U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 75-130-484

Westvaco Corporation
Carbon Plant, Chemical Division
Covington, Virginia

APRIL 1978

I. TOXICITY DETERMINATION

NIOSH conducted a health hazard evaluation at Westvaco Corporation, Carbon Plant, Chemical Division, on November 18-19, 1975, and May 4-6, 1976. The purpose of the evaluation was to determine whether exposures to carbon dust and carbon impregnated with phosphoric acid was posing a health hazard to the employees.

The evaluation on November 18-19, 1975, consisted of an environmental evaluation, medical interviews and limited chest examinations. The evaluation on May 4-6, 1976, included environmental evaluations, medical interviews and comprehensive medical examinations.

It has been determined that although airborne concentrations of airborne carbon impregnated with phosphoric acid were excessive during the evaluation of November 18-19, 1975, they were not excessive during the evaluation of May 4-6, 1976. These determinations are based on the environmental measurements made on the above dates. No conclusive determinations could be made from the medical tests performed on May 4-6, 1976. The process of activation with phosphoric acid was in existence at this plant for one year prior to this study.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are available from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies have been sent to:

a. Westvaco Corporation, Carbon Plant, Chemical Division, Covington, Virginia
b. United Paperworkers International Union and Local 675
c. U. S. Department of Labor - Region III
d. NIOSH - Region III

For the purpose of informing the approximately 200 "affected employees," the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health received such a request from an authorized representative of employees regarding inhalation exposures to dust and phosphoric acid; complaints of nausea, shortness of breath and general illness feelings were alleged.

An interim report on the atmospheric evaluation of November 18-19, 1975, was sent by NIOSH on February 27, 1976.

We regret the delay in submission of this report. Walter Chrostek, NIOSH Industrial Hygienist, had been transferred from the bureau in September 1976 and, due to his new duties, could not complete this report until this time.

IV. HEALTH HAZARD EVALUATION

A. Plant Process - Conditions of Use

This plant consists of three divisions: 1) paperboard, 2) carbon and 3) research. The area of interest during this evaluation was the carbon division. There are two types of carbon made at this plant: one type is made from ground wood pulp and the second type is made from bituminous coal.

1. Wood Carbon Process

Coarse wood pulp, either hardwood or pine, which is a by-product of other processes, is brought by truck and dumped on a screen where the debris and large particles are separated out. The large particles are reprocessed. Commercial phosphoric acid is then added to the sawdust and mixed for approximately forty-five minutes to form a slurry. This slurry is fed into a rotary activation kiln which is approximately thirty feet long. The temperature in the kiln starts at 1450°F and gradually decreases to 600°F. The material coming from the kiln has to be adjusted for acid content with soda ash or phosphoric acid. The material goes to a drying tank at 400°F. This material is ground, screened and finished. All acid coming from the process is recovered, concentrated and fed back into the operation.

In the finishing department, the material is briquetted, pulverized to the required size, screened and bagged.

2. Coal Process

Bituminous coal is ground to 200 mesh, briquetted, pulverized and sized and put in storage. From here, it is sent to an oxidation and devolitization furnace and heated in the presence of air at 500-600°F where the gases and tars are removed. From here, it is fed into a rotary kiln and heated to 1100°F. The additional volatiles and gases are burned off without recovery. From the rotary kiln, the material is conveyed to multiple hearth furnaces, heated to 2000°F and activated with steam and water. Following activation the material is put in storage. From storage it is ground to size as needed.

3. Bagging - Warehousing

Material is blown into a holding chamber and fed into an automatic bagging machine. The bags are then sealed with polyethylene plastic, machine stacked on pallets and conveyed by a lift truck to the storing area.

B. Evaluation Methods

1a. Environmental

On November 18-19, 1975, an evaluation of the work atmosphere was conducted utilizing pre-weighed mixed cellulose ester membrane filters and personal air samplers.

Sampling rate was at approximately 1.75 liters per minute for the majority of the work day. The air samples were subsequently analyzed gravimetrically for total dust and phosphoric acid content of the dust utilizing NIOSH method P & CAM #S333.

2a. Medical

A limited medical evaluation was also conducted by a NIOSH physician. The evaluation consisted of a work and health history questionnaire and a limited chest examination of thirty employees. The purpose of this examination was to ascertain if a definitive medical study should be performed.

1b. Follow-Up Environmental

On May 4-6, 1976, environmental samples were collected utilizing pre-weighed mixed cellulose ester membrane filters and personal air samplers. The sampling rate was approximately 1.75 liters per minute for the majority of the work day. The workers were sampled for exposure to total dust and respirable dust. These samples were subsequently analyzed gravimetrically for dust content and for phosphoric acid content utilizing NIOSH method P & CAM #S333.

2b. Follow-Up Medical

A total of 282 workers were evaluated at the Westvaco Corporation on May 3-8, 1976, with questionnaires and pulmonary function tests consisting of spirometry. Of these, 222 individuals had chest x-rays. Eighty-seven of the 104 workers presently employed in the carbon plant were studied. A group of 195 workers from the bleach board division of Westvaco were used as a control population. These controls had never been exposed to carbon, however, there was some exposure to chemicals in the paper-making process. Each worker's height and weight were recorded. A standardized questionnaire was administered which was a modified version of the British Medical Research Council's questionnaire on chronic bronchitis. A detailed occupational history was taken. Chest x-rays, both PA and lateral, were interpreted by a "B" reader according to the ILO/UICC classification. At least five measurements of the forced vital capacity were performed on an Ohio 800 waterless spirometer with each worker standing and a noseclip in place. Flow rates were chosen from the curve with the largest forced vital capacity (FVC) containing a peak flow within 15% of the largest peak flow. The largest observed FVC and forced expiratory volume in one second (FEV_1) were chosen regardless of the curves on which they occurred. The workers were divided into a control group and an exposed group.

The control group was further divided into two subsets: Control Group "A," who had never worked in a carbon plant, and Control Group "B," who were not presently employed in the carbon plant but had experienced at least five years' exposure involving carbon at some time in the past. The carbon plant workers were divided into Group "A," those presently employed in the carbon plant with more than five years' exposure, and Group "B," those who are presently employed in the carbon plant but have less than five years' exposure. Each of the control and exposed groups were further divided into subgroups of ex-smokers, non-smokers and smokers.

C. Evaluation Criteria

Environmental

Threshold Limit Values have not been established for carbon dust. The American Conference of Governmental Industrial Hygienists (ACGIH) lists an inert dust or nuisance dust as one when the toxic impurities are not present; e.g., quartz < 1%. For this evaluation the ACGIH criteria will be used.

The Occupational Health Standards relevant to this evaluation as promulgated by the U. S. Department of Labor (Federal Register, Volume 39, June 27, 1974, page 23541)[1] is as follows:

Substance	8-Hour Time-Weighted Average
Phosphoric Acid	1 mg/M^3*
Inert or Nuisance Dust	15 mg/M^3 (Total)
	5 mg/M^3 (Respirable Fraction)

The American Conference of Governmental Industrial Hygienists[2] standards relevant to this evaluation are:

Phosphoric Acid	1 mg/M^3
Inert Dust (< 1% quartz)	10 mg/M^3 (Total)
	5 mg/M^3 (Respirable Dust)

*mg/M^3 - denotes approximate milligrams of substance per cubic meter of air.

The American Conference of Governmental Industrial Hygienists has also proposed a short-term exposure limit for phosphoric acid at 3 mg/M^3 for a 15-minute period, provided that no more than four excursions per day are permitted, with at least 60 minutes between excursion periods, and provided that the daily Threshold Limit Value Time-Weighted Average is not exceeded.

D. Results and Discussion

1. Environmental

During the environmental evaluation conducted on November 18-19, 1975, eighteen operators were evaluated and twenty-two air samples were taken. The evaluation criteria was exceeded at the powder kiln operations for phosphoric acid and in the warehouse at the bag packer and lift truck operations, for both total dust and phosphoric acid. (See Tables I & II.) The quartz content of the atmospheric dust was less than one percent.

During the environmental evaluation conducted on May 4-6, 1976, thirty-two environmental samples were collected and analyzed for total dust and phosphoric acid and respirable dust. During this evaluation, all the air samples collected did not exceed the respective evaluation criteria for total dust, respirable dust and phosphoric acid. (See Table III.) The cristobalite and quartz content of all samples analyzed were less than one percent. (See Table IV.)

2. Medical

Table V shows the mean age and number in each group categorized by their smoking history. The mean age of the ex-smokers and smokers was approximately the same among the groups with the exception of the carbon workers, Group "B," where the mean age was lower in each smoking category. This was not unexpected since these men with less than five years' carbon exposure would be a younger group of employees in general. Table VI notes the prevalence of chronic bronchitis as defined by the MRC questionnaire among the control and exposed groups in relation to their smoking history. The control and exposed groups had no significant difference in their percent of bronchitis when comparing smokers and ex-smokers. However, there was an unexplained increase in the prevalence of chronic bronchitis among the non-smoking

group, especially in the controls. Thirty-one percent of non-smoking Group "A" controls and 50% of non-smoking Group "B" controls had symptoms of chronic bronchitis. This was much higher than would be expected in such a population. Table VII shows the FVC, FEV_1 and FEV_1/FVC ratio for the total non-smoking control group when separated into bronchitis and non-bronchitis. There was no difference in the pulmonary function tests between the bronchitis and non-bronchitis. Both groups had normal spirometry when compared to predicted normals. The symptoms of bronchitis could have been produced by chronic post nasal discharge. (Fifty percent indicated this symptom on the questionnaire.) However, one could also postulate that production of phlegm is an indication of early simple bronchitis with no detectable changes in flows or volumes by routine spirometry. This does not explain the increased incidence of chronic bronchitis in the control groups and a possibility that this is due to exposures other than carbon exists.

Table VIII shows the prevalence of pneumoconiosis among the groups, again separated by exposed vs. controls and smoking history. A total of seven workers with pneumoconiosis were detected by chest x-ray using the ILO/UICC classification, none of which were greater than category 1/0. There was no significant difference for prevalence of pneomoconiosis between the four groups. Table IX compares the smoking history in pack years as calculated by multiplying the number of packs or fractions of a pack smoked daily times the number of years of smoking. No significant pack year difference was found between the control "A" and carbon exposed "A" groups. Again, exposed Group "B" had a lower pack year history; however, the mean age is lower for this group. In Table X, the pulmonary function data for the control and exposed subgroups when separated into smoking status are shown. There were no significant differences in the FEV_1, FVC or FEV_1/FVC ratio when the controls are compared to the exposed group in the smoking, ex-smoking or non-smoking categories. Exposed Group "B" (those carbon workers with less than five years experience) had a mean FEV_1/FVC ratio of 69%. There were only eight subjects in this group, one of whom had classical asthma and an FEV_1/FVC ratio for the low exposed carbon workers was 72%.

E. Summary

1. Environmental

Based on the results of atmospheric sampling as evaluated on November 18-19, 1975, and compared with the evaluation performed on May 4-6, 1976, substantial progress in

engineering to contain the dust was accomplished. During the initial evaluation, there were many mechanical failures in the packaging department. One of the main problems noted was the bag spout configuration. Following the initial visit, the bag spouts were redesigned resulting in fewer breakdowns. During the breakdown, the employees had to enter the enclosed packaging machine where exhaust ventilation was minimal. Exhaust ventilation was increased during the subsequent evaluation.

During the initial survey, there was a thirty-inch wall exhaust located in a position so that any dust on the bags would be drawn past the breathing zone of the employees. This fan was relocated.

Throughout the carbon plant, it was noted that material handling ducts and exhaust ventilation ducts were in a state of disrepair. It was also noted that many valves and pipes were leaking causing an unnecessary exposure to phosphoric acid.

The American Conference of Governmental Industrial Hygienists has adopted Threshold Limit Values for mixtures of dusts and vapors; however, no Threshold Limits have been adopted for mixtures of dusts and acids.

It was noted that the employees were wearing non-approved respirators. Although carbon itself may be classified as an inert or nuisance type of dust when it is impregnated with phosphoric acid, NIOSH approved respirators for dusts and mists should be provided.

2. Medical

Several studies in the literature have shown that carbon and activated carbon deposition in the lungs have been implicated in pneumoconiosis. Carbon is still regarded as an inert or non-fibrogenic dust and the findings at autopsy are absence of significant collagenization in the reactive lung tissue and maintenance of anatomic integrity of the air spaces. These lesions are potentially reversible. In occupational exposure to this type of inert dust, unless complicating factors supervene, the dust reaction generally produces no measurable pulmonary disfunction. In our present study of workers exposed to carbon activated by phosphoric acid and heat, we showed that the prevalence of pneumoconiosis was no different for the control workers compared to the carbon

exposed workers. None of the subjects in either control or carbon worker groups had an ILO/UICC classification greater than 1/0, and, of the 222 chest x-rays examined, only seven had evidence of pneumoconiosis. When comparing symptoms in the carbon workers to the controls, there was no difference in the prevalence of bronchitis between the smoking and ex-smoking workers. However, the non-smoking controls showed more bronchitis than the non-smoking carbon workers (Table VI). Pulmonary function tests in the non-smoking bronchitic controls were not different from those of the non-smoking non-bronchitic controls (mean FEV_1/FVC ratios of 78% and 76% respectively). It is possible that some of these non-smoking controls did have early simple bronchitis which is still in the small airway stage and cannot be detected by conventional spirometry. If so, we cannot explain why they had more bronchitis than the activated carbon workers. Pulmonary function data for the control and exposed groups showed no significant difference between any of the groups. Exposed Group "B," that is those carbon workers with less than five years' experience, had a slightly lower FEV_1/FVC ratio than expected; however, the group was small and, as was noted earlier, one subject was an asthmatic with moderate obstructive airway disease, and with only eight subjects he would lower the mean values significantly. From the above findings, we conclude that activated carbon was not an important factor in the production of respiratory symptoms or changes in pulmonary function tests of the workers. There was no significant difference in the prevalence of pneumoconiosis in the control and exposed groups. The new process of using phosphoric acid in the manufacture of activated carbon had been in effect for only one year when the study was done. Therefore, it was not possible to determine whether the phosphoric acid is having any long-term effect. To help answer the question whether phosphoric acid was causing any detrimental effects, a future study might be performed. One could then compare the changes in pulmonary function tests and symptoms over the four-year period from 1972-1976 to the same data over the period from 1976-1980.

V. RECOMMENDATIONS

1. Supply only NIOSH approved respirators for dusts and mists.

2. Establish a periodic maintenance program for material handling and exhaust ventilation systems.

3. Supply additional exhaust ventilation on the packaging machine, which will clear the enclosed area of any dust generated prior to entry into the area to make repairs or adjustments.

4. Supply local exhaust ventilation at the point where the bags come from the packaging area into the general warehouse area. This will eliminate any spillage during the bag filling.

5. Establish a preplacement and periodic medical program for all employees exposed to dust. The program should include a work history, chest x-ray and a pulmonary function test.

VI. REFERENCES

1. U.S. Department of Labor, Occupational Safety and Health Administration, OSHA Safety and Health Standards (29 CFR 1910) OSHA 2206 (Revised, January 1976).

2. American Conference of Governmental Industrial Hygienists, "Threshold Limit Values for Chemical Substances in the Workroom Environment for 1977."

3. Gross, P. and Nau, C. A., "Lignite and the Derived Steam Activated Carbon: The Pulmonary Response to Their Dusts," Archives of Environmental Health 14:450-460.

4. Wehr, K. L., et al, "Pneumoconiosis Among Activated Carbon Workers," Archives of Environmental Health 30:578-582, December 1975.

5. Standardized questionnaire of respiratory systems, Medical Research Council's Committee on Aetology of Chronic Bronchitis, British Medical Journal 2:1665, 1960.

6. "ILO/UICC 1971 International Classification of Radiographs of the Pneumoconiosis," Medical Radiography and Photography, Volume 48, No. 3, 1972, page 67.

7. Rogen, John, "Coal Workers Pneomoconiosis: A Review," Journal of Occupational Medicine, Volume 12, No. 8, August 1970, pages 321-324.

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Table I
WESTVACO CORPORATION
Carbon Plant, Chemical Division
Covington, Virginia
Report No. 75-130
Operator's Breathing Zone Exposures to Airborne Total Dust and Phosphoric Acid
November 18-19, 1975

Operation	Time	Total Dust*	Phosphoric Acid**
		mg/M^3	
Wood Carbon Plant			
Acid Recovery	7:35-14:15	1.3	0.3
Powder Kiln	7:36- 8:30	19.1	11.0
	8:30-14:21	5.6	2.3
Millwright (Maintenance)	7:37-14:52	5.5	3.9
Rejuvenator	7:44- 9:26	1.9	N.D.***
	9:26-14:27	1.5	N.D.
Bulk Loader	7:50-14:15	2.1	0.1
Oiler	8:00-14:25	2.1	0.2
Warehouse			
Bag Packer	7:14- 9:25	670.2	33.5
	9:25-14:37	10.1	0.3
Bagger	7:07-14:35	15.4	0.6
Labeler	7:10-14.32	12.6	0.5
Lift Truck	7:00- 9:27	85.5	2.9
	9:27-14.39	5.3	0.2
Cleaner	7:05-14:34	4.9	0.1
Spent Carbon	6:32-14:00	3.1	0.1
Lab Tech	6:30-14:20	0.2	0.1
Laborer	6:50-14:20	3.7	0.1
Acid Recovery	14:20-22:02	1.0	0.4
Screen Finishing	14:34-21:55	1.0	0.1
Saw Dust Hauler	14:40-21:50	0.6	N.D.
Tour Supervisor	14:53-21:58	1.3	0.1

*Total Dust - permissible air concentrations for an 8-hour work day - 10 milligrams per cubic meter of air sampled.

**Phosphoric Acid - permissible air concentrations for an 8-hour work day - 1 milligram per cubic meter of air sampled.

***N.D. - denotes lower limit of detection less than 0.01 milligram per sample.

TABLE II
WESTVACO CORPORATION
Carbon Plant, Chemical Division
Covington, Virginia
Report No. 75-130
Operator's Breathing Zone Exposure to Airborne Dust
November 19, 1975

Operation	Time	Dust Concentrations* mg/M^3
Granular	7:25-14:40	22.4

* Dust - permissible air concentrations for an 8-hour working day - 10 milligrams per cubic meter of air sampled.

Table III
WESTVACO CORPORATION
Carbon Plant, Chemical Division
Covington, Virginia
Report No. 75-130
Operator's Breathing Zone Exposures to Airborne Total Dust and Phosphoric Acid
May 4-6, 1976

Operation	Time	Total Dust mg/M3*		Phosphoric Acid ug/M3**	
		Total	Respirable	Total	Respirable
Finish Carbon Operator	15:25-22:00	1.2	0.3	5.3	2.5
Packaging	7:36-14:02	4.4	1.5	49.9	23.6
Packaging	7:37-14:24	0.7	0.6	7.	26.3
Packaging	7:40-14:15	1.0	0.4	9.2	4.9
Coal Unloader	7:30-14:30	1.3	0.2	---	---
Laborer	7:47-14:20	.4	0.1	16.6	5.3
Laborer	7:44-14:10	14.6	0.5	---	---
Granular Utility	7:50-14:30	1.7	0.5	---	---
Bulk Loader	8:20-11:15	1.1	0.1	49.5	20.0
Packaging (General Air)	7:57-12:48	0.8	0.2	11.5	31.4
Laborer	8:05-14:47	0.4	0.2	8.3	---
Laborer	8:07-13:57	0.2	0.2	8.4	---
Oiler	8:10-14:25	0.4	0.3	77.0	44.6
Bulk Loader	8:12-14:15	1.0	0.3	24.2	---
Sawdust Screener	8:14-13:55	0.5	0.2	2.3	---
Millwright	8:43-14:48	0.4	0.5	3.8	---
No. 5 Paper Machine (General Air)	9:08-15.43	0.1	0.1	---	---
Laborer	9:53-13:00	6.7	1.6	65.9	---
Powder Kiln Operator	15:10-21:30	0.4	0.2	0.1	---
Carbon Screen Finisher	15:05-21:28	0.2	0.1	6.4	---
No. 1 Granular Packager	15:22-21:42	1.5	0.5	---	---
No. 2 Granular Packager	15:25-21:45	2.0	1.0	---	---
Multi Hearth Operator	15:23-21:45	1.4	0.5	---	---
No. 1 Packer	7:34-10:40	6.9	1.9	148.6	93.3
	10:45-14:02	3.8	2.0	171.1	75.6
Shrinker	7:35-14:00	2.7	.9	24.8	9.3
No. 2 Packer	7:35-10:40	2.6	1.2	41.8	44.8
	10:42-14:02	1.7	1.2	29.4	65.6
Cleaner	7:38-10:36	5.0	1.7	95.3	69.7
	10:37-14:00	3.0	1.1	48.4	49.2
Acid Recovery	7:57-14:23	0.5	0.3	2.9	7.1
Spent Carbon	15:04-21:36	0.5	0.2	---	---

* Dust - permissible air concentration (less than 1 percent quartz) for an 8-hour work day - 10 milligram (total dust) per cubic meter of air sampled, 5 milligrams (respirable dust) per cubic meter of air sampled.

** Phosphoric Acid - permissible air concentration for an 8-hour work day - 1000 micrograms per cubic meter of air.

Table IV
WESTVACO CORPORATION
Carbon Plant, Chemical Division
Covington, Virginia
Report No. 75-130
Operator's Breathing Zone Exposures to Total Dust
May 4-6, 1976

Operation	Time	Dust mg/M3* Total	Respirable	Cristobalite mg/M3**	Quartz
Multi Hearth Prep Operator	15:00 - 22:08	1.14	0.37	< 0.03	< 0.01
Multi Hearth Furnace Operator	15:07 - 22:04	1.28	0.49	< 0.03	< 0.01
Granular Package Operator	15:13 - 22:00	0.60	0.36	< 0.03	< 0.02
Granular Package Operator	15:15 - 22:00	0.99	0.32	< 0.03	< 0.01

* Dust - permissible air concentrations (less than 1 percent quartz - 10 milligrams (total dust), 5 milligrams (respirable dust) per cubic meter of air sampled.

** Lower Limit of Detection - Cristobalite - 0.03
Quartz - 0.01

TABLE V

Mean Age and Total Number in Each
Control and Exposed Sub-Group

	Smokers Age (N)	Ex-Smokers Age (N)	Non-Smokers Age (N)
Controls A	46 (56)	48 (53)	39 (36)
Controls B	43 (19)	49 (19)	50 (12)
Carbon Workers A	46 (19)	51 (20)	43 (10)
Carbon Workers B	34 (19)	38 (8)	31 (11)

Controls A - never worked in carbon
Controls B - now non carbon but previous carbon exposure
Carbon Worker A - greater than 5 years exposure
Carbon Worker B - less than 5 years exposure
(N) = number in each group

Table VI

Prevalence of Bronchitis

	Smokers	Ex-Smokers	Non-Smokers
Controls A	45% (56)	13% (53)	31% (36)
Controls B	42% (19)	37% (19)	50% (12)
Carbon Workers A	63% (19)	35% (20)	30% (10)
Carbon Workers B	42% (19)	38% (8)	18% (11)

(N) = number in entire group

Controls A - never worked in carbon
Controls B - now non carbon but previous carbon exposure
Carbon Workers A - greater than 5 years exposure
Carbon Workers B - less than 5 years exposure

Table VII

Comparison of Pulmonary Function Tests in Non-Smoking Controls With and Without Symptoms of Bronchitis

	FEV	FVC	FEV_1%	Age
Bronchitics (16)	3.9	5.2	76%	42 yrs.
Non-Bronchitics (30)	3.9	5.1	78%	41 yrs.

(N) = number in each group

Table VIII

Prevalence of Pneumoconiosis*

	Smokers	Ex-Smokers	Non-Smokers
Controls A	1 (48)	1 (44)	0 (29)
Controls B	1 (14)	1 (14)	1 (8)
Carbon Workers A	1 (13)	1 (15)	0 (7)
Carbon Workers B	0 (15)	0 (7)	0 (8)

(N) = number in each group

*Category 1 or above UICC/ILO classification

Controls A - never worked in carbon
Controls B - now non carbon but previous carbon exposure
Carbon Workers A - greater than 5 years exposure
Carbon Workers B - less than 5 years exposure

Table IX

Mean Pack Year Smoking History
With Prevalence of Bronchitis

	Pack Years Smokers	Pack Years Ex-Smokers
Controls A	33 (45%)	23 (13%)
Controls B	24 (42%)	24 (37%)
Carbon Workers A	32 (63%)	29 (35%)
Carbon Workers B	19 (42%)	18 (38%)

(%) = percent bronchitis
Controls A - never worked in carbon
Controls B - now non carbon but previous carbon exposure
Carbon Workers A - greater than 5 years exposure
Carbon Workers B - less than 5 years exposure

Table X

Mean FEV_1, FVC and FEV_1/FVC
Catagorized by Smoking History

	Smokers			Ex-Smokers			Non-Smokers		
	FEV_1 L.	FVC	FEV_1/FVC	FEV_1 L.	FVC	FEV_1/FVC	FEV_1 L.	FVC	FEV_1/FVC
Controls A	3.37	4.81	70%	3.52	4.81	73%	3.97	5.08	78%
Controls B	3.31	4.39	75%	3.44	4.58	75%	3.87	5.10	76%
Carbon Workers A	3.18	4.50	70%	3.52	4.74	74%	3.83	4.89	78%
rbon Workers B	3.45	4.81	72%	3.47	5.04	69%*	3.75	5.03	75%

L = liters
Control A - have never worked in carbon
Control B - now non carbon but previous carbon exposure
Carbon Workers A - greater than 5 years exposure
Carbon Workers B - less than 5 years exposure
*See Text