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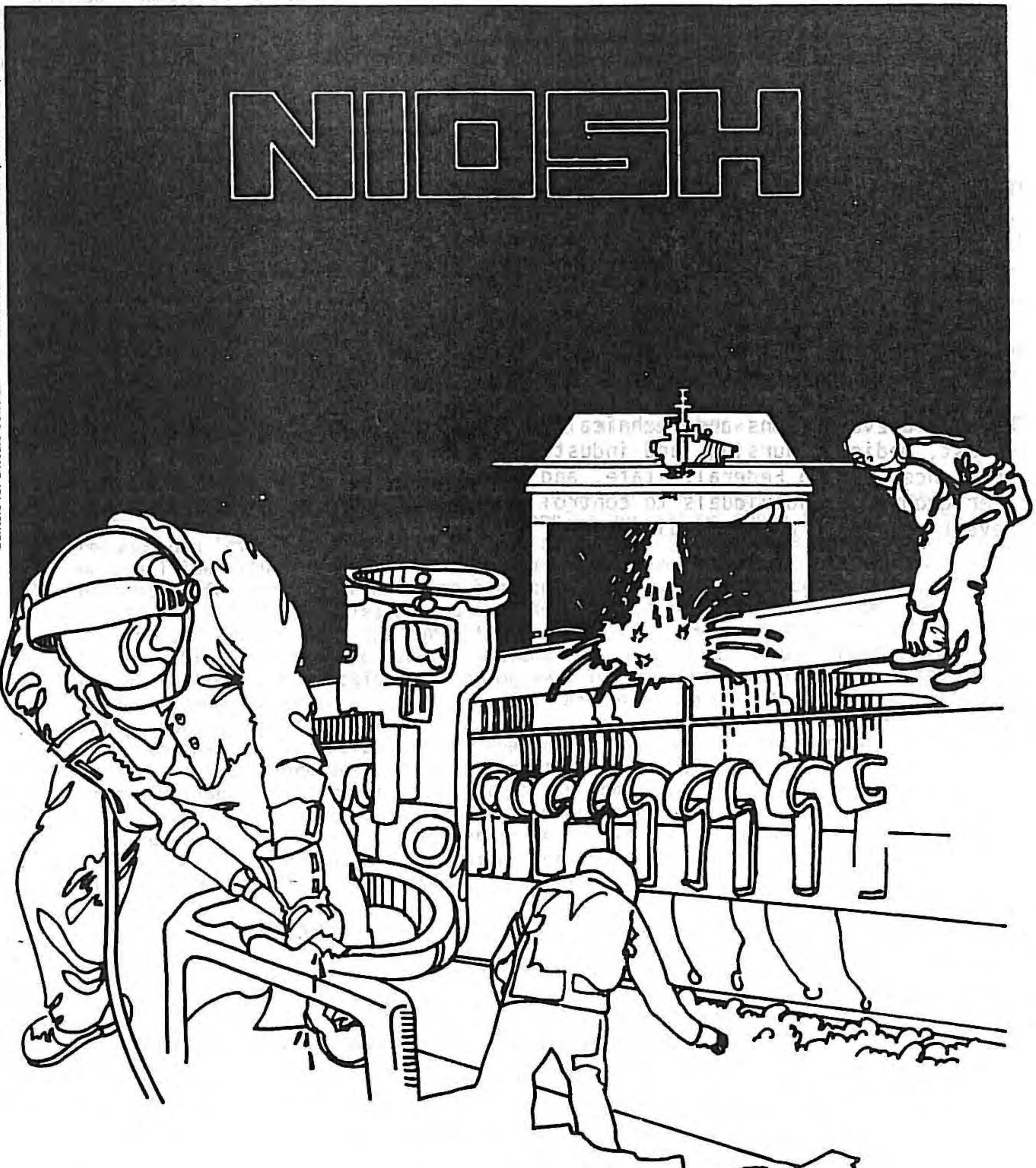

Health Hazard Evaluation Report

HETA 81-278-1371
WARRICK GENERATING STATION
YANKEETOWN, INDIANA

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 81-278-1371
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WARRICK GENERATING STATION
YANKEETOWN, INDIANA

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I. SUMMARY

In April 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Brotherhood of Electrical Workers, Local 702, for a health hazard evaluation of the Southern Indiana Gas and Electric Company, Warrick Generating Station, Yankeetown, Indiana, to evaluate employee exposures to boiler gases and coal dust. NIOSH conducted a combined environmental and medical evaluation at the Warrick facility in August 1981.

Environmental samples were collected to evaluate employee exposures to airborne concentrations of nitrogen dioxide, nitric oxide, sulfur dioxide, coal dust, fly ash, crystalline silica, and inorganic metals. In addition, gas leaks from the boilers were evaluated.

Nitric oxide was detected on one of six personal samples at a concentration of 0.24 milligrams per cubic meter of air (mg/m^3). This is approximately 1% of the current NIOSH and OSHA criteria of 30 mg/m^3. Nitrogen dioxide was not detected on any of the six personal samples.

Sulfur dioxide concentrations for ten personal samples ranged from less than 0.01 mg/m^3 to 10.5 mg/m^3. Three of the ten samples were at or above the NIOSH recommended level of 1.3 mg/m^3. Fly ash concentrations for five personal samples were all low with the highest (0.3 mg/m^3) being approximately 5% of the OSHA PEL of 5 mg/m^3 for respirable nuisance particulates. Coal dust concentrations for twenty-two personal samples ranged from <0.01 mg/m^3 to 4.24 mg/m^3. One sample was approximately double the current OSHA PEL (2.4 mg/m^3) and ACGIH TLV (2 mg/m^3). Crystalline silica concentrations for 10 personal samples ranged from below the limit of detection to 0.07 mg/m^3. Two samples were at or above the NIOSH recommended criteria of 0.05 mg/m^3. Airborne concentrations for metals on two personal samples were low. Four metals (calcium, iron, manganese, and sodium) found on both samples were all less than 5% of the lowest corresponding criteria. Boiler gas leaks were detected with direct reading indicator tubes. Highest concentrations were for sulfur dioxide at 15 and 20 parts per million (ppm). These values are 30 and 40 times the NIOSH recommended time weighted average (TWA) of 0.5 ppm, respectively. Grab samples cannot be compared directly to TWA criteria, but these results do indicate the potential for employee exposure to hazardous sulfur dioxide concentrations when working in or near the leaks.

The results of the medical evaluation revealed no statistically significant group decrement in FEV_1, FVC, and FEV_1/FVC for these workers. No case of pneumoconiosis was documented by the X-ray data from the Warrick plant. The health questionnaire completed with all of the participants revealed a symptom prevalence rate of 49% among these workers. These 85 workers reported at least one of the symptoms of cough, phlegm, breathlessness, or wheezing.

Based on these results, NIOSH has determined that while the majority of personal samples were below current criteria, a health hazard did exist for some employees exposed to sulfur dioxide, coal dust, and crystalline silica. Highest concentrations were obtained on samples worn by electrical and maintenance personnel and employees working on the positive pressure boiler (unit 4). In addition, the potential exists for employee exposure to boiler gases due to boiler leaks. Respiratory symptoms of cough, phlegm production, and wheezing were twice the expected rate for this group of workers. If preventive maintenance and engineering measures are employed, the occurrence of continued group health effects will likely be reduced. Recommendations are made (Section VIII) for an improved respiratory protection program, reducing leaks from boiler units, and for periodic environmental monitoring of the employees.

KEYWORDS: SIC 4911 (Electric Power Generation), electricity generation, nitrogen dioxide, nitric oxide, sulfur dioxide, fly ash, coal dust, crystalline silica.

II. INTRODUCTION

On April 13, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Brotherhood of Electricial Workers (I.B.E.W.), Local 702, for a health hazard evaluation of the Southern Indiana Gas and Electric Company (SIGECO), Warrick Generating Station, Yankeetown, Indiana, to evaluate employee exposures to boiler gases and coal dust. In addition, the request expressed concern about possible lung function problems associated with long-term exposures at the facility.

NIOSH originally contacted management to schedule the initial survey in April 1981. The initial survey was delayed several months due to legal challenges initiated by Southern Indiana Gas and Electric Company. NIOSH conducted a combined environmental and medical evaluation at the Warrick Generating Station in August 1981. An opening conference was conducted on August 7, 1981, involving representatives from management, the union, and NIOSH. Following the opening conference, an initial walk-through survey of the Warrick Facility was conducted. A combined environmental and medical survey was conducted on August 12-13, 1981, and a closing conference was conducted on August 14, 1981.

A similar request for a health hazard evaluation at a separate coal-fired power plant (Culley Generating Station) had been received from I.B.E.W., Local 702 in December 1980.

NIOSH distributed an interim report for this investigation in May 1982.

III. BACKGROUND

The Warrick Generating Station is jointly owned by Southern Indiana Gas and Electric Company and by the ALCOA Generating Corporation. This facility has four units. Units 1, 2, and 3 (all 140 megawatts) began production between the mid 1950's to 1960. Unit 4 (260 megawatts) was added in 1970. Units 1, 2, and 3 have balanced-draft boilers and Unit 4 has a positive-pressure boiler. Collectively, the four units burn approximately 610,000 pounds of coal per hour producing up to 680 megawatts of electricity during maximum load periods.

Coal enters the Warrick Generating Station by railroad car and is off loaded in the dumper building, where the cars are gravity emptied by being rotated upside down. Coal can be taken from the dumper building into the plant or to a storage area in the coal yard. When needed, the coal is moved via conveyor belts up to the tripper deck. At the tripper deck, coal may be directed to a conveyor for Units 1, 2, and 3 or to a separate conveyor for Unit 4. From the tripper, the coal is transferred into silos (round) or bunkers (rectangular). Next, the coal is gravity fed through feeders which control the flow of coal to coal mills, where it is ground to the consistency of face powder. From the mills, the powdered coal is blown through burner lines into the boiler, where it rapidly burns releasing energy as heat. Impellers, located inside the burner pipes at the point the pipes enter the boiler, act to distribute the powdered coal as it enters the fire box. This action provides for more complete and thus hotter combustion. The heat energy converts water into steam. The steam is used to turn a turbine shaft at approximately 3,600 revolutions per minute. The turbine shaft extends into a generator. As the shaft revolves, it turns a magnet at right angles to a coil of wire which produces electricity. From the turbine, steam flows into the condensers where the steam is converted into water via contact with pipes in which cooler river water is flowing. Next, the water is returned to the boilers, where it is converted to steam once more. From the fire box, boiler exhaust consisting of fly ash and boiler gases are sent through an economizer hopper where larger particulate material settles out of the air stream. The air stream then passes through an electrostatic precipitator where fly ash is removed. The remaining exhaust gases are carried through the precipitator to the smoke stack for atmospheric venting. All controls for boilers, turbines, and associated equipment are concentrated in one central control room. In this room, the operator monitors detailed data on numerous phases of the plant operation.

There are approximately 165 production employees at this facility. The breakdown of the workforce is as follows:

A. Operators

This category (approximately 85 employees) includes control operators, equipment operators, auxillary equipment operators, and coal equipment operators. Control operators work in the air-conditioned control room and are responsible for monitoring the operation of the entire plant. Equipment operators are responsible for equipment on the turbine side of a particular unit. They cover three floors, making equipment checks during the course of their shift. Auxillary equipment operators are responsible for the boiler side of each specific unit. They cover nine floors and make checks on the equipment throughout the shift. Coal equipment operators are responsible for running the dumper building and monitoring the movement of coal from the yard to the bunkers and silos. They also run bulldozers to move coal around in the coal yard.

B. Maintenance

This category (approximately 80 employees) includes maintenance, electricians, and janitors. Maintenance employees are responsible for routine maintenance and emergency repairs. The electricians are responsible for routine electrical maintenance and emergency repairs. Janitors are responsible for general housekeeping duties.

IV. METHODS AND MATERIALS

A. Environmental

Environmental sampling was conducted to evaluate employee exposures to airborne concentrations of nitrogen dioxide, nitric oxide, sulfur dioxide, fly ash, coal dust, crystalline silica, and inorganic metals (Table 1). In addition, a bulk material sample of insulation on a portable oven was collected to evaluate the potential for employee exposure to asbestos.

Nitrogen dioxide and nitric oxide samples were collected on three section impregnated molecular sieve sorbent tubes attached via flexible tubing to a battery-operated pump calibrated at 0.02 liters per minute (LPM). Nitrogen dioxide and nitric oxide were analyzed using spectrophotometry according to NIOSH Method No. P&CAM 231.[1]

Sulfur dioxide samples were collected using a two-filter sampling train consisting of a mixed cellulose ester membrane filter followed by an impregnated cellulose filter containing potassium hydroxide. These filters were attached via flexible tubing to a battery-operated pump calibrated at 1.5 LPM. Sulfur dioxide samples were analyzed by first determining particulate and gaseous sulfate and sulfites using ion chromatography. Then a formula was used to determine sulfur dioxide collected on the treated filter according to NIOSH Method No. P&CAM 268.[2]

Fly ash samples were collected on polyvinyl chloride filters attached via flexible tubing to a battery-operated pump calibrated at 1.7 LPM. Coal dust samples were collected on polyvinyl chloride filters attached via flexible tubing to a battery-operated pump calibrated at 2 LPM. Both fly ash and coal dust were respirable samples collected by loading each filter cassette into a 10 millimeter nylon cyclone. Fly ash and coal dust samples were analyzed by weighing the samples plus the filters on an electrobalance and subtracting the previously determined tare weights of the filters. Some of the fly ash and coal dust samples were analyzed for percent crystalline silica. These samples were analyzed according to NIOSH Method No. P&CAM 259 with a slight modification involving analysis of bulk material samples.[1]

Inorganic metal samples were collected on mixed cellulose ester filters attached via flexible tubing to a battery-operated pump calibrated at 1.5 LPM. Inorganic metal samples were ashed with nitric acid following NIOSH Method No. P&CAM 173.[1] The residues were dissolved in dilute nitric and perchloric acids and the resulting solutions analyzed for trace metal content using inductively coupled plasma-atomic emission spectroscopy. The bulk insulation sample was analyzed by a visual estimation of the percentage of asbestos utilizing polarized light microscopy and dispersion staining techniques.

In addition to personal monitoring, certified direct-reading indicator tubes were utilized to evaluate airborne concentrations of boiler gases (sulfur dioxide, oxides of nitrogen, and carbon monoxide) in specific area of the plant. Subsequent to collection the indicator tubes were evaluated visually. All samples (except direct reading indicator tubes) were returned to NIOSH laboratories for analysis.

Copies of the company's written respiratory protection program and OSHA Occupational Injuries and Illnesses Form 200 for 1979-1981 were obtained.

B. Medical

Medical data for both the Warrick and Culley power plant employees were combined and analyzed together in order to derive optimum power for statistical analysis of group health effects. Each study participant completed a medical test battery that included; a pulmonary function test (PFT), chest X-ray, and a standardized questionnaire (which elicited demographic information, work history, smoking history, medical history, and respiratory symptoms). The workers were classified by station (Warrick or Culley), smoking status, job category, and dust exposure group. A total of 117 Warrick workers completed the medical evaluation. The same medical test battery was given to 56 workers at the Culley plant.

Pulmonary function tests include measurement of forced vital capacity (FVC) and one-second forced expiratory volume (FEV_1) and calculation of the ratio FEV_1/FVC. FVC measures the total amount of air that can be forced out of the lungs after breathing in as deeply as possible; FEV_1 measures that amount of air that can be exhaled in one second. FEV_1 can be impaired by cigarette-related lung damage and/or occupational/environmental conditions. Any condition that impairs FVC also impairs FEV_1, but the reverse is not true. FEV_1/FVC, along with FEV_1 and FVC is used to evaluate breathing function.

These measured breathing parameters (FEV_1 and FVC) are evaluated by compairing them to "predicted" values, which take into account age, height, race and sex. Pulmonary function is considered "normal" if the FEV_1 and FVC are each 80% or more of the respective predicted value and FEV_1/FVC is 70% or more.

The chest X-rays were interperated by two radiologists certified by the American College of Radiology as "B-readers". B-readers use a special classification for interpretation of X-ray results, devised by the International Labor Organization and the International Union Against Cancer (ILO/UICC). The X-ray changes associated with the pneumoconioses are often very sutble. The classification provides a means for systematically recording X-ray changes and utilizes a set of standards to which X-rays are compared. These X-ray results were then classified into five groups: normal, density (due to artifact), opacities, density, or poor film. Workers with poor film results have been excluded from the analysis of the X-ray outcomes.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the

NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

All three criteria are listed in Table I. For most contaminants, the OSHA PEL and NIOSH recommendations are used to evaluate employee exposures during the survey. In those instances where ACGIH has recommended a TLV that is lower than the other two criteria, it is also discussed.

A. Nitrogen Dioxide

Nitrogen dioxide (NO_2) may cause health effects if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is ingested. Exposure to high levels of nitrogen dioxide may cause severe breathing difficulties which may cause death. Recovery may be slow with possible relapse and/or permanent lung damage. Pneumonia may occur. Irritation of the eyes, nose, throat, and skin may occur with acute exposures. The effects expected in humans from exposure to NO_2 for 60 minutes are: at 100 ppm, pulmonary edema and death; at 50 ppm, pulmonary edema with possible subacute or chronic lesions in the lungs; at 25 ppm, respiratory irritation and chest pain. A concentration of 50 ppm is moderately irritating to the eyes and nose; 25 ppm is irritating to some people.[3]

The OSHA PEL for nitrogen dioxide is 9 milligrams per cubic meter of air (mg/m^3) as a ceiling that should not be exceeded (5 ppm).[4] The NIOSH recommended standard is 1.8 mg/m^3 (1 ppm). This is a ceiling value that should not be exceeded during any 15-minute period.[5]

B. Nitric Oxide

Nitric oxide (NO) may cause health effects if it is inhaled or if it comes in contact with the eyes or skin. Exposure to high levels of nitric oxide causes narcosis (deep unconsciousness) in animals. Exposures of mice to 2500 ppm for six or seven minutes caused narcosis, and death occurred within 12 minutes. Some early reports attributed the toxicity of nitric oxide to the formation of methemoglobin in the bloodstream; however, more recent studies indicate that nitric oxide reacts in vitro with normal (ferrous) hemoglobin, but in exposed animals this interaction does not occur and no methemoglobin is formed. Nitric oxide is converted spontaneously in air to nitrogen dioxide; hence, some of the latter gas is invariably present whenever nitric oxide is found in the air. At concentrations below 50 ppm, however, this reaction is slow, and frequently substantial concentrations of nitric oxide may occur with negligible quantities of nitrogen dioxide.[3]

The OSHA PEL for employee exposure to nitric oxide is 30 mg/m^3 (25 ppm) based on an 8-hour TWA.[4] The NIOSH recommended standard is also 30 mg/m^3 for up to a 10-hour TWA.[5]

C. Sulfur Dioxide

Sulfur dioxide (SO_2) can affect the body if it is inhaled or if it comes in contact with the eyes or skin. Sulfur dioxide gas is intensely irritating to the eyes and respiratory tract causing tearing and burning of the eyes, coughing, and chest tightness. It may cause severe breathing difficulties. Exposures to high concentrations (dose) of sulfur dioxide may cause sudden death. Liquid sulfur dioxide may cause eye burns with loss of vision and skin burns. Initial cough and irritation have been reported at airborne concentrations of 5 and 13 ppm. The symptoms subsided after 5 minutes of exposure. Workers repeatedly exposed to 10 ppm experienced upper respiratory irritation and some nose bleeds.[3]

The OSHA PEL for sulfur dioxide is 13 mg/m^3 (5 ppm) based on an 8-hour TWA.[4] The NIOSH recommended standard is 1.3 mg/m^3 (0.5 ppm) for up to 10-hour TWA.[3]

D. Coal Dust

The inhalation of coal dust causes coal workers' pneumoconiosis (CWP). Simple CWP has no clinically unique symptoms, since it often occurs concomitantly with several respiratory impairments. CWP is associated with chronic bronchitis and emphysema, which are associated with shortened life span; the importance of CWP is that it may be a precursor of progressive massive fibrosis of the lungs.[6]

Statical analysis of the results from the first 10 years of the Pneumoconoisis Field Research of the National Coal Board (NCB) of the United Kingdom provided the data used to establish the current ACGIH TLV. Estimates of the probabilities of developing pneumoconiosis after 35 years' exposure to different coal dust concentrations were derived from the results. For ILO (International Labor Office) category "1" or greater the probability was calculated to be 10% at 4 mg/m^3, and essentially zero at 1.6 mg/m^3. For pneumoconiosis in ILO category "2" or greater, the 10% probability is at 6.5 mg/m^3, while the zero probability is at 2.2 mg/m^3.(7)

The current ACGIH TLV is 2 mg/m^3 for respirable coal dust containing less than 5% quartz.[7,8] The OSHA PEL is 2.4 mg/m^3 for respirable dust containing less than 5% quartz.[4] Both criteria are based on 8-hour TWA. NIOSH currently has no criteria for coal dust.

E. Fly Ash

At the present time, OSHA, NIOSH, and ACGIH have no specific criteria for fly ash. Fly ash, however, is subject to the crystalline silica criteria, depending on the percent crystalline silica it contains. OSHA and ACGIH in addition have a criteria for nuisance particulates. These criteria were used to evaluate fly ash exposures at this facility.

Nuisance particulates cause lung tissue reaction, but the reaction is reversible, does not cause scarring, and does not damage lung structure. Nuisance particulates may cause unpleasant deposits in the eyes, ears, and nasal passages and may cause skin or mucous membrane injury by chemical or mechanical action or secondary to cleaning procedures to remove the substances from the skin.[7]

The OSHA PEL for the respirable fraction of nuisance particulates is 5 mg/m^3 based on an 8-hour TWA.[4] The PEL was used to evaluate employee exposure to fly ash. NIOSH currently has no recommended standard for fly ash.

F. Silica

Inhalation of crystalline silica can cause silicosis, an irreversible scarring of the lungs with accompanying cough and shortness of breath. The clinical signs and symptoms of silicosis tend to be progressive with continued exposure to quantities of dust containing free silica, with advancing age, and with continued smoking habits. The disease tends to occur after an exposure measured in years rather than months. Exposures to very high concentrations of silica for short periods of time, have occured in occupations such as sandblasters and tunnel workers. In these cases of acute or rapidly developing silicosis there may be severe respiratory symptoms resulting in death.[3]

The OSHA PEL for respirable dust containing crystalline silica is 10 mg/m^3 divided by the percent silica plus 2 based on an 8-hour TWA.[4] The NIOSH recommended standard is 0.05 mg/m^3 for up to a 10-hour work shift, 40-hour workweek.[9]

VI. RESULTS

A. Environmental

Table II presents the results of sampling for airborne nitric oxide and nitrogen dioxide. Of a total of six personal samples, nitric oxide was found on one sample at a concentration of 0.24 mg/m^3. This is approximately 1 percent of the NIOSH recommended standard. Nitrogen dioxide was below the laboratory limit of detection (2 ug/sample) for all six samples.

Table III presents the results of sampling for airborne sulfur dioxide. The concentrations ranged from less than 0.01 to 10.5 mg/m^3. The highest concentrations were obtained on samples worn by an electrician and the auxillary equipment operators on Unit 4. These three samples were at/or above the NIOSH recommended standard (1.3 mg/m^3) and one of the three samples was 80 percent of the current OSHA PEL (13 mg/m^3).

Table IV presents the results of sampling for airborne fly ash. The airborne concentrations ranged from 0.16 to 0.3 mg/m^3 for five personal samples. The highest concentration was obtained on a sample worn by the auxillary equipment operator on Unit 4. All concentrations were below the current environmental criteria. The highest concentration was approximately 5 percent of the OSHA PEL for nuisance particulates (5 mg/m^3).

Table V presents the results of sampling for airborne coal dust. The concentrations for 22 personal samples ranged from <0.01 to 4.24 mg/m^3. The highest concentration was obtained on a sample worn by a maintenance employee. This sample was approximately 2 times the ACGIH TLV (2 mg/m^3) and the OSHA PEL (2.4 mg/m^3). Both criteria are for respirable coal dust containing <5% quartz.

Table VI presents the results of crystalline silica analysis of fly ash and coal dust samples. Of ten samples evaluated for crystalline silica, eight were below the limit of detection for quartz and cristobalite. Two samples worn by a coal equipment operator working on the tripper deck and an electrician had concentrations of 0.05 and 0.07 mg/m^3, respectively. Both samples are at or above the current NIOSH recommendation (0.05 mg/m^3). The concentration for both samples was below the calculated OSHA PEL of 0.22 and 0.83 mg/m^3, respectively.

Table VII presents the results of sampling for airborne metals. Two personal samples were collected on maintenance employees, who were involved in welding activities inside a coal mill. A total of 28 metals were evaluated on each filter. Four metals (calcuim, iron, manganese, and sodium) were found on both filters. Concentrations for these four metals were low, with all being less than 5 percent of the lowest corresponding criteria.

Table VIII presents the results of grab sampling (for CO, oxides of nitrogen, and SO_2) using certified direct-reading indicator tubes. The highest concentrations obtained were for sulfur dioxide on Unit 4. The two highest readings (15 and 20 ppm) were 3 to 4 times the OSHA PEL (5 ppm) and 30 to 40 times the NIOSH recommended standard (0.5 ppm). Carbon monoxide concentrations were <5 ppm for four samples, which indicates that all samples were much lower than the lowest current criterion of 35 ppm (NIOSH). Concentrations for oxides of nitrogen ranged from <0.5 to 3 ppm. The indicator tubes used to collect these samples do not distinguish between NO and NO_2. Therefore, it is not possible to know how much of each material was present. The lowest current criterion is 25 ppm for NO and 1 ppm for NO_2.

Certified direct reading indicator tubes are certified to have an accuracy of $\pm$35% at 1/2 the test gas concentration and $\pm$25% at 1, 2, and 5 times the test gas concentration (the test gas concentration usually corresponds to the OSHA PEL).[4,10] Therefore, the values listed in Table VIII should not be considered exact concentrations. In addition, the OSHA and NIOSH criteria for the boiler gases evaluated are based primarily on full shift exposures (NO_2 criteria represent ceiling values), conversely the grab samples represent airborne concentrations at a specific point in time. These values do, however, indicate the potential for employee exposures to excessive concentrations of sulfur dioxide when working in or near the areas where these samples were collected.

A bulk sample of the exposed insulation material from the portable oven located in the employees' lunchroom contained approximately 10-percent chrysotile asbestos by polarized light microscopy analysis. No airborne asbestos samples were collected, so it is not known if there were any measurable airborne asbestos fibers present. However, the fact that the insulation was exposed and that the oven was used to heat employees' food indicates the potential for ingestion and possibly inhalation of asbestos fibers.

During the NIOSH survey, electricity production by shift ranged from approximately 57 to 95 percent of the maximum net load. The production rate was higher on August 12, 1981 (88 to 95 percent), than on August 13, 1981 (57 to 70 percent). This was due to a planned outage on Unit 1, which began at 8:00 p.m. on August 12, 1981, and an unexpected temporary outage on Units 2 and 3, which occurred between 4:00 a.m. and 8:00 a.m. on August 13, 1981.

Leaks were observed in the boilers and other process equipment. The results of the leaks varied depending on which process equipment was involved. Leaks in the boilers resulted in escaping boiler gases and fly ash, particularly on the positive-pressure boiler (Unit 4). Leaks in the coal mills and burner pipes resulted in coal dust leaks.

Dry bulb temperatures collected around the boilers were consistently in the 90°F range. Some readings were in excess of 100°F (the maximum measurable temperature with the thermometer used) particularly on the upper levels. NIOSH industrial hygienists experienced discomfort in some locations. These factors indicate a potential for employee heat stress while working on the upper levels near the boilers. Normal activities would not require employees to remain in these areas for more than a few minutes. Nonroutine or emergency conditions could require that employees remain in hot areas for variable time periods. Heat stress potential also exists during the summer months for employees operating bulldozers (which are not air-conditioned) moving coal in the coal yard.

B. Medical

One hundred, seventy-three workers participated in these health hazard evaluations. Each study participant completed a medical test battery that included; a pulmonary function test (PFT), and a questionnaire (which elicited such demographic information as work history, smoking history, medical history, and respiratory symptoms). The workers were classified by station (Culley or Warrick), smoking status, job catogory, and dust exposure group.

The mean age of these workers was 31.2 years. Their average length of employment at these electric generating stations was 6.2 years. The pulmonary function data for this group of workers resulted in a FEV_1 of 99.2, FVC of 101.3, and a FEV_1/FVC of 80.3 (Table IX). We then compared these PFT data to the group dust exposure history and by job category, respectively. There were no significant PFT differences between workers who reported dust exposure and those who did not (Table X). Likewise, comparison of job category with PFT results produced no significant findings for the group (Table XI).

Individual responses to our questions regarding symptoms of cough, breathlessness, and wheezing detailed the presence of at least one of these symptoms in 49% of the group. Cough was reported by 35%, phlegm production by 31%, wheezing by 21%, and breathlessness by 8% of these workers (Table XII). The number of respiratory symptoms observed were compared with the number expected. A two fold increase for cough, phlegm production and wheezing was observed for both plants' workforces (Table XIII).

A comparison of individuals reporting symptoms to their job categories found roughly equal symptom rates for all categories (Table XIV). When symptoms were compared for dust exposure versus no dust exposure, generally equal prevalence rates were obtained (Table XV).

X-ray results were classified into five groups: normal, density (due to artifact), opacities, density, or poor film. Workers with poor film results have been excluded from the analysis of the X-ray outcomes (Table XVI). The X-ray results revealed abnormal findings in 57 of the individual films. These abnormal findings included four cases of pneumoconiosis at the Culley plant. The remaining 53 abnormal films were indicative of a wide range of radiologic diagnosis. NIOSH has determined the presence of two pneumoconiosis causing dusts in these two power plants (silica and asbestos). We have provided recommendations in these reports designed to reduce the potential for exposure to these lung scarring dusts.

VII. DISCUSSION AND CONCLUSIONS

Analysis of the environmental data indicates that concentrations for the majority of personal samples were low. Of approximately 67 analyses involving 45 personal samples, 61 of the analyses were below all current environmental criteria. As a group, the sulfur dioxide samples were the highest in comparison to current environmental criteria. Three of 10 samples were at or above the NIOSH recommended standard. Of the remaining personal samples, the coal dust were the highest when compared to current criteria. One sample was approximately 2 times the current criteria. In addition, 10 of the remaining 20 samples were 20 to 60 percent of the ACGIH TLV. Two of 10 samples analyzed for percent crystalline silica were at or above the NIOSH recommended standard.

In addition, results of sampling using certified direct-reading indicator tubes indicates that high concentrations of sulfur dioxide were present in specific areas near the boiler for Unit 4. The highest readings were obtained where boiler leaks were observed by NIOSH industrial hygiene personnel. In some instances, it was very difficult to collect detector tube readings for sulfur dioxide due to physical irritant discomfort while standing in the vicinity of a boiler leak. These results indicate that the potential for employee exposure to high concentrations of boiler gases exists if employees were involved in maintenance activities in the vicinity of boiler leaks. Employee exposure to high concentrations of materials during maintenance activities have been documented during NIOSH health hazard evaluations in other coal-fired power plants.[11,12] Some maintenance activities were monitored during this survey. In most instances, however, the maintenance activities were of short duration (maximum of 2 to 3 hours), and in some instances, employee maintenance activities for a shift included working in several areas of the facility.
Review of the medical data indicate some health effects in these 173 workers. These effects include four X-ray confirmed cases of pneumoconiosis (at the Culley plant), and an overall 49% prevalence rate of at least one respiratory symptom in this worker population. Though the workers who smoked had a higher prevalence of at least one of the symptoms of cough, phlegm, breathlessness and wheezing, 33% of their nonsmoking co-workers reported at least one of the same symptoms. The comparison of observed respiratory symptoms with expected symptoms was based on age and smoking specific prevalance rates from the Health and Nutrition Examination Survey (HANES I) for full time working males 25-64 years of age. The overall absence of chronic group health effects (low prevalance of breathlessness), is not surprising. This is a young workforce (mean age 31.2 years) with an average job senority of 6.2 years. These data suggest that no long-term exposure of the workers to the substances monitored at these generating plants has as yet occurred. If workplace exposures are reduced to a minimum via engineering controls and regular systems maintenance, the likelihood of chronic exposures and subsequent occupational disease, could be markedly reduced.

NIOSH has found that the pH of fly ash is alkaline and may reach 11.5 (neutral is pH of seven on a scale of pH 1-14).[13] Reports of skin irritation/rash in workers exposed to alkaline materials have been clearly documented.[13] The natural secretions of the skin are acidic at a pH of 5.4. This secretory mechanism plays an important role in protecting the skin against invading organisms or materials and is called the "acid mantle" of the skin.[14] It follows that frequent contamination of the skin with alkaline materials affects the natural protection (acid mantle) of the skin and is therefore to be avoided. Further studies may be warranted in order for NIOSH to generate a recommended standard for exposure to fly ash.

VIII. RECOMMENDATIONS

1. The respiratory protection program should be improved to ensure that employees are properly trained in the use and maintenance of respirators. A copy of the OSHA Standard Method for Determination of Respiratory Protection Program Acceptability has been forwarded to both management and the union.

2. Management should conduct environmental sampling to determine the extent of employee exposure to airborne concentrations of quartz. Emphasis should be given to employee activities most likely to involve high dust (coal dust or fly ash) exposure. In addition, due to the number of potentially hazardous occupational exposures associated with coal fired power plants, management should conduct periodic (at least annual) environmental evaluations of exposed employees with emphasis on equipment operators and maintenance activities.

3. A regular schedule of periodic maintenance should be installed and administratively monitored in order to minimize leaks from the boiler units.

4. A system incorporating item three above for leaking seals on coal mills and other process equipment should be designed and implimented.

5. The asbestos insulation material on the portable oven in the lunchroom should be covered or removed or the oven itself should be replaced. There is potential for ingestion and/or inhalation of asbestos fibers from the exposed insulation material.

6. A heat stress survey should be conducted on the boiler units and for employees operating dozers. Special consideration must be given to unacclimatized employees who are working in hot environments. Information concerning procedures for working in hot environments is contained in the NIOSH Recommended Standard for

Occupational Exposure to Hot Environments and in the Proceedings of a NIOSH Workshop on Recommended Heat Stress Standards.[15,16]

7. Efforts to create a viable joint labor/management health and safety committee should commence.

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XI. 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 NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Southern Indiana Gas and Electric Company
2. ALCOA Generating Corporation
3. Authorized Representative of Employees, Local 702, International Brotherhood of Electrical Workers

4. NIOSH, Region V
5. OSHA, Region V

For the purpose of informing the approximately 165 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 I

Environmental Criteria and Sampling and Analytical Methods

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

Contaminant	Flow Rate (LPM)	Collection Media	Analytical Method	Environmental Criteria (mg/m^3) OSHA PEL	NIOSH Recommendation	ACGIH TLV
Nitric Oxide	0.02	3 Section Sorbent Tube	P&CAM No. 231	30	30	30
Nitrogen Dioxide	0.02	3 Section Sorbent Tube	P&CAM No. 231	9[A]	1.8[B]	6
Sulfur Dioxide	1.5	Cellulose Ester Membrane Filter With Impregnated Cellulose Filter	P&CAM No. 268	13	1.3	5
Coal Dust	2	PVC Filter Loaded Into 10 mm Nylon Cyclone	Gravimetric	2.4	None	2
Fly Ash (Used Nuisance Particulate Criteria)	1.7	PVC Filter Loaded Into 10 mm Nylon Cyclone	Gravimetric	5	None	5

(continued)

TABLE I (continued)

Contaminant	Flow Rate (LPM)	Collection Media	Analytical Method	Environmental Criria (mg/m^3) OSHA PEL	NIOSH Recommendation	ACGIH TLV
Quartz*	**	PVC Filter Loaded Into 10 mm Nylon Cyclone	P&CAM No. 259	$\frac{10 \text{ mg/m}^3}{\% \text{ SiO}_2 + 2}$	0.05	$\frac{10 \text{ mg/m}^3}{\% \text{ respirable quartz} + 2}$
Boiler Gases (SO_2, CO, NO + NO_2) Grab Sample	-	Certified Direct Reading Indicator Tubes	Visual, direct reading	Used Time Weighted Average Criteria		
Asbestos - Bulk	-	Collected in Glass Sample Vial	Visual Estimate of % Asbestos Using Polarized Light Microscopy	-	-	-

- Does not apply.
* Quartz was only polymorph of crystalline silica present.
** Analysis was on coal dust and fly ash samples.
A = Ceiling Value that should not be exceeded at any time.
B = Ceiling Value for a 15-minute period.

TABLE II

Airborne Concentrations of Nitric Oxide and Nitrogen Dioxide
Personal Samples

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentration (mg/m^3) NO	Concentration (mg/m^3) NO_2
8-12	Maintenance*	0301-0631	4.1	LLD	LLD
8-12	Auxillary Equipment Operator - Unit 2	0822-1540	4.6	LLD	LLD
8-12	Auxillary Equipment Operator - Unit 3	0830-1535	6.6	LLD	LLD
8-13	Auxillary Equipment Operator - Unit 4	0009-0728	7.8	LLD	LLD
8-12	Auxillary Equipment Operator - Unit 4	0825-1535	8.2	0.24	LLD
8-13	Auxillary Equipment Operator - Unit 4**	0152-0557	2.9	LLD	LLD

* Sample for first part of shift invalid.
** Pump battery dead at 1:52 a.m., changed sample and pump.
LLD = Below the laboratory limit of detection (2 ug for NO and NO_2).

Environmental criteria (mg/m^3):

Nitric Oxide - OSHA=30 (based on an 8-hour TWA)
NIOSH=30 (based on an 8-hour TWA)

Nitrogen Dioxide - OSHA=9 (ceiling value that should not be exceeded)
NIOSH=1.8 (ceiling value not to be exceeded during any 15-minute period)

TABLE III

Airborne Concentrations of Sulfur Dioxide
Personal Samples

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentrations (mg/m^3)
8-13	Maintenance	2316-0631	653	<0.01
8-12	Electrician	0850-1513	575	10.5
8-12	Auxillary Equipment Operator - Unit 2	0822-1540	657	0.07
8-13	Auxillary Equipment Operator - Unit 2	0800-1545	698	0.03
8-12	Auxillary Equipment Operator - Unit 3	0830-1535	638	0.02
8-13	Auxillary Equipment Operator - Unit 4*	1105-1545	420	0.21
8-13	Auxillary Equipment Operator - Unit 4**	0016-0558	513	1.34
8-12	Auxillary Equipment Operator - Unit 4	0825-1535	645	2.61
8-13	Auxillary Equipment Operator - Unit 4	0009-0728	659	0.02
8-13	Auxillary Equipment Operator - Unit 4	1557-2322	668	0.46

Laboratory limit of detection = 5 ug.
* Sample for first half of shift invalid.
** Cassette top came off of treated filter. Concentration is questionable.
< = Less than.

Environmental criteria (mg/m^3): OSHA=13 (based on an 8-hour TWA)
NIOSH=1.3 (for up to a 10-hour TWA)

TABLE IV

Airborne Concentrations of Respirable Fly Ash Samples
Personal Samples

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentrations (mg/m^3)
8-13	Auxillary Equipment Operator - Unit 4	1558-2322	755	0.3
8-13	Electrician	0619-1515	707	0.16
8-13	Maintenance	0750-1500	731	0.19
8-13	Maintenance	0758-1545	794	0.25
8-12	Maintenance	0847-1510	651	0.2

Sensitivity of analytical balance = 0.01 mg.

Environmental criteria (mg/m^3): OSHA=5* (based on an 8-hour TWA)
NIOSH=none

* Nuisance particulate.

TABLE V

Airborne Concentrations of Respirable Coal Dust
Personal Samples

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentration (mg/m^3)
8-13	Maintenance	0746-1454	856	0.06
8-13	Maintenance	2318-0631	866	4.24
8-13	Maintenance	2321-0631	860	1.24
8-13	Maintenance	1501-2305	968	0.39
8-13	Maintenance	1503-2303	960	0.41
8-12	Janitor	0855-1510	750	0.65
8-13	Janitor	1508-2259	942	0.3
8-12	Coal Equipment Operator*	1035-1508	546	0.37
8-12	Equipment Operator - Units 1 to 4	0820-1537	874	0.07
8-13	Equipment Operator - Units 1 to 4	0005-0558	706	<0.01
8-13	Equipment Operator - Units 1 to 4	1601-2322	882	0.03
8-13	Control Operator - Units 1 to 4	0837-1545	856	0.05
8-13	Tripper Deck	1503-2254	942	0.38
8-13	Tripper Deck	0706-1510	968	0.51
8-13	Tripper Deck	0708-1512	968	0.63
8-13	Tripper Deck	2307-0706	958	0.41
8-13	Coal Yard Dozer Operator	0709-1513	968	0.11
8-13	Coal Yard Dozer Operator	0711-1515	968	0.13
8-13	Coal Yard - Box Car Dumper (Shag)	2309-0706	954	0.25
8-13	Coal Yard - Box Car Dumper (Shag)	1503-2254	940	0.21
8-13	Coal Yard - Box Car Dumper (Operator)	2310-0700	940	0.11
8-13	Coal Yard - Box Car Dumper (Operator)	1506-2255	938	0.26

* Pump and sample replaced at 1035 due to low flow rate.

Sensitivity of the analytical balance = 0.01 mg.

Environmental criteria (mg/m^3): OSHA=2.4A (based on an 8-hour TWA)
NIOSH=none
ACGIH=2A (based on an 8-hour TWA)

A = Less than 5-percent quartz.

TABLE VI

Airborne Concentrations of Respirable Crystalline Silica
Personal Samples

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

						Concentration (mg/m^3)		
Date	Job/Location	Sample Time	Volume Liters	Type of Sample	% Quartz	Quartz*	Respirable Dust	OSHA** PEL
8-12	Maintenance	0847-1510	651	Fly Ash	LLD	LLD	0.2	LLD
8-13	Maintenance	0750-1500	731	Fly Ash	LLD	LLD	0.19	LLD
8-13	Maintenance	0758-1545	794	Fly Ash	LLD	LLD	0.25	LLD
8-13	Electrician	0819-1515	707	Fly Ash	44	0.07	0.16	0.22
8-13	Auxillary Equipment Operator - Unit 4	1558-2322	755	Fly Ash	LLD	LLD	0.3	LLD
8-13	Equipment Operator - Units 1 to 4	1601-2322	882	Coal Dust	LLD	LLD	0.03	LLD
8-13	Coal Equipment Operator-Tripper Deck	2307-0706	958	Coal Dust	LLD	LLD	0.25	LLD
8-13	Coal Equipment Operator-Tripper Deck	1503-2254	942	Coal Dust	LLD	LLD	0.38	LLD
8-13	Coal Equipment Operator-Tripper Deck	0706-1510	968	Coal Dust	10	0.05	0.51	0.83
8-13	Coal Equipment Operator-Dozer Operator	0711-1515	968	Coal Dust	LLD	LLD	0.13	LLD

* Quartz was only polymorph of crystalline silica present.
** Calculated using OSHA formula.
LLD = Below the laboratory limit of detection (0.03 mg).

Environmental criteria: OSHA - (quartz) $\frac{10 \ mg/m^3}{\% \ SiO_2 + 2}$

NIOSH - 0.05 mg/m^3 (for up to a 10-hour TWA).

TABLE VII

Airborne Concentrations of Inorganic Metals
Personal Samples

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 13, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Analyte	Concentration (mg/m^3)
8-13	Maintenance - Welding Inside Coal Mill 3B	1609-2310	632	Ca	0.04
				Fe	0.19
				Mn	0.02
				Na	0.03
8-13	Maintenance - Welding Inside Coal Mill 3B	1607-2305	627	Ca	0.03
				Fe	0.2
				Mn	0.02
				Na	0.03

Aluminum, chromium, magnesium, phosphorus, titanium, and zinc were also found on one or both of the personal samples, but in very low quantities. Highest quantity was for magnesium at 4.8 ug. Samples analyzed for 18 other metals, but none were detected.

Environmental criteria (mg/m^3):

Ca (as calcuim oxide) -	OSHA=5*	
	NIOSH=none	
	ACGIH=2*	
Fe (as iron oxide fume) -	OSHA=10*	
	NIOSH=none	
	ACGIH=5*	
Mn (manganese fume) -	OSHA=15**	
	NIOSH=none	
	ACGIH=1*	
Na -	OSHA=15**	
	NIOSH=none	
	ACGIH=10**	

* 8-hour TWA
** Nuisance dust (8-hour TWA)

TABLE VIII

Airborne Concentrations of Boiler Gases Measured
Using Certified Direct-Reading Indicator Tubes

Warrick Generating Station
Yankeetown, Indiana
HETA 81-278

August 12-13, 1981

Date	Location	Shift	Material Sampled For	Concentration (ppm)
8-12	Unit 1 - Between Levels 2 and 3 Southeast Corner	2nd	SO_2	<0.1
		"	CO	<5
		"	NO_x	<0.5
8-12	Unit 1 - A Burner Level, Northside	2nd	SO_2	<0.1
		"	CO	<5
		"	NO_x	<0.5
8-13	Unit 1 - Level 8	1st	SO_2	<0.1
8-13	Unit 2 - C Burner Level	1st	SO_2	<0.1
8-13	Unit 2 - Level D	1st	SO_2	<0.1
8-12	Unit 4 - Level 7, by IK #18 25' from Boiler	2nd	SO_2	8
		"	NO_x	1
8-12	Unit 4 - Southeast Corner by F Burner Aisle	2nd	SO_2	<0.1
8-12	Unit 4 - 7th Landing by IK #22	2nd	SO_2	20
		"	CO	<5
		"	NO_x	3
8-13	Unit 4 - Level 3, F Mill Inspection Port	2nd	SO_2	15
		"	CO	<5
		"	NO_x	3

< = Less than

Environmental criteria (ppm):

CO - OSHA=50 (based on an 8-hour TWA)
NIOSH=35 (for up to a 10-hour TWA)

SO_2 - OSHA=5 (based on an 8-hour TWA)
NIOSH=0.5 (for up to a 10-hour TWA)

$NO_x(NO+NO_2)$* - OSHA= NO=25, NO_2=5 (ceiling value, not to be exceeded)
NIOSH= NO=25, NO_2=1 (ceiling value, not to be exceeded during any 15-minute period)

* These detector tubes collect both NO and NO_2. Cannot distinguish the amount of either material individually.

TABLE IX

Descriptive Statistics by Station

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and HETA 81-278

	Station:	Culley		Warrick		Total	
	Statistics:	n	x	n	x	n	x
Variable	Smoking						
Age	no	35	31.31	51	28.53	86	29.66
	yes	21	40.00	66	30.52	87	32.80
	Total	56	34.57	117	29.65	173	31.24
Year on Job	no	35	6.10	51	4.39	86	5.09
	yes	21	14.38	66	5.23	87	7.44
	Total	56	9.20	117	4.86	173	6.27
% Expected FEV_1	no	35	101.46	51	103.08	86	102.42
	yes	21	98.67	66	95.27	87	96.09
	Total	56	100.41	117	98.68	173	99.24
% Expected FVC	no	35	101.20	51	103.65	86	102.65
	yes	21	104.05	66	98.74	87	100.02
	Total	56	102.27	117	100.88	173	101.33
% FEV_1/FVC	no	35	82.49	51	81.90	86	82.14
	yes	21	76.95	66	79.02	87	78.52
	Total	56	80.41	117	80.27	173	80.32

n = Number
x = Mean

TABLE X

Descriptive Statistics by Dust Exposure

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and 81-278

Dusty Exposures:	YES		NO		TOTAL	
Statistics:	n	x	n	x	n	x
Variable						
Age	61	31.28	112	31.22	173	31.24
Years on Job	61	6.40	112	6.20	173	6.27
% Expected FEV_1	61	96.98	112	100.46	173	99.24
% Expected FVC	61	99.61	112	102.27	173	101.33
% FEV_1/FVC	61	79.87	112	80.56	173	80.82

n = Number Reporting
x = Mean

TABLE XI

Descriptive Statistics by Job Category

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and 81-278

Job Category:	Operator or Handler		Maintenance		Others			Total	
Statistics: / Variable	n	x	n	x	n	x	S.D.	n	x
Age	63	28.17	72	33.01	38	32.97	11.47	173	31.24
Years on Job	63	4.92	72	6.96	38	7.19	8.54	173	6.27
% Expected FEV_1	63	99.63	72	98.44	38	100.08	15.30	173	99.24
% Expected FVC	63	103.22	72	99.83	38	101.03	15.21	173	101.33
% FEV_1/FVC	63	79.76	72	80.63	38	80.66	6.47	173	80.82

n = Number Reporting
x = Mean

TABLE XII

Positive Responses to Symptoms by Station

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and HETA 81-278

Station:	Culley N=56		Warrick N=173		Total N=173	
Statistics:	n	%	n	%	n	%
Symptoms						
Cough	18	32.14	43	36.75	61	35.26
Phlegm	20	35.71	34	29.06	54	31.21
Breathlessness	6	10.71	7	5.98	13	7.51
Wheezing	13	23.21	24	20.51	37	21.39
Any of above symptoms	29	51.79	56	47.86	85	49.13

n = Number Reporting

TABLE XIII

Observed vs. Expected Respiratory Symptoms

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and HETA 81-278

Smoking:	Culley Station		Warrick Station	
Symptoms	OBS	EXP	OBS	EXP
Cough	13	6.6	32	11.2
Phlegm	14	7.1	25	15.5
Breathlessness	4	8.4	6	14.4
Wheezing	10	.4.7	18	9.9

TABLE XIV

Positive Responses to Symptoms by Job Category

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and HETA 81-278

Job Category:	Operator or Handler N=63		Maintenance N=72		Others N=38		Total N=173	
Statistics:	n	%	n	%	n	%	n	%
Symptoms								
Cough	21	33.33	26	36.11	14	36.84	61	35.26
Phlegm	19	30.16	22	30.56	13	34.21	54	31.21
Breathlessness	5	7.94	2	2.78	6	15.79	13	7.51
Wheezing	12	19.05	17	23.61	8	21.05	37	21.39
Any of above symptoms	30	47.62	35	48.61	20	52.63	85	49.13

n = Number Reporting

TABLE XV

Positive Responses to Symptoms by Dusty Exposure

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and HETA 81-278

Dusty Exposure:	No N=112		Yes N=16		Total N=173	
Statistics:	n	%	n	%	n	%
Symptoms						
Cough	40	35.71	21	34.43	61	35.26
Phlegm	34	30.36	20	32.79	54	31.21
Breathlessness	12	10.71	1	1.64	13	7.51
Wheezing	25	22.32	12	19.67	37	21.39
Any of above symptoms	54	48.21	31	50.82	85	49.13

n = Number Reporting

TABLE XVI

Summary of X-ray Test Results

Culley and Warrick Generating Stations
Yankeetown, Indiana
HETA 81-112 and HETA 81-278

X-Ray Test Result:	Normal		Density (Shadow or Vascular)		Opacities		Density		Histo/ Pneumonia	
Statistics:	n	%	n	%	n	%	n	%	n	%
Group										
Total[1]	113	66.47	26	15.29	19	11.18	8	4.71	4	2.35
Station										
Culley	35	62.50	5	8.93	10	17.86	6	10.71	0	0.00
Warrick	78	68.42	21	18.42	9	7.89	2	1.75	4	3.51
Smoking										
Non-smoker	63	73.26	12	13.95	7	8.14	2	2.33	2	2.33
Smoker	50	59.52	14	16.67	12	14.29	6	7.14	2	2.38
Dusty Exposure										
Yes	38	64.41	9	15.25	6	10.17	4	6.78	2	3.39
No	75	67.57	17	15.32	13	11.71	4	3.60	2	1.80
Job Category										
Operator or Handler	43	69.35	9	14.52	4	6.45	4	6.45	2	3.23
Maintenance	44	61.97	12	16.90	11	15.49	2	2.82	2	2.82
Others	26	70.27	5	13.51	4	10.81	2	5.41	0	0.00
Any Symptoms										
Yes	49	59.76	15	18.29	11	13.41	6	7.32	1	1.22
No	64	72.73	11	12.15	8	9.09	2	2.27	3	3.41

[1] Three workers have poor film