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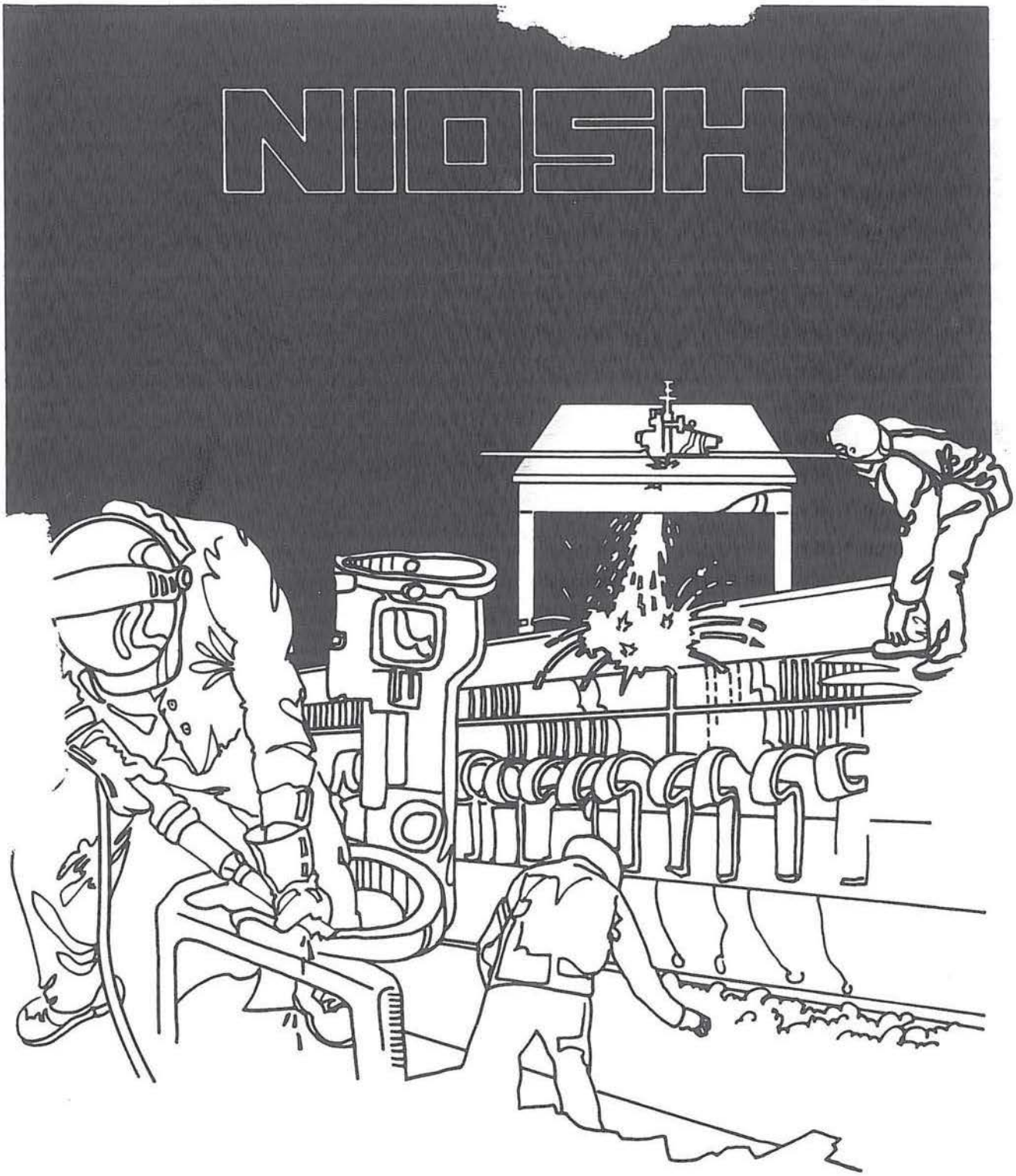

Health Hazard Evaluation R.

HETA 81-062-1211
HATFIELD'S FERRY POWER STATION
MASONTOWN, PENNSYLVANIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any 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 Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 81-062-1211
OCTOBER 1982
HATFIELD'S FERRY POWER STATION
MASONTOWN, PENNSYLVANIA

NIOSH INVESTIGATORS:
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I. SUMMARY

On November 11, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the local union at the Hatfield's Ferry Power Station, to evaluate employee exposures to asbestos, fly ash, coal dust, and sulfur dioxide. The dust exposures were suspected of causing such employee respiratory disorders as asthma, chest pains, shortness of breath, and coughing. NIOSH investigators conducted field evaluations on December 11, 1980; February 26-27, 1981; and September 26, 1981.

Six personal air samples for total dust (coal) ranged from 0.4 to 4.5 mg/m^3 compared to the NIOSH evaluation criterion of 3.9 mg/m^3 (based on quartz content). Five personal air samples for respirable dust (coal) ranged from 0.06 to 2.6 mg/m^3 (evaluation criterion: 2.0 mg/m^3). Ten personal air samples for fly ash dust ranged from 0.4 to 56 mg/m^3 (evaluation criterion: 10 mg/m^3). Six personal air samples for sulfur dioxide ranged from 0.2 to 0.9 mg/m^3 (evaluation criterion: 1.3 mg/m^3). Five personal air samples for benzene solubles ranged from 0.09 to 0.18 mg/m^3 (evaluation criterion: 0.10 mg/m^3). Analysis of the benzene soluble samples for 5 polynuclear aromatic hydrocarbons - benzo(a)pyrene, chrysene, pyrene, benzo(a)anthracene, and fluoranthene - showed levels below the laboratory limit of detection for each sample. For a number of years the company has had a comprehensive program for asbestos removal and control, but careless handling by contractors could result in asbestos contamination/exposures. The company has an adequate respirator program.

The medical evaluation included a respiratory questionnaire and measurement of blood pressure. Compared to other workers at the plant, coal handlers were statistically no more likely to have bronchitis (6 of 18 coal handlers, 4 of 18 others), asthma/wheezing (5 of 19, 12 of 51) or diastolic blood pressure greater than 90 mm Hg (6 of 18, 16 of 53).

Based on the environmental data of this study, it is concluded that there are potential overexposures to coal dust and fly ash dust --particularly for cleanup and maintenance work. Recommendations are included in the text of this report.

KEYWORDS: SIC 4911 (Electric Services), coal dust, fly ash, sulfur dioxide, quartz, benzene solubles, asbestos, respiratory disorders, bronchitis, asthma.

II. INTRODUCTION

On November 10, 1980, NIOSH received a request from the Utility Workers Union of America, AFL-CIO, Local 102, for a health hazard evaluation at Hatfield's Ferry Power Station, Division of Allegheny Power System, Masontown, Pennsylvania. The request stated that employees were exposed to airborne asbestos (from removal of existing insulation from steam lines, boiler lagging, etc.), coal dust, fly ash dust, and sulfur dioxide. These dusts were suspected to be the cause of employees experiencing respiratory disorders, including asthma, chest pains, shortness of breath, and coughing. In response to this request, NIOSH conducted environmental evaluations on December 11, 1980; February 26-27, 1981; and September 26, 1981. The medical evaluation was conducted on February 26-27, 1981, by the University of Pittsburgh, Graduate School of Public Health (under contract to NIOSH). Interim reports were distributed in January 1981 and November 1981.

III. BACKGROUND

This plant is engaged in producing electricity. Coal is brought in by barges (90%) or rail cars, unloaded, conveyed to the breakers, through tunnels into coal silos where excess moisture is driven off, dumped into the pulverizer where it is ground so that 65% goes through a 200 mesh screen, and burned by blowing it into the furnaces. The resulting ash is either clinkers, which is sold as paving material, or fly ash which is collected in precipitators and taken to a land fill. There are three boilers, each with pulverizing and feeding units. The building is six stories high. The coal is burned at 3000°F. Overhead fans are located in the boiler areas. Local exhaust ventilation is provided at the coal drop area.

More than 50% of the employees on the plant premises are contractor employees. Periodically they are engaged in dismantling of old installations which contain asbestos. Although the Allegheny Power System has an adequate procedure for handling asbestos for their own employees, this procedure is not always followed by the contractors. This may result in asbestos exposure to nearby employees. At the time of the NIOSH surveys, there wasn't any dismantling activity on the plant premises.

Exposure to sulfur gases occurs prior to overhaul when the lagging and gasket materials become deteriorated. The plant has a periodic maintenance program when the boilers are dismantled and the necessary repairs are made.

Exposure to fly ash and coal dust occurs while operating equipment to move coal, during clean up operations, while maintaining the equipment, and while doing preventive maintenance. Due to the scarcity of low sulfur coal and in order to control sulfur emissions, a proprietary additive (Coaltrol M.C.) is added to the pulverized coal.

IV. EVALUATION METHODS

A. Environmental

Coal dust - Five employees' exposures to "respirable" coal dust were evaluated by collecting the coal dust on pre-weighed mixed cellulose ester 37 mm diameter membrane filters, preceded by 10 millimeter diameter cyclones, with personal sampling pumps operating at 1.7 liters per minute. These samples were analyzed gravimetrically. Six personal samples for "total" coal dust were collected and analyzed in the same manner as the "respirable" samples except that the 10 millimeter diameter cyclone was not used in the sampling train. The free silica (quartz) contents of the coal dust samples were determined by X-ray diffraction (NIOSH Method P&CAM 259)[1].

Fly ash dust - Ten personal fly ash samples (total dust) were collected on pre-weighed mixed cellulose membrane filters and analyzed gravimetrically. Bulk samples were taken of the "Coaltrol" additive and the fly ash with and without the additive. These bulk samples were submitted for qualitative analysis by X-ray powder diffraction and X-ray fluorescence spectrometry. A pH analysis was also performed.

Sulfur dioxide and sulfates - Six personal air samples were collected on charcoal tubes with air sampling pumps operating at 200 cc per minute. These samples were analyzed by ion chromatrography.[2]

Coal tar pitch volatiles (benzene soluble fraction) - The employees engaged in fly ash operations were also evaluated for exposure to coal tar pitch volatiles. Five breathing zone samples were collected on silver membrane filters followed by porous polymer tubes. The samples were analyzed by benzene extraction (NIOSH Method P&CAM 217)[1]. Polynuclear aromatic hydrocarbons (PNA's) were determined by column chromatography with UV detection (NIOSH Method P&CAM 184)[1].

B. Medical

The medical evaluation included: 1) an occupational history and respiratory symptom questionnaire, the latter based on the standardized British Medical Research Council questionnaire; 2) physical examination of the chest; and 3) measurement of blood pressure. All employees with at least one year of seniority were invited to participate.

V. EVALUATION CRITERIA

A. Environmental

The sources of environmental evaluation criteria considered for this study were: 1) NIOSH criteria documents or other recommendations; 2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for 1981; and 3) U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) federal occupational health standards. The environmental criteria judged most appropriate for this study, and the OSHA legal standards are as follows:

Substance	Environmental Criteria (mg/m^3)	OSHA Standard[3] (mg/m^3)
Total Coal Dust	4 (ACGIH)[4]	---
Total Dust (based on % Quartz)	$\frac{30}{\%\ +\ 3}$ (ACGIH)	$\frac{30}{\%\ +\ 2}$
Respirable Coal Dust (less than 5% quartz)	2 (ACGIH)[4]	2.4
Respirable Quartz	0.05 (NIOSH)	0.1
Total Fly Ash Dust	10 (ACGIH)[4]	15
Sulfur Dioxide	1.3 (NIOSH)[5]	13
Coal Tar Pitch Volatiles (Benzene Soluble Fraction)	0.1 (NIOSH)[6]	0.2
Polynuclear Aromatic Hydrocarbons (PNA's)	Certain PNA's are carcinogenic and exposures should be minimized (NIOSH)	

*These criteria are based on time weighted average (TWA) exposures for a normal 8 to 10-hour workday of a 40 hour work week.

B. Toxicology

Coal dust[7] - Simple coal workers' pneumoconiosis has no clinically distinguishing symptoms (almost all miners have a slight cough and blackish sputum, which are of no help in establishing whether or not the disease is present). Simple CWP is diagnosed according to the number of small opacities present in the chest film; the small opacities may be linear (irregular) or rounded (regular). Simple CWP often occurs concomitantly with chronic bronchitis and emphysema.

Any opacity greater than 1 cm in diameter in a coal miner is classified as complicated pneumoconiosis or progressive massive fibrosis, unless there is evidence to suggest another disease, such as tuberculosis. Complicated pneumoconiosis is associated with a reduction in ventilatory capacity, low diffusing capacity, abnormalities of gas exchange, low arterial oxygen tension, pulmonary hypertension, and premature death; it may appear several years after exposure has ceased and may progress in the absence of further dust exposure.

Fly ash[8] - Fly ash is composed of 60-80% insoluble glass particles. These spherical or rounded particles are water-insoluble alumino-silicates. The water-soluble fraction (20-40%) consists mainly of calcium, sodium, and potassium sulphates and of some glassy material, so that the pH of ash leached water is usually between 8-10. The crystalline material which can constitute 15-30% by weight of the ash is composed of mullite, magnetite, carbon and quartz. From the point of view of potential hazards, only the quartz fraction needs to be considered since there is no evidence reported in literature showing that mullite or magnetite particles or the comparatively large particles of the carbon residue are particularly harmful. Evidence published in the literature on the toxic and non-toxic siliceous dusts suggests that fly ash is unlikely to have a high biological activity when inhaled.

Sulfur Dioxide[7] - Sulfur dioxide gas is a severe irritant of the eyes, mucous membranes, and skin. Its irritant properties are due to the rapidity with which it forms sulfurous acid on contact with moist membranes. In combination with certain particulate matter and/or oxidants, the effects may be markedly increased. Appoximately 90% of all sulfur dioxide inhaled is absorbed in the upper respiratory passages, where most effects occur; however, high concentrations may produce respiratory paralysis and pulmonary edma.

Coal Tar Pitch Volatiles - Coal tar pitch volatiles (CTPV) are products of the destructive distillation of bituminous coal and contain polynuclear aromatic hydrocarbons (PNA's). These hydrocarbons sublime readily. Epidemiologic evidence suggests that workers intimately exposed to the products of combustion or distillation of bituminous coal are at increased risk of cancer at many sites. These include cancer of the respiratory tract, kidney, bladder, and skin. Substances containing PNA's which may produce skin cancer may also produce contact dermatitis; examples are coal tar, pitch, and cutting oils. Although allergic dermatitis is readily induced by PNA's in guinea pigs, it is only rarely reported in humans from occupational contact with PNA's. Components of pitch and coal tar produce cutaneous photosensitization; skin eruptions are

usually limited to areas exposed to the sun or ultraviolet light. Some oils containing PNA's have been associated with changes of follicular and sebaceous glands which commonly take the form of acne. There is evidence that exposures to emissions at coke ovens and gas retorts may be associated with an increased occurrence of chronic bronchitis.

VI. RESULTS AND DISCUSSION

A. Environmental

Total coal dust - Table 1 summarizes the results of the February 26-27, 1981, personal air sampling for total dust (coal). Since the dust samples contained more than 1% quartz, the ACGIH formula for quartz (total dust) was used as the survey criterion. The six air samples ranged from 0.4 to 4.5 mg/m^3 with the one sample (4.5 mg/m^3) exceeding the sample specific, survey criterion (Table 1). This potential over exposure was for the cleanup-oiler job category which includes the sweeping and shoveling of coal/coal dust. Employees in the coal storage and transfer areas are supplied with NIOSH approved respirators for pneumoconiosis causing dusts. The respirator program at the plant was judged by the NIOSH industrial hygienist to be good.

Respirable coal dust - Table 2 summarizes the results of the September 16, 1981, personal air sampling for respirable dust (coal). Since the quartz content of two of these samples was less than 5%, the ACGIH recommendation of 2.0 mg/m^3 is used as the survey criterion. The air sample results ranged from 0.06 to 2.6 mg/m^3 with the one sample of 2.6 mg/m^3 exceeding the survey criterion of 2.0 mg/m^3 and the OSHA standard of 2.4 mg/m^3. This potential overexposure was again for the cleanup job category. Considering these samples on a quartz basis solely, two of the five samples exceeded the NIOSH recommendation of 0.05 mg/m^3 but none exceeded the OSHA standard of 0.1 mg/m^3.

Fly ash dust - Table 3 summarizes the results of the February 26-27, 1981, and the September 16, 1981, personal air sampling for fly ash dust. The air concentrations of fly ash ranged from 0.4 to 56 mg/m^3 with six of the 10 samples exceeding the survey criterion of 10 mg/m^3. Five samples exceeded the OSHA standard of 15 mg/m^3 for nuisance dusts. The potential overexposures were to the fly ash unloader, conveyor man, maintenance workers, and the equipment checker. Employees in these areas are supplied with NIOSH approved respirators for pneumoconiosis causing dusts.

"Coaltrol" additive - Qualitative analyses of the fly ash, with and without the "Coaltrol" additive, by X-ray powder diffraction and X-ray fluorescence spectrometry showed both samples to be identical in element content. Both had large amounts of silicon,

iron, potassium, calcium and titanium, medium amounts of aluminum, low amounts of magnesium and strontium, and trace amounts of phosphorus, sulfur, vanadium, nickel, copper, rubidium, zinc, and lead. Considering these analytical results and the composition of the "Coaltrol" additive, it is judged that use of the additive does not enhance any potential toxicity of the fly ash.

The pH analysis of the additive was 10.3, the coal fly ash was 11.2, and the coal fly ash with the additive was 10.0. These alkaline substances could cause skin rash or respiratory irritation/inflammation.

Sulfur dioxide and sulfates - Table 4 summarizes the results of the six personal air samples for sulfur dioxide. Air concentrations ranged from 0.2 to 0.9 mg/m^3 as compared to the survey criterion of 1.3 mg/m^3 for up to a 10-hour average daily exposure. Consequently, the sulfur dioxide results do not indicate hazardous exposures. Although there are not environmental recommendations for total sulfates as a class, the air concentrations were quite low, ranging from 0.02 to 1.4 mg/m^3 with a mean of 0.8 mg/m^3.

Benzene solubles - Table 5 presents the results of air sampling for benzene solubles (air contaminants soluble in benzene) and specific polynuclear aromatic hydrocarbons (PNA's). The five air samples for benzene solubles ranged from 0.09 to 0.18 mg/m^3 as compared to the survey criterion of 0.10 mg/m^3 or the OSHA standard of 0.20 mg/m^3. Three of the five samples exceeded the survey criterion for benzene solubles. Several PNA's --- benzo(a)pyrene, chrysene, pyrene, benzo(a)anthracene, and fluoranthene --- were below the laboratory limit of detection for each of the five samples. It must be recognized that the benzene solubles recommended criterion is intended to reflect exposures to PNA's. Since the five PNA's were not detectable on any of the five samples, it is judged that the "excessive" exposures to benzene solubles are probably of little significance. In industrial areas, "benzene solubles" may originate from many sources. Also, the "benzene solubles" concept of air sampling and analysis will reflect anything soluble in benzene, not just PNA's.

B. Medical

Nineteen coal handlers and 52 other employees were eventually examined, for a total of 71 out of a possible 117 employees. Selected characteristics of the total population examined are shown in Tables 6 and 7. The work force is relatively young and

the longest service is 12 years. This length of exposure may not be sufficient to demonstrate the chronic health problems which may arise from exposure to dust. In Table 7 are documented some signs and symptoms which may be relevant to cardiac and respiratory abnormalities.

Bronchitis was defined as: Productive cough for more than three months of the year, for more than two years.

Wheezing/asthma was defined as: A wheezing or asthmatic attack not related to upper respiratory infections or cold.

Blood pressure elevation was defined as: A diastolic blood pressure over 90mm Hg.

Respiratory abnormality on examination category was defined as: extended respiratory expiration, wheezing or rales, or increase in the anterior-posterior chest diameter. As can be seen from Table 7, very few respiratory abnormalities were detected, and this group of abnormalities are not examined in further detail.

Smoking history and use of respirators are detailed in Table 8. A non-smoker is defined as someone who has smoked for less than 5 pack-years and has not smoked for the last year. Ex-smokers include all those not currently smoking who have smoked more than 5 pack-years and have not smoked for more than one year.

Five workers gave a history of hemoptysis (coughing up blood), three of whom currently have the problem. The latter three all have symptoms of bronchitis and raised blood pressure. In addition, two of the three have had significant previous exposures to asbestos and coal dust and all are current or ex-smokers.

From Table 7, it can be seen that 28% of those examined fulfilled the criteria for a diagnosis of chronic bronchitis. As this seems to be a major complaint at the plant, further analyses were performed to attempt to define any relationship between bronchitis and working at the plant. Although smokers and non-smokers had apparently higher rates of bronchitis than ex-smokers, the difference is not statistically different (Table 9). Bronchitis is significantly more prevalent in those over the age of 35; 41% of those over 35 had symptoms of bronchitis whereas only 16% under the age of 35 had bronchitis (Table 10). A similar, though not statistically significant, pattern emerges with respect to bronchitis and years of service. Thirty percent of those with more than seven years service reported symptoms of chronic bronchitis compared to 14% of those with under seven years of service (Table 11).

There was no significant difference in the prevalence of bronchitis between the eighteen coal handlers and a group of 18 of the other workers matched for age (±5 years) to the coal handlers (Table 12). One unexpected result did occur, however. The four cases of bronchitis in the matched workers were all non-smokers, whereas the bronchitics among the coal handlers were all smokers.

The 18 cases of wheezing/asthma included 10 men who also had bronchitis. Wheezing/asthma was unrelated to age, seniority, smoking status, or coal handling (Tables 13-16).

Thirty-one percent of the workers examined had elevated blood pressures. The elevated blood pressures were highly correlated with age (Table 17) but not with years of service (Table 18) or coal handling (Table 19).

On the basis of the above results, it is concluded that the coal handlers were no more likely to have bronchitis, wheezing/asthma, or elevated blood pressure than the other employees. However, given the relatively few years of exposure for most of the employees, these results must be cautiously interpreted.

VII. RECOMMENDATIONS

1. Coal dust and fly ash leakages should be minimized. When leaks appear, they should be promptly repaired.

2. Manual dry sweeping of coal in the Surge Building should be discontinued. Cleaning should be done by wet or vacuum methods.

3. If engineering controls are not feasible, the wearing of NIOSH approved respirators for pneumoconiosis producing dusts should be mandatory (and enforced) when employees work in dusty conditions.

4. The company should perform periodic air monitoring of employees exposed to coal dust and fly ash.

5. Contractors on the company premises should adhere to the provisions of the company's asbestos control program.

6. Employees exposed to pneumoconiosis-producing dust -- coal, asbestos, silica -- should have preplacement and periodic medical evaluations, including chest X-rays (using the ILO system) and pulmonary function tests.

7. Employees who need to use respirators should have preplacement and periodic medical evaluations to determine whether they are physically able to work while wearing them.

VIII. REFERENCES

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Hatfield Power Station
2. Utility Workers Union of America, Local Union 102
3. Utility Workers Union of America, Branch Local 102-M
4. Utility Workers Union of America, National Headquarters
5. NIOSH, Region III
6. OSHA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

Results of Personal Air Sampling for Total Coal Dust

Date	Sample Period	Job Description	Total Coal Dust (mg/m^3)	Evaluation Criteria* (mg/m^3)	OSHA Standard** (mg/m^3)
2/26/81	0755-1502	Heavy Equipment Operator	0.4	2.6	2.9
"	0803-1456	Coal Sampler	0.5	2.2	2.4
"	0800-1452	Clean-up, oiler	2.1	3.6	4.1
2/27/81	0733-1443	Heavy Equipment Operator	0.6	1.8	2.0
"	0740-1443	Clean-up, oiler	4.5	3.9	4.5
"	0741-1443	Sampler	1.5	2.6	2.8

* Based on the formula: $\frac{30}{\% + 3}$

** Based on the formula: $\frac{30}{\% + 2}$

TABLE 2

Results of Personal Air Sampling for Respirable Coal Dust

September 16, 1981

Sample Period	Job Decription	Respirable Coal Dust (mg/m^3)*	Respirable Quartz (mg/m^3)
0732-1500	Barge Unloader & Clean-up	1.7*	0.053
0737-1500	Clean-up	2.6*	0.080
0739-1500	Clean-up	0.17**	< 0.040
0806-1450	Auger Sampler	0.09**	< 0.040
0735-1455	Heavy Equipment	0.06**	< 0.040
Evaluation Criteria		2.0	0.050
OSHA Standard		2.4	0.100

* Quartz content was less than 5%

** Quartz content was less than the laboratory limit of quantitation.

TABLE 3

Results of Personal Air Sampling for Fly ash Dust

Date	Sample Period	Job Description	Fly ash Dust (mg/m^3)
2/26/81	0753-1538	Fly ash unloader	22
"	0806-1516	Conveyor man	16
"	0810-1519	Maintenance	55
2/27/81	0816-1505	"C" Attendant	0.9
"	0819-1507	"B" Attendant	0.4
9/16/81	0806-1135 1230-1340	Maintenance	56
"	0732-1150 1225-1357	Equipment Checker	13
"	0730-1135 1230-1336	Maintenance	48
"	0947-1143 1227-1331	#3 Unit Control using Coaltrol Additive	1.8
"	0948-1136 1228-1331	#3 Unit Control using Coaltrol Additive	2.0
Survey Criteria			10.0
OSHA Standard			15.0

TABLE 4

Results of Personal Air Sampling for Sulfur Dioxide and Sulfates

Date	Sample Period	Job Decription	Sulfur Dioxide (mg/m^3)	Total Sulfates (mg/m^3)
2/26/81	0811-1519	Maintenance	0.2	0.3
"	0817-1505	"C" Attendant	0.6	0.9
"	0819-1507	"B" Attendant	0.4	0.5
2/27/81	0815-1445	"B" Attendant	0.9	1.4
"	0809-1444	"C" Attendant	0.8	1.2
"	0802-1445	Maintenance	0.5	0.7
Evaluation Criteria			1.3	
OSHA standard			13	

TABLE 5

Results of Personal Air Sampling for Coal Tar Pitch Volatiles (Benzene Soluble Fraction) and Polynuclear Aromatic Hydrocarbons*

Date	Sample Period	Job Description	Benzene Soluble Fraction (mg/m^3)
2/26/81	0815-1445	"B" Attendant	0.09
"	0809-1444	"C" Attendant	0.08
"	0802-1459	Maintenance	0.18
2/27/81	0800-1458	Flash Conveyer	0.14
"	0804-1500	Flash Unloader	0.14
Evaluation Criteria			0.10
OSHA Standard			0.20

*Benzo(a)pyrene, chrysene, pyrene, benzo(a)anthracene, and fluoranthene were below the laboratory limit of detection for each sample of this table.

TABLE 6

Characteristics of 71 Study Participants

Characteristic	Mean (yrs.)	Range (yrs.)
Age	33	20 - 57
Length of Employment	7.8	1 - 12

TABLE 7

Selected Current Health Characteristics

Characteristic	Present	Absent
Hemoptysis	3 (4%)	68 (96%)
Bronchitis*	19 (28%)	52 (73%)
Wheezing/Asthma*	17 (24%)	53 (76%)
Raised Blood Pressure*	22 (31%)	49 (69%)
Respiratory Abnormalities on Examination*	8 (11%)	63 (89%)

* For definitions, see text.

TABLE 8

Smoking History and Respirator Usage

	Current	Ex.	Non.
Smoking History	34 (48%)	14 (20%)	23 (32%)

	Frequently	Occasionally
Respirator Usage	33 (46%)	38 (54%)

TABLE 9

Smoking and Bronchitis

Smoking Status	Bronchitis Present	Absent
Smokers	10 (29%)	24 (71%)
Ex-Smokers	5 (36%)	9 (64%)
Non-Smokers	4 (17%)	19 (83%)

$X^2 = 1.72$

$p = 0.42$

TABLE 10

Relationship of Age and Bronchitis

	Bronchitis	
Age	Present	Absent
Under 35 years	7	37
Over 35 years	11	16

$X^2 = 5.45$

$p < 0.02$

TABLE 11

Bronchitis vs. Years of Service

	Bronchitis	
Years of service	Present	Absent
1-6	3	18
7-12	15	35

$X^2 = 1.93$

$p = 0.16$

TABLE 12

Bronchitis in Coal Handlers

	Bronchitis	
Group	Present	Absent
Coal Handlers	6	12
Other Employees	4	14

$X^2 = 0.55$
$p > 0.3$

TABLE 13

Smoking and Asthma/Wheezing

	Asthma/Wheezing	
Smoking Status	Present	Absent
Smoker	12	34
Non-smoker	5	18

$X^2 = 0.16$
$p > 0.5$

TABLE 14

Wheezing and Exposure to Coal Dust

	Wheezing	
Group	Present	Absent
Coal Handlers	5	14
Others	12	39

$X^2 = 0.06$
$p > 0.5$

TABLE 15

Effect of Age on Wheezing/Asthma

	Wheezing/Asthma	
Age	Present	Absent
under 35	13	31
over 35	5	22

$X^2 = 1.07$
$p > 0.3$

TABLE 16

Years of Service in Relation to Wheezing/Asthma

	Wheezing/Asthma	
Years of Service	Present	Absent
1-6	5	16
7-12	13	37

$X^2 = 0.03$
$p > 0.5$

TABLE 17

Relation of Age and Blood Pressure

	Blood Pressure	
Age	High	Normal
Under 35	7	37
Over 35	14	13

$X^2 = 10.37$

$p < 0.002$

TABLE 18

Relation of Years of Service and Blood Pressure

	Blood Pressure	
Years of Service	High	Normal
1-6	6	15
7-12	15	35

$X^2 = 0.014$
$p > 0.5$

TABLE 19

Relation of Exposure to Dust and Blood Pressure

	Blood Pressure	
Group	High	Normal
Coal Handlers	6	12
Others	16	37

$X^2 = 0.06$
$p > 0.5$