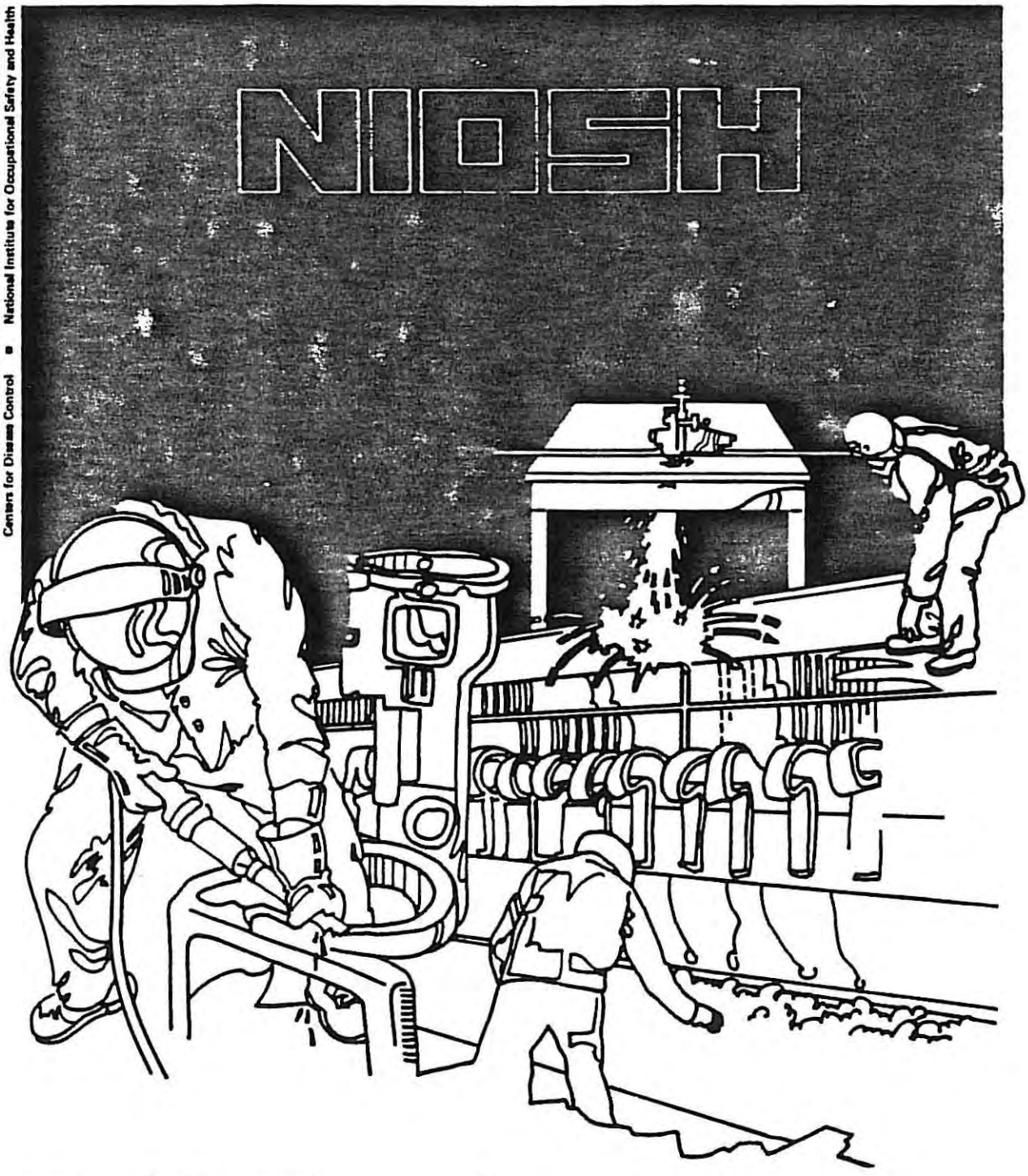
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-112-1372
CULLEY 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 81-112-1372
SEPTEMBER 1983
CULLEY GENERATING STATION
YANKEETOWN, INDIANA

NIOSH INVESTIGATORS:
John N. Zey, I.H.
Michael Donohue, PA-C.

I. SUMMARY

In December 1980, 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, Culley Generating Station, Yankeetown, Indiana, to evaluate employee exposures to boiler gases and coal dust. NIOSH conducted a combined environmental and medical evaluation at the Culley facility in August 1981.

Environmental samples were collected to evaluate employee exposure to airborne concentrations of nitrogen dioxide, nitric oxide, sulfur dioxide, coal dust, fly ash, crystalline silica, and asbestos. In addition, boiler gas leaks were evaluated.

Nitrogen dioxide and nitric oxide were not detected on any of eight personal samples. Sulfur dioxide concentrations ranged from <0.01 milligram per cubic meter of air (mg/m^3) to 3.34 mg/m^3 for fifteen personal samples. Two of the samples were above the NIOSH recommended criteria of 1.3 mg/m^3. Fly ash concentrations ranged from 0.05 to 0.26 mg/m^3 for five personal samples. All five samples were well below the OSHA PEL of 5 mg/m^3 for respirable nuisance particulates. Coal dust concentrations ranged from <0.01 to 1.31 mg/m^3 for 20 full shift samples. All samples were below the ACGIH TLV of 2 mg/m^3. Crystalline silica was detected on one of ten personal samples at a concentration of 0.03 mg/m^3. It was below the NIOSH recommended criteria of 0.05 mg/m^3. Asbestos was not detected on any of five airborne samples. One of four bulk insulation samples contained measurable quantities of asbestos material. Boiler gas leaks were detected with grab samples (using direct reading indicator tubes). Highest concentrations were for sulfur dioxide at 23 and 30 parts per million (ppm). These values are 46 and 60 times the NIOSH recommended time weighted average criteria (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 leaks.

The results of the medical evaluation revealed no statistically significant group decrement in FEV_1, FVC, and FEV_1/FVC for these workers. However, four workers were found to have pneumoconiosis during our review of the Culley X-ray data. The health questionnaires completed with each of the participants revealed a prevalence rate of 49% of the workers reporting 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. In addition, a potential for exposure to boiler gases exists due to boiler leaks. Respiratory symptoms of cough, phlegm production, and wheezing were twice the expected rate for this group of workers. The x-ray data revealed four cases of pneumoconiosis in the Culley workers. The relative youth and the low seniority of this workforce may explain the absence of group PFT reductions. If preventive engineering measures are employed, the occurrence of continued group health effects will likely be reduced.

Recommendations (Section VIII) are made for an improved respiratory protection program, reducing leaks from process equipment, and for periodic environmental monitoring of the employees.

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

II. INTRODUCTION

On December 12, 1980, 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), Culley 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 Culley 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 Culley Generating Station was conducted. A combined environmental and medical survey was conducted on August 10-12, 1981 and a closing conference was conducted on August 14, 1981.

A similar request for a health hazard evaluation at a second SIGECO coal-fired power plant (Warrick Generating Station) was received from IBEW, Local 702 in April 1981.

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

III. BACKGROUND

The Culley Generating Station began production in 1953. At that time there was one 50 megawatt unit in operation. In 1966 unit two (100 megawatts) was added and in 1973 unit three (250 megawatts) was added. Units one (balanced draft boiler) and two (positive pressure boiler) are in one building, and unit three (positive pressure boiler) is in a separate building. Collectively the three units can burn up to 370,000 pounds of coal per hour producing in excess of 3,000,000 pounds of steam. The three units pump and return 348,000,000 gallons of water to the Ohio River each day.

Coal comes into the Culley Generating Station by truck. Normally the coal will be stored in the coal yard; it can, however, be taken directly into the plant. From the storage pile, coal is moved to hoppers and then transferred via conveyor belts up to the tripper deck of units 1 and 2 or unit 3. From the tripper, the coal is transferred into silos (round) or bunkers (rectangular). Next the coal is gravity

feed through feeders which control the flow 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 burns releasing energy as heat. Impellers located inside the burner pipes, at the point the pipes enter the boiler, act to distribute the powered coal as it enters the fire box. This action produces a 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 condensers, where it is converted into water via contact with pipes in which cooler river water is flowing. Then 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 economizer hoppers, where the larger particulate material settles out of the air stream. The air stream then passes through an electrostatic precipitator, where smaller particulate material is removed. The remaining exhaust gases are carried through the precipitator to the smoke stack where they are vented into the atmosphere. All controls for boilers, turbines, and associated equipment are concentrated in one central control room. In this room the operator has complete and detailed data on all phases of the plant operation.

There are approximately 60 production employees at this facility. The breakdown of the workforce is as follows:

A. Operators

This category (approximately 35 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 process equipment on the turbine side of a particular unit. They cover three floors making checks on the equipment during the shift. Auxillary equipment operators are responsible for the boiler side of a specific unit. They cover nine floors making checks on the equipment throughout the shift. Coal equipment operators use bulldozers to move coal from the dump area to storage or to the conveyors.

B. Maintenance

This category (approximately 25 employees) includes maintenance employees, 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

Airborne monitoring was conducted to evaluate employee exposures to airborne concentrations of nitrogen dioxide, nitric oxide, sulfur dioxide, fly ash, coal dust, crystalline silica, and asbestos (Table I). In addition, bulk material samples of insulation suspected of containing asbestos and bulk settled dust samples of coal dust and fly ash were collected.

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). Nitric oxide and nitrogen dioxide samples 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 preceding each filter cassette with 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. Subsequent to the gravimetric analysis, samples designated for crystalline silica analysis were analyzed according to NIOSH Method No. P&CAM 259 with a slight modification involving analysis of bulk samples.[1]

Asbestos samples were collected on cellulose ester membrane filters attached via flexible tubing to a battery-operated pump calibrated at 1.5 LPM. Airborne asbestos samples were analyzed according to NIOSH Method No. P&CAM 239 utilizing phase contrast microscopy.[1] Bulk insulation samples were 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 areas of the plant. The indicator tubes were evaluated visually immediately following collection. Following collection in the field, all samples (except 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 Culley and Warrick 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 (Culley or Warrick), smoking status, job category, and dust exposure group. A total of 56 Culley workers completed this medical evaluation. The same medical test battery was given to 117 workers at the Warrick plant.

Pulmonary function tests include measurement of forced vital capacity (FVC), 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 swallowed. Exposure to high levels of nitrogen dioxide may cause severe breathing difficulties which are usually delayed in onset and which may cause death. Recovery may be slow with possible relapse and possible 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 exposures 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 value which 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

High levels of nitric oxide causes narcosis (deep unconsciousness) in animals. Exposure 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; 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 methhemoglobin 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 cause health effects 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 burning of the eyes and tearing, coughing, and chest tightness. It may cause severe breathing difficulties. Exposures to high concentrations 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 five 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 a 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 other respiratory impairments. CWP is associated with chronic bronchitis and emphysema which are associated with shortened life span; the importance of CWP is that it is a precursor of progressive massive fibrosis (PMF) of the lungs.[6]

PMF is associated with a reduction in ventilatory capacity, low diffusing capacity, abnormalities of gas exchange, low arterial oxygen tension, pulmonary hypertension, and premature death.

Stastical analysis of the results from the first 10 years of the Pneumoconiosis 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 increased probability of developing pneumoconiosis after 35 years' exposure to different coal dust concentrations were derived from the results. For ILO (International Labor Organization) category "1" (based on a scale of 1-4 with 1 representing the lowest exposure resulting in X-ray confirmation of CWP) 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 coal 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 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 dust can cause silicosis (a form of pneumoconiosis), an irreversible scarring of the lungs with progressive cough and shortness of breath. The disease tends to occur following 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 crystalline silica is 10 mg/m^3 divided by the % 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]

G. Asbestos

Asbestos, is a generic term applied to a number of hydrated mineral silicates, including chrysotile, amosite, crocidolite, tremolite, and anthrophyllite. Exposure to asbestos is known to cause asbestosis (a fibrosis of the lung), cancer of the lungs, digestive tract and the internal surfaces of the chest and abdomen (mesothelioma).[6]

The OSHA PEL for asbestos is 5 fibers (longer than 5 micrometers) per cubic centimeter of air (5 fibers >5 um/cc) based on an 8-hour TWA.[4] The NIOSH recommended standard is that exposure be at the lowest concentration detectable by current analytical techniques. At this time that level is 0.1 fiber >5 um/cc for up to a 10-hour TWA with a 15-minute ceiling value of 0.5 fibers >5 um/cc.[10]

VI. RESULTS

A. Environmental

Table II presents the results of sampling for airborne nitric oxide and nitrogen dioxide. Both compounds were below the laboratory limit of detection (2 ug/sample) for eight personal samples.

Table III presents the results of sampling for airborne sulfur dioxide. The concentrations ranged from <0.01 mg/m^3 to 3.34 mg/m^3 for 15 personal samples. The highest concentration was obtained on samples worn by the auxillary equipment operators on units one and two. Two samples were above the NIOSH recommended standard of 1.3 mg/m^3.

Table IV presents the results of sampling for airborne fly ash. The concentrations ranged from 0.05 mg/m^3 to 0.26 mg/m^3 for five personal samples. The highest concentration was obtained on a sample worn by a maintenance employee. All concentrations were below the current environmental criteria. The highest concentration (0.26 mg/m^3) was 5% of the OSHA PEL of 5 mg/m^3 for respirable nuisance particulates.

Table V presents the results of sampling for airborne coal dust. The concentrations ranged from <0.01 to 1.59 mg/m^3 for a 3-hour sample. The highest concentration for a full shift sample was 1.31 mg/m^3. This sample was worn by an employee working on the tripper deck. This sample is 55% of the OSHA PEL (2.4 mg/m^3) and 66% of the ACGIH TLV (2 mg/m^3). These criteria are for respirable coal dust containing <5% quartz.

Table VI presents the results of sampling for airborne free silica on both fly ash and coal dust samples. Of 10 samples evaluated for free silica all were below the limit of detection for quartz and cristobalite except for a sample worn by a coal equipment operator working on the tripper deck. The sample was below the limit of detection for cristobalite and had a concentration of 0.03 mg/m^3 of quartz. This is 60% of the NIOSH criteria and the concentration of 0.48 mg/m^3 is 38% of the calculated (using the PEL formula) OSHA PEL of 1.25 mg/m^3.

Table VII presents the results of sampling for airborne asbestos in areas where insulation material was exposed. In addition, Table VII presents the results of the laboratory analysis of bulk insulation samples. All airborne samples were below the limit of detection. One bulk insulation sample collected on the fifth level of unit 2 contained approximately 1% crocidolite and 10-20% amosite asbestos.

Table VIII presents the results of grab samoling using certified

direct reading indicator tubes. The highest concentrations obtained were for sulfur dioxide. The two highest readings (23 and 30 ppm) were 4 to 6 times the OSHA PEL and 40 to 60 times the NIOSH recommended standard. Carbon monoxide concentrations for three samples were all <0.5 ppm, which indicates they were all much less than the lowest current criterion (35 ppm, NIOSH). Concentrations for oxides of nitrogen ranged from <0.5 to 10 ppm for five samples. The detector 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 for NO is 25 ppm (NIOSH, OSHA) and for NO_2 is 1 ppm (NIOSH).

Criteria for these materials are based primarily on full-shift exposures (NO_2 criteria for NIOSH and OSHA represent ceiling values), conversely the grab samples represent airborne concentrations at a specific point in time. In addition, certified direct reading indicator tubes have an inherent accuracy of approximately ±25%. These tubes are certified to an accuracy of ±35% at 1/2 the test gas concentration and ±25% at 1, 2, and 5 times the test gas concentration (the test gas concentration usually corresponds to the OSHA PEL).[4,11] Therefore, the values listed in Table VIII should not be considered as exact concentrations. The values indicate, however, the potential for employee exposure to hazardous concentrations of sulfur dioxide when working in or near the areas where these samples were collected.

During the NIOSH survey, electricity production ranged from approximately 92% of the maximum net load during the day shifts to approximately 80% on the evening shifts and approximately 50% on the midnight shifts. This was due primarily to fluctuations in the demand for electricity.

Leaks were observed in the boilers and other process equipment resulting in escaping boiler gases and fly ash, particularly on the positive pressure boilers, and coal dust leaks in the coal mills and burner pipes.

Dry bulb temperature measurements collected around the boilers ranged from 80°F to in excess of 100°F (the upper limit of the thermometer used). Most of the measurements were over 90°F and many were in excess of 100°F, particularly on the upper levels. NIOSH industrial hygienists experienced discomfort in some locations. This was most evident on the upper levels when it was

necessary to remain in one location while collecting data. These factors indicate a potential heat stress for employees working around the boilers. Normal operating conditions would not require employees to remain in these areas for more than a few minutes. Nonroutine or emergency conditions, however, could require that employees remain in the hot areas for longer periods of time. In addition, dozer operators (operating dozers which are not air-conditioned) working in the coal yard also have a potential heat stress exposure during the summer months.

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 twofold increase for cough, phlegm production and wheezing was observed in 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 believe that workplace exposure to these dusts may be the cause of the four cases at the Culley plant. We have provided recommendations in these reports designed to reduce the potential for exposure to these lung scarring dusts.

VII. DISCUSSION

Analysis of the environmental data indicate that at the time of the survey employee exposures were low to most airborne contaminants. However, two personal samples were above the NIOSH recommendation for sulfur dioxide. Of the remaining samples, coal dust were the highest compared to current environmental criteria. One sample collected on an employee working on the tripper deck had a concentration of 1.31 mg/m^3 which is 66% of the ACGIH TLV. The TLV is the lowest of the current environmental criteria.

Heavy rains during the previous weekend may have affected airborne concentrations of particulates during this survey. In addition, results of sampling using certified direct reading indicator tubes suggests that very high concentrations of sulfur dioxide were present in specific areas near the boilers. 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 boiler leaks. These results suggest that the potential for employee exposure to high concentrations of boiler gases exists if employees are 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.[12,13] Some maintenance activities were monitored during this survey, but in most instances the activities were of short duration (a maximum of 2-3 hours). In addition, some maintenance employees worked in several areas of the facility during a shift.

Review of the medical data indicate some health effects in these 173 workers. These effects include four cases of pneumoconiosis at the Culley plant. These four workers had an average employment of 24 years with SIGECO. Only one of these employees was a smoker. Review of their occupational histories suggests no other prior work exposures sufficient to cause their lung disease. Three of the four were E.O's (equipment operators), the fourth has plantwide responsibility as an electrician. There was an overall prevalence rate of 49% 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 fulltime 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 exposure to the substances covered by this report, 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.[14] 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.[15] 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. Employees working near the boiler on Unit 3 should carry respirators certified for protection against sulfur dioxide. Suitable respirators are available at this facility (MSA COMFO, TC-23C-47). A copy of the OSHA Standard Method for Determination of Respiratory Protection Program Acceptability has been forwarded to both management and an authorized representative of the employees.

2. Due to the number of potentially hazardous occupational exposures associated with coal fired power plants, management should conduct periodic (at least annual) environmental and medical monitoring of the exposed employees with emphasis on equipment operators and maintenance workers.

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

4. Leaking seals on coal mills and other process equipment should be repaired or replaced.

5. Since some of the insulation materials contain asbestos, all such exposed insulation should be wrapped or covered. Workers should be required to wear respiratory protection, which is certified for use in atmospheres containing asbestos, when working with insulation materials unless the specific insulation being handled is known to be free of asbestos materials.

6. A heat stress survey should be conducted for employees working on the boiler units and operating dozers. Special care 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.[16,17]

7. Regularly scheduled maintenance operations should be made in order to minimize leaks from the boiler units.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 1, 2nd ed. Cincinnati, OH: National Institute for Occupational Safety and Health, 1977. (DHEW (NIOSH) publication no. 77-157-A).

2. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods. Vol 5, 2nd ed. Cincinnati, OH: National Institute for Occupational Safety and Health, 1979. (DHEW (NIOSH) publication no. 79-141).

3. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 81-123).

4. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

5. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to oxides of nitrogen. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-149).

6. Proctor NH, Hughes JP. Chemical hazards of the workplace. Philadelphia: J.B. Lippencott Company, 1978.

7. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values. 4th ed. Cincinnati, Ohio: ACGIH, 1980.

8. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1982. Cincinnati, Ohio: ACGIH, 1982.

9. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to crystalline silica. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975. (DHEW publication no. (NIOSH) 75-120).

10. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to asbestos. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-169).

11. National Institute for Occupational Safety and Health. Supplement to the NIOSH certified equipment list. Morgantown, WV: National Institute for Occupational Safety and Health, 1981.

12. National Institute for Occupational Safety and Health (NIOSH). Health Hazard Evaluation Report No. 81-034, 035-934. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981.

13. National Institute for Occupational Safety and Health (NIOSH). Health Hazard Evaluation Report No. 80-28-766. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1980.

14. National Institute for Occupational Safety and Health. Health hazard evaluation report no. HETA 82-48-626. Cincinnati, OH: National Institute for Occupational Safety and Health, 1982.

15. Aspects of Laboratory Hygiene by J. G. Davis Lab Practice 21:101-06 (1972).

16. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to hot environments. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1972. (DHEW publication no. (NIOSH) 72-10269).

17. National Institute for Occupational Safety and Health. Proceedings of a NIOSH workshop on recommended heat stress standards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS publication no. (NIOSH) 81-108).

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	John N. Zey, M.S. Industrial Hygienist Industrial Hygiene Section
	Michael T. Donohue, PA-C Physician Assistant-Certified Medical Section
Field Evaluation Assistance:	Richard Hartle, M.S. Industrial Hygienist Industrial Hygiene Section
	Cheryl Lucas, M.S. Industrial Hygienist Industrial Hygiene Section
	Shiu Tao Lee Statistician Support Services Branch
	Marion Coleman Medical Technician Support Services Branch
	James Collins Medical Technician Support Services Branch
	Tom Voit Medical Technician Support Services Branch
Laboratory Analyses:	Staff-Utah Biomedical Testing Laboratories Salt Lake City, Utah
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies
Report Typed By:	Betty C. Williams Clerk-Typist Industrial Hygiene Section

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. Authorized Representative of Employees Local 702, International Brotherhood of Electrical Workers
3. NIOSH, Region V
4. OSHA, Region V

For the purpose of informing the approximately 60 affected employees at the Culley Generating Station, 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

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-12, 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 Criteria (mg/m^3) OSHA PEL	NIOSH Recommendation	ACGIH TLV
Quartz*	**	PVC Filter Loaded Into 10 mm Nylon Cyclone	P&CAM No. 259	10 mg/m^3 / % SiO_2 + 2	0.05	10 mg/m^3 / % respirable quartz + 2
Asbestos - Airborne	1.5	Cellulose Ester Membrane Filter	P&CAM No. 239	2 Fibers >5 um/cc	0.1 Fiber >5 um/cc	0.5 Fiber >5 um/cc for Amosite 0.2 Fiber >5 um/cc for crocidolite
Asbestos - Bulk	-	Collected in Glass Sample Vial	Visual Estimate of % Asbestos Using Polarized Light Microscopy	-	-	-
Boiler Gases (SO_2, CO, NO + NO_2) Grab Sample	-	Certified Direct Reading Indicator Tubes	Visual, direct reading	Used Time Weighted Average Criteria		

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

TABLE II

Airborne Concentrations of Nitric Oxide and Nitrogen Dioxide
Personal Samples

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-11, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentration (mg/m^3) NO	Concentration (mg/m^3) NO_2
8-10	Maintenance*	1225-1542	3.8	LLD	LLD
8-11	Maintenance	0012-0709	9.7	LLD	LLD
8-11	Auxillary equipment operator-unit 2	0029-0732	8.8	LLD	LLD
8-11	Auxillary equipment operator-unit 3	0020-0719	8.8	LLD	LLD
8-11	Auxillary equipment operator-unit 1	0023-0730	8.3	LLD	LLD
8-10	Auxillary equipment operator-unit 1	0828-1525	7.6	LLD	LLD
8-10	Auxillary equipment operator-unit 2	0832-1525	8.9	LLD	LLD
8-10	Auxillary equipment operator-unit 3	0811-1525	4.7	LLD	LLD

* = Sample for first part of shift invalid. Hose came off of 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 which should not be exceeded during any 15-minute period)

TABLE III

Airborne Concentrations of Sulfur Dioxide
Personal Samples

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-12, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentration (mg/m^3)
8-11	Maintenance	0012-0709	626	0.97
8-10	Maintenance	0831-1542	646	0.68
8-11	Maintenance	0853-1605	648	0.04
8-10	Auxillary equipment operator-unit 1	0828-1525	626	3.34
8-11	Auxillary equipment operator-unit 1	0024-0731	640	0.02
8-11	Auxillary equipment operator-unit 1	0822-1532	645	0.23
8-11	Auxillary equipment operator-unit 2	0825-1524	629	0.09
8-11	Auxillary equipment operator-unit 2	0029-0731	633	<0.01
8-10	Auxillary equipment operator-unit 2	0832-1525	619	2.71
8-10	Auxillary equipment operator-unit 3	0811-1525	651	0.63
8-11	Auxillary equipment operator-unit 3	0022-0720	627	0.14
8-11	Auxillary equipment operator-unit 3	0814-1530	654	0.2
8-12	Auxillary equipment operator-unit 3	0013-0710	626	<0.01
8-11	Equipment operator units 1-2	0828-1537	644	0.04
8-11	Equipment operator-unit 3	0812-1530	657	0.01

< = Less than
Limit of detection = 5 ug

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
Personal Samples

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-11, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentration (mg/m^3)
8-10	Control operator - unit 3	0810-1520	731	0.05
8-10	Maintenance	0822-1535	736	0.26
8-11	Maintenance	0830-1600	765	0.05
8-11	Maintenance	0835-1603	762	0.09
8-11	Maintenance	0853-1605	734	0.07

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

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-12, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Concentration (mg/m^3)
8-10	Dozer operator*	1145-1510	410	1.59
8-11	Dozer operator	0810-1520	860	0.22
8-10	Tripper Deck	0731-1515	928	0.48
8-11	Tripper deck	0817-1520	846	1.31
8-10	Maintenance	0833-1542	858	0.03
8-11	Maintenance	0045-0740	830	0.13
8-11	Maintenance	0014-0713	838	0.72
8-11	Maintenance	0008-0708	840	0.6
8-11	Sweeping on feeder deck	0827-1516	818	0.82
8-10	Control operator units 1-2	0820-1520	840	0.14
8-10	Equipment operator units 1-2	0822-1520	834	0.17
8-11	Equipment operator units 1-2	0030-0729	838	<0.01
8-12	Equipment operator units 1-2	0022-0731	858	0.02
8-10	Equipment operator unit 3	0813-1515	844	0.25
8-11	Equipment operator unit 3	0015-0716	842	0.01
8-12	Equipment operator unit 3	0017-0710	826	<0.01
8-11	Auxillary equipment operator-unit 1	0822-1532	860	0.48
8-12	Auxillary equipment operator-unit 2	0025-0723	836	0.07
8-11	Auxillary equipment operator-unit 2	0825-1524	838	0.14
8-12	Auxillary equipment operator-unit 3	0013-0710	834	0.13
8-11	Auxillary equipment operator-unit 3	0814-1530	872	0.42

Sensitivity of analytical balance = 0.01 mg.
* = Sample for first part of the shift was invalid due to visible pieces of coal dust on filter.
Environmental criteria (mg/m^3): OSHA = 2.4^A (based on an 8-hour TWA)
NIOSH = none
ACGIH = 2^A (based on an 8-hour TWA)

A = less than 5% quartz

TABLE VI

Airborne Concentrations of Respirable Crystalline Silica
Personal Samples

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-12, 1981

Date	Job/Location	Sample Time	Volume (Liters)	Type of Sample	% Quartz	Concentration (mg/m^3) Quartz*	Respirable Dust	OSHA** PEL
8-10	Maintenance	0822-1535	736	Fly ash	LLD	LLD	0.26	LLD
8-11	Maintenance	0830-1600	765	Fly ash	LLD	LLD	0.05	LLD
8-11	Maintenance	0835-1603	762	Fly ash	LLD	LLD	0.09	LLD
8-11	Maintenance	0853-1605	734	Fly ash	LLD	LLD	0.07	LLD
8-11	Maintenance	0014-0713	838	Coal dust	LLD	LLD	0.72	LLD
8-10	Control operator - unit 3	0810-1520	731	Fly ash	LLD	LLD	0.05	LLD
8-12	Equipment operator - unit 3	0017-0710	826	Coal dust	LLD	LLD	<0.01	LLD
8-11	Auxillary Equipment operator-unit 2	0825-1524	838	Coal dust	LLD	LLD	0.14	LLD
8-11	Coal equipment operator-coal yard	0810-1520	860	Coal dust	LLD	LLD	0.22	LLD
8-10	Coal equipment operator-tripper deck	0731-1515	928	Coal dust	6	0.03	0.48	1.25

LLD = Below the laboratory limit of detection (0.03 mg or 1.5%)

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)

* Only polymorph of crystalline silica present.
** Calculated using PEL formula.

TABLE VII

Airborne Concentrations of Asbestos Samples
And Analysis of Bulk Insulation Material

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 11, 1981

Type of Sample	Location	Sample Time	% Asbestos Found	Volume (Liters)	Concentration (fibers/cc)
Area	Unit 2-4th Floor Landing, 20' from Elevator	1130-1145	-	22.5	LLD
Area	Unit 2-4th Floor Landing, 20' from Elevator	1130-1200	-	45	LLD
Area	Unit 2-Beside Economy Hopper	1400-1415	-	22.5	LLD
Area	Unit 2-Beside Economy Hopper	1400-1455	-	82.5	LLD
Area	Bottom of Boiler No. 2	1420-1500	-	60	LLD
Bulk	Unit 2-4th Floor Landing, 20' from Elevator		None detected		
Bulk	Beside Economy Hopper Unit 2		None detected		
Bulk	Bottom of Unit 2 Boiler		None detected		
Bulk	Unit 2-5th Floor in Front of Elevator		1% crocidolite 10-20% amosite		

LLD = below the laboratory limit of detection (0.03 fibers/field or 4500 fibers/filter).

Environmental criteria: OSHA = 5 fibers >5um/cubic centimeter of air (based on an 8-hour TWA).
NIOSH = 0.1 fiber >5um/cubic centimeter of air (for up to a 10-hour TWA with a ceiling value of 0.5 fibers/cc, not to be exceeded during any 15-minute period)

TABLE VIII

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

Culley Generating Station
Yankeetown, Indiana
HETA 81-112

August 10-11, 1981

Date	Location	Shift	Material Sampled For	Concentration (ppm)
8-10	Unit 3-Top Burner Deck	2nd	SO_2	15
8-11	Unit 2-Top IR Landing	2nd	SO_2	7
		2nd	NO_x	1
8-11	Unit 3-Feeding Level Lancing Port, NW Corner	2nd	SO_2	23
		2nd	NO_x	5
		2nd	CO	<5
8-11	Unit 3-Upper Burner Level	1st	SO_2	<0.1
		1st	CO	<5
8-11	Unit 3-Pulverizer 3F Being Repaired	1st	SO_2	30
		1st	NO_x	10
8-11	Unit 2-Level 5, South Side	2nd	SO_2	<0.1
		2nd	NO_x	<0.5
		2nd	CO	<5
8-11	Unit 1-Near Precipitator Exhaust Into Stack	2nd	SO_2	3
		2nd	NO_x	0.5
8-11	Unit 1-Level 8, Near Elevator	2nd	SO_2	<0.1

< = 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 (based on an 8-hour TWA).

$NO_x(NO+NO_2)$* - OSHA = NO = 25 (based on an 8-hour TWA),
NO_2 = 5 (ceiling value, not to be exceeded).
NIOSH = NO = 25 (based on an 8-hour TWA),
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

Variable	Station:	Culley		Warrick		Total	
	Statistics:	n	x	n	x	n	x
	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: Variable	n	x	n	x	n	x
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	n	x
Age	63	28.17	72	33.01	38	32.97	173	31.24
Years on Job	63	4.92	72	6.96	38	7.19	173	6.27
% Expected FEV_1	63	99.63	72	98.44	38	100.08	173	99.24
% Expected FVC	63	103.22	72	99.83	38	101.03	173	101.33
% FEV_1/FVC	63	79.76	72	80.63	38	80.66	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 Result

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: Group	n	%	n	%	n	%	n	%	n	%
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