concentration (fibers/cc) Range	Mean
Area-up wind	3	41-95	0-0.05	<0.02
-down wind	4	21-55	0-0.08	0.05
Personal-loader	7	13-55	0-0.18	0.10
-barrow	9	13-50	0.06-0.23	0.15
-operator	1	35	0.29	0.29

The area samples were collected approximately 50 yards from the work site at levels(4-6 feet above ground) to determine the exposure to the general populace in the vicinity. The difference between the up-wind and down-wind samples is not large enough to conclude definitely that the tear-off procedures create a hazard to the public. However, the particular situation must be considered in order to explain these results. In both cases the buildings being worked were 50-60 feet high, so the fibers released in the process could easily have been distributed over a sufficiently large area to appear insignificant.

The personal samples show somewhat higher exposures. Three different tasks were monitored. The loader removed the cut sections from the roof and stacked them into the wheelbarrow. These exposures ranged from 0-0.18 fibers/cc with a mean 0.10 fibers/cc. The wheelbarrow man pushed the stacked sections to the edge ot the roof and dumped them to the ground. The asbestos exposures in this case ranged from 0.06-0.23 fibers/cc with a mean 0.15

fibers/cc. The reason the difference in these exposures is most probably due to the work practice of throwing the cut sections onto the wheelbarrow so that clouds of dust were created. The worker who pushed the barrow received the full brunt of this dust cloud. The man who operated the roof cutter was exposed to the greatest amount of asbestos, 0.29 fibers/cc. This task was visibly the most dusty because as the cutter sectioned the roof it pulverized the roofing felts and insulation in the process. However, only one sample could be collected , therefore, the results cannot be assumed for every case.

Relationship to Recommended Exposure Limits

In light of the carcinogenic nature of asbestos, the recommended standards and legal limits are constantly being reevaluated and revised downward. Presently, the OSHA standard for an 8 hour time weighted average(TWA) is 2 fibers/cc which are greater than 5 microns in length, with a ceiling of 10 fibers/cc[11]. NIOSH has recommended a TWA of 0.1 fiber/cc with a ceiling of 0.5-1 0.05 fibers/cc because of the carcinogenic nature of asbestos. ACGIH has revised its limits in the intended changes for 1978 to 2 fibers/cc for chrysotile asbestos. Since chrysotile is the asbestos form used in the roofing industry this limit is in agreement with the OSHA standard.

Therefore, the asbestos exposures evaluated herein are significantly below the legal limit set by OSHA and also below the recommended ACGIH limit, however, the NIOSH recommended standard of 0.10 fibers/cc is exceeded for each of the tasks monitored.

Conclusions and Recommendations

It is impossible to extend the conclusions of this report to the entire roofing industry. Because roofs are installed only every 15-25 years the records concerning the old roof are impossible to obtain, therefore the exact composition of the roofing felts and insulation are unknown. The roofing contractor can identify the materials as asbestos or rag felts, or the insulation as fiberglass or asbestos but in most cases the manufacturer cannot be identified and therefore the percentages of various materials is unascertainable.

In light of this caution a few comments are in order. The tear-off operations compose only a short part of each day, approximately one quarter, therefore, if some precautions are followed during the ripout the asbestos fiber exposure will be reduced. To protect the workers disposable respirators should be distributed at the start of each tear-off period. Inasmuch as the periods are normally short, worker cooperation is more likely than if the masks were necessary for the entire day.

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8) Consumer Product Safety Commission: Review of Asbestos Use in Consumer Products(April 1978). p. V-1 Asbestos Product Fact Sheets

9) NIOSH Occupational Exposure Sampling Strategy Manual(January 1975).

10) NIOSH Manual of Sampling Data Sheets, 1977. DHEW #77-159. Sampling Data Sheet #2.02

11) NIOSH: Revised Recommended Asbestos Standard. U.S.DHEW.

12) TLV's: Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1980.

Johns-Manville
Sales Corporation

Ken-Caryl Ranch
Denver, Colorado 80217

Edmund M. Fenner
Vice President
Director, Environmental Services
Health, Safety & Environment Department

January 14, 1980

Mr. Lester Levin
Professor of Industrial Hygiene
Drexel University
Environmental Studies Institute
Philadelphia, PA 19104

Dear Mr. Levin:

In reply to your letter of January 9, 1980 relative to asbestos-containing roofing materials and asbestos-containing compressed gaskets, I have the following comments.

There are two major types of asbestos-containing roofing materials used in the past and today; asbestos-cement roofing and siding shingles, and asphalt saturated asbestos roofing felts. The shingles were generally used in residential applications and the roofing felts on commercial and industrial buildings. The shingles normally contained 15-25% asbestos and the roofing felts 45-65% asbestos; chrysotile in both cases.

The length of roof service prior to replacement is highly dependent on the type of exposure. Built-up roofs generally have a life of 10 to 20 years. Domestic roofs frequently last longer than 20 years.

We have considerable fiber release data relative to the application and removal of asbestos felt built-up roofs and a limited amount of data collected during the rapid demolition of a house built with asbestos-cement roofing and siding shingles. These data, which are enclosed, were all collected and analyzed by the NIOSH/OSHA occupational monitoring procedure.

For your information the Navy Regional Medical Center at Bremerton, Washington (Puget Sound Navy Yard) did extensive testing to determine the airborne fiber levels generated during various operations involving asbestos-containing compressed gaskets, including during gasket removal and removal of residual material. The study is entitled,

"Asbestos Exposure from Gasket Operations" and was published in May 1978. The summary from the study report is enclosed.

Please contact me if these comments are insufficient for your purposes.

Very truly yours,

Edward M. Flower

EMF:jh
Encl.

FROM Johns Manville

AIRBORNE FIBER CONCENTRATIONS
ASBESTOS ROOFING FELT - INSTALLATION AND TEAR-OFF

Date	Location	Job Type	Monitoring Data Fibers/cc
3-14-74	Gilmore Jr. H.S. Racine, Wisconsin	New	0.2 to 0.6
4-10-74	Ben Davis H.S. Indianapolis	Tear-Off	0.1 to 0.4
5-21-74	Hess Dept. Store Allentown, PA	Tear-Off & New Roof	0.0 to 0.2
7-25-74	Tolletson Jr. H.S. Gary, Indiana	Tear-Off $ New Roof	0.1 to 0.3
11-20-74	Cherry Creek H.S. #2 Denver, Colorado	New	0.1 to 0.2
12-16-75	John-Madden Bldg.-Inverness Denver, Colorado	New	Less than 0.1
8-16-75	Anderson H.S. Anderson, Indiana	Tear-Off & New Roof	Less than 0.1
8-16-75	Chesterfield G.S. Chesterfield, Indiana	New	Less than 0.1
5-9-77	Johns-Manville Waukegan, IL	Tear-Off & New Roof	Less than 0.1 to 0.3