Industrial Hygiene Report
Asbestos

Allied Brake Shop
Cincinnati, Ohio

SURVEY CONDUCTED BY:
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DATE OF SURVEY:
February 26, 1979

REPORT WRITTEN BY:
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DATE OF REPORT:
June 30, 1980

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Industry-wide Studies Branch
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National Institute for Occupational Safety and Health
Cincinnati, Ohio

PURPOSE OF SURVEY:	To characterize dust exposures resulting from vehicle brake maintenance and repair operations while taking into account work practices utilized. This survey is part of the study to evaluate health effects of exposure to asbestos containing dusts in brakelining maintenance and repair.
EMPLOYER REPRESENTATIVE CONTACTED:	Alvin White Service Manager (513) 241-1410
EMPLOYEE REPRESENTATIVE CONTACTED:	No union
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	7539

Mention of a manufacturer's name does not constitute a NIOSH endorsement.

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is required under Section 20(a)7 of the Occupational Safety and Health Act of 1970 to conduct and publish industry-wide studies of the effect of chronic or low level exposure to industrial materials, processes, and stresses on the potential for illness, disease, or loss of functional capacity in aging adults.[1]

An estimated workforce of 900,000 brake mechanics and garage workers in the U.S. are potentially exposed to asbestos.[2] Therefore, NIOSH is currently conducting an industry-wide study to evaluate dust exposures resulting from brake servicing operations.

As part of this study a contract has been let to conduct (1) a feasibility study in locating a cohort of brakelining repair and maintenance workers with sufficient latency to conduct a retrospective mortality study, and (2) a cross-sectional medical study to define the current health status of workers occupationally exposed to brakelining dusts. To supplement the cross-sectional medical study, NIOSH is undertaking industrial hygiene assessments at a number of brakelining facilities.

DESCRIPTION OF FACILITY

The Allied Brake Shop is operated primarily as a commercial auto brake system maintenance and repair business, but also performs front end alignment and shock absorber replacement. The shop is located in the central business district of Cincinnati, Ohio, in a one story building with approximately 4,000 square feet of shop area. The shop has been located at this site since the business was started in 1959.

DESCRIPTION OF WORKFORCE

There are five full-time male mechanics employed at the shop that work from four service stalls 8:00am to 6:00pm six days per week and perform from 35 to 45 total brake maintenance operations per week. There is no union representation.

DESCRIPTION OF PROCESS

The brake servicing procedure was basically the same for all vehicles and consisted of the following steps. The vehicle is driven into a repair stall and one end is elevated with a hydraulic jack. The brake drums are removed and placed on the floor with the brake wear dust allowed to fall on the floor. The brakes are inspected to determine if replace-

ment or repair is required. If no repairs are needed the brake drums are replaced and the brakes are adjusted. If repairs are needed the worn brake shoe assembly is dismantled and the backing plate is cleaned using compressed air/Stoddard solvent mixture during the winter months but compressed air only during the summer. If necessary the brake drum linings are turned down on the lathe specialized for this purpose. Prelined brake shoes are then installed with any other new replacement parts required and the brakes are adjusted. This procedure is repeated on all wheels after which all brake lines are bled to purge the air and the brake fluid level is topped-off in the master cylinder. The final phase of servicing is completed with test driving and final adjustments.

On the average the servicing requires about twenty minutes per wheel with 90 minutes to complete a four wheel job. The compressed air blow off of backing plates takes about forty-five seconds per wheel at about 40 PSI. The drums are not blown out with compressed air.

DESCRIPTION OF PAST EXPOSURES

Until about two years ago grinding and beveling of brake shoe linings was performed for contour fitting of brake shoes. This operation had the potential for generating airborne asbestos dust. Some grinding is still used but it is rare and of short duration. The increased presence of disc brakes on newer cars could possibly result in a lower overall exposure today to asbestos dust because there is less friction contact surface area with disc pads and the rotor and disc assembly does not trap as much dust as the drum and shoe assembly.

DESCRIPTION OF MEDICAL, INDUSTRIAL HYGIENE AND SAFETY PROGRAMS

Respiratory protection was available but was not worn. Safety glasses and gloves are available upon request. No employee is trained in first aid and there are no eating or smoking restrictions.

INSPECTION OF THE SHOP

The general housekeeping in the shop was good. There did appear to be a potential exposure to brake dust during hand floor sweeping since the brake dust present on the floor from brake drums could become airborne during this operation. This could also occur during the compressed air blow off of the backing plates.

Personal and general air samples were collected. Brake repair operations were monitored to provide asbestos exposure data. Personal air samples were collected in the breathing zone of the brake mechanics and other shop personnel using Millipore type AA, 37mm diameter, 0.8 µm pore size, membrane filters and MSA Model G pumps at a sampling flow rate of 2.0 liters per minute (lpm). The filters were changed periodically during the work shift to prevent overloading of the sampling media. Peak samples were also collected using 25mm diameter Millipore type AA membrane filters of 0.8 µm pore size at 4.0 lpm using Dupont P-4000 sampling pumps when workers were blowing dust from backing plates and assemblies. General area Hi-volume samples were collected on Wattman 81 mm 0.8 µm membrane filters with Staplex high-volume air samplers at a sampling rate of 10 to 15 cubic feet of air per minute for trace metal analysis. Analysis of the membrane filters for asbestos fibers was conducted in accordance with the procedures outlined by the Occupational Safety and Health Administration[3] and the NIOSH P&CAM No. 239.[4] These procedures entail the counting of fibers greater than 5 micrometers (µm) in length and with at least a 3 to 1 length to width (aspect) ratio using phase contrast optical microscopy at a magnification of 400-450X.

Fiber Characterization

Personal and area samples collected at the shop were analyzed on a transmission electron microscope (TEM) utilizing selected area electron diffraction (SAED) and an energy dispersive X-ray analyzer. Sample preparation and analysis were performed using the NIOSH methods described in the Technical Report, "Review and Evaluation of Analytical Methods for Environmental Studies of Fibrous Particulate Exposure".[5] Samples were observed at 17,000X magnification with fibers (>3:1 aspect ratio) sized by length and diameter. SAED was attempted on all observed fibers for possible identification. In addition, energy dispersive X-ray analysis was performed on individual fibers to determine their elemental composition. Forty-five percent of the fibers analyzed by SAED could not be identified due to ambiguous diffraction patterns. The remaining fibers were identified as chrysotile. Those fibers which revealed ambiguous SAED patterns were either too small for diffraction analysis or had undergone elemental metamorphosis probably as a result of the intense heat generated during braking. The elemental composition of many of these fibers appeared to indicate a stage of metamorphosis between chrysotile and forsterite.

Also, the fiber concentration (fibers/cc) of each sample was determined by TEM for fibers >5 µm in length and for total fibers observed. These concentrations were compared to those found by the optical microscopy method and are reported in Table 3. In 7 of 11 samples fiber concentrations (>5 µm) determined by phase contrast optical microscopy were

somewhat higher than those determined by TEM. This difference could have been caused by particulate loss during sample preparation for TEM and by the fact that there were small numbers of fibers observed on each sample and therefore a small difference in the number of fibers counted by both methods would produce significant differences in concentrations. However, the greatest number of fibers observed by TEM were shorter than 5 µm in length (83%).

Metal Analysis

Hi-volume airborne samples collected at the shop area were analyzed for trace metals by atomic absorption spectrophotometry in accordance with the NIOSH Manual of Analytical Methods, Volumes 1 and 3.[4,6] Samples were analyzed for trace amounts of the following metals: lead, iron, zinc, chromium, copper, and manganese. As shown in Table 2 all of the metals were found in concentrations well below the OSHA standards or the NIOSH recommended standards.

RESULTS

Fibrous dust concentrations (fibers >5 µm in length) found on the day of the survey are reported in Table 1. The time-weighted average (TWA) concentrations for the two mechanics sampled were 0.04 and 0.006 fibers/cc. General area airborne samples indicated a range of concentration from 0.001 to 0.02 fibers/cc in the brake service area. Two peak samples collected during the compressed air/Stoddard solvent mist blow-off of brake assemblies had concentrations of 0.25 and 0.37 fibers/cc.

DISCUSSION

The airborne asbestos sample results for the facility are within the current OSHA asbestos standard. This standard states:

> "The 8-hour time-weighted average (TWA) airborne concentration of asbestos fibers to which any employee may be exposed shall not exceed 2 fibers, longer than 5 micrometers in length per cubic centimeter of air (fibers >5 µm/cc). The ceiling airborne concentration to which no employee may be exposed shall not exceed 10 fibers >5 µm/cc."

The results are also within the NIOSH recommended standard, in which the 8-hour TWA exposure to asbestos allowed is 0.1 fibers >5 µm/cc with a ceiling exposure of 0.5 fibers >5 µm/cc for any 15-minute

sampling period. However, it is readily apparent that the compressed air solvent mist blow-off produces peak exposures that are higher than those for the other stages of brake servicing.

CONCLUSION

Results of this study and of other studies indicate varying concentrations of asbestos fiber exposures which appear to be dependent upon the types of brake servicing operations and work practices utilized. It is apparent that when brake shoes are beveled, ground, riveted, etc., that exposures to asbestos fibers can be quite high. Likewise, exposures generated during the cleaning of brake shoes and drums with compressed air and dry brush methods can be high for short durations of time.

NIOSH has undertaken a comprehensive industrial hygiene study to address the following areas:

1. Document work practices (e.g. protective clothing, respirator protection, eating and smoking practices, etc.)
2. Document the use of engineering controls (e.g. vacuum cleaners, local exhaust ventilation, etc.)
3. Document housekeeping practices (e.g. disposing of old brake and clutch materials, rags, etc.)
4. Determine 8-10 hour TWA exposures and peak exposures to workers as determined by the different work practices (e.g. compressed air, dry and wet brushing, etc.) utilized while engaged in brake servicing operations.
5. Characterize and identify airborne fiber exposures using optical and transmission electron microscopy.

Based on the data from other studies and the data from this study demonstrating significant asbestos exposures during brake servicing operations, NIOSH has published interim procedures, "Recommended Procedures for Asbestos Brake and Clutch Servicing" to minimize asbestos dust exposures (see Attachment). These recommended procedures are periodically updated as research data and engineering controls become available.

REFERENCES

1. Williams-Steiger. Occupational Safety and Health Act of 1970, Public Law 91-596, 91st Congress, S.2193, December 29, 1970.

2. Rohl, A.N., Langer, A.M., Wolfe, M.S., and Weisman, I. "Asbestos Exposure During Brake Lining Maintenance and Repair."

3. U.S. Code of Federal Regulations, Title 29, Part 1910.1001. U.S. Department of Labor, Occupational Safety and Health Administration, Occupational Safety and Health Standards.

4. Taylor, D.G., (1977). NIOSH Manual of Analytical Methods. 2nd Edition, Volume 1, P&CAM 239, Publication No. 77-157-A.

5. Zumwalde, R.D., and Dement, J.M., (1977). Review and Evaluation of Analytical Methods for Environmental Studies of Fibrous Particulate Exposures. DHEW (NIOSH) Publication No. 77-204.

6. Taylor, D.G., (1977). NIOSH Manual of Analytical Methods. 2nd Edition, Volume III, Publication No. 77-157.

Table 1

Allied Brake Shop
Fiber Air Sample Results
Optical Microscopy

Operation	Sample Number	Sample Volume (liters)	Sampling Time (min)	Concentration of Sample in fibers > 5 μm/cc
Brake Service				
(Mechanic I)				
Servicing front disc brakes only	AL-1	144	77	0.060
Servicing 4-wheel disc brakes	AL-3	478	239	0.030
Servicing front disc brakes only	AL-5	108	54	0.070
				Mechanic I TWA*=0.040
(Mechanic II)				
Complete service of front disc brakes and rear shoes	AL-2	224	162	0.002
Complete service of front disc brakes and rear shoes	AL-4	420	210	0.010
				Mechanic II TWA*=0.006
Peak Samples				
Compressed air/solvent blow-off of rear brake shoes	ALP-1	4	1	0.250
Compressed air/solvent blow-off of rear brake shoes	ALP-2	12	3	0.370
General Area				
Inside Office	GAL-1	874	437	0.020
Six feet outside work bay	GAL-2	866	433	0.001
Six feet outside work bay	GAL-3	866	433	0.004
Seven feet outside work bay	GAL-4	858	429	0.001

* TWA = Time-weighted average exposure for period of time sampled.

Table 2

Allied Brake Shop
Air Sample Results
Trace Metal Analysis

Sample Number	Sample Volume (cubic meters, m^3)	Sample Location	Trace Metal Concentration $\mu g/m^3$					
			Pb	Zn	Cu	Fe	Mn	Cr
ALHV-1	89.0	Brake Service Area	4.04	0.74	0.27	18.00	0.21	0.11
ALHV-2	125.7	General Shop Area	1.27	2.07	0.17	12.72	0.18	0.07

Limit of Detection (µg/sample)		OSHA Standard ($\mu g/m^3$)			NIOSH Recommended Standard ($\mu g/m^3$)	
Lead	4	Lead	50	(TWA)	100	(TWA)
Zinc	5	Zinc oxide fume	5,000	(TWA)	5000	(TWA)
Copper	2	Copper dust	1,000	(TWA)	None	
Iron	4	Iron oxide fume	10,000	(TWA)	None	
Manganese	2	Manganese	5,000	(ceiling)	None	
Chromium	3	Chromium metal	1,000	(TWA)	None	

Table 3

Fiber Air Sample Results
Comparison Between TEM and
Optical Microscopy Analysis

Sample Number	Optical Microscopy	Transmission Electron Microscopy		% Fibers
	> 5 μm in length fibers/cc	> 5 μm in length fibers/cc	Total fibers fibers/cc	> 5 μm in length (TEM)
AL-1	0.060	0.0	0.0	0
AL-3	0.030	0.05	0.34	15
AL-5	0.070	0.00	0.12	0
AL-2	0.002	0.00	0.20	0
AL-4	0.010	0.095	0.95	10
ALP-1	0.250	6.84	10.94	63
ALP-2	0.370	0.0	1.36	0
GAL-1	0.020	0.0	0.02	0
GAL-2	0.001	0.07	0.22	35
GAL-3	0.004	0.0	0.0	0
GAL-4	0.001	0.0	0.20	0

ATTACHMENT 1

RECOMMENDED (INTERIM) PROCEDURES
FOR ASBESTOS BRAKE AND CLUTCH SERVICING
AS OF NOVEMBER 1978

The National Institute for Occupational Safety and Health (NIOSH) has research underway concerning dust exposures during brake and clutch servicing. Due to preliminary data demonstrating significant asbestos exposures during presently used brake and clutch servicing techniques, NIOSH has reviewed alternate techniques whereby asbestos exposures are reduced. It should be mentioned that vacuum cleaner testing and efficiency data at this time are not available. However, when this research is completed this data will be included in the recommendations as applicable. The following are interim procedures by NIOSH to minimize asbestos dust exposures.

1. Where possible, an area should be designated and constructed for brake and clutch repairs and servicing. Entrances into this area shall be posted with the following asbestos exposure warning sign printed in letters of sufficient size and contrast to be readily visible and legible:

Asbestos
Dust Hazard
Avoid Breathing Dust
Wear Assigned Protective Equipment
Do Not Remain in Area Unless Your Work Requires It
Breathing Asbestos Dust May Cause Asbestosis and Cancer

2. Dust shall first be cleaned from brake drums, brake backing plates, brake assemblies, and clutch assemblies using an industrial type vacuum cleaner equipped with a high efficiency filter system (> 99% efficiency of 0.3 μm diameter aerosols). After vacuum cleaning, any remaining dust shall be removed using a water dampened cloth or rag. Under no circumstances shall compressed air or dry brushing be used for cleaning. Where wet brushing is necessary for cleaning an approved respiator shall be worn.

3. During brake pad grinding, riveting, and punching operations local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2 - 1977 to meet the asbestos airborne exposure standard.

4. During brake replacement and maintenance when engineering controls are not feasible or work practices are not effective in limiting exposures an air purifying respirator, either single use or with replaceable particulate filter(s), as approved by NIOSH, shall be worn during all procedures starting with the removal of the wheel and including reassembly. During manual clutch servicing, such a respirator shall be worn during the removal and cleaning of the clutch, pressure plate and housing assembly and during installation of the new clutch assembly. If needed a respirator program shall be established in accordance with the requirements of the American National Standards Practices for Respiratory Protection, ANSI Z88.2 - 1969.

5. All table and floor cleaning in areas where brakes and clutches are repaired shall be done with the high efficiency industrial vacuum cleaner as described in (2) above. Grinding and riveting machines shall also be cleaned with such a vacuum cleaner and the remaining dust wiped with a water dampened cloth. An approved respirator shall be used during this cleaning.

6. Industrial vacuum cleaner bags containing asbestos dust and cloths used for wiping brake and clutch assemblies shall be disposed of in sealed impermeable bags or other containers and labeled with the following warning label printed in letters of sufficient size and contrast to be readily visible and legible:

CAUTION
Contains Asbestos Fibers
Avoid Breathing Dust
Breathing Asbestos Dust May Cause Serious Bodily Harm

An approved respirator shall be worn during removal of vacuum bags.

7. Consumption of food and beverages shall not be permitted in work areas. The area designed or designated for food consumption shall be separate from work area so as to provide minimal protection against asbestos dust contamination.

8. If the employee is exposed to airborne concentrations of asbestos fibers which exceed the ceiling level the OSHA requirement regarding special clothing, change rooms, lockers, etc. (29 CFR 1910,1001(d)) shall be followed.

The current OSHA asbestos standard is as follows: The 8 hour time-weighted average (TWA) airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed 2 fibers, longer than 5 micrometers per cubic centimeter of air (fibers > 5 μm/cc).

The ceiling airborne concentration to which no employee may be exposed in excess of is 10 fibers > 5 µm/cc.

OSHA in a recent proposed revision of the asbestos standard has proposed a TWA of 0.5 fibers > 5 µm/cc with a 5 fibers > 5 µm/cc ceiling over a 15 minute sampling period.

NIOSH currently recommends that the TWA exposure to asbestos be 0.1 fibers > 5 µm/cc with a ceiling value of 0.5 fibers > 5 µm/cc over a 15 minute sampling period.

Note: Strict adherence to the above procedures should minimize exposures to mechanics during brake and clutch servicing. These are interim recommendations and are subject to revision pending results of ongoing NIOSH research.

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