Bell Laboratories

subject: Evaluation of Employee Asbestos Exposure During Brake Work Operations
Case 48106-3

date February 8, 1978

from V. R. Cohen
R. Deitchman

MEMORANDUM FOR RECORD

INTRODUCTION

The hazard of exposure to airborne asbestos during the changing of brake linings and clutches has been recognized for several years. (Hickish and Knight, 1970; Hatch, 1970). Mizutani et al. (1973) have reported that chrysotile in brake materials displays structural strain and substructure fragmentation caused by shear during braking processes. Material fatigue results from this shear strain and along with binder pyrolysis can produce disintegration of brake linings liberating chrysotile asbestos fibers. (Rohl et al, 1976).

The presence of chrysotile in brake drum dust has been demonstrated by X-ray diffraction, transmission electron microscopy, selected area electron diffraction and electron microprobe analysis (Rohl et al, 1976). In these studies the percentage of chrysotile by weight ranged from 2-15% with an average ranging from 3 to 6%. Other components identified in brake drum dust included lead compounds, quartz, calcite, mica, clays, barite, graphite and alpha-iron particles.

The three major constituents of brake linings are binders, fiber reinforcers and property modifiers. The binders are primarily phenolic-type resins noted for high binding efficiency and ability to withstand pyrolytic breakdown. The modifiers cover a wide range of materials and are used for a number of purposes. They are used as lubricants to reduce the coefficient of friction along the brake surface (lead compounds) and as agents to increase the coefficient of friction and enhance the action of the brake shoe (brass chips). Modifiers are also used as internal abrasives to help recondition braking surfaces and remove deposited decomposition products (e.g. rottenstone, quartz). Chrysotile asbestos is the major fiber reinforcement material and comprises from 40 to 50 percent of the brake.

In the past, methods of cleaning out brake drums have included blowing with compressed air, dry brushing and impacting the drums against the floor. These methods have been associated with high airborne asbestos fiber exposures. Peak exposure levels reported by the National Institute for Occupational Safety and Health (NIOSH, 1975)during the blowout of automobile drum brake assemblies, beveling of new truck brake linings and the grinding of used truck linings gave peak exposure results of 10.5, 37.3 and 3.75 fibers per cubic centimeter.

To reduce the hazard of asbestos fiber inhalation by garage workers in the Bell System, two industrial vacuums were purchased*. Studies were performed at Bell Laboratories and three operating company garages to determine employee exposure to asbestos during brake work operations.

DESCRIPTION

The industrial vacuum cleaner is modified to support a high efficiency particulate air (HEPA) filter. Caution and warning labels are attached to the vacuum cleaner alerting the operator to precautions to be taken when working with asbestos. The vacuum cleaner is mounted on a three wheel platform to make it portable. The vacuum cleaner hose has standard domestic shape attachments.

SUMMARY AND RECOMMENDATIONS

Employee asbestos exposure was evaluated during brake work operations using a vacuum cleaner. Two operating telephone companies were chosen for field trials. Employees at Michigan Bell were sampled twice, first a month after the vacuum was received and three months later. Chesapeake and Potomac Telephone Company employees were sampled two months after initial use of the vacuum cleaner. Results from these studies showed all personal exposure levels to range from below detectable limits (less than 0.01 fibers per cubic centimeter) to 0.09 fibers per cubic centimeter. The present Occupational Safety and Health Administration (OSHA) Standard for asbestos exposure is 2 fibers per cubic centimeter on a time weighted average. However, a new National Institute for Occupational Health Criteria Document calls for an asbestos standard of 0.1 fibers per cubic centimeter on a time weighted basis. Samples were analyzed by either phase contrast microscopy, scanning electron microscopy, or transmission electron microscopy.

One garage environmental sample indicated a number of small asbestos fibers appearing to be Forsterite, the decomposition product of chrysotile asbestos brakes. The health hazard of these small fibers is unclear.

* Tempo Vacuum Cleaners, Model AB-7515

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Respirator use is not necessary when performing brake cleaning work with the vacuum cleaner. A single use respirator is supplied for use during vacuum filter changing. The respirator is then disposed of in a properly sealed bag.

The following are recommended:

1. At the present time NIOSH is funding a study to evaluate asbestos vacuum cleaners for brake work. The study is under contract to Texas A&M University and results should be available by late 1978. NIOSH may at some time consider certifying vacuums cleaners for use in garages. This Texas A&M Study will include an evaluation of the vacuums cleaners in terms of collection efficiency of asbestos fibers. The Bell System Study only involved evaluation of the brake work operations, not the vacuum cleaner alone. The results of this NIOSH Study should be incorporated into Bell System vehicle maintenance operations.

2. Another alternative method to clean brake assemblies is use of a solvent with a collection unit. These units are less expensive than vacuum cleaner systems but have not been evaluated in terms of Bell System employee exposure. A solvent unit should be evaluated in an operating telephone company garage.

3. In order to function properly the vacuum cleaner requires some changes including new vacuum hose attachments. Formulation of information and documentation outlining procedures for brake work with the vacuum cleaner is necessary. In conjunction with the vacuum cleaner, a brake assembly cleaner (such as those manufactured by Per-Lux or Brake-Vac) may be necessary to sufficiently clean the brake assemblies. The brake assembly cleaner fits snugly over the wheel and uses compressed air to clean the brake assemblies. An evaluation from a vehicle maintainence and industrial hygiene view is necessary with these systems.

4. To comply with OSHA requirements, medical and environmental monitoring may still be necessary for employees exposed to asbestos fibers during brake work operations. Employees monitored in this study should be informed of their air sampling results.

METHODS

The asbestos samples were collected using the procedures outlined both by the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA). The procedure involves collection of the airborne fibers on a small filter, with later analysis using phase contrast or electron microscopy.

The filters used for collection of the samples were either 37mm Millipore cellulose ester filters or 37mm Nuclepore polycarbonate filters. Both filter types have nominal pore diameters of 0.8 micrometers (μm) and were used open faced.

Air was pulled through the filters using battery powered sampling pumps manufactured by Bendix and MSA at 2.0 liters per minute. The pumps were calibrated using the soap bubble flowmeter technique. An Anderson high volume pump was used to collect peak airborne samples during the actual vacuuming of the brake drums. The flow rate was 25.5 liters per minute.

A variety of analysis techniques have been used to identify asbestos fibers and determine their concentrations in air. These include optical microscopy, electron microscopy, and X-ray diffraction analysis. Asbestos fiber identification and quantitation in occupational and environmental air samples is difficult for a variety of reasons:

1. Asbestos fibers are generally present in low mass quantitites even though fiber number concentrations may be high.

2. Many instrumental analytical techniques cannot differentiate asbestos fibers from their nonfibrous mineralogic polymorphs. This is the case with light microscopy and thus, electron microscopic methods are necessary to be certain fibers are truly asbestos.

3. Many airborne asbestos fibers are generally below resolution limits of the optical microscope (phase contrast). These fibers may only be detected by using electron microscopic methods.

4. For identification of the various asbestos fiber types by electron microscopy, electron diffraction and microchemical analyses must be performed which require extensive instrumentation and analysis time.

The cellulose filters in this study were analyzed using phase contrast microscopy while analysis of the polycarbonate filters was performed using electron microscopy.

Light microscopy was completed by Ms. V. R. Cohen and Mr. C. P. Lichtenwalner of the Bell Laboratories Environmental Health and Safety Department. The light microscope uses phase contrast to identify fibers greater than 5 um in length and a greater than 3:1 aspect ratio.

Both transmission and scanning electron microscopy were used for asbestos fiber identification and quantitation. In addition to morphologic observation, selected area electron diffraction and energy dispersive X-ray analysis were used. Transmission electron microscopy will yield higher resolution than scanning electron microscopy, however, scanning will cover a larger optical field for analysis.

Transmission electron microscopy was performed by McCrone Associates, Inc., Chicago, Illinois. EMV Associates in Rockville, Maryland performed the scanning electron microscopy.

In order to test the performance of the filtration system, a modification of standard procedures for evaluating the performance of high efficiency particle filters and clean rooms was attempted. An aerosol generator capable of producing 0.3μm diameter mean particle size dioctyl phthalate was used to produce an aerosol for detection with a Virtis Particle Counter. Unfortunately, it was not possible to test the efficiency of the filtration system because of the high background particle concentration and the geometry of the vacuum system. A relatively elaborate test fixture and environmental chamber would be required to test the efficiency of the filtration system. This work was performed by Mr. C. P. Lichtenwalner and Mr. R. Deitchman of the Bell System Services Group.

RESULTS

Table I shows the results of air sampling for asbestos at the Livonia, Michigan garage of Michigan Bell on August 30, 1977 by Mr. R. Deitchman of the Bell System Services Group. This was the first attempt at field sampling of asbestos exposure of employees while using the vacuum cleaner during brake work. All samples were analyzed by transmission electron microscopy and all results were below detectable limits. The area sample in the garage, however, revealed an extremely large number of fine, single fibril, fibers which appear to be Forsterite, the decomposition product of chrysotile asbestos on extreme heating which might originate as brakes are applied. These fibers were in general less than 0.5 um with the size distribution between 0.1-1.0 μm.

Sampling during brake work using the second vacuum cleaner was completed on October 31, 1977 at a C & P Telephone Company

Garage in Washington, D. C. by Ms. V. R. Cohen and Mr. W. J. Schreibeis of the Bell System Services Group. Results are shown in Table II. A high volume Anderson pump was used to collect peak samples to gain greater accuracy and lower detectable limits. Samples were analyzed by light microscopy and transmission electron microscopy.

On November 14, 1977 additional sampling was completed by Mr. W. J. Schreibeis and Mr. R. Deitchman of the Bell System Services Group on the first vacuum cleaner which had been moved to the Romulus Garage of Michigan Bell. This sampling was to check employee exposure to asbestos during brake work after the vacuum cleaner had been in field use for three months. Samples were analyzed by scanning electron microscopy (SEM) and light microscopy. The SEM results from samples taken at the vacuum exhaust, using the Anderson high volume pump for collection, are all below the lower detectable limit. The long term, high volume samples of the background asbestos level analyzed by SEM shows one chrysotile fiber for a concentration of 0.0005 fibers per cubic centimeter. Light microscopy results of asbestos exposure showed levels ranging from 0.02-0.06 fibers per cubic centimeter.

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Table I

Asbestos Samples Collected in a Michigan Bell Garage, Livonia, Michigan

August 30, 1977

Description	Duration (minutes)	Volume (liters)	Lower Limit of Detection (fibers/cc)	Number of Fibers Detected	Concentration (fibers/cc)	Analytical Method
Area Sample in Garage	47	94	0.014	0	BDL	TEM
Personal Sample - Joe Kmet performing inspection of Ford van brakes and using vacuum cleaner and Perlux compressed air wheel cone for cleaning	6	12	0.116	0	BDL	TEM
Sample on vacuum cleaner exhaust during cleaning of brake drums	5	10	0.139	0	BDL	TEM
Personal Sample - Joe Kmet performing inspection of Dodge van brakes and using vacuum cleaner and Perlux compressed air wheel cone for cleaning	9	18	0.077	0	BDL	TEM
Sample on vacuum cleaner exhaust during cleaning of brake drums	9	18	0.077	0	BDL	TEM

BDL = Below Detection Limit

TEM = Transmission Electron Microscopy

Table II

Asbestos Samples Collected in C. & P. Co. Garage 1120 First Street, NE, Washington, D.C.,

October 31, 1977

Description	Duration (minutes)	Volume (liters)	Lower Limit of Detection (fibers/cc)	Number of Fibers Detected	Concentration (fibers/cc)	Analytical Method
Changing Brakes (4) on van (Dodge '69) using vacuum cleaner during initial part of sampling. Personal Sample-Leroy Dove. Wears Willson Respirator TC-21C-14[illegible]	87	156	.003	11	0.03	LM
Changing brakes (4) on van 1, ([illegible] '75) using vacuum cleaner, during initial part of sampling. Personal Sample-Harry Kraft. Wears Willson Respirator T[illegible]-21C-14[illegible]	81	162	.002	20	0.05	LM
General room air sample at [illegible] between vans	84	168	.002	23	0.05	LM
Sample at vacuum cleaner exhaust between 2 vans while vacuuming drums	8	204	.001	13	0.02	LM
Personal Sample-Harry Kraft inspecting front disc brakes on [illegible] Part Sedan wearing Willson Respirator. Did not use vacuum cleaner	16	32	.011	8	0.09	LM
General room air sample in office adjacent to work area. Source of heated air from work area.	124	235	.002	23	0.04	LM
Sample at vacuum cleaner exhaust between 2 vans while vacuuming	6	153	.021	0	BDL	TEM

BDL = Below Detection Limit
LM = Light Microscopy
TEM = Transmission Electron Microscopy

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Table III

Asbestos Samples Collected in a Michigan Bell Garage, Romulus, Michigan

November 14, 1977

Description	Duration (minutes)	Volume (liters)	Lower Limit of Detection (fibers/cc)	Number of Fibers Detected	Concentration (fibers/cc)	Analytical Method
Background Samples on Work bench in garage before brake work	152	3993	0.0005	1	0.0005	SEM
	152	304	0.001	8	0.01	LM
Personal Samples while performing brake change and cleaning of Ford van (8826FR) using vacuum cleaner						
Joe Kmet	61	122	0.003	8	0.02	LM
Whitey Kmet	62	124	0.003	9	0.03	LM
Samples on vacuum cleaner exhaust during cleaning of brake drums	6	154	0.013	0	BDL	SEM
	5	128	0.015	0	BDL	SEM
Background sample on work bench in garage during brake work	91	182	0.002	7	0.01	LM
Personal samples while performing brake change and cleaning of Ford van (8826FR) using vacuum cleaner						
Joe Kmet	25	50	0.007	8	0.06	LM
Whitey Kmet	26	52	0.007	9	0.06	LM
Sample on vacuum cleaner exhaust during cleaning of brake drums	7	179	0.011	0	BDL	SEM
Sample on vacuum cleaner during cleaning of brake drums using Perlux compressed air wheel cone	3	76	0.026	0	BDL	SEM
Background sample in enclosed garage office during brake work	45	90	0.004	10	0.04	LM

BDL = Below Detection Limit
SEM = Scanning Electron Microscopy
LM = Light Microscopy (phase contrast)

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Personal Sample - employee breathing zone area during actual spray operations with Ammco Brake Washer System	13	31	0.28	LM
	13	31	BDL (0.01)	SEM
8 Hour Time Weighted Average Exposure for Rick Malinowski	480		0.06	LM
OSHA Standard	480		2.00	LM

* LM = Light Microscopy
SEM = Scanning Electron Microscopy
BDL = Below Detection Limit (Lower Limit of Detection)