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WALK-THROUGH SURVEY

PURE CARBON COMPANY
441 HALL AVENUE
ST. MARY'S, PENNSYLVANIA 15857

SURVEY CONDUCTED BY:

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REPORT WRITTEN BY:

Alice Greife

DATE OF SURVEY:

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REPORT NUMBER:

142.10

Industrial Hygiene Section
Industrywide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Centers for Disease Control
Cincinnati, Ohio

REPRODUCED BY:
U.S. Department of Commerce
National Technical Information Service
Springfield, Virginia 22161

NTIS

PURPOSE:

To ascertain the feasibility of conducting an industrywide industrial hygiene and epidemiology study of the carbon products industry.

EMPLOYER REPRESENTATIVE:

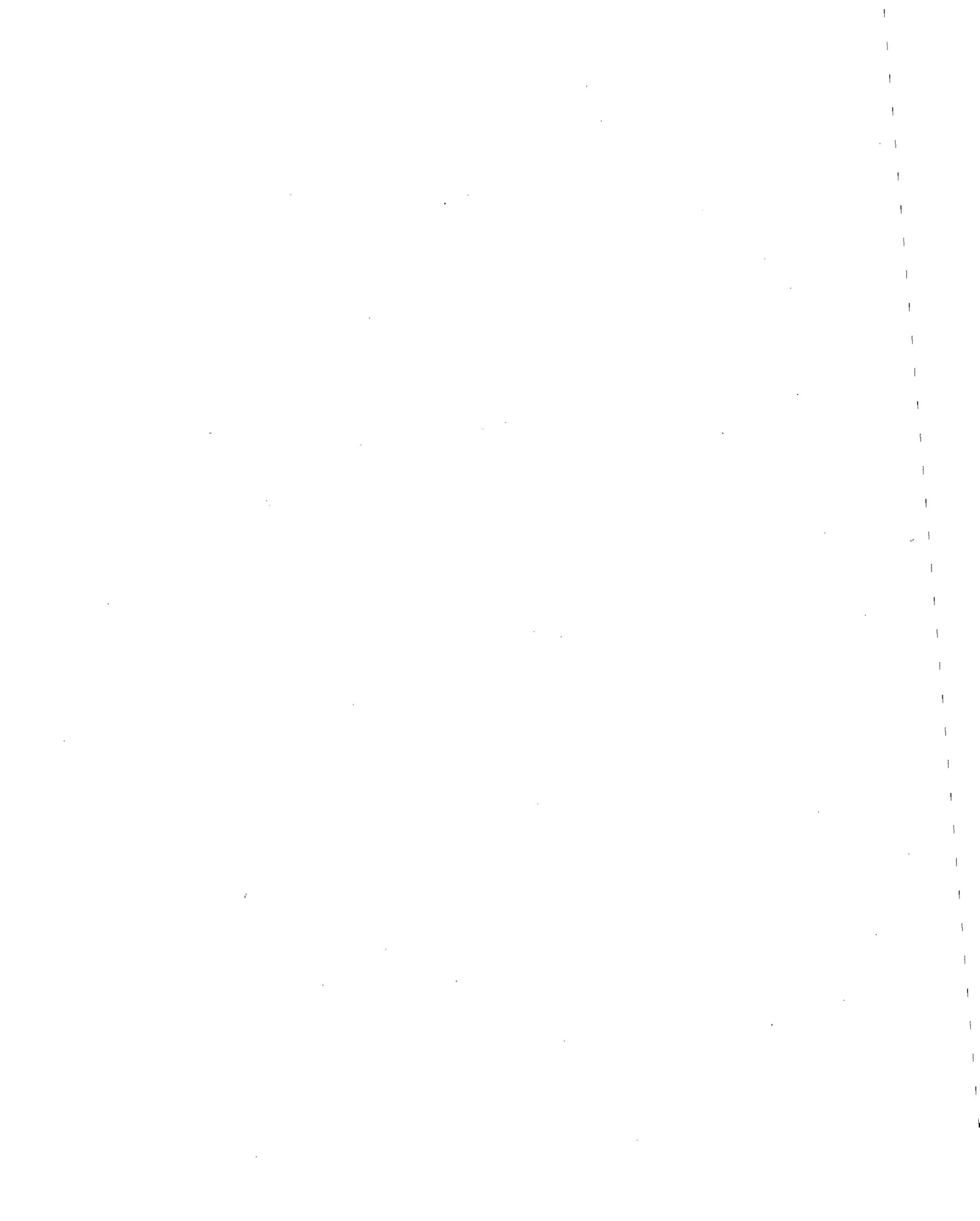
Thomas Dippold, Manager
Health and Safety
Bill Northey, Personnel Manager

EMPLOYEE REPRESENTATIVE:

Bonnie Lechner, Chief Steward
International Union of Electrical
Radio and Machine Workers
Local 512

SIC CLASSIFICATION:

3624 Electrical Industrial
Apparatus - Carbon and Graphite
Products



ABSTRACT

On March 2 and 3, 1983, a site visit to Pure Carbon Company, a carbon products manufacturer, St. Mary's, Pennsylvania, was conducted to gather data concerning the feasibility of conducting an industrywide study of the carbon products industry. Pure Carbon was selected for a walk-through survey and examination of personnel records because it was one of several carbon products manufacturers in the area. This company was established about 1940, and there are currently about 302 employees. The company produces mechanical carbon products such as rings, seals, and bearings from the basic raw materials calcined petroleum coke and coal tar pitch.

Industrial Hygiene sampling was conducted in the following areas of the facility: mixing, baking, and finishing. General area air samples were collected in each aforementioned area and were analyzed for 17 polycyclic aromatic hydrocarbons (PAH). There were 13 PAHs quantitated, the remaining 4 were not present in any sample at or above the limit of detection. The baking area had the highest levels of PAHs while the finishing area had the lowest (Table I).

General area air samples were also collected in the mixing and baking areas to be analyzed for the benzene soluble fraction of the PAHs present. The levels of the benzene solubles were quite variable, ranging from $.05 \text{ mg/m}^3$ to $.22 \text{ mg/m}^3$ (Table III).

This company was not chosen for inclusion in an industrywide study of the carbon products industry because it did not meet the selection criteria for the study namely: use of petroleum pitch.

BACKGROUND AND PURPOSE

The carbon and graphite products industry produces a variety of carbon products ranging from brushes to electrodes utilizing petroleum coke, coal tar pitch and/or petroleum pitch as basic raw materials. Petroleum coke, a by-product of the petroleum industry, is a solid carbonaceous residue resulting from a high temperature treatment of heavy petroleum fractions.¹ It contains hydrocarbons with a high carbon to hydrogen ratio. Petroleum coke is generally calcined (900-1200°C) to decrease moisture content prior to being ground and sized for use by the carbon industry. Calcining also causes any volatile material in the petroleum coke to elute.² Coal tar pitch is a dark brown or black solid material which is obtained as a residue in the partial evaporation or fractional distillation of coal tar. Coal tar is produced by the destructive distillation of bituminous coal. Petroleum pitch is a highly aromatic and resinous substance which is produced by dehydration and dealkylation and subsequent condensation and polymerization of low boiling aromatic oils and residues.¹ These oils and residues are obtained from extraction and/or cracking processes in the refinement of crude petroleum.

There are 100 companies listed under SIC 3624 in the Dunn and Bradstreet Index; these companies employ about 14,500 workers.³ The major exposures of concern in this industry are coal tar pitch and petroleum pitch. These compounds release a complex mixture of polycyclic aromatic hydrocarbons (PAHs) when heated. These PAHs have traditionally been measured as the benzene soluble fraction of total airborne particulates. Several of these PAHs, which are released as pyrolysis products of coal tar pitch and petroleum pitch, have been identified and several have proven to be animal carcinogens e.g. benzo(a)pyrene, benzo(a)anthracene, chrysene and benzo(b)fluoranthene.⁴ These airborne PAH mixtures have traditionally been called coal tar pitch volatiles (CTPVs), even when they are produced from combustion of non-coal substances.

Petroleum pitch has been documented to be carcinogenic and mutagenic in laboratory studies.¹ The collection of human data however, has been hampered because most worker populations exposed to petroleum pitch are also exposed to coal tar pitch. The most closely related industries or processes which have been evaluated are aluminum reduction and production of coal tar products e.g., coke oven workers. Comparison between these industries can not be done, however, without a more comprehensive study of the carbon products industry.

The relative carcinogenicity, mutagenicity, and health effects of coal tar pitch versus petroleum pitch has recently been under debate because of the January, 1983, re-interpretation of the 1971 OSHA standard for CTPVs. The carbon products industry may yield a useful study population to evaluate the chronic health effects of exposures to coal tar pitch and petroleum pitch and/or petroleum pitch alone. There appears to be a trend toward regulating CTPVs by industry and exposure type, rather than by a generic standard (promulgating a more stringent standard for CTPV exposure in coke ovens,

exemption of petroleum asphalt from CTPV standard). An epidemiologic/industrial hygiene study estimating the risk of CTPV exposures in the carbon products industry may provide useful information to be used in the formulation of occupational health standards relating to this industry.

Preliminary perusal of available data on this industry indicates there are several large U.S. plants which have been in operation for 20 years or more. An epidemiologic/industrial hygiene study may therefore be feasible. The purpose of this walk-through survey was to aid in the determination of the need to and feasibility of conducting an industry-wide epidemiological mortality and industrial hygiene study of the carbon products industry. Specifically this walk through ascertained the following:

1. The existence of any operation in this plant with a sole or predominant exposure of workers to petroleum rather than coal tar pitch volatiles.
2. The existence of historic use e.g., past exposure to coal tar pitch and petroleum pitch, and characterize current exposures to coal tar pitch and petroleum pitch by PAH content.
3. The feasibility of using this facility for an industrywide mortality study based on such information as demographic data and work histories contained in the personnel files.
4. The availability of records for alternate study designs (PMR, SMR).

Pure Carbon Company, the facility being examined in this walk through, was chosen because of the type of product produced, and its close proximity to several other carbon product manufacturers in the area.

DESCRIPTION OF FACILITY

Pure Carbon, a carbon products manufacturer, was founded in St. Mary's Pennsylvania about 1932. The facility has been located in the same location since that time. The product line, which consists of mechanical carbon parts such as seals, rings, and bearings, has been essentially the same over the years.

DESCRIPTION OF WORKFORCE

The workforce has steadily increased since the founding of the company in 1932, reaching a peak of about 434 workers in the mid 1970's. After this time, the size of the workforce was cyclic with a total of 371 persons currently employed, 184 are hourly production employees. There are currently three (3) workshifts.

The personnel files were standardized in 1964, on a "Visifile" system. The records contain all demographic information plus a history of job and pay rate changes for all current employees. These files are maintained in the plant

personnel office. Records of terminated employees have been stored on microfilm. Duration of employment appears to be very short for many past employees, however of the 300 currently employed there are more than 100 in the "quarter century club."

The workforce was unionized by the International Union of Electrical, Radio, and Machine Workers, Local 502 in 1955.

DESCRIPTION OF PROCESS

The primary raw materials used in the production of the carbon products in this plant are calcined petroleum coke and coal tar pitch (Figure 1). The company does not use petroleum pitch. Calcined petroleum coke and solid coal tar pitch arrive at the plant and are introduced into a heated rotary mixer as received. The pitch adsorbs onto the coke and serves as a binding material. The coated material is then dumped into pans or trays, and allowed to cool to ambient temperature in cooling bays in the same room as the mixers. The cooled material is then crushed and milled into flour. Lubricants, are then combined with the flour to aid in the compression process and removal of product from the molds. The flour is loaded into fifty gallon drums which are then hoisted above the compression molds or presses. The flour is then fed into the molds where it is compressed into the desired shape at room temperature. The green or unbaked product is then sent to the baking area.

The baking process which converts the coal tar pitch binder to solid coke utilizes a continuous type furnace. The green product is loaded into a sagger can, which is insulated with sand and keeps the product from warping, and travels through the furnace very slowly. The entire baking process takes several hours, and temperatures of 800-1000°C are reached in the middle of the baking cycle. Following baking, the product may go directly to finishing which may include some machining, or it may undergo further processing such as impregnation before finishing.

Impregnation, a batch process, utilizes various metals or resins. This facility does not use petroleum pitch as an impregnation material. In this step, the impregnation material enters the open pores of the baked carbon product under high temperature and pressure serving to improve the properties of the product. The impregnated product is then cured (300-500°F) to cross-link the resins and render them insoluble. The material is then sent to the machining area. The product line is not graphitized. Graphitizing is an electrical heat treatment in which the carbon atoms in the petroleum coke filler and pitch binder are oriented into the graphite lattice configuration. This ordering process which occurs about 3000°C produces graphite, a form of carbon.

Machining or finishing involves several steps. The product is first ground into the generally desired shape. It is then sent to the specialty finishing area where lathing and/or lapping may be done to create a highly refined

product. The finished product is sent through a quality control check before it is sent to shipping.

DESCRIPTION OF ENGINEERING CONTROLS

There have been a few engineering modifications made to existing operations. All machinery in the finishing areas (grinding, lapping and lathing) has been equipped with permanent exhaust ventilation equipment. In some cases, a water mist is also used to control the dust generated in these operations. A hopper system has been devised to feed the finely milled petroleum coke flour into the compression presses. The company was relocating the mixing of coal tar pitch with petroleum coke, to another plant located some distance away. The entire process should be relocated by April, 1983. This should greatly reduce employee exposure to CPTVS.

DESCRIPTION OF MEDICAL, INDUSTRIAL HYGIENE AND SAFETY PROGRAMS

Each employee has a pre-employment physical which consists of a general medical examination administered by a local physician. The company employs a full time nurse who handles routine injuries. Periodic physical examinations are administered to employees working in the impregnation and laboratory areas.

A limited industrial hygiene and safety program is conducted by in-house personnel. Safety training is given to all employees on an as-needed basis.

RECOMMENDED LEVELS OR APPLICABLE STANDARDS

The recommended levels or applicable standards used in this report as related to toxic substances are (1) NIOSH recommended levels, (2) Federal Occupational Standards as promulgated and enforced by the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor (29 CFR 1910, 1000) Permissible Exposure Limit (PEL) and, (3) American Conference of Government Industrial Hygienist (ACGIH) Threshold Limit Values (TLVs).^{5,6,7}

Listed below are the recommended levels or applicable standards for the substances sampled in this survey:

Substance	NIOSH Recommended Level	OSHA PEL	ACGIH TLV
Coal Tar Pitch Volatiles as Benzene Solubles	0.1mg/m ³ 10 hr TWA	0.2mg/m ³ 8 hr TWA	0.2mg/m ³ 8 hr TWA

DESCRIPTION OF SURVEY METHODS

General area air samples were collected in several processing areas to qualitate and quantitate the PAHs present. Samples were collected with a sampling train consisting of a Zefluor 2-micron filter and a cellulose acetate o-ring in an opaque cassette. This was followed by a 7-mm O.D. glass tube

containing two sections of Supelpak-2 (pre-washed XAD-2 resin) 100 mg/50 mg. Additional samples were collected for analysis of the benzene soluble fraction of the PAHs present. The sampling train consisted of the aforementioned filter and opaque cassette without the back-up tube. All samples were collected at 2.0 liter per minute (Lpm) utilizing a Dupont pump Model P4000. Specific PAH sample quantification and all bulk sample analysis were done according to Technical Bulletin TB-001.⁸ Benzene solubles were analyzed by NIOSH method P&CAM 217.⁹

The general area samples were collected in the following areas:

<u>DEPARTMENT</u>	<u>LOCATION</u>	<u>SAMPLE NUMBER</u>	<u>ANALYTE</u>
Mixing	Mixer	10	PAH quantitation Benzene soluble fraction
		7	
	Cooling Bay #1	5	PAH quantitation Benzene soluble fraction
		6	
Baking	Furnance Inlet	1	PAH quantitation
	Furnance Outlet	2	PAH quantitation
	Sagger Loading	3	PAH quantitation
Machining	Wet Grinding	8,9	PAH quantitation

Bulk samples of the molding flour and coal tar pitch were also collected for PAH quantitation.

RESULTS & DISCUSSION

The results of the sample analyses are presented in Tables I, II, III and IV. Raw data are listed in Tables V and VI. There were 17 PAH compounds quantitated in the airborne samples, however, four were not present in any airborne sample at or above the limit of detection (Indeno(1,2,3-cd)pyrene, Benz(g,h,i)perylene, Dibenz(a,h)anthracene and Acenaphthylene respectively.

The data presented here indicated that airborne PAHs were present in the work environment of this facility, however overall levels of specific PAHs were generally low (see Table I). The levels of benzene solubles were quite variable ranging from .05 mg/m³ to .22 mg/m³ (Table III). The baking area of the facility appeared to have the highest overall concentrations of PAHs, however, this finding was not unexpected due to the nature of the process. It was not possible to identify the source of most of the PAHs in this area, as 16 of the 17 PAHs were common to both the coal tar pitch and molding flour bulk samples. It can be assumed that the source of acenaphthene detected in this area was the coal tar pitch, however, as acenaphthene was not found during analysis of the bulk molding flour.

It was of interest to note the airborne PAHs found in the finishing or machining area. All carbon products entering this area have previously been baked in the various ovens or pits, and all volatile PAHs should have been eluted. Therefore it was assumed that the PAHs released during the grinding process were either associated with or adsorbed onto the released carbon dust particles and were not present due to volatilization.

All of the 17 PAHs identified in these samples are tumorigenic compounds, many of which are listed as positive animal carcinogens (Benz(a)anthracene, Benzo(b)fluoranthene, Chrysene, Benzo(a)pyrene, Dibenz(a,h)anthracene, Indeno(1,2,3-cd)pyrene) in the 1983 Registry of Toxic Effects.⁴ The 1983 American Conference of Governmental Industrial Hygienists TLV booklet lists benzo(a)pyrene and chrysene as suspected human carcinogens, but does not give recommended exposure limits.⁷

CONCLUSIONS

From the data collected, it was not possible to identify a population of workers at this plant exposed to airborne quantities of PAHs relating only to exposure to petroleum pitch, because petroleum pitch was not used at this facility. The area with the highest overall airborne PAH values (baking) represented a mixed exposure to coal tar pitch and petroleum coke. Analysis of the bulk samples of the two compounds revealed that 16 of the 17 PAHs identified were common to both analytes. Assignment, therefore, of the source(s) (coal tar pitch or petroleum coke) of a specific PAH in an area would be very difficult.

The finishing area, which represents exposure to PAHs from rebaked-impregnated carbon, exhibited low overall levels. These low levels may be due to the wet grinding system in place and the absence of any volatile PAHs due to the baking process. The PAHs that were found, therefore, were associated with or adsorbed on to the airborne carbon particles. These exposures may be of interest, however, due to the co-carcinogenicity potential of the carbon particles.¹⁰

This company was not chosen for inclusion in an industrywide study of the carbon products industry because it did not meet the selection criteria for the study namely: use of petroleum pitch.

RECOMMENDATIONS

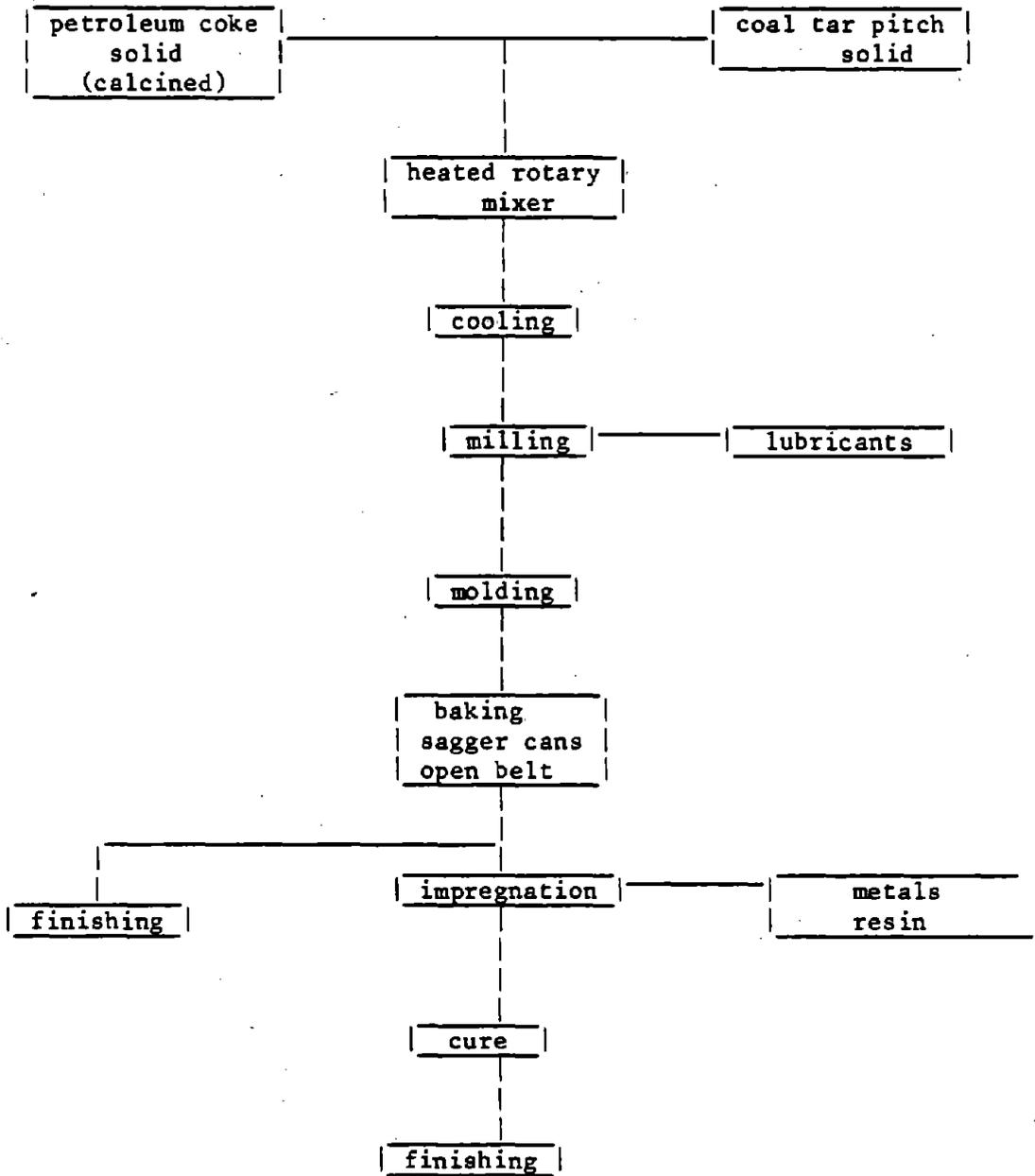
Clean-up operations in the pressing or molding areas should be done with a vacuum system.

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4. Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, (1980).
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6. Occupational Safety and Health Administration (OSHA) Safety and Health Standards 29 CFR 1910, General Industry Standards OSHA 2206, revised June, (1981).
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9. NIOSH Manual of Analytical Methods, P&CAM 217, Vol. 1, (1981).
10. Sellakumar, A., Stenback, F., Rowland, J., Effects of Different Dusts on Respiratory Carcinogenesis in Hamsters Induced by Benzo(a)pyrene and Diethylnitrosamine, Europ J Cancer, 12:313, (1976).

FIGURE 1

PURE CARBON COMPANY
PROCESS FLOW DIAGRAM



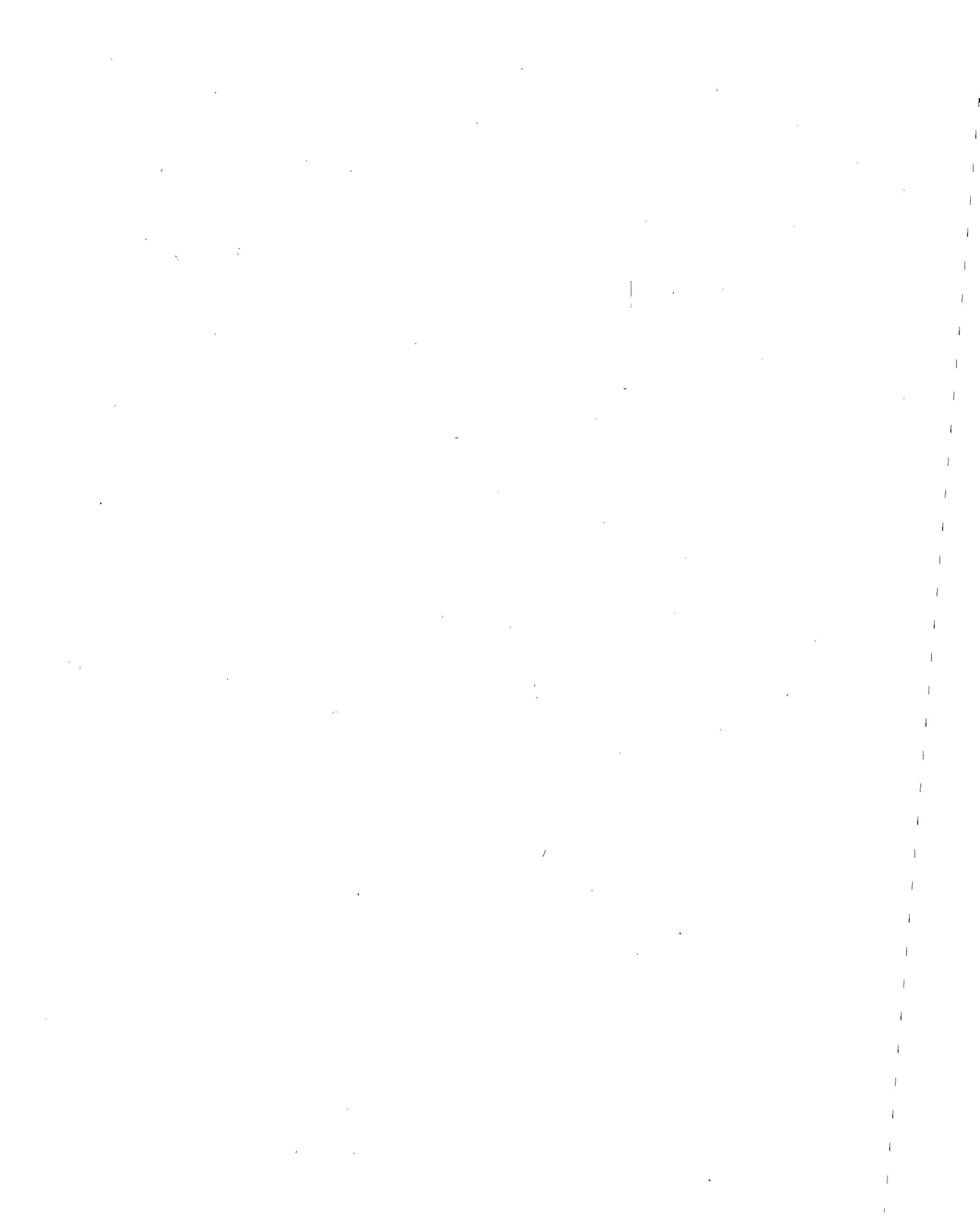


TABLE I

PURE CARBON COMPANY
ST. MARYS, PENNSYLVANIA
MARCH 2 & 3, 1983

Summary of Airborne PAH Levels by Sample, ug/m³

AREA	SAMPLE NUMBER	1*	2	3	4	5	6	7	8	9	10	11	12
Mixing	10**	0.34	ND***	4.76	0.40	2.22	1.29	ND	1.12	ND	ND	ND	ND
	5**	ND	ND	ND	0.51	1.17	0.90	ND	0.91	0.93	ND	0.66	ND
Baking	1	1.78	0.38	5.40	ND	6.55	4.45	.50	3.22	3.78	6.0	2.44	3.0
	2	0.64	ND	2.99	ND	4.51	3.19	ND	1.07	2.70	3.54	1.43	1.32
	3	1.54	ND	3.84	ND	6.37	6.38	1.06	6.06	8.59	10.90	4.96	7.05
Finishing	8	2.28	ND	0.96	ND	ND	ND	ND	ND	ND	0.97	0.81	ND
	9	1.2	ND	1.44	ND	ND	1.05	ND	ND	ND	2.05	1.70	ND

**Limit of
Detection .25
ug/sample

Limit of
Detection .54
ug/sample

***ND = Amount present was less than the limit of detection

*1 = Acenaphthene
2 = Fluorene
3 = Phenanthrene

4 = Anthracene
5 = Fluoranthene
6 = Pyrene

7 = Benzo(c)phenanthrene
8 = Benz(a)anthracene
9 = Chrysene

10 = Benzo(b)fluoranthene
& Benzo(k)fluoranthene
11 = Benzo(e)pyrene
12 = Benzo(a)pyrene



TABLE II

PURE CARBON COMPANY
ST. MARYS, PENNSYLVANIA
MARCH 2 & 3, 1983

Individual Results of Airborne PAH Levels, ug/m³

SAMPLE NUMBER	1*	2	3	4	5	6	7	8	9	10	11	12
10**	ND***	ND	ND	ND	0.51	0.46	ND	1.12	ND	ND	ND	ND
10T**	0.34	ND	4.76	0.40	1.71	0.83	ND	ND	ND	ND	ND	ND
5**	ND	ND	ND	ND	1.17	0.90	ND	0.91	0.93	ND	0.66	ND
5T**	ND	ND	ND	0.51	ND	ND	ND	ND	ND	ND	ND	ND
1	ND	ND	0.51	ND	2.33	1.89	0.50	3.22	3.78	6.0	2.44	3.0
1T	1.78	0.38	4.89	ND	4.22	2.56	ND	ND	ND	ND	ND	ND
2	ND	ND	0.35	ND	1.21	1.21	ND	1.07	1.65	2.53	1.43	1.32
2T	0.64	ND	2.64	ND	3.30	1.98	ND	ND	1.05	1.01	ND	ND
3	ND	ND	0.76	ND	3.96	4.07	1.06	6.06	8.59	10.90	4.96	7.05
3T	1.54	ND	3.08	ND	3.41	2.31	ND	ND	ND	ND	ND	ND
8	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.97	0.81	ND
8T	2.28	ND	0.96	ND	ND	ND						
9	ND	ND	ND	ND	ND	1.05	ND	ND	ND	1.68	.73	ND
9T	1.2	ND	1.44	ND	ND	ND	ND	ND	ND	.37	.97	ND

**Limit of Detection ug/sample

.25	.25	.25	.25	.25	.25	.25	.25	.50	.50	1.0	.50	.50
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Limit of Detection ug/sample

.54	.28	.28	1.2	1.1	.70	.39	.52	.77	.60	.65	.52	
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T = backup tube for corresponding filter

***ND = Amount present was less than the limit of detection

*1 = Acenaphthene
2 = Fluorene
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7 = Benzo(c)phenanthrene
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9 = Chrysene

10 = Benzo(b)fluoranthene
& Benzo(k)fluoranthene
11 = Benzo(e)pyrene
12 = Benzo(a)pyrene

TABLE III

PURE CARBON COMPANY
ST. MARYS, PENNSYLVANIA
MARCH 2 & 3, 1983
Airborne Concentrations of Benzene Soluble PAHs, mg/m³

AREA	SAMPLE NUMBER	EXPOSURE LEVEL mg/m ³	SAMPLE CONCENTRATION (mg/SAMPLE)	TOTAL VOLUME (L)	TIME ON	TIME OFF	TOTAL MINUTES
Formulation	6	0.22	0.18	828	8:05	14:59	414
	7	0.05	0.04	840	8:00	15:00	420
Limit of detection mg/sample		.02					

TABLE IV

PURE CARBON COMPANY
ST. MARYS, PENNSYLVANIA
MARCH 2 & 3, 1983

PAH Quantitation of Bulk Raw Materials, ug/g

SAMPLE	* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Molding Flour	20	4	450	61	2200	2200	440	2000	2100	3000	1100	2100	550	260	630	10
Coal Tar Pitch	310	73	1200	190	5100	5000	1000	6300	4900	6800	2800	7000	2300	750	2000	10
Limit of Detection ug/sample	2	1	1	3	3	2	1	1	2	2	2	2	7	10	10	10

*1 = Acenaphthene
2 = Fluorene
3 = Phenanthrene
4 = Anthracene

5 = Fluoranthene
6 = Pyrene
7 = Benzo(c)phenanthrene
8 = Benz(a)anthracene

9 = Chrysene
10 = Benzo(b)fluoranthene & Benzo(k)fluoranthene
11 = Benzo(e)pyrene
12 = Benzo(a)pyrene

13 = Indeno(1,2,3-cd)pyrene
14 = Dibenz(a,h)anthracene
15 = Benz(g,h,i)perylene
16 = Acenaphthylene

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TABLE V

PURE CARBON COMPANY
ST. MARYS, PENNSYLVANIA
MARCH 2 & 3, 1983

Individual Results of Airborne PAH Levels, ug/sample

SAMPLE NUMBER	1*	2	3	4	5	6	7	8	9	10	11	12
10**	ND***	ND	ND	ND	0.42	0.38	ND	0.92	ND	ND	ND	ND
10T**	0.28	ND	3.9	0.33	0.14	0.68	ND	ND	ND	ND	ND	ND
5**	ND	ND	ND	ND	1.0	0.77	ND	0.78	0.80	ND	0.57	ND
5T**	ND	ND	ND	0.44	ND	ND						
1	ND	ND	0.46	ND	2.1	1.7	.45	2.9	2.9	3.4	5.4	2.2
1T	1.6	0.34	0.44	ND	3.8	2.3	ND	ND	ND	ND	ND	ND
2	ND	ND	0.32	ND	1.1	1.1	ND	0.97	1.5	2.3	1.3	1.2
2T	0.58	ND	2.4	ND	3.0	1.8	ND	ND	0.95	0.92	ND	ND
3	ND	ND	0.69	ND	3.6	3.7	0.96	5.5	7.8	9.9	4.5	6.4
3T	1.4	ND	2.8	ND	3.1	2.1	ND	ND	ND	ND	ND	ND
8	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.81	0.67	ND
8T	1.9	ND	0.80	ND	ND							
9	ND	ND	ND	ND	ND	0.87	ND	ND	ND	1.4	0.61	ND
9T	1.0	ND	1.2	ND	ND	ND	ND	ND	ND	0.31	0.81	ND

**Limit of Detection ug/sample

	.25	.25	.25	.25	.25	.25	.25	.50	.50	1.0	.50	.50
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Limit of Detection ug/sample

	.54	.28	.28	1.2	1.1	.70	.39	.52	.77	.60	.65	.52
--	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

T = backup tube for corresponding filter

***ND = Amount present was less than the limit of detection

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9 = Chrysene

10 = Benzo(b)fluoranthene
& Benzo(k)fluoranthene
11 = Benzo(e)pyrene
12 = Benzo(a)pyrene

+ = See Table VI for Sampling Time and Volume

TABLE VI+

PURE CARBON COMPANY
ST. MARYS, PENNSYLVANIA
MARCH 2 & 3, 1983
Sampling Time and Volume for PAH Quantitation Samples

SAMPLE NUMBER	TIME ON	TIME OFF	TOTAL TIME (MIN)	SAMPLE VOLUME (L)
10	7:50	15:00	410	820
10T				
5	7:50	14:59	429	858
5T				
1	7:35	14:55	450	900
1T				
2	7:37	14:57	454	908
2T				
3	7:38	14:56	454	908
3T				
8	8:10	15:04	416	832
8T				
9	8:10	15:04	416	832
9T				

- 41 -
+ = See Table V for Individual PAH Values