Investigation of Health Hazards in Brake Lining Repair and Maintenance Workers Occupationally Exposed to Asbestos

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INTRODUCTION

Several investigations have indicated that significant asbestos exposure may occur during brake maintenance and repair work (Nicholson, 1979; Rohl, et al. 1976; Hickish and Knight, 1970). Limited studies have suggested that exposure may be associated with the risk of asbestos-induced disease including both pulmonary asbestosis and asbestos-associated cancer (Lorimer et al, 1976; Greenberg and Lloyd-Davies, 1974). These limited reports do not, however, indicate whether the risk of asbestos-associated disease is common or uncommon. The question is of importance because over one million workers are regularly or intermittently engaged in vehicle maintenance work in the United States at this time (Bureau of Labor Statistics, 1979). Additionally, a large number of other workers were formally engaged in such work in the past and now are either retired or employed otherwise. It is estimated that 4,940,000 individuals are currently alive with such current or past employment (Nicholson et al., 1982).

There are several sources of asbestos exposure to garage mechanics and automobile repairmen. First, of course, is that the asbestos exposure from the debris of brake or clutch lining wear, particularly when the brake or clutch housing are cleaned using a high pressure air hose. Second, garage mechanics may be at risk from exposures during the use of autobody filler and, finally, asbestos dust can be disseminated during mixing and application of undercoating materials each of which has contained the fiber in previous years.

In order to determine the extent of the asbestos-related risk from garage maintenance work, NIOSH has contracted with the Environmental Sciences Laboratory to conduct a clinical examination of garage mechanics. The examination was to focus specifically upon those manifestations of asbestos disease, such as X-ray abnormalities and pulmonary function deficits, that would elucidate the possible effects from exposure to asbestos in garage employment.

MATERIALS AND METHODS

STUDY POPULATION

The study population for this project consisted of members of the following union groups who routinely performed brake maintenance repair work:

1. Local 259 of the United Automobile Workers (UAW) whose members were employed in commercial garages in New York, New Jersey and Connnecticut. Also included were all pensioners maintaining vested rights in a program administered by the Local.

2. Local 246 of the Service Employees International Union (SEIU) employed in New York City municipal garages.

The unexposed control population for the above brake workers consisted of:

1. Local 259 members and pensioners employed currently or previously in parts warehouses (New York City) and amphibious vehicle construction in Stamford, Connecticut and Schenectady, New York.

2. District Council 37 (DC 37), Municipal State and Federal Employees Union members employed in New York City as motor vehicle operators or traffic device repairmen.

The above groups were selected prior to the beginning of the project as the study and control groups for determining the effects of possible asbestos exposure on workers engaged in brake maintenance and repair work. The control groups were chosen because of membership in the same union and similar employment circumstances but without brake maintenance work. As the study progressed it was found that many of the control population had had exposure to asbestos in other circumstances such as shipyard work, and that fewer DC 37 members were participating in the examination than was initially expected. Thus, in consultation with the project officer, it was decided to add to the control groups the X-rays to be taken in examinations of Local 595, UAW members employed in production (non-maintenance) jobs in an automobile body construction facility in Linden, New Jersey. These workers were to be examined for effects of lead exposure associated with their work in an examination April 7-10, 1980. An analysis of their work activities had indicated that their current employment provided only limited opportunity for asbestos exposure. The decision to include this group was made prior to the April examination.

In order to reflect the effects of asbestos exposure, only those individuals with ten years of employment in a particular trade were considered for examination. In the case of the UAW members this consisted of all individuals with ten years of union membership. For SEIU members who were classified as mechanics in the New York City Civil Service Employees categorization, five years of prior automobile maintenance work were required in order to obtain such a status. Thus, the criteria of five years of union membership identified individuals who had at least ten years of employment in garage work as a mechanic or apprentice. Table 1 lists the distribution by seniority date and union affiliation of all individuals who were invited and who participated in the examinations.

The response was limited by several circumstances. One was the distance many individuals had to travel in order to reach an examination site. For example, both Local 259 and DC 37 Headquarters at which most examinations were held are located in lower Manhattan, whereas most study participants lived in Brooklyn or Queens. Many lived at even greater distances in Westchester or Nassau County, N.Y. or in New Jersey. Examination sites were arranged to accomodate as many of the study population as possible, but many individuals still lived at considerable distance from a site. Another factor was that most shops organized by these unions are relatively small (79% of the population workers in shops employing fewer than 30 members, only one-sixth of whom would have been employed for longer than ten years).

Table 1

The number of individuals invited and participating in the examinations by union affiliation

Years of union seniority	UAW 259 garage workers		UAW 259 vehicle construction		DC 37 motor vehic. opers. or sign maintenance		SEIU 246[1] garage mechanics	
	invited	participated	invited	participated	invited	participated	invited	participated
< 10			45	28		4	575	177
10.0-19.9	426	187	115	69	292	53	315	116
20.0-29.9	197	77	43	12	34	30	2	33
30.0-39.9	48	27	3	1		5		12
40 or more	5	2						
Total	676	293	206	110	326	92	892	338
Percentage	(43.3)		(53.4)		(28.2)		(37.9)	
Retirees	395	63	36	15				
Percentage	(15.9)		(41.6)					

1 Because of its recent establishment SEIU seniority was limited to less than 20 years although individuals were employed for longer by the city as mechanics. The DC 37 seniority was that of time in the particular job and employment with the city was usually longer. These circumstances are reflected in the distributions of job employment times for those participating in the examinations

The contact with individuals in these shops was by mail with letters from the Union President and Dr. Irving J. Selikoff of Mount Sinai School of Medicine, followed by a phone call from Mount Sinai personnel. In the larger shops where the program was also described by the Union health and safety representative and attendance encouraged, greater participation resulted. Finally, only one examination was held at each of the sites outside of Manhattan and those unable to attend on a given day could only be accomodated at a clinic in New York City. These factors led to a particularly low response of the 264 individuals invited to the examination site in Long Island where only 23.8% participated versus 53.4% at the large shops of Condec.

Information was obtained by phone, and from the return mailer, of the reasons for non-participation. These are tabulated in Table 2. It also was found that, of those sent invitations, 2.1-5.3% were undeliverable by the post office.

EXAMINATION LOCATIONS AND PROTOCOL

Examinations were held at approximately monthly intervals from May 1978 through February 1980 at a variety of sites chosen for their convenience to the residence or employment location of the participants. These included the union headquarters of Local 259, UAW in New York City and Schenectady, New York; the Community Center, Stamford, Connecticut; the headquarters of DC 37, State, County and Municipal Employees Union in New York City; the Paterson Clinic, Paterson, New Jersey; the Multiphasic Medical Center, Hempstead, Long Island; and Mount Sinai School of Medicine, New York City. For those locations without X-ray facilities, portable units were obtained. In each location spirometry stations were established using field survey equipment of the Pulmonary Function Laboratory of Mount Sinai School of Medicine. Laboratory, examining and interview stations were easily established in the available space in all facilities.

Appendix 1 is the form used for all examinations. The examinations consisted of a complete occupational history with detailed descriptions

Table 2

Reasons given for non-participation in examinations

	Telephone response	Mail-in response
Do not wish to participate		175
Not interested	20	
Too busy at this time	20	
Inconvenient time	20	
Recent examination	7	5
Current illness, injury or incapacitation	5	3
Illness or death in family	3	
Too far to come or moved away	4	5
Miscellaneous non-health reasons	5	1

of work activities that could affect the health of the individual, descriptions of work practices during brake maintenance and repair work, and the use of personal protection devices. Special care was taken to elicit information on previous exposures to asbestos and other dusts that might be pneumoconiotic.

The clinical examination, tests, and procedures consisted of:

1. complete medical history;
2. current and past uses of medications;
3. current and past symptoms;
4. physical examination;
5. complete blood count, including a differential count on individuals with an abnormal white cell count;
6. 20 channel blood chemistry analysis;
7. pulmonary function tests, including determination of complete flow-volume characteristics;
8. 14 x 17 inch, full size postero/anterior chest X-ray.

All chest X-rays, laboratory results, and examination findings were reviewed immediately for conditions that might require urgent attention. If such conditions were found, the patient was notified and, if he wished, his personal physician was called. The radiographs were subsequently interpreted using the ILO U/C International Classification of Pneumoconioses. Parenchymal changes of 1/0 or greater were considered abnormal as were pleural thickening, pleural plaques and pleural calcification. Additionally other abnormal disease conditions were noted. (See Appendix 2.)

Predicted values for spirometry were based upon the revised analysis by Miller et al. (1980) of data of Morris, Koski, and Johnson (1971). The criteria for individual spirometric abnormalities are listed in Table 3. After interpretation of the X-rays and review of all laboratory and clinical findings, a report and letter were prepared and sent to each participant. The two most important parameters for the assessment of health effects from asbestos exposure are the manifestation of small irregular opacities on an interpretable X-ray and restrictive pulmonary

Table 3

Criteria for normality of spirometry

FVC	> 80% of predicted
FEV_1	$\geq$ 80% of predicted
MMF	$\geq$ 75% of predicted
FEV_1/FVC	age $\leq$29, $\geq$.75 age 30-59, $\geq$.70 age $\geq$60, $\geq$.65

FVC predicted = 0.147 x Height (in.) - 0.025 x Age (yr.) - 4.241

FEV_1 predicted = 0.094 x Height (in.) - 0.032 x Age (yr.) - 1.426

(For Blacks, the predicted values were 89% of the above.)

MMF predicted 0.044 x Height (in.) - 0.046 x Age (yr.) + 2.806

(For Blacks, the same values were observed.)

From: Miller, Thornton, Smith and Morris. Am. J. Ind. Med. 1:55-68, (1980).

function deficits. Of the 916 individuals from the four groups listed above who participated in the examinations, readable X-rays were available on 860 individuals and interpretable pulmonary function tests on 883. The 6.1% unsatisfactory X-rays stemmed from the use of portable X-ray facilities that did not have processing facilities immediately available. In one examination, a light leak developed in the X-ray cassette holder that rendered 30 X-rays unreadable (24 from SEIU members and 6 from DC 37 members). Because of the extensive travel involved, few with unreadable X-rays from the examination took advantage of the availability of another X-ray at a later examination. The distributions by union affiliation and work activity of participants with valid X-rays and pulmonary function tests are shown below in Tables 6 and 7.

X-ray developing facilities were not available for films taken by the portable units and by two of the fixed installations used in this survey. The unavailability of a film for review at the time it was taken led to a less than desired quality for the readable X-rays. Both over- and under-penetrated films present difficulties in the interpretation of the minimal changes seen with low level asbestos exposure. Thus, a greater degree of inter- and intra-observer variability exists with the interpretation of the films of this survey by the physicians reading the X-rays than with films taken by the same technician, with the same equipment, and continuously monitored for quality.

Following the completion of the examinations, all X-rays from all examinations were intermixed, masked, and identified with a coded number. If multiple films of the same individual were taken; these were labeled with a single number and designated as A, B, C, etc. These films were read as a group individually by three experienced readers who were free to utilize the best P-A film for the determination of an X-ray reading. Results for the three readers and that of the individual who read the X-rays following each examination were entered on a code sheet for each participant. The results of the four readings were then averaged using the following criteria:

1. All parenchymal readings within given categories (rounded, irregular and combined) were averaged utilizing the ILO U/C twelve point scale. If the average came exactly half-way between two values, as is possible with an even number of readers, the values of the three readers who read the entire group of X-rays at one time determined whether one averaged up or down.

2. If the reading of one individual differed by three units from that of the average of the others, all readers re-read that particular film. The readers were told that a disagreement existed on parenchymal readings, but no other information was provided. If the subsequent reading brought the outlying interpretation into closer agreement, the average of the second readings was utilized. If a disagreement of the same magnitude still persisted, the X-ray was interpreted by the entire group of readers and a consensus obtained. (This occurred for fewer than five X-rays.)

3. If a disagreement existed among the readers as to whether or not pleural changes existed such films were also re-read with the specification that a disagreement existed with respect to interpretation of the pleura. Following a second interpretation, a determination was based upon the average of the second reading. If an X-ray was interpreted as normal by two individuals and abnormal by two others, the interpretations of the same three readers as before determined the overall classification.

Approximately 110 X-rays read early in the sequence were reintroduced into the group at a later time to provide information on reproducibility of the individual readers. For this analysis no "second" readings as described above were used. Table 4 shows the distribution of differences of parenchymal and pleural readings of each of the four readers along with the average score of the parenchymal readings for each individual (based on a 12 point scale). As can be seen both the interobserver reproducibility and intra-observer comparability of readers is well within similar variations determined by other interpretation groups (Rossiter, 1972; Glover, Bevan, Cotes, et al., 1980). (See Table 12 for the results of individual and averaged readings by job category.)

Table 4

The variability and reproducibility of three X-ray readers participating in this study

Reader	Subcategory difference (Second reading - first reading) -3	-2	-1	0	1	2	3
1.	0	4	13	93 (82)	1	1	0
	Standard deviation: 0.77						
	Average score: First reading 2.40, Second reading, 2.24[1]						
2.	0	5	20	66 (56)	10	4	0
	Standard deviation: 0.83						
	Average score: First reading, 2.67; Second reading, 2.55						
3.	3	8	13	63 (57)	14	5	0
	Standard deviation: 1.01						
	Average score: First reading, 2.51; Second reading, 2.38						

( ) = Number of films read as 0/0 both times.

[1] 0/- = 1; 0/0=2; etc.

RESULTS

OCCUPATIONAL HISTORIES

A careful review of all jobs each person held revealed that many examinations participants had previously been employed in a job with potential for significant asbestos exposure. This is shown in Table 5 for each union group that participated in the examination or whose X-rays were utilized for analysis. Overall 21.5% of the study participants had an identified or highly probable exposure to asbestos in previous employment or military service. The percentages were particularly high in the groups that included men with skills as welders (vehicle construction and city maintenance mechanics). Here, asbestos exposure in shipyards or during the welding and cutting of high temperature equipment insulated with asbestos was identified. Of the 234 with identified or possible asbestos exposure and readable X-rays, 87 (8.9% of all X-rays) were of men previously employed in shipyards. In order to eliminate any confounding exposure in the analysis of brake work, the health effects of individuals with identified and possible exposures to asbestos and other dusts were analyzed separately, according to the four broad exposure categories of Table 5, direct occupational asbestos exposure, shipyard and heating trades, possible asbestos exposure, and exposure to other dusts. In the direct occupational category were those individuals that insulated pipes, worked in asbestos manufacturing operations or had similar exposures. Among those classified in shipyard or heating trades were those with any shipyard employment or work that involved the repair, installation, or maintenance of boiler room equipment or equivalent exposures. Also included in this category were a group of men (12) that insulated mufflers with asbestos or installed brake linings on a continuous basis during the construction of amphibious vehicles.

An individual was classified in the category with the highest potential asbestos exposure (as ordered above), irrespective of the total employment time in that category. It should be noted that while every care was utilized in attempting to elicit a past asbestos exposure, this may

Table 5

The distribution by union affiliation and type of work activity[1] of study participants

Type of work activity	Union affiliation: UAW 259 Maint.	UAW 259 Const.	UAW 595	DC 37	SEIU 246	Totals
No identified asbestos exposure or garage work	14 (3.9)	70 (55.6)	85 (69.1)	28 (28.9)	8 (2.4)	205
Garage employment but no brake work	82 (23.0)	2 (1.6)	-	18 (18.6)	22 (6.5)	124
Brake work	217 (61.0)	2 (1.6)	-	18 (18.6)	213 (63.2)	450
Other dust exposure	7 (2.0)	3 (2.4)	18 (14.6)	1 (1.0)	7 (2.1)	36
Possible asbestos exposure	14 (3.9)	23 (18.3)	11 (8.9)	13 (13.4)	22 (6.5)	83
Shipyard, heating trades	22 (6.2)	26[2] (20.6)	5 (4.1)	17 (17.5)	61 (18.1)	131
Direct asbestos exposure (insulation, factory work)	-	-	4 (3.3)	2 (2.1)	4 (1.2)	10
Totals	356	126	123	97	337	1039
Totals with other possible asbestos exposure	36 (10.1)	37[2] (29.4)	20 (16.3)	32 (33.0)	7 (25.8)	224 (21.5)

( ) = Percentage of union members in job category.

[1] Four men had missing occupational histories and. These were excluded from further analysis.

[2] Ten of these 26 individuals insulated mufflers and 2 continuously installed brakes during amphibious vehicle construction. Their "other asbestos exposure" occurred as part of the job under study. These were not included in totals with other possible asbestos exposure. In subsequent analysis, however, they were included in the category of shipyard, heating trades.

not have been successful in every instance, due to inadequate recall of the worker or because an asbestos exposure may have occurred without his knowledge. The large number of workers with identified exposures suggests the possible scope of the problem. Such unidentified exposures would, however, contribute proportionately to the abnormalities found in both the exposed (brake workers) and unexposed groups under study. In the analysis that follows workers will be classified according to their asbestos exposure irrespective of their union affiliation or job classification at recruitment.

It is striking that 8.9% of all participants had previous employment in the shipbuilding and ship repair industry. As approximately 45% of the study participants were over age 55, many had opportunity for employment in one of the several New York area shipyards that operated during and after World War II (Brooklyn Navy Yard, the Hoboken yards of Todd and Bethlehem Steel). [Approximately 4,500,000 men (and women) were employed in ship construction and repair during World War II (Nicholson, Perkel, and Selikoff, 1982). This constituted 9.4% of the non-agricultural national male work force in 1943, but a much smaller percentage was employed after World War II (0.2%-0.5%) (Bureau of Labor Statistics, 1979). Thus, the finding of such a large number with shipyard employment in this study is understandable and provides an opportunity to evaluate the effects of past short-term shipyard work as well as that of garage employment.

Tables 6 and 7 display the distributions, by work activity, of those for whom interpretable X-rays are available and for whom valid pulmonary function tests were obtained. As can be seen, lower percentages of readable X-rays were available for DC 37 and SEIU 246 members because of the previously mentioned loss of 30 X-rays. The individuals involved, however, were randomly scattered among the different exposure categories. The percentage of individuals with valid pulmonary function tests (96.4%) compares favorably with other surveys. Again, those with missing tests are randomly distributed among all occupational categories.

Table 6

The distributions and percentages of readable X-rays by union affiliations and type of work activity[1]

Type of work activity	Union affiliation UAW 259 Maint.	 Const.	 UAW 595	 DC 37	 SEIU 246	 Totals
No identified asbestos exposure or garage work	14 (100.0)	67 (95.7)	85 (100.0)	25 (100.0)	8 (100.0)	202 (98.5)
Garage employment but no brake work	81 (98.8)	2 (100.0)	-	14 (77.8)	19 (86.4)	116 (93.5)
Brake work	214 (98.6)	2 (100.0)	-	18 (100.0)	187 (87.8)	421 (93.6)
Other dust exposure	7 (100.0)	3 (100.0)	18 (100.0)	0 (0.0)	7 (100.0)	35 (97.2)
Possible asbestos exposure	14 (100.0)	21 (91.3)	11 (100.0)	9 (81.8)	20 (90.9)	77 (92.8)
Shipyard, heating trades	22 (100.0)	26 (100.0)	5 (100.0)	13 (76.5)	57 (93.4)	123 (94.0)
Direct asbestos exposure (insulation, factory work)	-	-	4 (100.0)	1 (50.0)	4 (100.0)	9 (90.0)
Totals	352 (98.8)	121 (96.0)	123 (100.0)	80 (87.0)	302 (89.6)	983 (94.6)

( ) = Percentage of category with readable X-ray.

Table 7

The distribution of valid pulmonary function tests by union affiliation and type of work activity[1] [2]

	Union affiliation				
	UAW 259				
Type of work activity	Maint.	Const.	DC 37	SEIU 246	Totals
No identified asbestos exposure or garage work	13 (92.9)	69 (98.6)	25 (89.2)	8 (100.0)	115 (95.8)
Garage employment but no brake work	80 (97.6)	2 (100.0)	18 (100.0)	22 (100.0)	122 (98.4)
Brake work	211 (97.2)	2 (00.0)	17 (94.4)	206 (96.7)	436 (96.9)
Other dust exposure	7 (100.0)	2 (67.7)	1 (100.0)	7 (100.0)	17 (94.4)
Possible asbestos exposure	14 (100.0)	23 (100.0)	11 (100.0)	20 (90.9)	68 (97.1)
Shipyard, heating trades	21 (95.5)	26[2] (100.0)	17 (100.0)	56 (91.8)	120 (95.2)
Direct asbestos exposure (insulation, factory work)	-	-	1 (50.0)	4 (100.0)	5 (83.3)
Totals	346 (97.2)	124 (98.4)	89 (96.7)	323 (95.8)	883 (96.4)

( ) = Percentage of category with valid pulmonary function test.

1 Two men with valid pulmonary function tests had missing occupational histories.

2 No pulmonary function tests were performed at the Linden, New Jersey examination of UAW 595 members.

X-RAY ABNORMALITIES

Tables 8a and 8b list the averaged readings for the parenchymal X-ray abnormalities according to the ILO U/C International Classification of Pneumoconioses for the various asbestos-exposed groups established in this survey. Seven hundred and ninety-nine of 983 readable X-rays were classified as having 0/0 or 0/1 readings for parenchymal fibrosis. One hundred and seventy-seven were classified in category 1 (1/0-1/2) and seven were classified as having 2/1-2/3 abnormalities. Of those with normal pleura, 735 of 871 (84.5%) were also normal for parenchymal changes. For those with abnormal pleura, the percentage with normal parenchyma was much less. Only 64 of 113 (56.6%) of the readings were categorized as 0/0 or 0/1.

Tables 9a and 9b list the pleural abnormalities according to the severity (extent and thickness) of pleural thickening and whether or not calcification or pleural plaques were seen. The greatest proportion of pleural abnormalities consisted of pleural thickening (89 of 113). Pleural calcification was seen only infrequently, being identified on only 12 X-rays, including eight for which pleural thickening was also noted. Pleural plaques were seen on 38 X-rays, including 16 for which pleural thickening was also identified and one with pleural calcification. The degree of pleural abnormalities was relatively minor. Of those with pleural thickening, 42 had the lowest category of extent and thickness (A/1). Twenty-nine were categorized as either A/2 or B/1. The more severe examples of pleural thickening were largely confined to individuals who had either direct asbestos exposure or had previously been employed in shipyards.

Tables 10 and 11 list the percentages in the different occupational categories according to the type(s) of X-ray abnormality. As can be seen from Table 11, the percentage with any abnormality among those with garage employment is 24.2% compared to 18.8% among individuals with no stated asbestos exposure or garage employment. Corresponding percentages for parenchymal abnormalities are 19.0% vs. 15.3% and for pleural abnormalities 8.4% vs. 8.9%, respectively for those with garage

Table 8a

The number and category of parenchymal X-ray abnormalities according to work activity

Normal pleura

	Profusion of small irregular opacities							
	Normal X-ray		Abnormal Parenchyma					
Type of work activity	0/0	0/1	1/0	1/1	1/2	2/1	2/2	2/3
No identified asbestos exposure or garage work	107	57	17	3	0	0	0	0
Garage employment	264	143	61	16	4	3	1	0
No brake work	60	27	13	4	0	1	0	0
Brake work	204	116	48	12	4	2	1	0
Other dust exposure	10	17	4	2	0	0	0	0
Possible asbestos exposure	30	23	8	0	1	0	0	0
Shipyard, heating trades	52	27	7	4	1	0	0	1
Direct asbestos exposure (insulation, factory work)	5	0	2	0	0	0	0	0
Totals	468	267	99	25	6	3	1	1

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e., a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories higher in the table, such as brake work.

Table 8b

The number and category of parenchymal X-ray abnormalities according to work activity

Abnormal pleura

Type of work activity	Normal X-ray		Abnormal Parenchyma					
	Profusion of small irregular opacities							
	0/0	0/1	1/0	1/1	1/2	2/1	2/2	2/3
No identified asbestos exposure or garage work	5	2	9	1	0	0	1	0
Garage employment	10	17	9	6	2	0	0	0
No brake work	3	2	3	2	1	0	0	0
Brake work	7	16	6	4	1	0	0	0
Other dust exposure	0	2	0	0	0	0	0	0
Possible asbestos exposure	6	2	3	4	0	0	0	0
Shipyard, heating trades	7	11	10	1	1	0	1	0
Direct asbestos exposure (insulation, factory work)	1	0	1	0	0	0	0	0
Totals	29	35	32	12	3	0	2	0

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e., a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories higher in the table, such as brake work.

Table 9a

The number and category of pleural X-ray abnormalities according to work activity

Normal parenchyma (0/0-0/1)

Type of work activity	Normal pleura	Abnormal pleura	Pleural abnormality — Extent and thickness of pleural thickening: A1	A2	B1	B2	C1	C2	Pleural calcification	Pleural plaque
No identified asbestos exposure or garage work	164	7	4	1	0	0	1	0	0	1
Garage employment	407	27	11(3)^{2}	3	3	0	0	0	0	13(3)
No brake work	87	5	2	2	0	0	0	0	0	1
Brake work	320	23	9(3)	1	3	1	0	0	0	12(3)
Other dust exposure	27	2	1	0	1(1)	0	0	0	0	1(1)
Possible asbestos exposure	53	8	4	2	0	0	0	0	0	2
Shipyard, heating trades	79	18	4(2)	0	6[1]^{1}	2{1}^{3}	2	2(1)	3[2]	5(4)
Direct asbestos exposure (insulation, factory work)	5	1	0	0	0	1	0	0	0	0
Totals	735	64	24(5)	6	10[1](1)	4{1}	3	2(1)	3[2]	22(8)

^{1} [ ] = calcification present with pleural thickening.
^{2} ( ) = plaque(s) present with other conditions.
^{3} { } = both pleural calcification and plaque(s) present with pleural thickening.

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e., a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories in the table, such as brake work.

Table 9b

The number and category of pleural X-ray abnormalities according to work activity

Abnormal parenchyma (1/0-2/3)

Type of work activity	Normal pleura	Abnormal pleura	Pleural abnormality: Extent and thickness of pleural thickening						Pleural calcification	Pleural plaque
			A1	A2	B1	B2	C1	C2		
No identified asbestos exposure or garage work	20	11	3[1][1]	3	1	1{1}[3]	0	0	2[2]	4(1)
Garage employment	85	17	8[1](2)[2]	3	3	0	0	0	2[1]	4(2)
No brake work	18	6	3(2)	1	1	0	0	0	1	2(2)
Brake work	67	11	5[1]	2	2	0	0	0	1[1]	2
Other dust exposure	6	0	0	0	0	0	0	0	0	0
Possible asbestos exposure	9	7	3	0	0	3[1](1)	0	0	1[1]	2(1)
Shipyard, heating trades	13	13	4{1}(1)	1	2[1]	2(1)	2	0	4[2](1)	5(4)
Direct asbestos exposure (insulation, factory work)	2	1	0	0	0	0	0	1(1)	0	1(1)
Totals	135	49	18{1}[2](3)	7	6[1]	6{1}[1](2)	2	1(1)	9[6](1)	16(9)

[1] [ ] = calcification present with pleural thickening.
[2] ( ) = plaque(s) present with other conditions.
[3] { } = both pleural calcification and plaque(s) present with pleural thickening.

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e., a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories in the table, such as brake work.

Table 10

Number and percentage of X-ray abnormalities according to work activity

	Parenchymal Reading						
Work activity	Normal x-ray	Normal pleura 1	Normal pleura 2	Abnormal pleura 0	Abnormal pleura 1	Abnormal pleura 2	Number in category
No stated asbestos	164	20	0	7	10	1	202
exposure or garage work	81.2%	9.9%	-	3.4%	5.0%	0.5%	
All garage work	407	81	4	27	17	0	537
	75.8%	15.1%	0.7%	5.0%	3.2%	-	
No brake work	87	17	1	5	6	0	116
	75.0%	14.7%	0.9%	4.3%	5.2%	-	
Brake work	320	64	3	23	11	0	421
	76.0%	15.2%	0.7%	5.5%	2.6%	-	
Other dust exposure	27	6	0	2	0	0	35
	77.1%	17.1%	-	5.7%	-	-	
Possible asbestos exposure	53	9	0	8	7	0	77
	68.8%	11.7%	-	10.4%	9.1%	-	
Shipyard, heating trades	79	12	1	18	12	1	123
	64.2%	9.8%	0.8%	14.6%	9.8%	0.8%	
Direct asbestos exposure	5	2	0	1	1	0	9
(insulation,factory work)	55.6%	22.2%	-	11.1%	11.1%	-	
Totals	735	130	5	64	47	2	983
	74.8%	13.2%	0.5%	6.5%	4.8%	0.2%	

Table 11

Number and percentage of X-ray abnormalities according to work activity and X-ray criteria

Work activity	1/0 or greater parenchymal change	Any pleural change	1/0 or greater parenchymal and/or any pleural change	1/1 or greater parenchymal and/or pleural thickening or calcification	Number in category
No stated asbestos exposure or garage work	31 15.3%	18 8.9%	38 18.8%	17 8.4%	202
All garage work	102 19.0%	45 8.4%	130 24.2%	59 11.0%	537
No brake work	24 20.7%	11 9.5%	29 25.0%	15 12.9%	116
Brake work	78 18.5%	34 8.1%	101 24.0%	44 10.5%	421
Other dust exposure	6 17.1%	2 5.7%	8 22.9%	4 11.4%	35
Possible asbestos exposure	16 20.8%	15 19.5%	24 31.2%	13 16.9%	77
Shipyard, heating trades	26 21.1%	31 25.2%	44 35.8%	34 27.6%	123
Direct asbestos exposure (insulation, factory work)	3 33.3%	2 22.2%	4 44.4%	2 22.2%	9
Totals	184 18.7%	113 11.5%	248 25.2%	129 13.1%	983

employment compared to those with no such employment or no stated asbestos exposure. The minimal overall differences between these two groups are more manifest in parenchymal abnormalities, there being little difference in the percentages of pleural abnormalities. On the other hand, significant differences exist in the percentages of pleural abnormalities among those employed in work having direct asbestos exposure or shipyard employment and those only employed in garage work or having no asbestos exposure. We will thus utilize both parenchymal and pleural abnormalities to characterize the various exposed groups.

Other criteria could have been utilized for the determination of an abnormal X-ray. For example, we could have required that all four readers read an X-ray as abnormal before it would be so categorized, or that an averaged reading of 1/1 be required for the establishment of parenchymal fibrosis, or that pleural plaques not constitute an abnormality. To investigate whether more stringent criteria for abnormalities would have altered the analysis, the overall results were calculated with the criteria for abnormality being an X-ray categorized as 1/1 or greater and/or the presence of pleural thickening of calcification (plaques were not considered abnormal). These data are shown in the last column of Table 11 and demonstrate the identical trends that were present in the data with less stringent criteria for abnormalities.

Table 12 shows the distribution of abnormal X-rays for each reader according to work category. While different percentages of abnormal X-rays were obtained by the various readers, the trends according to work activity were highly consistent. Those engaged in brake work had a higher percentage of abnormalities compared to those who did not and those with other asbestos exposures had the greatest percentage of abnormalities according to all four readers. Thus, the overall X-ray results are relatively independent of the individual readers and independent of the criteria for abnormality established.

Table 12

Percentage of X-ray abnormalities
according to individual readings of four readers,
by job category

Reader	No exposure	Job category: Brake work	Garage, no brake	Heavy exposure	Shipyard work	Possible asbestos	Other dust	Totals
Averaged reading	18.8 (38/202)	24.0 (101/421)	25.0 (29/116)	44.4 (4/9)	35.8 (44/123)	31.2 (24/77)	22.9 (8/35)	24.8 (248/983)
1	16.8 (34/202)	20.0 (84/421)	18.1 (21/116)	44.4 (4/9)	34.4 (42/122)	22.4 (17/76)	28.6 (10/35)	21.6 (212/981)
2	31.7 (64/202)	37.1 (156/421)	33.6 (39/116)	55.6 (5/9)	45.1 (55/122)	36.8 (28/76)	51.4 (18/35)	37.2 (365/981)
3	19.3 (39/202)	25.3 (106/419)	27.6 (32/116)	44.4 (4/9)	38.2 (47/123)	33.8 (26/77)	17.1 (6/35)	26.5 (260/981)
4	18.3 (37/202)	22.2 (93/419)	25.9 (30/116)	33.3 (3/9)	37.4 (46/123)	33.8 (26/77)	25.7 (9/35)	24.9 (244/981)

Age standarization of X-ray readings

Inasmuch as the prevalence of X-ray abnormalities reflects various assaults to the lung (separate from that under study) that accrue overtime, it is necessary to consider age in comparisons of groups exposed to asbestos in different circumstances. Any age effect can, in part, be due to unknown exposures to various dusts, including asbestos, the opportunities for which increase with time. Additionally, any dust-related changes progress with time and the manifestation of relatively minor exposures early in life can be significant in later years. As discussed previously, a selection criteria for the exposed and control groups resulted in study populations that had similar age distributions. However, to more accurately take into account any age effect, the overall percentages of X-ray abnormalities were standardized to the age distribution of all 983 individuals for whom readable X-rays were available. A standardized percentage, P_{std}, was calculated using equation (1).

$$P_{std} = \Sigma_i \; P_i \; N_i^T/983 \qquad (1)$$

Where P_i is the percentage of abnormal X-rays in the ith age category of the group of interest and N_i^T, the number of all 983 individuals in the ith age group. For a group having an age cell with no data (insulation/factory, other) standardization was based on those cells with data using equation (2)

$$P_{std} = \sum_{\text{avail } i} P_i \; N_i^T/983 \; [\sum_{\text{all } i} P_i^T \; N_i^T / \sum_{\text{avail } i} P_i^T \; N_i^T] \qquad (2)$$

Where P_i again equals the percentage of abnormal X-rays in the ith age category of the group of interest and N_i^T, the number of all 983 individuals in the ith age category; P_i^T is the percentage of abnormal X-rays among all 983 individuals in the ith age category. These overall age-standardized percentages are shown in Table 13. The difference between the individuals performing brake work and those with no identified asbestos exposure remains, while the percentage of abnormalities in those employed in a garage but not engaged in brake repair work

Table 13

Percentage of X-ray abnormalities according to work activity, by age

Type of work activity	Age <40	40-49	50-59	60-69	>70	Totals	Age standardized percentage[1]
No identified asbestos exposure or garage work	4.3 (2/47)	14.9 (7/47)	20.0 (13/65)	37.8 (14/37)	33.3 (2/6)	18.8 (38/202)	21.4 ± 3.5
Garage employment	11.9 (8/69)	15.7 (19/121)	26.7 (55/206)	34.4 (44/128)	30.8 (4/13)	24.2 (130/537)	24.3 ± 2.1
No brake work	25.0 (2/8)	0.0 (0/11)	25.6 (9/38)	22.9 (8/35)	28.6 (2/7)	21.2 (21/99)	18.6 ± 4.1
Brake work	11.1 (6/54)	17.8 (19/107)	24.5 (38/155)	36.5 (31/85)	40.0 (2/5)	23.6 (96/406)	24.5 ± 2.5
Body work	0.0 (0/7)	0.0 (0.3)	57.1 (8/14)	71.4 (5/7)	0.0 (0/1)	30.6 (13/32)	38.6 ± 10.7
Other dust exposure	----	18.2 (2/11)	16.7 (2/12)	33.3 (3/9)	33.3 (1/3)	22.9 (8/35)	20.3 ± 7.2
Possible asbestos exposure	40.0 (4/10)	26.3 (5/19)	35.5 (11/31)	18.8 (3/16)	100 (1/1)	31.2 (24/77)	32.0 ± 6.5
Shipyard, heating trades	0.0 (0/8)	20.0 (3/15)	39.6 (21/53)	40.5 (17/42)	60.0 (3/5)	35.8 (44/123)	30.8 ± 4.6
Direct asbestos exposure (insulation, factory work)	----	----	40.0 (2/5)	33.3 (1/3)	100 (1/1)	44.4 (4/9)	32.6 ± 6.3
Totals	10.4 (14/134)	16.9 (36/213)	28.0 (104/372)	34.9 (82/235)	41.4 (12/29)	25.2 (248/983)	25.2 ± 1.6

[1] Standardized to the age distribution of all 983 individuals for whom readable X-rays were available.

decreases to somewhat below the level of those unexposed otherwise. The percentages of abnormalities among those with other asbestos exposure remain significantly different from those unexposed.

If we consider the percentage of X-ray abnormalities a manifestation of a normal distribution with a variance reflected by the number of abnormal X-rays, the respective standard deviations in the final column of Table 13 are calculated. While the percentage of abnormal X-rays in each of the job categories of Table 13 has a large uncertainty associated with it because of the limited number of individuals in a work activity (other than brake work), the pattern of observed percentages yields a remarkable consistency. The two groups with no identified asbestos exposure, non-garage controls and garage workers with no brake or body work have the lowest percentages of abnormalities, the various activities with probable asbestos exposure have the highest percentages, and brake workers are intermediate. Individuals with other dust exposure appear to be unaffected by such materials. This is probably the result of the relatively short exposure times or the marginal exposure circumstances. The other dusts included coal (23 men), silica (9 men), and other dusts (3 men). Five of the other dust exposures were for longer than ten years. (One of the five had an abnormal X-ray.) The average exposure of the other 30 was 3.2 years. In subsequent analysis these 35 individuals will be characterized by their garage (or non-garage) employment. One notable feature of Table 13 is the high percentage of abnormal X-rays among the 32 individuals who worked for some time in auto body repair. (See subsequent sections on auto body repair and undercoating work.)

<u>Smoking standardization of X-ray abnormalities</u>

Smoking has been identified as exacerbating the non-malignant effects of asbestos. Death rates from asbestosis among 20+ cigarette/day smokers are 2.8 times greater than among nonsmokers (Hammond, Selikoff, and Seidman, 1979) and both parenchymal and pleural X-ray abnormalities have been reported as more common among current and ex-smokers than nonsmokers (Weiss, 1971; Rossiter and Harries, 1979; Weiss, Levin, and

Goodman, 1981). An effect of smoking on the prevalence of X-ray abnormalities was also found in this study with both parenchymal and pleural abnormalities found more among ex-smokers than nonsmokers and more frequently among current smokers than ex-smokers. The age standardized data for the overall X-ray readings are shown in Table 14a.

Table 14b lists the percentage distribution of smoking histories according to job category. As the unexposed group contains 25% more current smokers than the other exposure groups, the X-ray results, where possible, should be standardized for cigarette smoking as well as for age. This can be done for major work categories, but is unreliable for most subcategories because of the absence of data in some smoking-age cells. The standardization procedure follows that of age standardization and utilizes the overall smoking histories of the study group (31.6% were smokers; 42.4%, ex-smokers; and 26.0% nonsmokers).

Standardized X-ray abnormalities by work activity

Table 15 lists the age and smoking standardized percentages of X-ray abnormalities among those with no identified asbestos exposure, those engaged in brake maintenance and repair, and those with probable asbestos exposure, including auto body repair work. The overall percentage of abnormal X-rays among individuals with probable asbestos exposure differs significantly from those unexposed ($P<0.005$, two sided). The difference is particularly significant ($P<0.0002$) for pleural abnormalities. This occurs because pleural abnormalities often appear from relatively low asbestos exposures and can exceed parenchymal abnormalities in prevalence at long times from onset of exposure. (See Anderson, et al. 1976, e.g.) As many of the individuals in this "probably exposed" category worked during World War II in shipyards, we are observing effects in this group after 35 years from onset of exposure.

Table 16 lists the age and smoking standardized percentages of abnormalities according to garage activity and union. There is relatively little difference between the percentages of abnormal X-ray for the auto workers of UAW Local 259 while a large and significant ($p < 0.05$)

Table 14a

Age standardized percentage of X-ray abnormalities according to smoking history (all exposure categories)

Smoking History

Abnormality	Smokers	Ex-smokers	Nonsmokers	Smoking standardized
Pleural	14.0	11.2	9.1	11.5
Parenchymal	26.3	16.0	13.9	18.8
Any	32.6	22.9	20.4	25.3

Table 14b

Percentages of distribution of smoking histories according to job category

	Smokers	Ex-smokers	Nonsmokers
No exposure including non-mechanic garage work	39.1	39.1	21.7
Brake work	29.1	43.1	27.8
Probable asbestos exposure	31.8	42.0	26.1

Table 15

The age and smoking standardized percentages of X-ray abnormalities according to exposure category

Exposure category	Pleural	Parenchymal	Any
No identified asbestos exposure	8.4 ± 1.6	15.8 ± 2.1	20.1 ± 2.5
Non-garage work	10.4 ± 2.3	17.0 ± 2.8	21.9 ± 3.2
Garage work but no brake work	6.6 ± 2.2	14.4 ± 3.5	17.8 ± 3.9
Brake work	7.2 ± 1.3	19.3 ± 2.2	24.4 ± 2.5
Probable asbestos exposure including body work	19.8 ± 2.7	19.9 ± 2.7	32.5 ± 3.5

Table 16

Age and smoking standardized percentages[1] of X-ray abnormalities for different groups of garage workers according to work activity

	Group			
Work activity	UAW 259	UAW 595	DC 37 SEIU	Overall
Brake work[2]	19.8 ± 3.0		28.9 ± 4.0	24.4 ± 2.5
No brake work[2]	17.3 ± 3.3	21.7 ± 4.4	18.7 ± 4.7	20.1 ± 2.5
Percentage of participants with other asbestos exposure	15.1[3]	16.3	25.8	21.5

[1] Standardized to age and smoking distribution of all 983 men for whom readable X-rays were available.

[2] No identified asbestos exposure.

[3] Does not include 12 individuals with asbestos exposure during amphibious vehicle construction.

difference exists between those employed in city garages and all other groups combined. This can be attributed to the greater grinding and finishing of brake lining material that the city workers do. The work in commercial garages is virtually exclusively on automobiles in which brake shoes are simply removed and replaced. Asbestos exposures largely occur through the air blowing of residual dust in the drum housing. Many of the city workers, on the other hand, repair truck brakes and, here, machining of the lining may be required to obtain a proper fit. This additonal exposure can be significant. Rohl, Langer, Wolff, and Weisman (1976) found short-term asbestos concentrations during the machining of new brake linings to range from 24 f/ml to 72 f/ml.

Tables 17a and 17b show the percentages of individuals with X-ray abnormalities according to years of garage employment and years since onset of garage work. As can be seen, there is an increasing percentage of X-rays according to either variable. However, to some extent, this would be a reflection of the previously discussed age effect seen in both the exposed and unexposed populations analyzed in this study. In order to take into account age, the age-standardized percentages of abnormal X-rays were calculated for the age decades 40 through 69 years for those employed more than or less than 30 years, and more than or less than 30 years from onset of employment. (Individuals in each of these three age decades were included in both the 30+ years and 30-year groups so difficulties with empty cells was avoided.) However, the small numbers in each age cell prevented any smoking standardization. The results show that those employed for more than 30 years or with 30 or more years from onset of exposure have the greater percentage of abnormal X-rays. The differences between the age standardized abnormalities in the group with 30 or more years of employment and those with no asbestos or garage exposure or those with less than 30 years of garage employment achieve a one-sided level of significance of $P<0.05$.

An analysis by the estimated number of brake jobs per week, however, does not indicate any trend (Table 18). The estimates are necessarily uncertain because of poor recall and the analysis did not consider either duration of work or time from onset of employment.

Table 17a

Percentage of individuals with X-ray abnormalities according to years of garage work

Garage work	Years of garage employment <20	20-29	30-39	40+	Totals
Brake work	13.8 (13/94)	20.0 (34/170)	28.8 (34/18)	45.2 (14/31)	23.0 (95/413)
No brake work	27.0 (3/48)	16.7 (6/36)	16.7 (2/12)	0.0 (0/3)	21.2 (21/99)
Total	18.3 (26/142)	19.4 (40/206)	27.7 (36/130)	41.2 (14/34)	24.2 (116/512)

Age standardized	<30	30+
Brake work	19.4 ± 3.0	28.7 ± 4.2

Table 17b

Percentage of individuals with X-ray abnormalities according to years since onset of garage work

Garage work	Years since onset <20	20-29	30-39	40+	Totals
Brake work	13.2 (10/76)	20.3 (30/148)	24.4 (33/135)	40.7 (22/54)	23.0 (95/413)
No brake work	22.5 (9/40)	21.2 (7/33)	11.1 (2/18)	37.5 (3/8)	21.2 (21/99)
Totals	16.4 (19/116)	20.4 (37/181)	22.9 (35/153)	40.3 (25/62)	24.2 (116/512)

Age standardized	> 30	30+
Brake work	21.2 ± 3.6	25.3 ± 3.5

Table 18

Percentage of abnormal X-rays according to the frequency of brake work, by age

Frequency of brake work	Age: <40	40-49	50-59	60-69	70+	Totals	Age standardized percentage[1]
Any brake work	11.1 (6/54)	17.8 (19/107)	4.5 (38/155)	36.5 (31/85)	40.0 (2/5)	23.6 (96/406)	24.5
Daily	13.0 (3/23)	13.5 (7/52)	23.3 (14/60)	35.7 (15/42)	33.3 (1/3)	22.2 (40/180)	23.0
1-4 times weekly	12.0 (3/25)	25.0 (11/44)	23.1 (18/78)	39.4 (10/34)	0.0 (0/1)	23.1 (42/182)	22.8
Less than weekly	0.0 (0/6)	9.1 (1/11)	35.3 (6/17)	66.7 (6/9)	100 (1/1)	31.8 (14/44)	34.2
No brake work	25.0 (2/8)	0.0 (0/11)	25.6 (9/37)	22.9 (8/35)	0.0 (0/7)	21.2 (21/99)	18.6
Total	12.9 (8/62)	16.1 (19/118)	24.9 (47/192)	32.5 (39/120)	33.3 (4/12)	23.0 (117/505)	23.4

[1] Standardized to the age distribution of all 983 individuals for whom readable X-rays were available.

Among those members of Local 259 of the UAW who were examined, 27 had been examined previously (Lorimer, 1976). Table 19 shows the comparison of the two sets of readings for these individuals. Of the 27 pairs of X-rays read, ten received identical readings. The 1979/1980 reading was one subcategory higher than that of 1974 in seven; in six it was one subcategory less. One reading was two subcategories higher in 1979-80 and three were two subcategories lower. Thus the overall readings were very similar between the two periods of time and there was no evidence for any progression of fibrosis among the small group of individuals examined in two periods of time.

Auto body repair and undercoating work

The highest percentage of X-ray abnormalities in any group observed in this study was among men employed in auto body shops for varying periods of time (38.6% versus 24.5% for brake workers and 18.6% for garage workers who did no brake work). While relatively few men were in the category, the percentage of abnormalities was significantly higher than garage workers who did no brake repair ($P<0.05$, one-sided). The average time of employment of the group in body shops was 13.3 years. Of those employed more than 20 years, 5 of 7 (71%) had abnormal X-rays.

In past years asbestos was commonly used as a reinforcing agent in plastic auto body fillers used for dent patching. Extensive dust exposure was common as the material was sanded smooth. The extent of asbestos exposure is unknown because no fiber counts are available from such operations. Fortunately, with the increased awareness of asbestos hazards and with the introduction of the occupational asbestos standard, most manufacturers removed asbestos from their formulations. In a current (1981) analysis of six compounds used in shops employing UAW 259 members, no asbestos was identified. However, while current asbestos risks no longer exist in these shops (at least to our knowledge), persons exposed previously should be made aware of their asbestos exposure, the risk associated with it, the synergistic effect of cigarette smoking, and the desirability of appropriate medical surveillance.

Table 19

Comparison of X-ray readings
of garage employees 1974-1979/80

1974 reading	1979/1980 Reading 0/1	0/1	1/0	1/1	1/2
0/0	6	2	0	0	0
0/1	5	4	4	1	0
1/0	0	0	0	0	0
1/1	0	3	0	0	1
1/2	0	0	0	1	0

Automobile undercoating materials also contained asbestos as a reinforcement fiber and disease had been suggested in individuals engaged principally in undercoating work. Thirteen men were identified in this study with significant periods of undercoating work. Of the group three had abnormal X-rays, but two of the three also work in body shops. Thus, we have insufficient data to evaluate a risk from this activity in this population. Parenthetically, numerous other men reported having occasionally (one to two times per year) applied undercoating materials. These individuals were not segregated in any analysis. In all cases where undercoating was done, ready-mixed compounds were utilized. It would be expected that the spraying of such material would not lead to the release of high concentrations of resirable asbestos fibers. However, the grinding underfoot of dry, over-sprayed material on shop floors could release the encapsulated fibers.

Effect of previous shipyard employment

Of the 983 individuals with readable X-rays, 87 had been previously employed for some period of time in a shipyard, generally during World War II. Overall, 39.1% of the X-rays of this group were abnormal. On an age standardized basis, 28.6% were abnormal compared to 20.5% for all groups unexposed to asbestos (control group, garage workers with no brake or body work exposure, and those exposed only to other dusts). Because of the relatively small number of cases, the difference between these percentages is not significant at $P<0.05$ level. Tables 20 and 21 show the number and percentages of abnormal X-rays according to years of shipyard employment and time since onset of shipyard work. To the extent possible, age standardized percentages have been calculated for each exposure category although, with the small numbers in a given time cell, the procedure has large statistical uncertainties. The average time of employment of all 87 individuals in shipyard work was five years. As few (15) worked longer than ten years, the data in Table 20 on the trend according to shipyard employment are unstable because of the small numbers in longer term employment categories. In Table 21 however, a significant trend with years since onset of shipyard employment is seen. On an age standardized basis, 37.9% of those with more

Table 20

Number and percentage of X-ray abnormalities according to years of shipyard employment

Parenchymal reading	Years of shipyard employment 0-4.9	5-9.9.	10-14.9	15-19.9	Totals
			Normal pleura		
0	31	14	4	4	53
1	3	4	0	2	9
2	1	0	0	0	1
			Abnormal pleura		
0	7	1	4	1	13
1	8	2	0	0	10
2	1	0	0	0	1
Any abnormality	20 39.2%	7 33.3%	4 50.0%	3 42.9%	34 39.1%
Age standardized percentage of abnormality	27.2%	24.7%	45.5%	37.1%	28.6%

Table 21

The number and percentage of X-ray abnormalities according to years from onset of shipyard employment

Parenchymal abnormality	Years since onset of employment < 10	10-19.9	20-29.9	30-39.9	40+	Totals
			Normal pleura			
0	3	3	12	33	2	53
1	0	0	2	7	0	9
2	0	0	0	1	0	1
			Abnormal pleura			
0	0	0	2	9	2	13
1	0	0	0	9	1	10
2	0	0	0	1	0	1
Any abnormality	0 0.0%	0 0.0%	4 25.0%	27 45.0%	3 60.0%	34 39.1%
Age standardized percentage of abnormality	-	-	19.2%	36.6%	47.6% 37.9%*	28.6%

* Age standardized percentage of those 30 or more years from onset of shipyard employment.

than 30 years from onset of shipyard employment had abnormal X-rays. This percentage is different from that of unexposed individuals at a $P<0.02$ (two-sided) level of significance.

It is possible to compare the results of the prevalence of abnormal X-rays among different shipyard populations, 30 years or more from onset of employment. The finding here of 17% more X-ray abnormalities compared to controls among former shipyard workers, employed for an average of five years, is in agreement with studies of the effects of long-term shipyard employment. In a study of ship repair workers, employed for more than 20 years, 87% of the X-rays of those 30 or more years from onset of employment were abnormal (Selikoff, Nicholson, and Lilis, 1980). The percentages of abnormal X-rays in the two groups are approximately in the ratio of the periods of employment.

Evidence of malignancy

In any X-ray screening of a population of this size, it would not be unexpected that a chest malignancy would be identified. Such was the case with one individual in this study. He was referred to the chest service at Mount Sinai Hospital for follow-up diagnosis. His bronchogenic carcinoma was not operable, and while alive two years later, was in poor condition. Parenthetically, at examination his CEA level was 1.3 nanogram/ml and his sputum analysis showed moderate atypia, but no malignant cells present.

PULMONARY FUNCTION TESTS

Principal spirometric tests

Tables 22, 23, 24 and 25 show the mean values of forced vital capacity as a percent of that predicted (100 x FVC/PFVC), the forced expiratory volume in 1 second as a percent of forced vital capacity (100 x FEV_1/FVC), the forced expiratory volume in 1 second as a percent of that predicted (100 x FEV_1/$PFEV_1$), and the maximal midexpiratory flow between 25% and 75% of forced vital capacity as a percent of that pre-

Table 22

Forced vital capacity as a percent of that predicted (FVC/PFVC) according to job category and smoking history

Type of work	Smoking History: Current smokers	Ex-smokers	Non-smokers	Smoking standardized[1]
No stated asbestos exposure or garage work	94.1±1.8 (45)	94.7±1.9 (47)	99.2±2.6 (25)	95.7±1.2
Garage employment with no brake or body work	86.0±2.6 (36)	92.1±2.4 (42)	96.4±2.6 (29)	91.3±1.5
Garage employment including brake work	93.6±1.2 (128)	98.5±1.2 (181)	98.2±1.4 (118)	96.9±0.7
Garage employment including body work	93.0±2.8 (12)	92.8±4.6 (15)	92.9±4.5 (5)	92.9±2.4
All identified and possible asbestos exposure	94.0±2.0 (63)	94.7±1.5 (83)	100.8±2.2 (53)	96.1±1.1
Possible asbestos exposure	94.9±3.3 (24)	94.7±2.2 (26)	99.8±2.7 (18)	96.1±1.6
Shipyard, heating trades	93.0±2.7 (37)	94.3±2.0 (56)	101.5±3.2 (33)	95.8±1.5
Direct asbestos exposure (insulation, factory work)	101.6±3.4 (2)	118.9 (1)	98.4±19.1 (2)	*

± = standard error of the mean
( ) = number of individuals in category
* = Too few in category to be meaningful

[1] Standardized to the smoking distribution of all with valid pulmonary function test. (Smokers, 31.6%; Ex-smokers, 42.4%; Non-smokers, 26.0%)

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e, a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories higher in the table, such as brake work.

Table 23

Forced expiratory volume in one second as a percent of forced vital capacity (100 x FEV_1/FVC) according to job category and smoking history

Type of work	Smoking history: Current smokers	Ex-smokers	Non-smokers	Smoking standardized[1]
No stated asbestos exposure or garage work	76.5±1.4 (45)	77.3±1.7 (47)	80.1±1.2 (25)	77.8±0.9
Garage employment with no brake or body work	75.6±1.3 (36)	74.7±1.7 (43)	76.3±1.9 (29)	74.9±1.0
Garage employment including brake work	75.7±0.8 (128)	79.0±0.6 (182)	80.6±0.6 (118)	78.4±0.4
Garage employment including body work	74.5±3.3 (12)	74.7±2.5 (15)	79.0±4.9 (5)	75.7±1.9
All identified and possible asbestos exposure	74.3±1.1 (61)	76.2±0.9 (83)	78.4±1.0 (52)	76.2±0.6
Possible asbestos exposure	75.4±1.9 (24)	75.5±1.7 (26)	76.4±1.6 (18)	75.7±1.0
Shipyard, heating trades	73.7±1.4 (35)	76.4±1.1 (56)	79.9±1.2 (32)	76.4±0.7
Direct asbestos exposure (insulation, factory work)	72.4±5.6 (2)	81.6 (1)	72.7±12.8 (2)	*

± = standard error of the mean
( ) = number of individuals in category
* = Too few in category to be meaningful

[1] Standardized to the smoking distribution of all with valid pulmonary function test. (Smokers, 31.6%; Ex-smokers, 42.4%; Non-smokers, 26.0%)

The categorization of work activity is such that an individual in a given category would have no gory would have no exposure of a category lower in the table, i.e., a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories higher in the table, such as brake work.

Table 24

Forced expiration volume in one second as a percent of that predicted ($FEV_1/PFEV_1$) according to job category and smoking history

Type of work	Smoking history: Current smokers	Ex-smokers	Non-smokers	Smoking standardized[1]
No stated asbestos exposure or garage work	98.1±2.2 (45)	101.3±2.7 (47)	110.1±3.1 (25)	102.6±1.6
Garage employment with no brake work	91.8±2.9 (36)	97.6±3.3 (42)	104.5±3.2 (29)	97.6±1.9
Garage employment including brake work	97.9±1.4 (128)	108.0±1.3 (181)	109.6±1.5 (118)	105.2±0.8
Garage employment including body work	95.9±5.5 (12)	96.9±5.5 (15)	100.6±6.5 (5)	97.6±3.4
All identified and possible asbestos exposure	97.6±2.4 (61)	101.8±2.0 (83)	110.4±2.5 (52)	102.8±1.3
Possible asbestos exposure	98.8±4.0 (24)	99.3±3.1 (26)	107.8±3.7 (18)	101.7±2.0
Shipyard, heating trades	96.7±3.2 (35)	102.4±2.6 (56)	112.5±3.5 (32)	103.1±1.8
Direct asbestos exposure (insulation, factory work)	100.2±10.0 (2)	135.1 (1)	101.3±5.1 (2)	*

± = standard error of the mean
( ) = number of individuals in category
* = Too few in the category to be meaningful

[1] Standardized to the smoking distribution of all with valid pulmonary function test. (Smokers, 31.6%; Ex-smokers, 42.4%; Non-smokers, 26.0%)

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e., a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories higher in the table, such as brake work.

Table 25

The forced expiratory flow between 25% and 75% of forced vital capacity as a percent of that predicted (100 x MMF/PMMF) according to job category and smoking history

Type of work	Smoking History			
	Current smokers	Ex-smokers	Non-smokers	Smoking standardized[1]
No stated asbestos exposure or garage work	83.6± 5.5 (39)	92.3± 5.8 (42)	113.8± 6.5 (19)	95.1±3.5
Garage employment with no brake or body work	78.0± 5.9 (30)	78.3± 6.3 (32)	86.9± 6.3 (24)	80.5±3.6
Garage employment including brake work	78.9± 2.9 (110)	98.4± 2.6 (149)	103.5± 2.6 (90)	93.6±1.6
Garage employment including body work	82.3± 9.7 (11)	71.3±9.4 (11)	91.3±27.9 (4)	80.0±8.8
All identified and possible asbestos exposure	76.2± 4.1 (58)	89.2± 4.8 (65)	104.2± 5.6 (36)	89.0±2.8
Possible asbestos exposure	81.5± 7.1 (23)	82.6± 8.6 (23)	101.1±11.5 (12)	87.0±5.2
Shipyard, heating trades	72.8± 5.3 (33)	92.8± 5.7 (42)	104.9± 6.5 (23)	89.6±3.4
Direct asbestos exposure (insulation, factory work)	70.4±26.9 (2)		123.3 (1)	

± = standard error of the mean
( ) = number of individuals in category
* = Too few in category to be meaningful

[1] Standardized to the smoking distribution of all with valid pulmonary function test. (Smokers, 31.6%; Ex-smokers, 42.4%; Non-smokers, 26.0%)

The categorization of work activity is such that an individual in a given category would have no exposure of a category lower in the table, i.e, a person classified as a brake worker would not have other exposure to asbestos or other dusts. On the other hand, categories low in the table, shipyard workers, e.g., could also have exposure to asbestos in categories higher in the table, such as brake work.

dicted (100 x MMF/PMMF) according to job category and smoking history. The prediction equations used were those of Miller et al. (1980) (See Table 3). The distribution of these parameters is shown in Tables 26, 27, 28, 29. With the exception of auto body workers and garage workers who do not work with brakes, there are no differences between the means or in the distributions of the three principal spirometric test results (FVC/PFVC, $FEV_1/PFEV_1$, FEV_1/FVC) for all other groups of workers, including those with possible past exposure to asbestos. While there are some differences between the various job categories in smoking category subgroups, these are largely the result of statistical variations. The more stable, smoking standardized data, show virtually identical results for the unexposed control population, brake workers and individuals exposed, or possibly exposed, to asbestos. These data are shown in Table 30. This might be anticipated as only marginal differences were seen in the percentage of X-ray abnormalities among individuals in different work categories. As forced vital capacity is usually a less sensitive determination of asbestos-related changes than the presence of X-ray abnormalities and forced expiratory volume in one second relates to exposures other than asbestos, the absence of a definite trend among the groups with varying asbestos exposure is not unexpected (see section on measures of small airway disease for a discussion of MMF/PMMF).

Measures of small airway disease

As was seen in Tables 22-24, with the exception of non-mechanic garage workers and those men engaged in auto body work, no differences existed in the means of the spirometric test results between the three major occupational groups studied, those unexposed to asbestos or to garage work, those engaged in brake work, and those with a probable asbestos exposure. However, in the case of MMF/PMMF (Table 25) individuals with an identified asbestos exposure had a lower smoking standardized mean compared to those in the other two categories although not at a $P<0.05$ level of significance. The unexposed control group had the highest mean values, followed closely by mechanics engaged in brake work. Those with identified and possible exposure to asbestos had interme-

Table 26

The distribution of forced vital capacity
as a percentage of that predicted (100 x FVC/PFVC)
by job category and smoking history

Job category	100 x FVC/FVCP <60	60-79.9	80-99.9	100+
Smokers				
No identified asbestos exposure or garage work	0 (0.0)	5 (11.1)	29 (64.4)	11 (24.4)
Garage employment but no brake work	2 (5.6)	7 (19.4)	23 (63.9)	4 (11.1)
Brake work	1 (0.8)	20 (15.6)	67 (52.3)	40 (31.3)
Body work	0 (0.0)	0 (0.0)	11 (91.7)	1 (8.3)
Ex-smokers				
No identified asbestos exposure or garage work	0 (0.0)	4 (8.5)	27 (57.5)	16 (34.0)
Garage employment but no brake work	2 (6.7)	9 (20.9)	16 (37.2)	16 (37.2)
Brake work	2 (1.1)	21 (11.5)	75 (41.2)	84 (46.2)
Body work	1 (6.7)	1 (6.7)	10 (66.7)	3 (20.0)
Nonsmokers				
No identified asbestos exposure or garage work	0 (0.0)	3 (12.0)	11 (44.0)	11 (44.0)
Garage employment but no brake work	0 (0.0)	4 (13.8)	16 (55.2)	9 (31.0)
Brake work	2 (1.7)	7 (5.9)	59 (50.0)	50 (42.4)
Body work	0 (0.0)	0 (0.0)	4 (80.0)	1 (20.0)

( ) = Percentage

Table 27

The distribution of forced expiratory volume in one second as a percentage of forced vital capacity (100 x FEV_1/FVC) according to job category and smoking history

Job category	100 x FEV_1/FVC <55	55-64.9	65-74.9	75-84.9	85+
Smokers					
No identified asbestos exposure or garage work	0 (0.0)	7 (15.6)	12 (26.7)	17 (37.8)	9 (20.0)
Garage employment but no brake work	0 (0.0)	4 (11.1)	10 (27.8)	18 (50.0)	4 (11.1)
Brake work	4 (3.1)	11 (8.6)	42 (32.8)	53 (41.4)	18 (14.1)
Body work	1 (8.3)	0 (0.0)	3 (25.0)	8 (66.7)	0 (0.0)
Ex-Smokers					
No identified asbestos exposure or garage work	3 (6.4)	3 (6.4)	8 (17.0)	23 (48.9)	10 (21.3)
Garage employment but no brake work	3 (7.0)	2 (4.7)	14 (32.6)	18 (41.9)	6 (14.0)
Brake work	1 (0.6)	9 (5.0)	35 (29.2)	99 (54.4)	38 (20.9)
Body work	1 (6.7)	0 (0.0)	6 (40.0)	6 (40.0)	2 (13.3)
Nonsmokers					
No identified asbestos exposure or garage work	0 (0.0)	1 (4.0)	2 (8.0)	19 (76.0)	3 (12.0)
Garage employment but no brake work	2 (6.9)	2 (6.9)	5 (17.2)	15 (51.7)	5 (17.2)
Brake work	0 (0.0)	0 (0.0)	26 (22.0)	64 (54.2)	28 (23.7)
Body work	0 (0.0)	1 (20.0)	0 (0.0)	3 (60.0)	1 (20.0)

( ) = percentage.

Table 28

The distribution of forced expiratory volume in one second to that predicted ($100 \times FEV_1/PFEV_1$) by job category and smoking history

Job category	$100 \times FEV_1/PFEV_1$ <60	60-79.9	80-99.9	100+
Smokers				
No identified asbestos exposure or garage work	0 (0.0)	5 (11.1)	19 (42.2)	21 (46.7)
Garage employment but no brake work	1 (2.8)	6 (16.7)	20 (55.6)	9 (25.0)
Brake work	2 (1.6)	14 (8.6)	57 (44.5)	58 (45.3)
Body work	1 (8.3)	0 (0.0)	7 (58.3)	4 (33.3)
Ex-smokers				
No identified asbestos exposure or garage work	2 (4.3)	2 (4.3)	15 (31.9)	28 (59.6)
Garage employment but no brake work	4 (9.3)	3 (7.0)	17 (9.5)	19 (44.2)
Brake work	2 (1.1)	9 (5.0)	41 (22.5)	130 (71.4)
Body work	1 (6.7)	1 (6.7)	6 (40.0)	7 (46.7)
Nonsmokers				
No identified asbestos exposure or garage work	0 (0.0)	0 (0.0)	7 (28.0)	18 (72.0)
Garage employment but no brake work	1 (3.5)	1 (3.5)	9 (31.0)	18 (62.1)
Brake work	1 (0.9)	4 (3.4)	29 (24.6)	84 (71.2)
Body work	0 (0.0)	0 (0.0)	3 (60.0)	2 (40.0)

( ) = percentage

Table 29

The distribution of forced expiratory flow between 25% and 75% of forced vital capacity as a percent of that predicted (100 x MMF/PMMF) according to job category and smoking history

Job category	100 x MMF/PMMF <60	60-74.9	75-89.9	90-104.9	105+
Smokers					
No identified asbestos exposure or garage work	10 (25.6)	9 (23.1)	3 (7.7)	5 (12.8)	12 (30.8)
Garage employment but no brake work	9 (30.0)	9 (30.0)	4 (13.3)	3 (10.0)	5 (16.7)
Brake work	37 (33.6)	16 (14.6)	19 (17.3)	14 (12.7)	24 (21.8)
Body work	2 (18.2)	3 (27.3)	2 (18.2)	1 (9.1)	3 (27.2)
Ex-Smokers					
No identified asbestos exposure or garage work	7 (16.7)	5 (11.9)	7 (16.7)	5 (11.9)	18 (42.9)
Garage employment but no brake work	12 (36.4)	5 (15.2)	5 (15.2)	3 (9.1)	8 (24.2)
Brake work	14 (9.3)	17 (11.3)	33 (22.0)	31 (20.7)	51 (36.7)
Body work	4 (36.4)	1 (9.1)	5 (45.5)	0 (0.0)	1 (9.1)
Nonsmokers					
No identified asbestos exposure or garage work	0 (0.0)	3 (15.8)	1 (5.3)	1 (5.3)	14 (73.7)
Garage employment but no brake work	3 (12.5)	5 (20.8)	5 (20.8)	6 (25.0)	5 (20.8)
Brake work	1 (1.1)	11 (12.2)	16 (17.8)	21 (23.3)	41 (45.6)
Body work	1 (25.0)	1 (25.0)	1 (25.0)	0 (0.0)	1 (25.0)

( ) = percentage.

Table 30

Smoking standardized[1] means and percentages of abnormal pulmonary function tests by job category

Job category	Mean value	Percent abnormal[2]
	$100 \times FVC/PFVC$	
No identified asbestos exposure or garage work	95.7 ± 1.2	10.2 ± 2.9
Garage employment but no brake work	91.3 ± 1.5	23.2 ± 4.7
Brake work	96.9 ± 0.7	10.9 ± 1.6
Body work	92.9 ± 2.4	5.7 ± 4.0
Definite and possible asbestos exposure	96.1 ± 1.1	13.1 ± 2.6
	$100 \times FEV_1/PFEV_1$	
No identified asbestos exposure or garage work	102.6 ± 1.6	7.2 ± 3.2
Garage employment but no brake work	97.6 ± 1.9	14.9 ± 4.9
Brake work	105.2 ± 0.8	7.1 ± 1.3
Body work	97.6 ± 3.4	8.3 ± 4.8
Definite and possible asbestos exposure	102.8 ± 1.3	8.7 ± 2.1
	$100 \times MMF/PMMF$	
No identified asbestos exposure or garage work	95.1 ± 3.5	31.6 ± 5.4
Garage employment but no brake work	80.5 ± 3.6	49.5 ± 7.5
Brake work	93.6 ± 1.6	27.5 ± 2.8
Body work	80.0 ± 8.8	46.6 ± 13.5
Definite and possible asbestos exposure	89.0 ± 2.8	43.9 ± 5.2

1 Standardized to the smoking distribution of all with valid pulmonary function test. (Smokers, 31.6%; Ex-smokers, 42.4%; Non-smokers, 26.0%).

2 Abnormal is less than 80 for $100 \times FVC/PFVC$ and $100 \times FEV_1/PFEV_1$ and less than 75 for $100 \times MMF/PMMF$

diate values and those non-mechanic garage workers the lowest values. The difference between the mechanic and non-mechanic garage workers is significant at the $P<0.001$ (two-sided) level. (See section on possible health effects of non-mechanic garage employment.) The same difference was seen in auto body repair workers, but, because of the smaller number of individuals, it did not achieve significance at the 0.05 level ($P=0.12$).

Possible effects from non-mechanic garage employment

For the principal three spirometric tests, as well as for MMF/ PMMF, individuals with garage employment, but who did not engage in brake maintenance work, had significantly lower means and a greater percentage of abnormal pulmonary function results than either controls, brake workers, or those with possible exposure to asbestos otherwise. We investigated whether this may be the result of the greater percentage of blacks and Hispanics employed in this category compared to other job activities, coupled with improper pulmonary function standards for these groups. Table 31 shows the percentage of individuals in the various job categories according to their race. As can be seen, among those with garage employment, but no brake work, more than 40% were black or Hispanic compared to 28% of those with no identified asbestos exposure and 16% of those who worked in brake maintenance and repair. To the extent possible, we took into account the known differences between black and white populations in the predicted standards for forced vital capacity and forced expiratory volume in one second (black normals were 89% of those of whites). For MMF the same prediction parameters were used for blacks and whites as there appears little racial difference in flow rates (Schoenberg et al., 1978). However, data on these standards are relatively limited and they may not be fully accurate. For Hispanics we used the same criteria as for whites. Table 32 shows the overall spirometric data according to race. As can be seen, the means for FVC/PFVC and $FEV_1/PFEV_1$ for the black population are generally lower than the white population in all smoking categories. [The smoking standardized difference is significant at the $P<0.01$ level (two-sided) for FVC/PFVC.] On the other hand, the data for the Hispanic

Table 31

The distribution and percentages by race according to the work activity of study participants who had valid pulmonary function tests

	Race		
Type of work activity	White	Black	Hispanic
No identified asbestos exposure or garage work	89 (76.1)	19 (16.2)	9 (7.7)
Garage employment but no brake work	63 (58.9)	40 (37.4)	4 (3.7)
Brake work	356 (83.4)	56 (13.1)	15 (3.5)
Body work	24 (75.0)	6 (18.7)	2 (6.3)
Identified and possible asbestos exposure	177 (88.9)	19 (9.5)	3 (1.5)
Totals	709 (86.3)	140 (17.0)	33 (4.0)

Table 32

The means of spirometric tests by race

Race	Current smokers	Ex-smokers	Nonsmokers	Smoking standardized[2]
		Smoking history		
		100 x FVC/PFVC		
White	93.0±0.9 (222)	97.4±0.9 (300)	99.6±1.0 (187)	96.6±0.5
Black[1]	91.2±2.3 (53)	89.9±1.9 (51)	96.5±3.0 (36)	92.0±1.4
Hispanic	96.9±3.4 (9)	94.4±2.8 (17)	81.6±5.6 (7)	91.9±2.2
		100 x $FEV_1/PFEV_1$		
White	96.2±1.1 (220)	104.9±1.1 (300)	110.0±1.2 (186)	103.5±0.7
Black[1]	98.4±2.8 (53)	100.4±2.2 (51)	106.8±3.6 (36)	101.4±1.6
Hispanic	105.0±5.3 (9)	101.7±4.7 (17)	95.3±5.9 (7)	101.1±3.0
		100 x MMF/PMMF		
White	77.5±2.2 (197)	92.7±2.3 (248)	102.9±2.5 (144)	90.6±1.4
Black	83.5±4.9 (44)	89.8±4.7 (40)	95.5±6.1 (24)	89.3±3.0
Hispanic	95.9±14.1(7)	94.1±9.3(11)	113.3±6.4 (5)	99.7±6.2

[1] PFVC and $PFEV_1$ for blacks were 0.89 that for whites.

[2] Standardized to the smoking distribution of all with valid pulmonary function tests. (Smokers, 31.6%; Ex-smokers, 42.4%; Nonsmokers, 26.0%.)

population is similar to that of whites with the exception of the nonsmoking group, which is comprised of only six individuals. Thus, the use of the same prediction function for Hispanics as for whites would appear to be a correct procedure but the prediction correction for blacks remains in question.

Table 33 depicts the means of FVC/PFVC and $FEV_1/PFEV_1$ for blacks and whites by smoking history and job category and Table 34, the smoking standardized means by race and job category. (Too few Hispanics were available for this analysis.) As can be seen, the deficits for those categorized as garage employees, but who do no brake repair or maintenance work, exist for both racial groups. However, it is particularly notable for the blacks where the means of PVC/PFVC and $FEV_1/PFEV_1$ for non-brake garage workers are 10% lower than for blacks employed in other jobs. The pulmonary function deficits in this group largely account for the lower values seen for blacks overall in Table 32 and suggest that proper normal spirometry parameters were used.

The origin of these deficits is not clear. The group is largely comprised of "car jockeys," auto polishers, and new car preparation men. (There was considerable movement of individuals among these jobs and often a person would do all three.) They are employed in the same facilities as the brake workers. Also included are a small group of skilled mechanics who would perform difficult mechanical or electrical repairs, parts department personnel, and a few men in DC 37 who were dispatchers working out of the repair area. Table 35 lists the spirometric data for the three groups in commercial garages, compared to those engaged in brake work, those exposed to asbestos otherwise, or the unexposed control group. As can be seen, the deficits are associated with the group working as car jockeys or car preparation men and those employed in auto body shops. The differences in the smoking standardized means for FVC/PFVC and $FEV_1/PFEV_1$, between the car jockey-vehicle preparation men and mechanics (including those who do brake work) are significant at $P<0.01$ (two-sided).

Table 33

Smoking standardized means of spirometric tests according to race and job category

Type of work activity	Means		
	100 x FVC/PFVC	100 x $FEV_1/PFEV_1$	100 x MMF/PMMF
		Whites	
No identified asbestos exposure or garage work	96.2±1.3	102.9±1.7	94.7±3.7
Garage employment but no brake work	94.2±1.7	98.9±2.6	78.5±4.6
Brake work	97.5±0.8	105.1±0.9	93.0±1.8
Body work	94.3±3.1	99.0±4.0	83.5±11.6
		Blacks	
No identified asbestos exposure or garage work	95.6±2.3	103.7±3.7	88.5±10.4
Garage employment but no brake work	86.2±2.5	95.2±3.1	83.5±7.1
Brake work	95.0±2.0	106.0±2.3	93.9±3.6
Body work	87.4±4.5	90.1±6.1	66.1±12.9

Table 34

Pulmonary function results of garage workers who do not repair brakes according to work activity and smoking history

Pulmonary function parameter	Current Smoker	Ex-smokers	Non-smokers
	Mechanical Work/Parts Department		
FVC/PFVC	88.8± 3.4(6)	105.3± 1.4(4)	95.2±4.4(7)
$FEV_1/PFEV_1$	98.8± 4.3(6)	110.7± 6.5(4)	100.1±6.2(7)
MMF/PMMF	106.1±14.7(6)	80.7± 7.5(4)	89.0±12.1(7)
	Auto body repair work		
FVC/PFVC	93.0± 2.8(12)	92.8±4.6(15)	92.9± 4.5(5)
$FEV_1/PFEV_1$	95.9± 5.5(12)	96.9±5.5(15)	100.6± 6.5(5)
MMF/PMMF	82.3± 8.8(11)	71.4±9.4(11)	91.3±27.9(4)
	New vehicle preparation-car jockey-car polisher		
FVC/PFVC	83.6± 4.7(15)	88.5± 3.1(21)	96.9± 6.6(8)
$FEV_1/PFEV_1$	87.0± 5.2(15)	93.7± 4.0(21)	108.3± 6.9(8)
MMF/PMMF	76.2±10.6(12)	81.0± 8.2(16)	94.2±15.3(5)

Table 35

Smoking standardized[1] pulmonary function results of garage workers who do not repair brakes compared to other groups

Job category	FVC/PFVC	$FEF_1/PFEV_1$	MMF/PMMF
No identified asbestos exposure or garage work	102.6±1.6	102.6±1.6	95.1±3.5
Brake work	96.9±0.7	105.2±0.8	93.6±1.6
Parts department	97.5±1.7	104.2±3.5	90.9±6.4
Body work	92.9±2.4	97.6±3.4	80.0±8.8
Vehicle preparation car jockeys, car polishers	89.1±2.6	95.4±3.0	82.9±6.3
Definite and possible asbestos exposure	96.1±1.1	102.8±1.3	89.0±2.8

[1]Standardized to the smoking distribution of all with valid pulmonary function test. (Smokers, 31.6%; Ex-smokers, 42.4%; Non-smokers, 26.0%.)

To the extent that occupational factors may be associated with these deficits, the possibility exists that greater exposure to automobile exhaust among individuals in this group has contributed to these findings. A greater exposure could arise if the mechanics generally worked on cars with engines off or, if on, with exhaust hoses attached. That auto exhaust may be contributory is suggested by the data of Ayers et al. (1973) who have observed significant pulmonary deficits among bridge and tunnel workers who are heavily exposed to automobile exhaust during the course of their work in the bridges and tunnels in and around New York City. There, deficits in forced vital capacity of 9% for nonsmokers and 13% for smokers, compared to a normal population (smoking not specified) were seen. Greater deficits were seen for various measures of airway flow. The association of automobile exhaust with the deficits in pulmonary function among a limited group of garage workers is, of course, only suggestive. For a definitive association to be demonstrated, it is necessary that a detailed study be made of the work activities and the exposures of this group of workers in order to determine if they do have significantly more exposure to auto exhaust than do garage mechanics.

Auto body repair

Workers who were engaged in auto body repair had mean values for the various spirometric tests that were considerably lower than those of garage mechanics, unexposed controls and even the groups exposed to asbestos otherwise. Because of the few individuals in this group, the differences between the auto body workers and garage mechanics only achieve two-sided statistical significance for $FEV_1/PFEV_1$. In addition to asbestos and other dusts, which could primarily affect FVC, the auto body shop workers are exposed to solvents from paints and fillers, and welding fumes. The manifestations of disease seen in both the X-rays and the pulmonary function tests in the limited populations observed in this study warrant further definiation. Similarly, an industrial hygiene survey of the materials to which auto body repairmen are exposed is also necessary.

Correlations between X-ray abnormalities and pulmonary function tests

Table 36 lists three pulmonary function results according to the X-ray reading of the individuals. Two criteria were utilized for X-ray abnormality, a 1/0 or greater parenchymal reading and/or any pleural change, including the presence of diaphragmatic plaques, and a 1/1 or greater parenchymal reading and/or pleural thickening or calcification. (The presence only of a diaphramatic plaque was not considered abnormal in the latter criterion.) The results show that in general those with abnormal X-rays have lower pulmonary function than those with normal X-rays. This is evident for smokers and ex-smokers. The pulmonary function means for the nonsmokers, however, are the same for those with abnormal X-rays as for those with normal X-rays. This is to be expected as minimal asbestos effects can be seen on X-ray before significant deficits in FVC occur. However, even minimal asbestos effects can be exacerbated by smoking, leading to the deficits seen in Table 36. The data of Table 36 are consistent with the previous discussed data suggesting a greater percentage of X-ray abnormalities among current and previous smokers compared to nonsmokers. Also, as expected, the pulmonary deficits in those with abnormal X-rays are greater when the criteria for abnormality is more stringent.

Comparisons with other populations

Table 37 provides a comparison between pulmonary function results measured in this study and those determined in a study of the general population of Michigan (Miller et al., 1980). For this comparison, the non-mechanic garage workers are excluded because of factors that may be unique to that group. The studies overlapped considerably in time and the same technical personnel were used in each. (The field dates for the Michigan survey were February 1978 through December 1979 and for this study, May 1978 through February 1980.) The purpose of the Michigan survey was to measure levels of polybrominated biphenyls in blood and adipose tissue and to evaluate other health indicators. The group was chosen by a random selection process using Michigan phone numbers. Predicted values utilized the regression equations for the data of

Table 36

The means of spirometric values according to X-ray reading and smoking history using two criteria for X-ray abnormality

Spirometric parameter (x 100)	X-ray reading			
	Normal	Abnormal	Normal	Abnormal
	(1/0, Pl.Th. or Pqs.)		(1/1 or Pl.Th)	
Smokers				
FVC/PFVC	92.7±1.1 (176)	91.6±1.6 (84)	94.0±1.0 (213)	89.2±2.3 (43)
$FEV_1/PFEV_1$	97.2±1.3 (175)	94.0±1.9 (83)	96.8±1.2 (212)	89.0±2.5 (42)
MMF/PMMF	80.3±2.6 (152)	76.1±3.8 (73)	80.7±2.3 (190)	69.5±5.2 (35)
Ex-smokers				
FVC/PFVC	97.2±0.9 (264)	92.4±1.9 (81)	98.1±0.9 (299)	90.1±2.7 (43)
$FEV_1/PFEV_1$	105.2±1.1 (264)	98.7±2.5 (81)	104.1±1.0 (299)	96.1±3.3 (43)
MMF/PMMF	92.4±2.3 (216)	89.4±4.8 (62)	91.6±2.3 (243)	91.3±6.0 (34)
Nonsmokers				
FVC/PFVC	98.5±1.2 (173)	98.3±1.6 (48)	99.8±1.1 (191)	99.2±2.3 (24)
$FEV_1/PFEV_1$	108.8±1.4 (172)	110.2±1.9 (48)	108.5±1.2 (190)	108.6±2.5 (24)
MMF/PMMF	101.0±2.5 (127)	105.3±4.9 (37)	101.9±2.4 (144)	107.6±7.1 (17)

( ) = Number in category

Table 37

A comparison of spirometric results in this cohort with those observed in the general population of Michigan *

	Observation group: This study (excluding non-mechanic garage workers)		Observation group: Michigan general population
Smoking history	Blacks	Whites	Whites
	100 x FVC/PFVC		
Smokers	96.5±2.4	94.3±1.0	94.7
Ex-smokers	93.7±2.3	98.6±0.9	97.3
Nonsmokers	98.2±3.7	101.1±1.1	99.2
	100 x $FEV_1/PFEV_1$		
Smokers	104.1±2.7	95.5±1.2	96.1
Ex-smokers	102.4±2.6	104.8±1.1	101.6
Nonsmokers	106.7±4.3	110.2±1.2	105.8
	100 x MMF/PMMF		
Smokers	90.2±5.2	76.5±2.4	80.5
Ex-smokers	90.8±5.5	95.5±2.3	88.2
Nonsmokers	98.9±6.0	106.6±2.6	97.6

* Predicted values were obtained from the data of Morris et al.

Morris et al., 1971). As can be seen, the data for the whites in this study compare very favorably with Michigan white males. (Had the non-mechanic garage workers been included, mean values from 1% to 2% lower would have been obtained (c.f. Table 30).

A variety of different research groups have produced regression equations for pulmonary function parameters on the basis of measurements on "normal" populations. The equations of Kory et al, 1961; Cherniak and Raber, 1972; and Morris, Koski, and Johnson, 1971, particularly, have gained widespread acceptance for comparative purposes. The populations utilized and the criteria for acceptable data are shown in Table 38 for these three studies along with five others that have also established regression equations for normal populations and this study. As can be seen, only two of these research groups included only nonsmokers in the study group. A third included individuals who smoked for less than six months and one included individuals who were ex-smokers of less than five-pack years of cigarettes. In some cases averages of best efforts were utilized; in others, values for all parameters were taken from the flow volume curve of the best effort as determined by forced vital capacity. Of most importance, a considerable diversity exists in the age distributions of the study populations selected. Values for FVC and FEV_1 increase until about age 25, then remain relatively unchanged until about age 35, and thereafter declining steadily with age. Because of this complexity, regression equations, based upon a wide range of ages and utilizing only a single linear term to account for age, can be significantly in error. The errors are such as to produce overestimates of pulmonary functions for young and older groups and underestimates for those in the middle years (see, e.g., Schoenberg et al., 1978). As the population in this study is largely between the ages of 40 and 70, most regression equations are likely to understate the values for these parameters. Additionally, lower predicted values will clearly be obtained from populations that include smokers or from studies that include averages of several expiratory efforts rather than the maximal ones. The use of standards from such populations can lead to underestimates of effect from agents in the workplace that can affect pulmonary function.

Table 38

<u>The criteria for spirometry in several studies of "normal" subjects</u>

	Number of individuals tested	Age range	Number of individuals age 30	Smoking habits included	Min. number of trials	Selection process	FEV_1 determination	Spirometer utilized
Morris et al	517 (507)	20-84	348	Non-smokers (no cigs ≥ 6mo)	2	Best effort	After 200 ml	Stead-Wells
Cherniak & Raber	870	15-79	336	Non-smokers	3	Max. values	Direct	Wedge
Knudson et al	128	25-79	95	Non-smokers	5	Best 2 of 5 Best of any flow	Direct	Pneumotachygraph corrected to Stead-Wells
Kory et al	468	18-66	335	Any	2	Best effort	After 200 ml	Collins
Higgens & Keller	1035	20-74	∿760	Any	2	Best effort	Direct	Wedge
Ferris et al	156	25-74	NA	Non-smokers Ex-smokers	5	Best 3 of 5	Direct	Collins
Bass	149	21-71+	125	Non-smokers (<5 pk-yrs)	2		Direct	Wedge
This study	163	26-70	160	Non-smokers	3	Best effort	Extrapolation	Rolling Seal

In this study valid pulmonary function tests exist for 163 nonsmokers in other than the non-mechanic garage group. The previous discussion has indicated their pulmonary function parameters (FVC, FEV_1 and MMF) compare favorably with the group studied by Morris, Koski and Johnson. It is instructive to utilize the regression equations from the above studies of normal populations to obtain other comparative data. The various regression equations utilized are shown in Table 39 and the percent ratios of observed to predicted spirometry parameters are listed in Table 43. As can be seen, the values obtained for FVC/PFVC and $FEV_1/PFEV_1$ are in excess of 1.00 for all regression equations. This is the result of the inclusion of smokers among comparative groups, the use of averages of several efforts, or the underprediction resulting from the broad age distributions utilized for the regression equations. High values of $FEV_1/PFEV_1$ result, in part, from an extrapolated origin of expiration (c.f. Table 39). The values for MMF/PMMF, FEF_{50}/-$PFEF_{50}$, and $FEF_{75}/PFEF_{75}$ are less than 1.00 for the prediction equations of Cherniak and Knudson. This is the result of their use of the maximum flow value obtained in any effort rather than the flow in the effort with maximum FVC. It is generally found that lower flow rates are obtained during the achievement of a maximal FVC. The Morris, Koski and Johnson equations would appear to give the best comparison for FVC_1 and MMF because a large proportion of their population was above age 30, only nonsmokers were studied, and the best effort was utilized. The very complicated equation of Schoenberg, which was developed to properly take account of age, is limited by the relatively few individuals over age 30 and the use of averages of efforts.

Regression equations for the various spirometric parameters obtained from data on the 163 white, nonsmokers tested in this survey are listed in Table 41. Because only three individuals were under age 30, only the linear dependence on age could be established.

PHYSICAL EXAMINATION RESULTS

Table 42 lists the number and percentage of abnormalities found on physical examination according to job category and organ system. The only

Table 39

The parameters in regression equations for the prediction of spirometric functions in nine studies

Study	x Ht. (in.)	x Age (yrs.)	Constant
	FVC		
Morris et al.	0.148	-0.025	-4.241
Miller et al.	0.147	-0.026	-4.053
Cherniak & Raber	0.12102	-0.01357	-3.18373
Knudson et al.	0.1651	-0.029	-5.459
Ferris et al.	0.11684	-0.027	-2.79
Kory et al.	0.13208	-0.022	-3.60
Bass	0.159	-0.023	-5.72
Higgens & Keller	0.15748	-0.024	-5.38
	FEV_1		
Morris et al.	0.092	-0.032	-1.260
Miller et al.	0.094	-0.032	-1.426
Cherniak & Raber	0.09107	-0.0232	-1.50723
Knudson & Keller	0.13208	-0.027	-4.203
Ferris et al.	0.07366	-0.028	-0.70
Kory et al.	0.09398	-0.028	-1.59
Higgens & Keller	0.11684	-0.028	-3.18
	MMF		
Morris et al.	0.047	-0.045	+2.513
Miller et al.	0.044	-0.046	+2.806
Cherniak & Raber	0.05948	-0.037	+2.61187
Knudson et al.	0.1143	-0.031	-1.864
Higgens & Keller	0.05588	-0.044	+1.89
	FEF_{50}		
Cherniak & Raber	0.06526	-0.03049	+2.40337
Knudson et al.	0.069	-0.015	-5.4
Higgens & Keller	0.0635	-0.037	+1.577
Michigan	0.10255	-0.0252	-1.1121
	FEF_{75}		
Cherniak & Raber	0.0903	-0.01987	+2.72554
Knudson et al.	0.044	-0.012	-4.143
Michigan	0.0497	-0.02895	0.03562

Table 40

The ratios of the means of observed to predicted values for spirometric parameters according to regression equations determined in ten studies

Study	FVC/PFVC (x100)	$FEV_1/PFEV_1$ (x100)	MMF/PMMF (x100)	$FEF_{50}/PFEF_{50}$ (x100)	$FEF_{75}/PFEF_{75}$ (x100)
Morris et al.	101.7 ± 1.1	110.0 ± 1.2	107.3 ± 2.6		
Miller et al.	100.2 ± 1.1	111.1 ± 1.2	106.0 ± 2.6		
Cherniak & Raber	105.3 ± 1.1	104.8 ± 1.1	76.3 ± 1.8	87.3 ± 2.0	66.6 ± 2.2
Knudson et al.	108.9 ± 1.2	109.7 ± 1.3	85.0 ± 2.1	81.0 ± 1.9	53.4 ± 1.7
Ferris et al.	122.7 ± 1.3	128.3 ± 1.4			
Kory et al.	108.4 ± 1.2	109.4 ± 1.2			
Bass	119.2 ± 1.4				
Higgens & Keller	113.5 ± 1.3	111.5 ± 1.2	106.4 ± 2.6	116.6 ± 2.7	
Schoenberg et al.	111.3 ± 1.3	111.2 ± 1.3		115.3 ± 2.6	112.5 ± 3.6
Michigan				101.7 ± 2.4	82.5 ± 2.7

Table 41

Prediction equations determined for various spirometric parameters from 163 nonsmoking whites[1] in this study

Parameters	Regression equation	R^2
FVC	0.0136 x Ht. - 0.0267 x Age - 3.29	0.43
FEV_1	0.0858 x Ht. - 0.0270 x Age - 0.792	0.43
MMF	0.0159 x Ht. - 0.0289 x Age + 4.017	0.09
FEF_{50}	- 0.0033 x Ht. - 0.0259 x Age + 6.124	0.04
FEF_{75}	0.0060 x Ht. - 0.0196 x Age + 2.093	0.12

1 No non-mechanical garage workers are included. However, there were no other exclusions based on health information or job.

Table 42

The percentage and number of abnormalities found on physical examination according to job category

Organ system examined	No identified exposure	Garage work	Brake work	Asbestos exposure
Cyanosis/extremities	8.7 (10)	9.6 (12)	6.0 (27)	7.9 (16)
Clubbing	2.7 (3)	3.2 (4)	2.2 (10)	2.1 (4)
Joints	8.4 (9)	8.1 (9)	8.6 (32)	8.1 (14)
Skin	11.5 (13)	18.4 (23)	10.0 (45)	13.1 (26)
Eyes	8.0 (9)	4.0 (5)	5.4 (24)	6.6 (13)
Mouth	7.8 (9)	2.4 (3)	4.9 (22)	5.0 (10)
Thyroid	0.0 (0)	1.6 (2)	0.0 (0)	0.5 (1)
Lymphatics	11.2 (12)	0.0 (0)	2.3 (10)	1.6 (3)
Chest	18.3 (21)	20.2 (25)	19.5 (87)	18.7 (38)
Dry rales	2.9 (6)	4.8 (6)	5.8 (26)	4.4 (10)
Cardiac	17.3 (18)	9.3 (10)	9.9 (37)	12.4 (23)
Gastrointestinal[1]	11.5 (9)	24.2 (8)	9.5 (11)	8.3 (8)
Any abnormality	37.4 (43)	46.8 (59)	56.4 (257)	52.0 (106)

[1]Abdominal palpation was not done on all individuals.

( ) = Number of individuals with abnormality.

circumstance in which a statistically significant greater percentage of abnormalities is found is for abnormal lymph glands among the population serving as an unexposed control. With the number of subcategories established in Table 42, such a finding would be expected on the basis of chance alone. We attribute no significance to it.

Table 43 shows the number and percentage of individuals with rales or finger clubbing according to their X-ray reading. A greater percentage of individuals with abnormal X-rays have dry rales than do individuals with normal X-rays. The numbers, however, are so small that the data do not achieve significance. There was no correlation of finger clubbing with X-ray findings. Overall, rales were observed in 4.8% of the entire study group and clubbing in 2.6% compared to 25.2% with abnormal X-rays [or 13.1% if more stringent X-ray reading criteria were utilized (c.f. Table 11)]. Thus, in contrast to earlier data from Great Britain (British Occupational Hygiene Committee, 1968), it would appear that the presence of X-ray abnormalities is a considerably more sensitive parameter than rales (or restrictive pulmonary function deficits) for the categorization of asbestos disease. This has also been seen in several other asbestos-exposed groups, including shipyard workers (to be published) and chemical or oil refinery maintenance employees (Lilis et al., 1980).

Data for the blood pressures are shown in Table 44 according to age, job category, and race. As can be seen, the systolic and diastolic blood pressures of the blacks are significantly above those of the whites. Systolic pressures increase from 5 to 7 percent per decade and diastolic from 2 to 3 percent each decade with the rates of increase being greater for blacks than whites. The analyses of the age standardized blood pressures according to smoking history or job category are shown in Table 45. White cigarette smokers appear to have somewhat lower blood pressures, but this could be artifactual as it is not reflected in blacks. No significant differences are seen in the analysis of blood pressures according to work activity.

Table 43

The number and percentage of individuals with rales and/or finger clubbing according to X-ray reading

	X-ray reading	
	Normal	Abnormal
Rales present	30 (4.3)	17 (6.9)
Clubbing present	16 (2.6)	6 (2.7)
Both rales and clubbing present*	3 (0.5)	1 (0.5)

* The cases with both rales and clubbing are included in the separate categories as well.

Table 44

The systolic and diastolic blood pressures by race and age

Age	Race: White	Black	Hispanic
	Systolic pressure		
20 - 29	123.4 ± 3.8 (13)	137.0 ± 3.0 (2)	120.0 (1)
30 - 39	126.6 ± 1.9 (67)	131.8 ± 2.5 (23)	123.2 ± 2.6 (6)
40 - 49	128.0 ± 1.4 (143)	134.0 ± 3.3 (28)	128.4 ± 5.1 (10)
50 - 59	136.8 ± 1.1 (283)	142.7 ± 2.7 (41)	143.4 ± 6.1 (12)
60 - 69	142.9 ± 1.6 (170)	155.4 ± 4.0 (28)	146.7 ±12.0 (3)
70+	152.2 ± 5.0 (13)	166.5 ± 6.8 (12)	
Age standardized	135.4 ± 0.6	143.2 ± 1.6	138.7 ± 3.9
	Diastolic pressure		
20 - 29	76.2 ± 1.8 (13)	75.5 ± 9.5 (2)	75.0 (1)
30 - 39	81.3 ± 1.0 (67)	83.6 ± 2.0 (23)	83.5 ± 5.2 (6)
40 - 49	83.1 ± 0.8 (143)	85.3 ± 2.6 (28)	79.8 ± 2.2 (10)
50 - 59	85.6 ± 0.6 (283)	90.4 ± 1.7 (41)	89.1 ± 2.1 (12)
60 - 69	85.8 ± 0.8 (170)	93.3 ± 2.2 (28)	81.3 ± 5.9 (3)
70+	89.3 ± 2.1 (13)	93.5 ± 5.0 (12)	
Age standardized	84.6 ± 0.4	89.0 ± 1.1	84.4 ± 1.8

Table 45

Age standardized systolic and diastolic blood pressures according to race, smoking history, and job category

Smoking history	Race: White	Race: Black
	Systolic	
Smokers	131.5 ± 1.3	140.8 ± 3.3
Ex-smokers	137.3 ± 1.0	143.4 ± 2.2
Nonsmokers	135.6 ± 1.4	141.7 ± 3.8
	Diastolic	
Smokers	82.9 ± 0.8	88.5 ± 2.1
Ex-smokers	85.3 ± 0.6	90.0 ± 1.6
Nonsmokers	84.8 ± 0.7	86.3 ± 2.3

Job category	White	Black
	Systolic	
No identified exposure	140.1 ± 2.5	150.4 ± 5.3
Garage work but no brakes	136.1 ± 2.7	139.4 ± 4.0
Brake work	134.5 ± 1.0	140.5 ± 2.7
Asbestos exposure	135.5 ± 1.4	149.6 ± 5.2
	Diastolic	
No identified exposure	85.1 ± 1.2	89.9 ± 3.6
Garage work but no brakes	85.5 ± 1.3	87.8 ± 1.5
Brake work	84.4 ± 0.6	87.0 ± 1.9
Asbestos exposure	84.4 ± 0.6	94.9 ± 2.4

LABORATORY FINDINGS

The data on the blood analyses (CBC and SMA) are shown in Tables 46 and 47. No unusual findings are present for any parameter. The means of the various parameters according to job category are listed in Table 48 and do not show anything remarkable. Tables 49 and 50 show the results of the analysis of sputum specimens for abnormal cytology and the blood analysis for carcinogenic embryonic antigen (CEA). They show no findings suggestive of neoplasia, most values are within the normal range. Further, there is no difference in the distribution of either parameter for the different job categories.

MRC RESPIRATORY SYMPTOMS

The principal results of the respiratory symptoms questionnaire are shown in Tables 51, 52 and 53. Tables 51 and 52 show the expected correlation with cigarette smoking. In Table 53, the smoking standardized percentages of chronic bronchitis and shortness of breath categories are listed for different job categories.

NICKEL CONCENTRATIONS IN WELDERS

As part of a study to assess effects on welders, plasma nickel concentrations were measured in twelve welders in the control group engaged in amphibious vehicle construction. The results are shown in Table 54 and indicate that the particular group within this study had higher nickel concentrations than a group of 62 welders in a large shipyard and ten times the concentration of hospital controls. While no physiological effects can be associated with such concentrations, the toxic and potentially carcinogenic effects of nickel would suggest identification of the exposure source and implementation of abatement measures.

Table 46

The distribution of blood count values
(CBC Analysis)

Range (See headings for concentration unit)	Individuals within range Number	Percentage
White blood cell count (thousands) [3.9-11.3]		
< 3.00	1	0.1
3.00 - 4.99	70	7.9
5.00 - 6.99	342	38.7
7.00 - 8.99	308	34.9
9.00 -10.99	124	14.0
≥11.00	39	3.1
Red blood cell count (millions) [4.3-6.3]		
< 4.25	5	2.0
4.25 - 4.74	130	14.7
4.75 - 5.24	462	52.3
5.25 - 5.74	228	25.8
5.75 - 6.24	34	3.8
≥ 6.25	12	1.4
Hemoglobin (gm/dl) [12.9-18.2]		
<13.0	12	1.4
13.0 - 13.9	54	6.1
14.0 - 14.9	237	26.8
15.0 - 15.9	335	37.9
16.0 - 16.9	186	21.0
17.0 - 17.9	54	6.1
≥ 18.0	6	0.7
Hematocrit (percent) [38.9-54.9]		
<37.5	4	0.5
37.5 -39.9	13	1.4
40.0 -42.4	92	10.4
42.5 -44.9	245	27.7
45.0 -47.4	308	34.8
47.5 -49.9	154	17.4
50.0 -52.4	53	6.0
≥52.5	15	1.7

[ ] = Laboratory normal range

Table 47

The distribution of concentrations of various blood components (SMA Analysis)

Range (See headings for concentration unit)	Within range Number	Within range Percentage
Glucose (mg/dl) [65-125]		
< 80	46	5.0
80 - 99	415	46.8
100 - 119	294	33.2
120 - 139	61	6.9
140 - 159	25	2.8
≥ 160	47	3.5
Urea-nitrogen (ng/dl) [8-25]		
< 10	44	5.0
10 - 14	250	28.2
15 - 19	420	47.4
20 - 24	150	16.9
≥ 25	22	2.5
Creatinine (mg/dl) [0.7-1.5]		
< 0.80	5	0.6
0.80 - 0.99	113	12.8
1.00 - 1.19	339	38.4
1.20 - 1.39	315	35.6
1.40 - 1.59	89	10.0
≥ 1.60	22	2.5
Sodium (meq/L) [135-145]		
< 138	14	1.6
138 - 139	102	11.5
140 - 141	234	26.4
142 - 143	237	26.7
144 - 145	125	14.1
146 - 147	76	8.6
≥ 148	98	11.1
Potassium (meq/L) [3.5-5.0]		
< 3.00	5	0.6
3.00 - 3.49	38	4.3
3.50 - 3.99	222	25.2
4.00 - 4.49	451	39.8
4.50 - 4.99	209	23.7
≥ 5.00	56	6.2

Table 47 (continued-2)

Range (See headings for concentration unit)	Within range Number	Percentage
Chloride (meq/L) [95-107]		
< 100	50	5.6
100.0 - 102.4	215	24.3
102.5 - 104.9	212	23.9
105.0 - 107.4	229	25.8
107.5 - 109.9	88	9.9
≥ 110.0	92	10.4
Carbon dioxide (meq/L) [24-32]		
< 25.0	39	4.4
25.0 - 27.4	238	26.9
27.5 - 29.9	310	35.0
30.0 - 32.4	244	27.5
≥ 32.5	55	6.2
Uric acid (mg/dl) [3.5-9.0]		
< 4.0	24	2.7
4.0 - 5.9	376	42.4
6.0 - 7.9	392	44.2
8.0 - 9.9	88	9.9
≥ 10.0	6	0.8
Calcium (mg/dl) [8.5-10.5]		
< 9.0	16	1.8
9.0 - 9.9	510	57.8
10.0 10.9	340	38.5
≥ 11.0	17	1.9
Inorganic phosphate (mg/dl) [2.0-4.5]		
< 2.00	16	1.8
2.00 - 2.49	134	15.1
2.50 - 2.99	331	37.4
3.00 - 3.49	280	31.6
3.50 - 3.99	92	10.4
≥ 4.00	33	3.8
Total protein (g/dl) [6.0-8.5]		
< 6.50	26	2.9
6.50 - 6.90	197	22.3
7.00 - 7.49	401	45.4
7.50 - 7.99	197	22.3
8.00 - 8.49	55	6.2
≥ 8.50	7	0.8

Table 47 (continued-3)

Range (See headings for concentration unit)	Within range Number	Within range Percentage
Albumin (g/dl) [3.0-5.5]		
3.50 - 3.99	18	2.0
4.00 - 4.49	439	49.7
4.50 - 4.99	398	45.0
5.00 - 5.49	29	3.3
Cholesterol (mg/dl) [140-330]		
< 150	13	1.5
150 - 174	66	7.4
175 - 199	162	18.3
200 - 249	443	50.0
250 - 299	178	20.1
≥ 300	24	2.7
Creatine phosphokinase (U/L) [0-225]		
< 50	52	5.9
50 - 74	162	18.3
75 - 99	196	22.1
100 - 149	258	29.0
150 - 199	104	11.7
200 - 249	49	5.6
250 - 299	22	2.5
≥ 300	43	4.9

Table 48

The mean values of blood count parameters and concentrations of various blood components according to job category

Blood parameter	No identified exposure or garage work		Garage employment but no brake work		Brake work		Definite and possible asbestos exposure	
White blood count	7.17	± 0.20	7.14	± 0.19	7.40	± 0.09	7.55	± 0.14
Red blood count	5.00	± 0.03	5.06	± 0.04	5.14	± 0.02	5.10	± 0.03
Hemoglobin	15.40	± 0.09	15.27	± 0.11	15.45	± 0.05	15.33	± 0.08
Hematocrit	45.4	± 0.3	45.7	± 0.3	46.0	± 0.1	45.3	± 0.2
Glucose	104.9	± 2.2	111.0	± 4.4	104.9	± 1.8	113.5	± 3.9
Urea nitrogen	15.4	± 0.4	15.7	± 0.5	16.2	± 0.2	16.5	± 0.3
Creatinine	1.18	± 0.01	1.18	± 0.01	1.15	± 0.01	1.13	± 0.01
Sodium	142.1	± 0.3	143.5	± 0.4	143.4	± 0.2	142.1	± 0.2
Potassium	4.24	± 0.04	4.14	± 0.05	4.21	± 0.02	4.21	± 0.04
Chloride	103.6	± 0.3	105.2	± 0.4	105.1	± 0.2	103.7	± 0.2
Carbon dioxide	28.1	± 0.2	28.5	± 0.3	28.8	± 0.1	28.7	± 0.2
Uric acid	6.20	± 0.12	6.42	± 0.14	6.43	± 0.17	6.10	± 0.09
Calcium	9.78	± 0.05	9.90	± 0.04	9.94	± 0.02	9.77	± 0.03
Inorganic phosphate	2.83	± 0.05	2.97	± 0.05	2.95	± 0.03	2.89	± 0.03
Protein	7.10	± 0.04	7.39	± 0.05	7.29	± 0.02	7.15	± 0.03
Albumin	4.50	± 0.02	4.41	± 0.03	4.47	± 0.01	4.42	± 0.02
Cholesterol	217.4	± 2.8	222.7	± 3.6	222.2	± 1.9	225.2	± 2.6
Billirubin	0.58	± 0.03	0.57	± 0.03	0.59	± 0.01	0.53	± 0.02
Alkaline phosphatase	72.5	± 1.8	83.35	± 4.2	80.4	± 1.8	77.3	± 2.1
SGPT	19.6	± 1.6	19.5	± 1.0	21.0	± 0.7	20.1	± 0.9
SGOT	23.7	± 1.0	22.5	± 1.4	22.3	± 0.6	20.9	± 0.6
Lactate dehydrogenase	168.9	± 5.6	177.7	± 3.6	177.9	± 2.0	171.9	± 3.0
Creatine phosphokinase	119.0	± 6.8	133.8	± 8.6	133.1	± 4.7	111.7	± 4.9

Table 49

The distribution of sputum cytology results and CEA concentrations according to job category

	Sputum cytology				CEA analysis (nanogm/ml)			
Job Category	1	2	3	4	<5	5-9.9	10-14.9	15-19.9
No garage work or asbestos exposure	17 (39.6)	22 (51.2)	10 (23.3)	0 (0.0)	107 (97.3)	3 (2.7)	(0.0)	(0.0)
Garage work but no brakes	24 (43.6)	21 (38.2)	8 (14.6)	2 (3.6)	113 (95.0)	5 (4.2)	1 (0.8)	0 (0.0)
Garage work with brake repair	90 (45.0)	68 (34.0)	39 (19.5)	3 (1.5)	419 (96.3)	14 (3.2)	1 (0.2)	1 (0.2)
Identified and possible asbestos exposure	33 (38.4)	32 (37.2)	20 (23.3)	1 (1.2)	184 (96.3)	6 (3.1)	1 (0.5)	0 (0.0)
Totals	164 (42.0)	143 (36.7)	77 (19.7)	6 (1.5)	823 (96.3)	28 (3.3)	3 (0.4)	1 (0.1)

( ) = percentages
1. Normal cytology
2. Regular metaplastic cells, no atypia (considered normal)
3. Mild atypia or dysplasia
4. Moderate atypia or dysplasia

Table 50

The distribution of sputum cytology results and CEA concentrations according to smoking category

Smoking Category	Sputum cytology 1	2	3	4	CEA analysis (nanogm/ml) <5	5-9.9	10-14.9	15-19.9
Smokers	65 (36.7)	70 (39.5)	40 (22.6)	2 (1.1)	248 (93.2)	16 (6.0)	2 (0.8)	0 (0.0)
Ex-smokers	63 (44.7)	49 (34.8)	25 (24.8)	4 (2.8)	359 (97.8)	6 (1.6)	1 (0.3)	1 (0.3)
Nonsmokers	33 (45.2)	27 (34.0)	12 (16.4)	1 (1.4)	215 (97.3)	6 (2.7)	0 (0.0)	0 (0.0)
Totals	161 (41.0)	146 (37.3)	77 (19.7)	7 (1.8)	822 (96.3)	28 (3.3)	3 (0.4)	1 (0.1)

( ) = percentages
1. Normal cytology
2. Regular metaplastic cells, no atypia (considered normal)
3. Mild atypia or dysplasia
4. Moderate atypia or dysplasia

Table 51

The number and percentage of individuals with reported shortness of breath (MRC) according to smoking category

MRC shortness of breath category	Smoking category		
	Smokers	Ex-smokers	Non-smokers
None	199 (72.6)	274 (76.3)	181 (82.6)
Walking fast or up a slight hill	51 (18.6)	55 (15.3)	28 (12.8)
Walking with others of own age	10 (3.6)	19 (5.3)	6 (2.7)
Walking at own pace	14 (5.1)	11 (3.1)	4 (1.8)
Total	274	359	219

( ) = percentage

Table 52

The number and percentage of individuals reporting symptoms of chronic bronchitis (MRC) according to smoking category

Chronic bronchitis	Smoking category Smokers	Ex-smokers	Non-smokers
Yes	80 (29.1)	34 (9.5)	21 (9.5)
No	195 (70.9)	325 (90.5)	199 (90.5)
Totals	275	359	220

Table 53

The number and smoking standardarized percentage of individuals reporting symptoms of chronic bronchitis according to work activity

Job Category	Smokers	Ex-smokers	Non-smokers	Smoking standardized percentage
No garage work or asbestos exposure	20/68 (29.4)	12/56 (21.4)	7/28 (25)	24.9
Garage work but no brakes	7/36 (19.4)	2/40 (5.0)	2/27 (7.4)	10.2
Garage work with brake repair	40/126 (31.7)	20/186 (10.8)	11/118 (9.3)	17.0
Identified and possible asbestos exposure	28/69 (40.6)	10/88 (11.4)	5/50 (10.0)	20.3
Auto body work	5/12 (41.7)	3/15 (20.0)	1/7 (14.3)	25.4

( ) = percentage

Table 54

Nickel concentrations in the plasma of amphibious vehicle construction welders compared to other groups

Group	No. of individuals	Plasma nickel concentrations (μg/liter) Median	Range	Mean ± SD
Vehicle welders	12	11.8	5.4 - 14.3	10.8 ± 3.2
Shipyard welders	62	2.5	<0.5 - 15.3	3.1 ± 3.3
Hospital controls	15	0.7	<0.5 - 2.6	1.0 ± 0.7

ASBESTOS EXPOSURE DATA

REVIEW OF PUBLISHED RESULTS

Review of fiber concentration data for brake work

A variety of measurements have been made of asbestos air concentrations during brake lining repair and maintenance activities in the United States and Great Britain. These include both long-term sampling over a working day to obtain information on time-weighted average exposures to workers, and short-term sampling to document the concentrations during various work practices.

The largest set of samples of brake maintenance work is that obtained by NIOSH during the years 1975 through 1976 where 283 samples were taken in five brake repair facilities, including 152 over a one week period in one facility, documenting both long-term, time-weighted average (TWA) exposures and asbestos concentrations in specific brake repair activities (NIOSH, 1972-1976). Unfortunately, no documentation exists as to the number of brake jobs performed in a facility or by workmen during sampling periods or on the work practices utilized during the repair and maintenance work. Table 55 summarizes the data on time-weighted exposures, over a sampling period, for men changing lining material, punching out rivets, riveting linings to shoes, and working in the parts department. Table 56 lists general area samples taken during the course of a day. These data demonstrate that, in general, the long-term asbestos exposures of garage employees are below 0.5 f/ml. However, during the air blowing of drums, punching out of rivets and riveting asbestos concentrations can be considerably higher. Further, area samples taken distant from the location of brake repair show widespread dissemination of airborne asbestos with concentrations up to 1.3 f/ml found to be present.

More limited data are available from industry sources. In Great Britain, Hickish and Knight (1970)[2] of the Ford Motor Company have provided information on both long and short-term sampling during different

Table 55

Long-term personal sampling of brake lining repair and maintenance work

Garage	Number of samples	Number of sets of samples	Time weighted average asbestos concentration during sampling period (fibers/ml) Range	Mean
			Changing Lining Materials	
A (1976)	16	5	0.05-1.68	0.59
B (1976)	71	21	0.01-0.17	0.09
C (1976)	3	1	0.12	0.12
D (1975)	4	1	0.04	0.04
E (1976)	2	2	0.02-0.03	0.03
			Riveting	
A	14	2	3.71-4.47	4.09
			Punching out rivets	
A	11	2	0.95-7.52	4.24
			Parts Man	
A	1	1	1.21	1.21
B	13	5	0.03-0.16	0.10
			Replacing Lining Materials	
F (1972)	2	1	0.2	0.2

From: NIOSH (1975-1976, unpublished data)

Table 56

Long-term area sampling of brake lining repair and maintenance work

Garage	Number of samples	Number of sets of samples	Time weighted average asbestos concentration during sampling period (fibers/ml)	
			Range	Mean
			General Area Samples	
A (1976)	30	6	0.03-1.34	0.57
B (1976)	99	18	0.01-0.17	0.07
C (1976)	4	1	0.04	0.04
D (1975)	7	1	0.02	0.02
E (1976)	1	1	0.01	0.01
F (1972)	1	2	0.6-0.9	0.8

From: NIOSH (1972-1976, unpublished data)

Table 57

Long-term asbestos fiber concentrations during brake maintenance service involving air blowing of drum dust

Sampling circumstances	Approximate total sampling interval	Number of samples	Asbestos concentrations (fibers/ml)		Activities or comments
			Range	Mean	
Static samples by side of car	90	2	1.12-1.42	1.25	3 brake changes done
Static samples by car in dust cloud	90	2	1.71-3.62	2.55	" "
Personal samples on mechanic engaged in brake cleaning	480	6	0.38-1.12	0.68	11 vehicles serviced
Personal sample	100	1	7.09	7.09	truck brake service incl. cleaning
Personal sample	300	1	0.08	0.08	truck brake service after cleaning
Time weighted average of above two samples				1.83	
Static area samples	180	4	0.07-0.28	0.15	nearby work bays

From: Hickish, O. E., and K. L. Knight, Ann. Occup. Hyg. 13, 17-21 (1970) brake repair activities. These are shown in Table 57. The work practices sampled by Hickish and Knight appeared typical of those of past years with the drum dust being removed by air blowing. During the full course of brake service air concentrations of from 0.4 to 3.6 f/ml were found. More recent information has been supplied by Raybestos-Manhattan (Marsh, 1979). These show that during the course of well controlled brake repair work with exhaust ventilation utilized asbestos exposures of 0.02 to 0.3 f/ml may occur during the course of a brake job.

Short-term asbestos concentrations during specific work activities have been measured by several groups in both automotive and truck servicing. These are shown in Table 58.

They demonstrate that short-term asbestos concentrations during brake maintenance work can be high. However, because they comprise only a portion of the work involved in brake maintenance, the TWA concentrations are generally much lower. Clearly, reduction of these peak exposures by engineering controls or by work practices can significantly reduce TWA exposures.

Two sets of data on the time course of asbestos concentrations exist. The measurements of total dust by Lee[8] indicate that after air blowing short-term dust concentrations are high but fall within minutes to lower values. The data on fiber counts by Rohl[4] indicate that measurable concentrations of asbestos persists in the workplace for as long as 15 minutes after air blowing as far as 75 feet away. These data, coupled with the previous information on asbestos concentrations in general garage areas, indicate that a general, low-level background contamination of asbestos can exist throughout a garage where brake repair is conducted.

MEASUREMENTS IN NEW YORK CITY FACILITIES (1979)

During 1979, NIOSH made measurement at three New York City facilities employing workers who attended examinations in this survey. These were the repair shops of the Departments of Sanitation, Transporation and Police. The results are shown in Table 59. They are similar to those

Table 58

Summary of asbestos concentrations during automobile and truck brake maintenance activities

Short-term samples during specific brake repair activities

Activity	Study	Range of concentrations measured (f/ml)	Number samples	Mean concentration (f/ml)
Air blowing dust from drums	Rohl et al, 1976	6.6-29.8	4	16.0
	NIOSH, 1972-76	0.45-14.54	11	2.9
	Knight& Hickish,1970	87	1	87
		2.1-8.2	8	
Brushing of dust from drums	Rohl et al,1976	1.3-3.6	2	2.5
	Marsh, 1979	0.02-0.2		0.1
Grinding linings				
good exhaust	Marsh, 1979	0.02-0.4	3	0.3
poor exhaust	Rohl et al, 1976	1.7-7.0	10	3.8
	Marsh, 1979	2.8-14	4	8.3
		0.4-21.5	6	
Beveling	Rohl et al, 1976	23.7-72.0	5	37.3
Riveting	Rohl et al, 1976	1.9-2.0	2	1.9
Sweeping and cleaning	Rohl et al, 1976	2.4-3.6	2	3.0

Table 59

Long- and short-term sampling of brake lining repair and maintenance work in New York City garage facilities

Activity	Sampling time	fiber concentration (f/ml) Sample	TWA
		Department of Sanitation	
Brake change	136	0.33	0.21
After finishing job	190	0.12	
Wet brushing of dust	10	0.54	
Area sample	395	0.06	
Area sample	390	0.05	
		Department of Transporation	
Brake mechanic 1	150	0.15	0.23
	196	0.30	
Brake mechanic 2	175	0.31	0.28
	194	0.26	
Brake mechanic 3	135	0.24	
Wet brushing of dust	3	2.62	
(mechanics 1,2,3)	3	2.22	
	9	0.87	
		Police Department	
Brake mechanic 1	129	0.20	0.20
	68	0.21	
Brake mechanic 2	124	0.34	0.19
	177	0.08	
Brake mechanic 3	47	0.03	
Dry brushing of dust	12	0.81	
	21	0.61	

discussed previously. TWA exposures during a full brake job averaged about 0.20 f/ml. During either wet or dry brushing of brake dust concentrations could exceed 2 f/ml.

ESTIMATES OF STUDY POPULATION EXPOSURE

TWA exposures during automobile brake maintenance ranged generally between 0.2 to 0.7 f/ml if brushing or air blowing of brake dust occurred. Prior to 1950, riveted brake linings were used and somewhat higher concentrations may have occurred. Table 60 lists the distribution of brake jobs per week done by U.A.W. Local 259 members. The average is about one every two days for those who do brake work. If the exposure during the 1-2 hours required for a job is 1 f/ml, an approximate TWA exposure would be 1 f/ml (1.5/16) or about 0.1 f/ml. General garage exposure from other jobs would add slightly to this, but the upper limit of the average exposure for the commercial garage mechanics examined in this study would be 0.2 f/ml. For the S.E.I.U. Local 246, mechanics employed by the City, higher average exposures would have occurred from the riveting, drilling and grinding that was done on large truck brake assemblies. However, these high exposure work activities would only require a few minutes of work. As with commercial garage workers, few City employees worked on a brake job as often as daily. Thus, even with the intermittently higher exposures experienced by S.E.I.U. members, the average exposure for the group over time is unlikely to exceed 0.5 f/ml.

SUMMARY

The clinical examination of garage employees engaged in the repair and maintenance of vehicles indicate the following results:

1. A greater prevalence of X-ray abnormalities is found among garage mechanics who repaired brakes than among blue collar controls or garage workers who do not engage in brake or auto body work. The age standardized percentage of abnormalities is significantly greater ($P<0.05$) in those with 30 or more years of employment

Table 60

Distribution of frequency of brakework in U. A. W. Local 259 shops from personal estimates

Number of brake jobs done	Number of men	Percentage of men
1/day or more	24	14
1-4 /week	71	41
1 -5/month	27	16
less than 1/month	4	2
no brake work (engine mechanics, parts personnel, etc.)	46	27
Totals	172	100

compared to workers with lesser service. The increased prevalence in commercial garage workers exposed, on average, to less than 0.2 f/ml was not statistically significant while a significant excess is seen in workers who had occasion to grind and machine brake linings prior to installation on larger vehicles. The prevalence of X-ray abnormalities is in accord with estimates of asbestos exposure in the different circumstances.

2. The prevalence of X-ray abnormalities among workers in auto body shops was particularly high and, although the number of such individuals was limited, also achieved a level of significance at $P<0.05$. The higher percentage of abnormalities in this group can be attributed to the past sanding of auto body fillers containing asbestos.

3. Individuals who had previous employment in shipyards, averaging five years in duration, also had a greater percentage of abnormal X-rays. The percentage age standardized percentage was significantly greater in those whose shipyard employment began 30 or more years previously.

4. The pulmonary function results of garage mechanics engaged in brake work are no different from non-garage workers and other general population controls. As the major spirometric tests are less sensitive measures of asbestos exposure than X-rays, this finding is in accord with the low exposures of the groups under study.

5. Car jockeys, new vehicle preparation men and auto body shop workers have significantly reduced pulmonary function tests (FVC_1, FEV_1, and MMF) compared to other garage workers and general population controls.

   The auto body shop employees had exposure to asbestos and a variety of solvents. The causal exposure among the car jockey-vehicle preparation men is uncertain. The role of automobile exhaust should be investigated.

6. Pulmonary function deficits correlated with X-ray abnormalities. Greater percentages of X-ray abnormalities and pulmonary function deficits were seen among current and former smokers than among non-smokers.

7. No unusual physical examination of laboratory findings were identified. As in other studies, a high prevalence of hypertension was observed among blacks, which was not correlated with any job category.

8. A small group of welders in amphibious vehicle construction showed significantly elevated plasma concentrations of nickel.

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APPENDIX I

BRAKE REPAIR AND MAINTENANCE WORKERS SURVEY

No. ____________________

Name: ________________________________ Date: __________ Union Local #: __________

Address: ____
Street City State ZIP

Telephone: __________________ Date of Birth: ____________ Age _____ Sex ___

Garage Facility: ______________________________

Name of Physician (optional) ____________________________

Address: ____________________________

____

____

URINE:

Albumin __________

Protein __________

ENVIRONMENTAL SCIENCES LABORATORY
MOUNT SINAI SCHOOL OF MEDICINE OF THE CITY UNIVERSITY OF NEW YORK

Name ______________________ No. __________

OCCUPATIONAL HISTORY - GARAGE WORKERS

(DESCRIBE BRAKE AND CLUTCH WORK IN TERMS OF JOBS/WEEK, JOBS/MONTH, etc. This is IMPORTANT)

Period from/to	Job Title	Job Description, By Task and Location	Hrs/Wk	Exposures	Protective Measu

PREVIOUS EMPLOYMENT -- OTHER THAN GARAGE WORK

Name ______________________ No. __________

PERIOD From / To	Type of Trade	CLASSIFICATION OF WORK	DESCRIPTION OF WORK	EXPOSURES	PROTECTIVE MEASURES

Non-occupational activities with possible exposure to: ______________________

NAME (1 2 3 4) ____________ Last ____________ First NUMBER ______ B 5

Year first exposed to asbestos (occupationally) 11

Year last exposed to asbestos (occupationally) 13

Total number of years and months exposed to asbestos 15

- subtract # yrs during period not exposed

	MO.	YR.			
Dates employed as Garage worker			to		19
			to		27
			to		35
Dates performing brake or clutch work			to		43
			to		51
Dates performing undercoating			to		59
			to		67
Date preforming body work					

Exposed to other dusts 1-No 2-Yes 11

If yes, Silica

Year first exposed 12

Year last exposed 14

Total number of years and months exposed 16

Coal

Year first exposed 20

Year last exposed 22

Total number of years and months exposed 24

Total years underground 28

Other

Year first exposed 32

Year last exposed 34

Total number of years and months exposed 36

Prior to becoming a garage worker did any member of your immediate family work with asbestos? 1-No 2-Yes 40

If yes, who, and employed as					
	employed as		to		41
	employed as		to		49
	employed as		to		57

RESPIRATORY QUESTIONNAIRE

NAME [ ] Last First Middle initial NUMBER [ ] I 5

I am now going to ask you some questions, mainly about your chest. I would like you to answer "YES" or "NO" whenever possible.

COUGH

1. Do you usually cough first thing in the morning (on getting up+)? Count a cough with first smoke or on first going out of doors. Exclude clearing throat or a single cough. 1 - No 2 - Yes [ ] 11

2. Do you usually cough during the day (or at night+)? Ignore an occasional cough. 1 - No 2 - Yes [ ] 12

3. If yes: Do you cough like this on most days (or nights) for as much as three months each year? 1 - No 2 - Yes [ ] 13

Have you been coughing like this:
(1) - less than two years
(2) - more than two years [ ] 14

PHLEGM

Do you usually bring up any phlegm from your chest first thing in the morning (on getting up*)? [ ] 15
Count phlegm with first smoke or on first going out of doors.
Exclude phlegm from the nose.
Count swallowed phlegm. 1 - No 2 - Yes

5. Do you usually bring up any phlegm from your chest during the day (or at night+)? 1 - No 2 - Yes [ ] 16

6. If yes: Do you bring up phlegm like this on most days (or nights+) for as much as three months each year? 1 - No 2 - Yes [ ] 17

Have you done so for:
(1) - less than two years
(2) - more than two years [ ] 18

What color is your sputum or phlegm?
(1) - whitish
(2) - yellow and/or green
(3) - grey and/or black
(4) - brown [ ] 19

* Column Number

+ For night shift employees

Is your cough and/or phlegm production related to any season? [20]

(1) - spring
(2) - summer
(3) - fall
(4) - winter
(5) - all year

DOES THE PHYSICIAN THINK THAT THE PATIENT FULFILLS THE CRITERIA FOR CHRONIC BRONCHITIS? [21]

(1) - No
(2) - Yes
(3) - Can't specify

7. In the past three years have you had a period of (increased) cough and phlegm lasting for three weeks or more? 1 - No 2 - Yes [22]

8. Have you had more than one such period? 1 - No 2 - Yes [23]

9. Have you ever coughed up blood? 1 - No 2 - Yes [24]

If yes: how often? [25]

(1) - only occasionally
(2) - only occasionally with a severe cold
(3) - sputum streaked with blood (frequently)
(4) - hemorrhage
(5) - other (specify other)

____

____

10. Was this in the past year? 1 - No 2 - Yes [26]

BREATHLESSNESS

11. Are you troubled by shortness of breath when hurrying on level ground? 1 - No 2 - Yes [27]

12. Do you get short of breath walking with other people of your own age? 1 - No 2 - Yes [28]

13. Do you have to stop for breath when walking at your own pace on level ground? 1 - No 2 - Yes [29]

WHEEZING

14. Does you chest ever sound wheezing or whistling? 1 - No 2 - Yes [30]

15. If yes: Do you get this mostly during the day or mostly at night, or both? 1 - Days 2 - Nights 3 - Both [31]

16. Have you ever had attacks of shortness of breath with wheezing? 1 - No 2 - Yes [32]

Use of air hoses to blow out brake shoes:

Which years done ______________________ | 65

Do/did you bevel or machine shoes?

Which years done ______________________ | 66

What current dust removal practice is used during brake or clutch jobs at your garage? | 67

____

____

When did this begin? ______________________ | 68

What was done before? ______________________ | 69

____

Did you do undercoating work or were you near such work? | 70

Describe: ______________________

____

RESPIRATORS:

1. Do you wear a respirator? | 71
   1 = No 2 = Yes

2. What type is it, mainly? | 72
   1 - Filter
   2 - Cartridge
   3 - Air Supply

3. Do you wear it usually? | 73
   1 - Usually
   2 - Occasionally
   3 - Infrequently

HYGIENE:

1. Do you eat at your work site: | 74
   1 - No 2 - Yes

2. Do you smoke at your work site? | 75
   1 - No 2 - Yes 3 - Nonsmoker

3. Do you change your clothes before going home? | 76
   1 - No 2 - Yes

4. Does your employer furnish work clothes and launder them? | 77
   1 - No 2 - Yes

5. Do you have separate lockers for street and work clothes? | 78
   1 - No 2 - Yes

6. Do you shower before going home? | 79
   1 - No 2 - Yes

17. *If yes:* Is/was your breathing absolutely normal between attacks? 1 - No 2 - Yes [33]

WEATHER

18. Does the weather affect your chest? [34]
Only record "YES" if adverse weather definitely and regularly causes chest symptoms.

19. *If yes:* Does the weather make you short of breath? [35]

Type of weather (1) - heat [36]

(2) - cold [37]

(3) - dampness [38]

(4) - dryness [39]

(5) - any extreme [40]

NASAL CATARRH

20. Do you usually have a stuffy nose or catarrah at the back of your nose in the winter? 1 - No 2 - Yes [41]

21. Do you have this in the summer? [42]

PHYSICIAN COMMENT: Nasal catarrh: (1) has no relation to chest condition [43]
(2) aggravates cough and phlegm production from chest, as described above.
(3) is a cause of cough and phlegm
(4) is a separate entity - no cough and phlegm are produced by patient.
(5) cannot be specified

CHEST ILLNESSES

22. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? [44]

23. *If yes:* Did you bring up more phlegm than usual in any of these illnesses? [45]

24. How many illnesses like this have you had in the past three years? [46]

25. Do you have a heart condition for which you are under a doctor's care? 1 - No 2 - Yes [47]

If "YES" specify conditions and drug therapy

____

____

____

TOBACCO SMOKING

26. Do you now smoke cigarettes? | 48

27. If "NO": Have you ever smoked cigarettes? 1 - No 2 - Yes

28. How old were you when you started smoking regularly? | 50

29. How old were you when you last gave up smoking cigarettes? | 52

_________ years.

List year person last stopped smoking. _________ | 54

30. How much do/did you smoke on the average? _________ | 56

31. Do/did you inhale the cigarette smoke? 1 - No 2 - Yes | 58

32. What do/did you mostly smoke?

Type (1) - filter
(2) - non-filter | 59

Size (1) - regular
(2 - king size
(3) - 100 millimeter | 60

33. Do you smoke a pipe? 1 - No 2 - Yes | 61

34. If "NO": Have you ever smoked a pipe? 1 - No 2 - Yes

35. How many pipefuls a day do/did you smoke? | 63

36. Do you smoke cigars? 1 - No 2 - Yes | 65

37. If "NO": Have you ever smoked cigars? 1 - No 2 - Yes | 66

38. How many cigars a day/do/did you smoke? | 67

39. Do you chew tobacco? 1 - No 2 - Yes | 69

NAME | | | ______________ First ______________ MI

NUMBER | | | | | | D | 5 |

AGE ____ ____

DATE OF BIRTH | | | | | | | 11 |

... last examined by a physician? (month & year) | | | | | 17 |

... 1. acute illness (not hospitalized, other than trauma) | | 21 |

2. acute illness (hospitalized, other than trauma)
3. trauma (not hospitalized)
4. trauma (hospitalized)
5. follow-up, acute illness
6. follow-up, chronic illness
7. routine check-up
8. occupational surveillance program (exam, supplied by employer)
9. pre-employment physical

...n was your last chest x-ray? (month, year) | | | | | 22 |

PHYSICIAN: Code 0001 if never had chest x-ray

Result: 1 = normal 2 = abnormal 3 = doesn't know | | 26 |

Have you ever been hospitalized? 1. No | | 27 |
2. Yes
Describe below

DATE	HOSPITAL	REASON
1.		
4.		

FOR PHYSICIAN: Have release forms been signed? 1 = No 2 = Yes | | 28 |

Have you ever been told by a doctor that you had any of the following conditions?

Cardio-Vascular

01. Heart murmur
02. Angina
03. Heart Attack
04. Any other heart condition for which you are under the care of a doctor? (specify)
05. High blood pressure
06. Claudication

Pulmonary

07. Pneumonia
08. Pleurisy
09. Asthma
10. Bronchitis
11. Emphysema
12. Bronchiectasis
13. Pulmonary tuberculosis
14. Silicosis
15. Asbestosis
16. Other Pulmonary (specify)

Gastrointestinal

17. Gastric ulcer - told by M.D.
18. " " - UGIS
19. " " - Hemorrhage
20. Duodenal ulcer - told by M.D.
21. " " - UGIS
22. " " - Hemorrhage
23. Bleeding from ulcer
24. Other GI bleeding
25. Hiatus hernia
26. Hepatitis
27. Jaundice
28. Gall bladder disease
29. Liver disease
30. Enlarged liver
31. Cirrhosis - alcoholic
32. " - Other
33. Ulcerative colitis
34. Diverticulitis
35. Other GI (specify)

Genitourinary

36. Nephritis
37. Kidney disease (indicate type)
38. Urinary infection
39. Kidney stones
40. Prostate enlargement
41. Blood in urine (not caused by above)
42. Protein in urine (not caused by above conditions)
43. Other genitourinary

Skin

44. Psoriasis
45. Eczema
46. Other skin (specify)

Blood

47. Acute Anemia
48. Chronic Anemia
49. Low white blood count
50. Problems with blood clotting or bleeding
51. Sickle cell
52. Thalessemia
53. Other Blood (specify)

Eye

54. Require glasses
55. Glaucoma
56. Cataracts
57. Weak or lazy eye
58. Optic neuritis
59. Other Eye (specify)

Ear, Nose and Throat

60. Chronic Sinusitis
61. Impaired hearing
62. Nasal allergies

63. Nasal polyps
64. Laryngeal polyps
65. Tonsilectomy
66. Other ENT (specify)

Nervous System

67. Seizure disorder
68. Stroke
69. Parkinson's Disease
70. Psychiatric illness
71. Other Nervous (specify)

Musculoskeletal

72. Rheumatoid arthritis
73. Other arthritis
74. Back injury
75. Degenerative disc disease
76. Yes: Neurologic involvement?
77. Bone lesions
78. Other Musculoskeletal (specify)

General and Metabolic

79. Thyroid disease or goiter
80. Diabetes
81. Gout
82. Night sweats
83. Fever
84. Other (specify)

Cancer

85. Skin
86. Throat
87. Lung
88. Stomach
89. Bowel
90. Rectum
91. Prostate
92. Breast
93. Cervix
94. Uterine
95. Other CA (specify)

A	B	C	D

A,B = condition number   C,D = year diagnosed

Currently inactive

				7 *
				11
				15
				19
				23
				27
				31
				35
				39
				43

Active, not under physician's care

				47
				51
				55
				59
				63
				67
				71
				75
				7 **
				11

Active, under care of physician

				15
				19
				23
				27
				31
				35
				39
				43
				47
				51

* Col 1-5 as above; punch E in col 6   **Col. 1-5 as above; punch H in col. 6

Other ______________________________

ALCOHOL

approx. 10 shots = 1 pint

1.	Type	Quantity	
1.	Beer	________	cans/week
2.	Wine	________	quarts/week
3.	Whisky	________	pints/week

1. no alcohol intake
2. < 6 cans; < 1 qt.; < 1/2 pint
3. 6-24 cans; 1-4 quarts 1/2-2 pints/week
4. > 24 cans; > 4 quarts; > 2 pints/week
5. ex-alcoholic < 1 year
6. ex-alcoholic 1-5 years
7. ex-alcoholic > five years

[ ] 55

MEDICATION: ARE YOU CURRENTLY TAKING ANY OF THE FOLLOWING MEDICATIONS?

1 = Not taking any medication
2 = Currently taking medication

[ ] 56

01 - Diuretics (water pills)
02 - High Blood Pressure meds (other)
03 - Nitroglycerine
04 - Digitalis
05 - Other cardiac
06 - Antihyperlipidemics
07 - Anticoagulants (blood thinner)
08 - TB medication
09 - Long-term antibiotics
10 - Short-term antibiotics
11 - Steroids - oral
12 - Steroids - topical
13 - Broncho-dilators
14 - Insulin
15 - Oral diabetes meds
16 - Thyroid meds
17 - Gout medication
18 - Tranquilizers
19 - Anti-depressants
20 - Anti-psychotics
21 - Sleeping pills daily
22 - Have you ever had radiotherapy?
23 - Anti-convulsants
24 - Anti-inflammatories
25 - Laxatives
26 - Antihistimines
27 - Decongestants
28 - Analgesics
29 - Antacids
30 - Other (specify) ______________________

List medications currently being taken, by number

		57
		59
		61
		63
		65
		67
		69
		71
		73
		75
		77
		79

PHYSICAL EXAMINATION

NAME | | | | | ______ Number | | | | | | J | 5 |
1 2 3 4 Middle initial

Height | | | 11 | (in.) Weight | | | | 13 |

Sex 1 - male 2 - female | | 16 |

Blood pressure | | | | | | | 17 |

Pulse: rate | | | | 2 3 |

Regularity | | 26 |

1 = normal
2 = irregular
3 = other

| | 27 |

GENERAL APPEARANCE.. | | 28 |

1 = well developed, well nourished
2 = obese
3 = underweight
4 = appears chronically ill
5 = pale
6 = other

CYANOSIS.. | | 29 |

1 = absent 2 = lips, tongue 3 = fingers, toes

EXTREMITIES

clubbing 1 = No 2 = Yes | | 30 |

nails (normal = 1, other = 2); characterize | | 31 |

ankle edema 1 = No 2 = Yes | | 32 |

JOINTS | | 33 |

1 = normal
2 = abnormal

joint description

| | | | | 34 |

| | | | | 37 |

| | | | | 40 |

If abnormal:

Joint code: 1 = PIP
2 = DIP
3 = Wrist
4 = Elbow
5 = Shoulder
6 = Knee
7 = Ankle
8 = More than 3
9 = other

descriptive code: 1 = swelling
2 = redness, heat
3 = deformity
4 = crepitations
5 = associated with hx of trauma
6 = other

SKIN .... [| 43]

1 = normal
2 = abnormality present

If abnormal: [| | 44]

1 = seborria ______________________

2 = acne valgaris ______________________

3 = psoriasis ______________________

4 = other (describe) ______________________

EYES

Pupils (1=normal, 2=abnormal) (Specify ______________________ [| 46]

Sclera icteric (1=No, 2=Yes) .... [| 47]

Conjunctiva (1=normal, 2=injected, 3=pale, 4=other .... [| 48]

Describe "other": ______________________

____

____

MOUTH (1=normal, 2=gingival abnormality 3=other) .... [| 49]

Describe "other": ______________________

____

____

THYROID .... [| 50]

1 = normal
2 = enlarged
3 = nodular

LYMPHADENOPATHY (list locations) [| | | | 51]

1 = normal
2 = cervical
3 = supraclavicular
4 = axillary
5 = inguinal
6 = more than 3 sites
7 = other

CHEST INSPECTION .... [| 55]

1 = normal
2 = dullness, right
3 = dullness, left
4 = increased AP diameter
5 = flaring of costal margins

CHEST PERCUSSION.. 56

1 = normal
2 = dullness, right
3 = dullness, left
4 = hyper-resonant, right
5 = hyper-resonant, left
6 = hyper-resonant, bilateral, bases
7 = other

Describe "other": ____________________

____

AUSCULTATION.. 57

1 = normal breath sounds
2 = decreased - right
3 = decreased - left
4 = decreased bilaterally
5 = wheezing and/or rhonchi in a localized area: ____________
6 = wheezing and/or rhonchi-diffuse
7 = lenghtening of respiratory phase
8 = moist rales
9 = other

Describe "other" ____________________

RALES.. 60

1 = none
2 = RAAL
3 = RPAL
4 = RMAL
5 = R-Base
6 = LAAL
7 = LPAL
8 = L-Base
0 = diffuse (more than 3)

CARDIAC PALPATION AND PERCUSSION.............................. 63

1 = normal
2 = heart palpable in epigastrum
3 = heart enlarged by percussion
4 = left ventrical heave
5 = right ventricular heave
6 = displaces P.M.I.

HEART SOUNDS.. 66

1 = normal
2 = murmur
3 = distant heart sounds
4 = pII >A II
5 = S_3
6 = other

Describe "other": ____________________

ABDOMEN

Inspection: ____________________

Masses: ____________________

Abdominal tenderness to palpation.............................. 69

1 = none
2 = RUG
3 = RLQ
4 = Epigastric
5 = Peri-umbilical
6 = LUQ
7 = LLQ
8 = other

Describe "other" ____________________

____

PALPABLE LIVER (1=not palpable, 2=palpable) 70

If palpable, span on mid-clavicular line - in cm 71

Liver tenderness (1=No, 2=Yes) 73

Liver consistency 74

1=normal 3=irregular nodular
2=increased firmness 4=other

PALPABLE SPLEEN (1=not palpable, 2=palpable 75

If palpable, two dimensions by percussion (cm) 76

PALPABLE KIDNEYS (1=not palpable, 2=palpable, right, 3=palpable, left) 78

ABDOMINAL MASSES BY PALPATION (1=none, 2=present) 79

Location, size and consistency ______________________________

____

NEUROLOGICAL EXAMINATION

Deep tendon reflexes

1=normal 3=decreased
2=hyperactive 4=absent

Specify abnormality: ankle 11* biceps 12
knee 13 wrist 14

MOTOR 15

1=normal
2=decreased strength
Indicate muscle group involved: ______________________________
3=wrist drop
4=telcky sign
5=extensor weakness
6=Babinski
7=other

TREMOR 18

1=none
2=outstretched hands
3=intention
4=face
5=other

Describe "other": ______________________________

*Col. 1-9 as above; punch K in col. 10

SENSORY: pin

Arms (1 = absent, 2 = present) [| 20]

Legs (1 - absent, 2 = present) [| 21]

OTHER NEUROLOGIC [| 22]

1 = none

2 = present (describe) ______________________________

____

____

EXAMINER'S CODE.. [| | 23]

1 = Selikoff
2 = Anderson
3 = Daum
4 = Fischbein
5 = Holstein
6 = Lilis
7 = Lorimer
8 = Rom
9 = Rosenmann
10 = Todaro

HUMAN RESEARCH CONSENT FORM

I. PROJECT DESCRIPTION

1. Investigation of Health Hazards in Brake Lining Repair and Maintenance Workers Occupationally Exposed to Asbestos (NIOSH 210-77-0119-0000)
2. Investigators: Irving J. Selikoff, M.D. and William J. Nicholson, Ph.D.
3. Purpose: To identify any human health hazards associated with brake repair and maintenance.

II. CONSENT TO PARTICIPATE

I, ______________________, age _______, hereby voluntarily agree to cooperate in the above named study and to undergo the tests listed in Attachment A. The study has been discussed with me and I have been given a copy of this document. I understand that:

1. The procedures and tests to be followed are as stated in Attachment A; no procedures are experimental.
2. Attendant discomforts and risks are as noted in Attachment A and, except as noted, are minimal and provision has been made for any necessary medical care, and I have been told what to do if I have any reaction.
3. Benefits are as indicated in the Purpose statement above (Part I, Item 3).
4. If alternative procedure advantageous to me are available, they are specified in Attachment A; and if they become available during the project, the procedure most advantageious for me will be indicated and used or an explanation will be given to me as to use of any other procedure.
5. My inquiries will be answered by the project directors or other personnel invovled in the project. (Telephone 212-650-5823)
6. I am free to terminate my consent and to discontinue participation in the project at any time without prejudice to myself.
7. My identity and my relationship to any information (1) disclosed by me in completing any project questionnaire and (2) reported by me or derived from me during my participation in the above named project shall be kept confidential and will be disclosed to others without my written consent except as required by law and except that such information will be used for statistical and research purposes in such a manner that no individual can be identified. I understand that if any information is found out concerning me that can endanger the health and safety of others, this information will be given to the proper authority.
8. If any of my medical records are required for purposes of this project, a separate written consent for release of the records will be requested from me.

9. There will be questions that I will be asked to answer, and my inquiries concerning the questions will be answered by:

Dr. Selikoff or Dr. Nicholson 212-650-5823

10. A report of any significant information from the study that specifically concerns me, including medical information, will be furnished by the project officer or his designated representative to me or to my designated physician(s) upon completion of the study or earlier if appropriate.

SIGNATURE ______________________________ ______________
Subject's Name Date

11. INVESTIGATOR: William J. Nicholson, Ph.D., Associate Professor

____
Signature

III. CONSENT FOR MAINTENANCE OF RECORDS

I hereby give consent for Mount Sinai School of Medicine to maintain all records of this examination. They will be completely confidential as above and information will be released to any physician I designate upon my written request and authorization at any time in the future.

SIGNATURE ______________________________ ______________
Subject' Name Date

IV. REQUEST AND AUTHORIZATION FOR RELEASE OF INFORMATION

I, ______________________________, hereby request and authorize the Project Director to inform the following physicians whose names and addresses I have entered below of any significant findings from the above named study concerning me. (DO NOT LEAVE BLANK: WRITE "NO" WHERE YOU DO NOT WISH TO GIVE A NAME AND ADDRESS).

1. My personal physician:	2. Other physician:
Dr. ______________________	Dr. ______________________
Street: ______________________	Street: ______________________
City: ______________________	City: ______________________
State/Zip: ______________________	State/Zip: ______________________

ATTACHMENT A

A. Investigation of Health Hazards in Brake Lining Repairs and Maintenance Workers Occupationally Exposed to Asbestos (NIOSH 210-77-0119-0000)

B. The procedures and tests which involve human subjects in conduct of this project are as follows:

Blood tests

Urine analysis

Sputum cytology

Chest x-ray

Pulmonary function tests

Physical examination

Each of the above provides important information for the evaluation of health status. There is minor discomfort associated with the drawing of blood from the arm. The sputum cytology involves coughing up phlegm from the throat into a container which is provided. The pulmonary function test involves a maximum breathing effort.

C. Rights under the Privacy Act of 1974 Title 5 United States Code, Section 552(a)(e)(3)

The information required to be given to me under the Privacy Act of 1974 is as follows:

1) Authority for collecting information is the Occupational Safety and Health Act of 1970,

2) The principal purpose of this study is as stated in Section I, Item 3.

3) Routine use of this information is in developing criteria and programs for a safe and healthy place of employment.

4) I do not have to furnish any information I do not wish to. Nothing happens to me as a result of my not providing information, whether all or in part of that requested, except that I may be terminated from the project.

Brakeworkers

Occupational History Asbestos Exposure Code

Work Practice (Primary Code)

1. Brake work: (Greater than 1 job per 6 months) or garage procedures which would result in heavy direct exposure, e.g. brake work, clutch work, or front end work which involves the air blowing of asbestos containing debris.

2. Garage work not directly involving brakes but where other exposure to asbestos could occur in the facility (i.e. brake work done elsewhere at the work site).

   2A. Body repair work involving an asbestos filler.
   2B. Undercoating work on a regular basis.

3. Heavy occupational exposure (activity would normally raise visible dust), e.g. factories, insulation work.

4. Indirect asbestos exposure, e.g. in shipyard work, taping by painters, construction work near spraying of asbestos or insulation work, work in plumbing and heating trades with asbestos exposure.

5. Low indirect exposures, possible indirect, or very occasional direct.

Brake Work Codes

Secondary Code
(For a Primary Code of 1, only)

Frequency

A 1 job/day or greater
B 1 - 4 jobs per week
C 1 - 4 jobs per month
D 1 - 5 jobs/6 months

Tertiary Code

0 No grinding or beveling
1 Some grinding or beveling

Sample Entry: 1 B 1
1 C 0
2 0 0

ENVIRONMENTAL SCIENCES LABORATORY

MOUNT SINAI SCHOOL OF MEDICINE OF THE CITY UNIVERSITY OF NEW YORK

Number ____________________

Research Group ____________________

Name ____

Comment: ____

ILO U/C International Classification of Radiographs of Pneumoconioses   BIT U/C Classification Internationale des Radiographies de Pneumoco[illegible]

		ROUNDED SMALL OPACITIES			IRREGULAR SMALL OPACITIES			SMALL OPACITIES	LARGE OPACITIES			PLEURAL THICKENING			ILL DEFINED DIAPHRAGM	ILL DEFINED CARDIAC OUTLINE	PLEURAL CALCIFICATION					
Date	Quality	Type	Profusion	Zones	Type	Profusion	Zones	Combined Profusion	Type	Size	Costo-phrenic angle	Site	Width	Extent			Diaph	Wall	Other	Grade	Symbols	Comments
	+	p	0/- 0/0 0/1	Check zones involved	s	0/- 0/0 0/1	Check zones involved	0/- 0/0 0/1		0	0			0	0	0				0	ax bu ca	cn co
	±	q	1/0 1/1 1/2		t	1/0 1/1 1/2		1/0 1/1 1/2	wd	A	R	R	a	1	R	1		R		1	cp cv di	ef em
	±	r	2/1 2/2 2/3		u	2/1 2/2 2/3		2/1 2/2 2/3	id	B	L	L	b		[illegible]	[illegible]		L		2	es hi ho	k od
	U/R		3/2 3/3 3/4			3/2 3/3 3/4		3/2 3/3 3/4		C			c							3	pq px rl	tba tbu

		Codes	Definitions
Small opacities	**Rounded** Profusion*		The category of profusion is based on assessment of the concentration (profusion) of opacities in the affected zones. The standard films define the mid categories (1/1, 2/2, 3/3).
		0/- 0/0 0/1 1/0 1/1 1/2 2/1 2/2 2/3 3/2 3/3 3/4	Category 0 - small rounded opacities absent or less profuse than in category 1. Category 1 - small rounded opacities definitely present but few in number. Category 2 - small rounded opacities numerous. The normal lung markings are usually still visible. Category 3 - small rounded opacities very numerous. The normal lung markings are partly or totally obscured.
	Type	p, q(m), r(n)	The nodules are classified according to the approximate diameter of the predominant opacities. p - rounded opacities up to about 1.5mm diameter. q(m) - rounded opacities exceeding about 1.5mm and up to about 3mm diameter. r(n) - rounded opacities exceeding about 3mm and up to about 10mm diameter.
	Extent	RU RM RL LU LM LL	The zones in which the opacities are seen are recorded. Each lung is divided into three zones—upper, middle and lower.
	Irregular Profusion*		The category of profusion is based on the assessment of the concentration (profusion) of opacities in the affected zones. The standard films define the mid-categories.
		0/- 0/0 0/1 1/0 1/1 1/2 2/1 2/2 2/3 3/2 3/3 3/4	Category 0 - small irregular opacities absent or less profuse than in category 1. Category 1 - small irregular opacities definitely present but few in number. The normal lung markings are usually visible. Category 2 - small irregular opacities numerous. The normal lung markings are usually partly obscured. Category 3 - small irregular opacities very numerous. The normal lung markings are usually totally obscured.
	Type	s t u	As the opacities are irregular, the dimensions used for rounded opacities cannot be used, but they can be roughly divided into three types. s - fine irregular or linear opacities. t - medium irregular opacities. u - coarse (blotchy) irregular opacities.
	Extent	RU RM RL LU LM LL	The zones in which the opacities are seen are recorded. Each lung is divided into three zones—upper, middle and lower—as for rounded opacities.
	Combined Profusion *		When both rounded and irregular small opacities are present, record the profusion of each separately and then record the combined profusion as though all the opacities were of one type. This is an optional feature of the classification.
Large opacities	Size	A B C	Category A—an opacity with greatest diameter between 1cm and 5cm, or several such opacities the sum of whose greatest diameters does not exceed 5 cm. Category B—one or more opacities larger or more numerous than those in category A, whose combined area does not exceed the equivalent of the right upper zone. Category C—one or more large opacities whose combined area exceeds the equivalent of the right upper zone.
	Type	wd id	As well as the letter 'A', 'B' or 'C', the abbreviation 'wd' or 'id' should be used to indicate whether the opacities are well defined or ill defined.
Other features	**Pleural thickening** Costophrenic angle	Right Left	Obliteration of the costophrenic angle is recorded separately from thickening over other sites. A lower limit standard film is provided.
	Walls and diaphragm Site Width	Right Left a b c	Grade a - up to about 5mm thick at the widest part of any shadow. Grade b - over about 5mm and up to about 10mm thick at the widest part of any shadow. Grade c - over about 10mm thick at the widest part of any shadow.
	Extent	0 1 2	Grade 0 - not present or less than grade 1. Grade 1 - definite pleural thickening in one or more places such that the total length does not exceed one half of the projection of one lateral chest wall. The standard film defines the lower limit of grade 1. Grade 2 - definite pleural thickening in one or more places such that the total length exceeds one half of the projection of one lateral chest wall.
	Diaphragm Ill defined	Right Left	The lower limit is one third of the affected hemidiaphragm. A lower limit standard film is provided.
	Cardiac outline Ill defined (shagginess)	0 1 2 3	Grade 0 - not present or up to one third of the length of the left cardiac border or equivalent. Grade 1 - above one third and up to two thirds of the length of the left cardiac border or equivalent. Grade 2 - above two thirds and up to the whole length of the left cardiac border or equivalent. Grade 3 - more than the whole length of the left cardiac border or equivalent.
	Pleural calcification Site Diaphragm Walls Other Extent	Right Left 0 1 2 3	Grade 0 - no pleural calcification seen. Grade 1 - one or more areas of pleural calcification, the sum of whose greatest diameters does not exceed about 2cm. Grade 2 - one or more areas of pleural calcification, the sum of whose greatest diameters exceeds about 2cm, but not about 10cm. Grade 3 - one or more areas of pleural calcification, the sum of whose greatest diameters exceeds about 10cm.

ax coalescence of small rounded pn eumoconiotic opac

bu bullae

ca cancer of lung or pleura

cn calcification in sr pneumoconiotic opacities

co abnormality of c diac size or shape

cp cor pulmonale

cv cavity

di marked distortio the intra-thoracic organs

ef effusion

em marked emphyse

es eggshell calcificat of hilar or medias tinal lymph node

hi enlargement of hi or mediastinal lyr nodes

ho honeycomb lung

k septal (kerley) lin

od other significant disease. This inclu disease not related dust exposure, e.g surgical or trauma damage to chest walls, bronchiecta etc.

pq pleural plaque (un calcified)

px pneumothorax

rl rheumatoid pneum coniosis (Caplan's syndrome)

tba tuberculosis, prob ably active

tbu tuberculosis, activi uncertain

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			/			/		/								
	+	p	0/- 0/0 0/1	Check zones involved	s	0/- 0/0 0/1	Check zones involved	0/- 0/0 0/1		0	0			0	0	0
	±	q	1/0 1/1 1/2		t	1/0 1/1 1/2		1/0 1/1 1/2	wd	A	R	R	a	1	R	1
	[illegible]	r	2/1 2/2 2/3		u	2/1 2/2 2/3		2/1 2/2 2/3	id	B	L	L	b	[illegible]	[illegible]	[illegible]
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	Diaphragm Ill defined	Right Left	The lower limit is one third of the affected hemidiaphragm. A lower limit standard film is provided
	Cardiac outline Ill defined (shagginess)	0 1 2 3	Grade 0 - not present or up to one third of the length of the left cardiac border or equivalent. Grade 1 - above one third and up to two thirds of the length of the left cardiac border or equivalent. Grade 2 - above two thirds and up to the whole length of the left cardiac border or equivalent. Grade 3 - more than the whole length of the left cardiac border or equivalent.
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