

Worker Exposure to Asbestos During Removal of Sprayed Material and Renovation Activity in Buildings Containing Sprayed Material

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Contents and types of asbestos in fireproofing insulation materials sprayed on ceilings of 127 buildings throughout the U.S. were studied. Asbestos was found to be present in more than 50% of the buildings and chrysotile was the main component identified. Frequency distribution of airborne fiber concentrations was lognormal. During renovation activities by various workers, including sheet-metal workers, carpenters and electricians, average fiber concentrations at workers' breathing zones were less than 2 fibers/cc, but exceeded 0.1 fibers/cc. During removal of sprayed materials, workers were exposed to extremely high concentrations (average 16.4 fibers/cc) when dry methods were used. When wet methods were used during removal, the airborne fiber concentrations were sharply reduced to less than 2 fibers/cc.

Introduction

In 1970, more than half of all multistory buildings constructed in the U.S. contained sprayed inorganic fibers as a fireproofing agent. The material usually contains 5 to 35% asbestos fibers, mineral wools, clay binders, adhesives, synthetic resins, and other proprietary agents such as oils.⁽¹⁾ In 1973, the U.S. Environmental Protection Agency (EPA)⁽²⁾ banned the spray application of fireproofing material containing more than 1% asbestos by weight because occupational hazards associated with inhalation of asbestos fibers had been well established. However, material already sprayed within the structures still remains a potential source of exposure to asbestos fibers. Complete removal of the sprayed material from the structures is a permanent control method for eliminating asbestos exposures. Workers are heavily exposed to asbestos when they remove sprayed fireproofing materials without using wetting agents. Workers such as carpenters, electricians and duct workers are also frequently exposed to airborne asbestos fibers when they perform renovation or maintenance within buildings containing sprayed fireproofing material. This paper presents the results of bulk

sample analyses and investigations of worker exposures to airborne asbestos during renovation activities and removal of sprayed material.

Scope and Methods

This study was conducted from February 18, 1980 to December 8, 1981 to determine worker exposures to airborne asbestos fibers during both renovation activity and removal of sprayed materials. Eleven multistory buildings located in various cities of the U.S. were investigated during renovation activities and three buildings were surveyed while the sprayed materials were being removed. Bulk samples were collected from sprayed fireproofing materials to identify the types of asbestos and to determine asbestos content in the materials. X-ray diffraction using a Norelco Type 120-102-20 X-ray diffractometer was employed for the analyses of bulk samples. Airborne asbestos fiber concentrations were measured at the workers' breathing zones using the method specified by both the Occupational Safety and Health Administration (OSHA)⁽³⁾ and the National Institute for Occupational Safety and Health (NIOSH).⁽⁴⁾ Samples were collected by drawing air at measured flow rates (nomi-

TABLE I
Type and Content of Asbestos in Fireproofing Material Sprayed in 11 Buildings Investigated

Building	Type of Asbestos Identified	Asbestos Content (% by Weight)
A (Illinois)	Chrysotile	4
B (Kansas)	Chrysotile	6
C (Wisconsin)	Amosite	2
D (Texas)	Chrysotile	4
E (Oklahoma)	Chrysotile	6
F (New York)	Chrysotile	2 - 15
G (Arizona)	Chrysotile	10 - 12
H (Georgia)	Chrysotile	8 - 9
I (Florida)	Chrysotile	6 - 8
J (Tennessee)	Chrysotile	8
K (New York)	Chrysotile	3

TABLE II
Results of Analysis of Bulk Samples from 127 Buildings in the U.S.

Results	Number of Buildings	Asbestos Content (%)
Amosite identified	2	2 - 6
Chrysotile identified	64	2 - 35
Both amosite and chrysotile identified	2	2 - 3 (amosite) 4 - 5 (chrysotile)
No asbestos found	59	--
Total	127	

TABLE III
Distribution of Airborne Asbestos Fiber Concentrations by Job Titles
During Renovation Activity in Office Buildings

Job Title	Number of Samples by Fiber Concentrations (Fibers/cc)									Total Number of Samples
	<0.05	0.05-0.10	0.11-0.20	0.21-0.30	0.31-0.40	0.41-0.50	0.51-1.0	1.1-2.0	>2.0	
Carpenter	21	25	22	9	8	7	7	1	5	105
Electrician	5	11	7	5	1	2	-	1	3	35
Sheet-metal worker	-	10	10	5	2	3	2	2	3	37
Painter	2	3	1	1	-	-	-	-	-	7
Total	28	49	40	20	11	12	9	4	11	184

TABLE IV
Distribution of Airborne Asbestos Fiber Concentrations by Removal Methods
During Removal of Sprayed Fireproofing Material in Office Buildings

Removal Method	Number of Samples by Fiber Concentrations (Fibers/cc)											Total Number of Samples
	<0.1	0.1-0.5	0.6-1.0	1.1-2.0	2.1-10.0	11.0-20.0	21.0-30.0	31.0-40.0	41.0-50.0	51.0-100.0	101.0-200.0	
Dry	1	3	3	4	20	14	11	4	6	10	3	79
Wet	1	7	5	1	1	-	-	-	-	-	-	15
Total	2	10	8	5	21	14	11	4	6	10	3	94

nal 2.0 Lpm) through open-face cassettes containing Millipore Type AA filters using battery-powered, portable pumps (Mine Safety Appliances Company, Model G). Each sample was analyzed for asbestos fibers using a phase-contrast microscope (Olympus Series BH-P-2).

Results

Table I presents the results of analyses of bulk samples taken from sprayed fireproofing materials in 11 buildings investigated. Ten of the 11 buildings contain 2 to 15% chrysotile in the sprayed ceilings and one building contains 2% amosite in the sprayed material.

Table II presents the results of analyses of 214 bulk samples collected from 127 office buildings throughout the U.S. from January 1978 to March 1982. Sixty-four buildings were sprayed with fireproofing materials consisting of 2 to 35% chrysotile, two buildings contained sprayed materials consisting of 2 to 6% amosite, and two buildings contained sprayed materials consisting of both amosite and chrysotile. No asbestos was found in the other 59 buildings. Tables III and IV and Figures 1 and 2 present detailed results of analyses of 278 personal samples collected during renovation and during removal of sprayed materials in the buildings listed in Table I. The airborne asbestos fiber concentrations during renovation are presented by job titles, and fiber concentrations during removal of sprayed materials are presented by the removal methods, i.e., dry and wet methods. The distribution of the results is presented in Figures 1 and 2.

Tables V and VI summarize the values of geometric mean (GM) and geometric standard deviations (GSD) during renovation and removal, respectively.

Discussion

Identification and Content of Asbestos in Sprayed Ceiling Material

As presented in Table I, 10 of 11 buildings investigated contain 2 to 15% chrysotile in the sprayed materials; one building contains 2% amosite. According to the American Conference of Governmental Industrial Hygienists (ACGIH),⁽⁵⁾ chrysotile constitutes 95% of all asbestos used in North America, with amosite and crocidolite making up the other 5%. This conforms with the results presented in Table II. Clayton Environmental Consultants, Inc. analyzed 214 bulk samples collected from 127 buildings throughout the U.S. from January 1978 to March 1982. Table II indicates that 68 (54%) of 127 buildings contained 2 to 35% asbestos of some form. The type of asbestos was identified as chrysotile in 94% of the 68 buildings, amosite in 3%, and both chrysotile and amosite were found in 3% of the buildings.

Distribution of Airborne Asbestos Fiber Concentrations

Various studies have pointed out that airborne concentrations of dust, benzene and radioactive particles are better described by a lognormal distribution⁽⁶⁻⁹⁾ than by a normal distribution. Limited information has been reported on the frequency distribution of airborne asbestos fiber concentrations. This study consists of a total of 278 samples which

were analyzed for airborne asbestos fiber concentrations during renovation in buildings and during removal of sprayed materials. Frequency distribution of the data was observed and is presented in Tables III and IV and Figures 1 and 2. The data were plotted on lognormal probability paper and showed straight lines. It is concluded that airborne asbestos fiber concentrations are lognormally distributed, and GM and GSD best represent the data. Geometric mean is the 50% probability value and GSD is calculated from the following formula.

$$\text{GSD} = \frac{84\% \text{ value}}{50\% \text{ value}}$$

Airborne Asbestos Fiber Concentrations During Renovation

Renovation and maintenance activities are performed frequently in buildings which contain sprayed fireproofing materials consisting of asbestos and other materials. The main activities are installation of partitions or walls, replacement of air ducts and electrical wires, painting walls, and installation of carpets. Carpenters, electricians, sheet-metal workers and painters carry out this work. Tables III and V show the frequency distribution and geometric means of fiber concentrations by job titles of employees. The average exposure levels were highest for sheet-metal workers — 0.19 fibers/cc, followed by carpenters and electricians — both 0.13 fibers/cc, and lowest in painters — 0.08 fibers/cc. Generally, the sheet-metal workers disturbed the sprayed mate-

rials more extensively (when they replaced ventilation systems) than did other workers. Painters did not directly disturb the sprayed ceilings. Eleven of 184 samples indicated fiber concentrations exceeding 2 fibers/cc, the OSHA 8-hour, time-weighted average (TWA) permissible exposure limit (PEL).⁽⁹⁾ All workers except painters were exposed to average fiber concentrations exceeding the NIOSH-recommended standard of 0.1 fibers/cc for an 8-hour period.⁽¹⁰⁾ ACGIH⁽¹¹⁾ adopted 8-hour, TWA threshold limit values (TLVs[®]) by the type of asbestos as follows:

- 0.5 fibers/cc - amosite
- 2.0 fibers/cc - chrysotile
- 0.2 fibers/cc - crocidolite
- 2.0 fibers/cc - other forms

ACGIH also lists all types of asbestos in a category of A, proven human carcinogens.

In summary, workers, especially sheet-metal workers, carpenters and electricians, were exposed to average airborne fiber concentrations exceeding 0.1 fibers/cc, but below both the OSHA PEL of 2 fibers/cc and ACGIH TLVs for chrysotile and amosite.

Airborne Fiber Concentrations During Removal of Sprayed Material

OSHA requires use of wet methods when practicable during removal of asbestos ceiling insulation. This study was con-

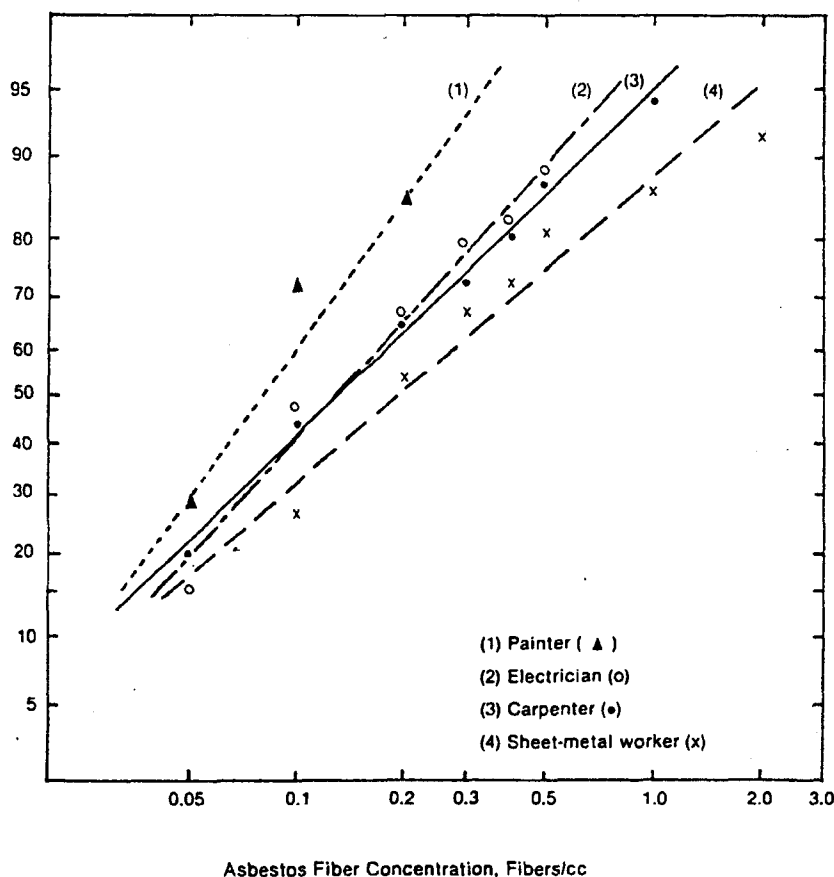


Figure 1 — Asbestos fiber concentrations during renovation activities.

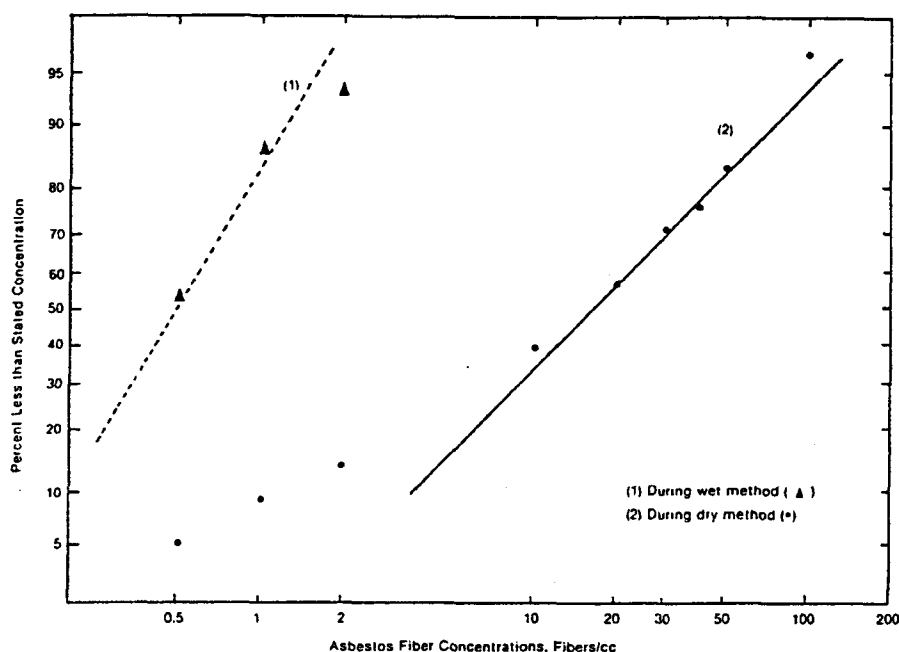


Figure 2 — Asbestos fiber concentrations during removal of sprayed fireproofing materials.

ducted during sprayed ceiling material removal using both dry methods and wet methods. Workers removed sprayed ceiling materials using dry methods on the seventh floor of a seven-story building (Building C). Wet methods were not used because electrical equipment such as air handling machines and elevator controls was located on the seventh floor of the building. Removals using wet methods were performed in other buildings. During removal using dry methods, short-term air samplings were conducted for a period from 30 minutes to 60 minutes to prevent particulate overloading of filter samples. As presented in Tables IV and VI, and Figure 2, mean airborne fiber concentrations were sharply reduced from 16.4 fibers/cc to 0.5 fibers/cc by employing wet methods. Three of 79 samples showed fiber concentrations exceeding 100 fibers/cc during dry removal. Sawyer⁽¹²⁾ reported average airborne fiber concentrations of 82.2 and 8.1 fibers/cc during removal of asbestos ceilings using dry and wet methods, respectively. Sawyer used arithmetic means instead of geometric means. There were eleven samples for dry removal in his paper.

In summary, 86% of samples taken during removal of sprayed materials using dry methods indicated fiber concen-

trations exceeding the OSHA PEL of 2 fibers/cc. The concentrations sharply decreased to levels below the OSHA PEL when wet methods were used.

Conclusions

Based on the results of analyses of bulk samples collected from fireproofing materials sprayed on ceilings of buildings throughout the U.S., and the results of sampling and analyses of personal samples taken during renovation work in the buildings containing asbestos and during removal of sprayed materials, it is concluded that:

- (1) Fifty-four percent of the 127 buildings surveyed contain 2 to 35% asbestos in the sprayed materials. The asbestos was identified as chrysotile in 94% of the buildings and as amosite in 3%. Both chrysotile and amosite were identified in 3% of the buildings.
- (2) The frequency of airborne asbestos fiber concentrations was distributed lognormally. Therefore, geometric means and geometric standard deviations best represent the data.
- (3) During renovation activities in the buildings containing asbestos, workers, such as sheet-metal workers,

TABLE V
GM and GSD of Data
Taken During Renovation Activity

Job Title	GM Fibers/cc	84th Percentile Fibers/cc	GSD
Carpenter	0.13	0.45	3.46
Electrician	0.13	0.42	3.23
Sheet-metal worker	0.19	0.77	4.05
Painter	0.08	0.19	2.38

TABLE VI
GM and GSD of Data
Obtained During Removal of Fireproofing
Material by Removal Methods

Removal Method	GM Fibers/cc	84th Percentile Fibers/cc	GSD
Dry	16.4	51.8	3.16
Wet	0.5	1.0	2.0

carpenters, and electricians, were exposed to average airborne fiber concentrations exceeding 0.1 fibers/cc, but below the OSHA PEL of 2 fibers/cc.

- (4) During removal of sprayed materials containing asbestos, workers were exposed to extremely high fiber concentrations when dry methods were used. The fiber concentrations sharply decreased to levels below the OSHA PEL when wet methods were used.

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