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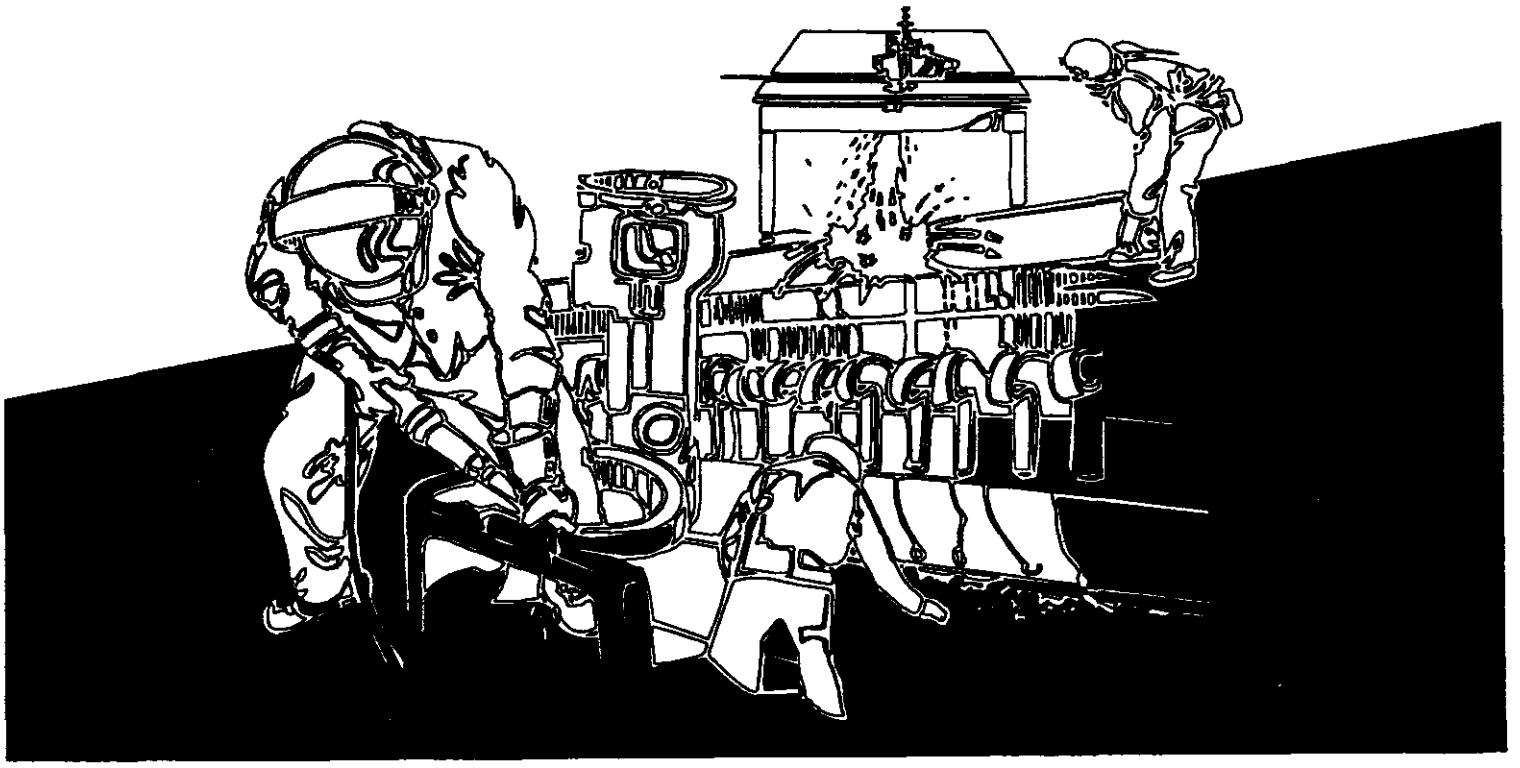
NIOSH

HEALTH HAZARD EVALUATION REPORT

HETA 89-252,293-2178
CHEMPOWER, INCORPORATED
COMBUSTION ENGINEERING, INCORPORATED
ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control

CDC

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 and 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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 89-252,293-2178
FEBRUARY 1992
CHEMPOWER, INCORPORATED
COMBUSTION ENGINEERING, INCORPORATED
ALBRIGHT POWER STATION
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I. SUMMARY

On May 22, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a Health Hazard Evaluation (HHE) at the Albright Power Station, Albright, West Virginia (HETA 89-252). The International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers (IBB), Local 667, asked NIOSH to evaluate an outbreak of acute illness among workers involved in a renovation/asbestos removal project. The request listed arsenic, lead, and other metals as potential exposures. On May 23-24, 1989, NIOSH investigators conducted environmental sampling during oxyacetylene cutting operations within the asbestos abatement enclosure, collected bulk material samples, interviewed workers, and collected urine specimens for metal analyses. On June 5-7, 1989, additional environmental monitoring was performed and additional urine and blood specimens were collected.

Worker interviews revealed symptoms similar to those of metal fume fever, but the timing and duration were not typical of this syndrome. Fifteen of the 36 workers who were interviewed met the case definition of possible work-related illness defined by the presence of at least three of the following symptoms: cough, shortness of breath, chest tightness or pain, chills, headache, nausea, and bloody sputum. Reports from the local hospital indicated that 11 of 19 workers who sought medical care had elevated blood mercury levels. However, no elevated mercury levels were detected either in blood or urine specimens collected by the NIOSH investigators. Possible explanations for these apparent discrepancies are addressed in the discussion section of this report.

Epidemiologic analyses suggested that workers who performed a particular job task (burning through the metal boiler casing with oxyacetylene torches) appeared more likely than workers who performed other tasks to become ill (Rate Ratio [RR] = 2.21, 95% confidence interval [CI] 0.73-6.70) and to have elevated blood mercury levels (RR = 2.67, 95% CI 0.47-15.11). It was hypothesized that the paint on the boiler may have contained mercury as an antifouling agent, and that workers who cut through this paint may have been exposed to mercury vapor. The survey participants who met the symptom-based case definition were three times as likely to have elevated mercury levels as non-cases (RR = 2.96, 95% CI 1.12 - 7.85).

Although biological monitoring data obtained by a local hospital showed elevated levels of mercury in workers' blood samples, no elevated blood or urine mercury levels were found by NIOSH and only trace levels were

found in personal-breathing-zone (PBZ) air samples. No environmental data for mercury is available prior to NIOSH involvement. Bulk material samples collected by NIOSH investigators showed the presence of mercury in one of two bulk samples of the boiler insulation, two bulk samples of coal, and one of two bulk samples of fly ash. Three analyses of the painted metal boiler casing failed to show the presence of mercury. Sampling for airborne mercury during oxyacetylene cutting of the casing at the NIOSH laboratories showed no detectable mercury. On June 6, 1989, six of 11 PBZ air samples collected on boilermakers, insulators, and laborers contained trace quantities of mercury (<0.0008 mg/m^3), well below the NIOSH Recommended Exposure Limit (REL) of 0.05 mg/m^3. No mercury was detected in three full-shift, general area air samples obtained inside the enclosure to a limit of detection of (0.004 mg/m^3). Direct reading instrumentation was also used to assess airborne mercury concentrations during this survey, but it was later learned that heat results in a positive interference. Therefore, the results obtained with this instrument are inconclusive.

On May 24, 1989, general-area and PBZ sampling during oxyacetylene cutting of the painted boiler casing (1/4-inch mild carbon steel) showed that airborne arsenic, iron, and lead concentrations exceeded the applicable environmental criteria. The results of PBZ sampling for airborne sulfur dioxide showed concentrations of 0.61 mg/m^3, 4.73 mg/m^3, and 9.17 mg/m^3; one of three sample results exceeded the NIOSH REL of 5 mg/m^3. Two bulk paint samples indicated that the paint contained 1300 to 1400 micrograms of lead per gram of paint; no arsenic was detected in these samples.

On June 22, 1989, NIOSH received an additional HHE request (HETA 89-293) from IBB Local 667, representing employees working for Combustion Engineering, to evaluate worker exposures to heavy metals during another phase of the renovation of boiler #3 at the Albright Power Station. The request listed lead, arsenic, iron oxide, mercury, and sulfur dioxide as potential exposures. On June 27, 1989, NIOSH investigators conducted environmental sampling for airborne mercury and other metals.

Eurther sampling of oxyacetylene cutting operations after hydroblasting and/or sandblasting of painted surfaces showed that some samples exceeded the NIOSH REL for airborne arsenic, while iron and lead exposures were below applicable environmental evaluation criteria. Mercury vapor was not detected in five PBZ samples collected on boilermakers to a limit of detection of (0.006 mg/m^3).

Epidemiologic evidence suggests that the reported illnesses during the first evaluation were work-related even though environmental overexposures were not documented and biological samples (blood and urine) obtained by the NIOSH investigators did not show elevated mercury levels. Elevated blood mercury levels were reported for some workers evaluated by a local hospital and mercury was detected by NIOSH in bulk material samples and in trace concentrations in some PBZ air samples. The type of respirators worn during May 1989 would not have provided protection against mercury vapor. Airborne sulfur dioxide, lead, arsenic, and iron oxide dust and fume concentrations exceeded the environmental criteria during the May 1989 survey. While respirators were worn by employees, not all employees wore the type that would have provided protection against sulfur dioxide. Recommendations are made in the report concerning the need to thoroughly evaluate all potential hazards prior to beginning abatement and renovation activities and to establish a comprehensive occupational safety and health program.

KEYWORDS: SIC 1542 (General Contractors), 4911 (Electric Services), 9999 (nonclassifiable), lead, mercury, heavy metals, sulfur dioxide, boilermakers, oxyacetylene cutting, electrical power plant.

II. INTRODUCTION

From May 22, 1989, to July 29, 1989, the National Institute for Occupational Safety and Health (NIOSH) received four separate requests to conduct Health Hazard Evaluations (HHE) at the Albright Power Station, Albright, West Virginia. All four requests are summarized below. This final report focuses on only the first and third HHE requests (HETA 89-252 and HETA 89-293). The second request is the subject of a previously issued NIOSH Health Hazard Evaluation Final Report (HETA 89-262-1994).[1] A separate NIOSH HHE report will be issued regarding the fourth request (HETA 89-327).

On May 22, 1989, NIOSH received an HHE request (HETA 89-252) from the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers (IBB), Local #667, to evaluate an outbreak of acute illness among workers involved in a renovation/asbestos removal project on the #3 boiler at the Albright Power Station, Albright, West Virginia. The requester was concerned about employee exposures to metal fumes generated during oxyacetylene cutting of the outer metal casing of boiler #3 and listed arsenic, lead, and other metals as potential exposures. NIOSH investigators conducted an initial site-visit on May 23 and 24, 1989. At that time, an environmental survey was performed, workers were interviewed, and urine samples were collected for analysis of metals. A follow-up visit was conducted on June 5, 6, and 7, 1989, during which further environmental monitoring was performed and additional urine and blood specimens were collected.

On May 31, 1989, NIOSH received a second request (HETA 89-262) to conduct an HHE at the Albright Power Station, Albright, West Virginia. This request was submitted by the International Brotherhood of Electrical Workers (IBEW), Local #425, and asked that NIOSH evaluate asbestos exposures of electrical workers in the work areas surrounding the asbestos abatement containment area (boiler #3). In November 1989, the NIOSH Final Report of this evaluation was issued.[1] This report eoncluded that employees working in the vicinity of boiler #3 were potentially exposed to airborne asbestos concentrations at levels greater than ambient air concentrations.

On June 22, 1989, NIOSH received a third request (HETA 89-293) to conduct an HHE at the Albright Power Station, Albright, West Virginia. This request was submitted by representatives of the IBB, Local #667, working for Combustion Engineering, and requested that NIOSH evaluate worker exposures to heavy metals during another phase of the renovation of the #3 boiler. The request listed lead, arsenic, iron oxide, mercury, and sulfur dioxide as potential exposures during oxyacetylene cutting operations. On June 27, 1989, NIOSH investigators responded by conducting an environmental sampling survey.

On July 29, 1989, NIOSH received a fourth request (HETA 89-327) to conduct an HHE at the Albright Power Plant, Albright, West Virginia. This request was submitted by the Plumbers and Pipefitters Union, Local 152. The requester was concerned about employee complaints of stomach cramps and diarrhea, and potential exposures to metals during removal and replacement of piping on the #3 boiler. On August 1-4, 1989, NIOSH investigators conducted an environmental/medical survey. The results of this HHE will be included in a future NIOSH report.

III. BACKGROUND

The Albright Power Station is located on 42 acres in Albright, West Virginia. This coal-fired, electric-power generating plant was built in the early 1950s. Electricity is produced at the plant from two steam-powered turbine generators. Steam is generated from three coal-fired boilers (boiler #3 generates 150 megawatts of power and boilers #1 and #2 generate 75 megawatts each).

In late May 1989, several boilermakers working in the asbestos abatement enclosure became ill and sought care at a nearby hospital. The hospital staff collected blood samples from the affected employees for heavy metal analyses.

At the time of the NIOSH surveys, a complete refurbishing of boiler #3, which had begun several months prior, was underway. This refurbishing project involved several subcontractors to complete various phases of the project. The renovation project initially included an asbestos abatement project on the #3 boiler. Chempower Incorporated was contracted by the Monongahela Power Company (part of the Allegheny Power System), owners of the plant, to remove and dispose of approximately 40,000 square feet of asbestos-containing insulation located behind the outer boiler casing of boiler #3 and nearly 12,000 linear feet of pipe covering at the Albright Power Station. During this asbestos abatement phase of the renovation project, the entire boiler was enclosed in plastic sheeting. In order to remove the asbestos insulation, the outside metal casing first had to be systematically removed by boilermakers using oxyacetylene cutting torches. After the outside casing was removed, insulators removed the asbestos insulation. A schematic drawing of boiler #3, a five and one-half story structure, is included as Figure I.

The Combustion Engineering Corporation was contracted by the Monongahela Power Company to repair and replace the boiler piping inside boiler #3. This phase of the renovation project began in June 1989 after the metal boiler casing and asbestos insulation had been removed and the asbestos abatement containment was taken down. The Combustion Engineering Corporation hired members of the IBB, Local 667, and the Plumbers and Pipefitters Union, Local 152 to

complete the contracted work. Before this phase of work was begun, the surfaces to be cut using oxyacetylene torches were sandblasted and/or waterblasted to remove paint from the metal surfaces.

It should be noted that various types of respiratory protection were used during the NIOSH surveys conducted at the Albright Power Station. Prior to and during the initial NIOSH survey of May 23-24, 1989, some workers working inside the asbestos abatement enclosure were provided with half-mask air-purifying respirators equipped with high efficiency particulate air filters, while other employees wore combination organic vapor/acid gas/HEPA cartridges. The HEPA cartridges used are approved for protection from dust, fumes, and mists (i.e. metal dusts and fumes), but do not provide protection from mercury vapor or sulfur dioxide. The combination cartridges used are approved for protection from metals and sulfur dioxide, but not from mercury vapor. During the June 5-7, 1989, survey, workers working inside the asbestos enclosure wore airline respirators, which are approved for protection against particulates, sulfur dioxide, and mercury.

IV. EVALUATION DESIGN AND METHODS

The industrial hygiene and medical components of NIOSH Health Hazard Evaluations (HETA 89-252 and HETA 89-293) are summarized below.

A. Industrial Hygiene

During the initial survey of May 23-24, 1989, bulk samples of the painted metal boiler casing, the boiler insulation, and fly ash were obtained for analysis. Additionally, environmental samples for airborne respirable particulates, silica, sulfate particulates, and metals were collected.

On June 5-7, 1989, a follow-up survey was conducted during which bulk samples of coal and paint (similar in color to the paint used on the boiler casing) were obtained, and full-shift, general-area and personal-breathing-zone (PBZ) samples for airborne mercury vapor were collected. Additionally, direct reading instrumentation (Jerome Mercury Vapor Analyzer) was used to obtain instantaneous airborne mercury concentrations.

On June 27, 1989, additional full-shift PBZ samples for airborne mercury vapor and metals were collected, and drinking water samples were collected for mercury analyses.

The following information describes how these samples were collected and analyzed.

1. Analyses of metal casing for mercury content

A 1-1/2 foot square (ft^2) section of the painted metal casing surrounding boiler #3 was obtained during the initial survey for possible qualitative and quantitative mercury analysis.

On May 26, 1989, a gross qualitative mercury analysis of the painted metal casing was attempted by acid digestion. A solution of hydrochloric acid (HCl), nitric acid (HNO_3), and water was placed on a small portion (two inches in diameter) of the painted metal casing and allowed to digest the paint/metal for about two hours. A sample of this solution was removed from the metal and placed in a Drager direct reading mercury detector tube containing a copper iodide reagent.

A second analysis of the painted metal casing was conducted at NIOSH on May 26, 1989. To simulate worker exposures at the power plant, a 1 ft^2 section of the painted metal casing was cut with an oxyacetylene torch. During the oxyacetylene cutting, a Drager direct reading detector tube was used to measure airborne mercury. Additionally, two short-term samples [one PBZ and one process] for airborne mercury vapor were collected on SKC Hydrar solid-sorbent tubes connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric flow rate of 1.5 liters per minute (lpm). Sample volumes were 24 liters for the PBZ sample and 20 liters for the process sample. Analysis of the Hydrar solid-sorbent tube samples was conducted via Cold Vapor Atomic Absorption (AA) Spectroscopy according to NIOSH Method 6009.[2] The limit of detection (LOD) and limit of quantitation (LOQ) were 0.03 microgram per sample (μg/sample) and 0.05 μg/sample, respectively. This corresponds with an LOD of $\leq$0.002 mg/m^3.

A third analysis of the painted metal casing was conducted at NIOSH laboratory on June 2, 1989. Two short-term process area samples for airborne mercury vapor were collected, while a 1-1/2 ft^2 section of the painted metal casing was cut in an open area using an oxyacetylene torch. A Drager direct reading detector tube was also used to measure the airborne elemental mercury concentration. Process area air samples were collected in midget impingers (containing 10 ml each of reagent) connected via Tygon® tubing to battery-powered sampling pumps, calibrated to provide a volumetric flow rate of 1.0 lpm. Sample volumes were 10 liters for both samples. The impinger reagent solution was prepared by dissolving 25 grams of potassium dichromate in a 500 ml solution of 50% HNO_3. Five ml of the impinger solution were diluted with one liter of

distilled, deionized water. Analysis of the impinger samples was conducted using a Cold Vapor AA Spectrophotometer equipped with a Gold Foil Concentrator. The laboratory LOD for this method is 0.02 μg of mercury per sample (μg Hg/sample). This corresponds with an LOD of 0.002 mg/m^3.

2. Analyses of boiler insulation for mercury content

During the initial survey of May 23-24, 1989, two bulk samples of the boiler insulation were collected from behind the metal casing of boiler #3. The bulk insulation samples were analyzed for elemental mercury because it was suspected that if mercury was present in the paint coating or in the metal boiler casing, elemental mercury would be liberated during oxyacetylene cutting operations and mercury vapor could contaminate the boiler insulation material. The two insulation samples were analyzed for mercury by Cold Vapor AA Spectroscopy using a modification of EPA Method 245.5.[3] One gram of each sample was placed into beakers along with 25 ml of aqua regia; 50 ml of distilled, deionized water; and 25 ml of potassium permanganate. Samples were digested for one-half hour and then diluted to 250 ml with distilled, deionized water. Fifty ml aliquots of the solution were placed in BOD bottles, diluted to 100 ml with distilled, deionized water, and stannous chloride was added to reduce the mercury. Using the PE305 Cold Vapor AA Spectrophotometer, 0.20 gram of the solution was analyzed for mercury. The LOD and LOQ were 0.05 μg/gram and 0.09 μg/gram, respectively.

3. Analyses of bulk paint samples for mercury content

On June 5-7, 1989, two bulk paint samples were obtained from an old can of paint stored in the maintenance area. Although it could not be verified that the bulk paint samples collected were from the same paint used to coat the exterior of boiler #3, the color (lime green) of the paint was similar to that of the boiler exterior.

Bulk paint samples were analyzed for arsenic and lead by AA spectroscopy and for mercury by cold vapor AA spectroscopy. The bulk paint samples were digested for analysis of arsenic and lead according to EPA Method 3050.[3] The samples were analyzed for arsenic with a PE 5000 Zeeman Graphite Furnace AA Spectophotometer according to EPA Method 206.2[3] and for lead with a PE 5000 Flame AA Spectrophotometer according to EPA Method 239.1.[3] The samples were analyzed for mercury with the PE 305 Cold Vapor AA Spectrophotometer using a modification of EPA Method 245.5.[3] These bulk paint samples would not dissolve using aqua regia, but when sulfuric and

HNO_3 acids were substituted, they digested with no apparent problems. One gram of sample was placed into beakers with 10 ml of sulfuric acid; 5 ml of HNO_3; 50 ml of distilled, deionized water; and 25 ml of potassium permanganate were added. After the samples were allowed to digest for 30 minutes, they were diluted with 250 ml of distilled, deionized water. Fifty ml aliquots of these solutions were transferred to BOD bottles, diluted to 100 ml with distilled, deionized water, and stannous chloride was added to reduce the mercury. The limits of detection and quantitation were as follows:

	LOD μg/gram	LOQ μg/gram
arsenic	0.2	0.56
lead	8.0	28.0
mercury	0.05	0.096

4. Analyses of coal & fly ash bulk samples for mercury content

During the initial NIOSH survey on May 24, 1989, two bulk samples of fly ash were collected from behind the metal casing of the boiler. Additionally, two bulk samples of coal were collected during the follow-up survey on June 6, 1989, from the first floor boiler chute. Fly ash and coal samples were submitted for mercury analysis. All samples were analyzed for mercury by cold vapor AA spectroscopy using a modification of EPA Method 245.5.[3] One gram of each sample was placed into beakers along with 25 ml of aqua regia; 50 ml of distilled, deionized water; and 25 ml of potassium permanganate. Samples were digested for one-half hour and then diluted to 250 ml with deionized water. Fifty ml aliquots of the solution were placed in BOD bottles, diluted to 100 ml with distilled, deionized water, and stannous chloride was added to reduce the mercury. Two-tenths of one gram (0.20 g) of the sample was analyzed. The LOD and LOQ were 0.05 μg/gram and 0.09 μg/gram, respectively.

5. Analyses of fly ash for silica content

Two bulk samples of fly ash were collected from behind the boiler casing during the initial survey of May 1989. Both samples were submitted for qualitative silica analysis via X-ray powder diffraction (XRD). A portion from each sample was packed into XRD holders and analyzed qualitatively by a computer-controlled XRD.

6. Sulfur dioxide & sulfuric acid sampling

Three full-shift PBZ air samples were collected on May 24, 1989, to evaluate potential worker exposures to sulfur dioxide (SO_2) during oxyacetylene cutting operations on the painted metal casing within the asbestos abatement containment area. The method used to analyze these air samples, NIOSH Method 6004,[2] does not quantitate SO_2 directly, but rather measures sulfate and sulfite ion concentrations by ion chromatography. Samples were collected on two 37-mm diameter cassette filter holders connected in series. The front cassette contained a 0.8 micron (um) pore size, cellulose ester membrane filter with backup pad; the backup filter cassette contained a cellulose filter (Whatman 40) which had been saturated with potassium hydroxide. The filters were connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric flow rate of 1.0 lpm. Sulfuric acid, sulfate salts, and sulfite salts are collected on the front filter and may be quantitated as total particulate sulfate and sulfite. Sulfur dioxide is collected on the back (treated) filter. The LOD and LOQ for sulfate were 4 μg/sample and 13 μg/sample respectively. The LOD and LOQ for sulfite were 9 μg/sample and 26 μg/sample.

7. Metal sampling

On May 24, 1989, six PBZ air samples for trace metals were collected on mixed cellulose ester (MCE) filters connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 2.0 lpm. The samples were wet-ashed with concentrated nitric and perchloric acids. The residues were dissolved in a dilute solution of the same acids and the resulting solutions were analyzed for 31 metals via Inductively Coupled Argon Plasma, Atomic Emission Spectroscopy (ICP-AES) according to NIOSH Method 7300.[2] The analyses included the following elements (metals and minerals): silver (Ag), aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lanthanum (La), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), phosphorous (P), lead (Pb), platinum (Pt), antimony (Sb), selenium (Se), strontium (Sr), tellurium (Te), titanium (Ti), thallium (Tl), vanadium (V), yttrium (Y), zinc (Zn), and zirconium (Zr).

In June 1989, nine PBZ air samples for metals were collected and analyzed according to NIOSH Method 7300.[2]

8. Respirable particulate and free silica sampling

During the initial survey of May 1989, two PBZ air samples for respirable silica were collected on pre-weighed 37-mm polyvinyl chloride (PVC) filters attached to a 10-mm cyclone and connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1.7 lpm. The samples were analyzed for respirable particulate weight by gravimetric analysis according to NIOSH Method 0500.[2] The samples were also analyzed for quartz and cristobalite using x-ray diffraction according to NIOSH Method 7500.[2]

9. General-area and personal-breathing-zone sampling for mercury

On June 6, 1989, a total of 14 samples for airborne mercury vapor were collected to evaluate personal exposures of boilermakers, insulators, and laborers, and to determine general area concentrations of airborne mercury vapors during oxyacetylene cutting operations on the painted metal boiler casing. On June 27, 1989, five PBZ samples for airborne mercury vapor were collected to evaluate personal exposures of boilermakers. General-area and PBZ air samples were collected on SKC solid-sorbent tubes containing Hydrar granules connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric flow rate of 0.2 lpm. Analysis of the Hydrar tube samples for mercury was conducted via Cold Vapor AA Spectroscopy according to NIOSH Method 6009.[2] The LOD and LOQ were 0.03 μg/sample and 0.10 μg/sample, respectively. This corresponds with an LOD of $\leq$0.0008 mg/m^3.

10. Mercury sampling using direct reading instrumentation

A Jerome Instrument Corporation Gold Film Mercury Vapor Analyzer Model 411 was used for direct reading (instantaneous) measurement of airborne mercury. This instrument contains a thin gold film which selectively adsorbs inorganic mercury from an air sample. An increase in electrical resistance is produced across the film which is proportional to the mass of mercury in the sample.[4] The Model 411 was operated in the "sample mode" which collects a 125 ml air sample and has a lower LOD of 1 μg of mercury per cubic meter of air (μg HG/m^3). Sampling was performed at various locations within the boiler where oxyacetylene cutting operations were performed.

11. Analyses of drinking water samples for mercury content

On June 27, 1989, NIOSH investigators collected six drinking water samples for mercury analyses. Two samples were collected in the basement of the power station at the incoming water

supply piping, two were collected from the machine shop tap, and two were collected off-site at the Kingwood Mining Company. The Kingwood Mining Company does not have potable water on-site; distilled water is brought in for drinking proposes. All samples were sent to the United States Environmental Protection Agency (EPA), Office of Drinking Water, Technical Support Division for analysis. Samples were analyzed for mercury by cold vapor AA spectroscopy using EPA Method 245.5.[3] The EPA Office of Drinking Water, Technical Support Division, has established a reporting limit of 0.2 μg of mercury per liter.

B. Medical Evaluations

Confidential interviews were conducted on-site with all 26 workers who were working inside the asbestos containment enclosure during the initial site visit on May 22-23, 1989. Seven additional interviews were conducted during the second site visit on June 5-7, 1989, with employees who had been hired in the interim. Three former boilermakers who had left the job due to illness and who were briefly hospitalized were also contacted and interviewed. "Spot" urine specimens (single samples obtained anytime during the day) were collected from the current workers on May 23 and 24, 1989, and 12- to 24-hour urine specimens were collected for heavy metal analysis from the current workers on June 5, 6, and 7, 1989. Workers who met a case definition of possible work-related illness (onset of at least three of the following symptoms since beginning work on the renovation of boiler #3: cough, shortness of breath, chest tightness or pain, chills, headache, nausea, bloody sputum) were offered blood tests during the June site visit. Blood and urine specimens were analyzed for arsenic, lead, and mercury.

The case definition for possible work-related illness was based on the symptoms most frequently reported during the initial site visit, but excluding the two most commonly reported symptoms, odd taste and eye irritation. These two symptoms were not included in the case definition, since they were reported by a majority of the workers (74% and 70% respectively), often in the absence of other symptoms, and were felt to be non-specific irritant symptoms. The medical records of employees who had sought medical care for their illnesses were reviewed.

Two medical laboratories analyzed blood and/or urine specimens from workers during the NIOSH investigation. A third laboratory (A) was used by some workers who became ill and sought care at a local hospital. During the first NIOSH site visit, investigators collected and sent urine specimens to the NIOSH contract laboratory, laboratory B. Laboratory C is a university laboratory

with extensive experience in mercury analysis. Researchers at this university were consulted, and additional analyses of the NIOSH blood and urine specimens were conducted by this laboratory.

1. Medical Laboratory Analysis Methods

Laboratory A used a hydride vapor atomic absorption technique to test blood specimens for mercury and arsenic, and atomic stripping voltammetry for lead.[5] The lower limits of detection were 1 microgram per liter (μg/L) for arsenic and mercury, and 1 microgram per deciliter (μg/dL) for lead.

Laboratory B analyzed urine specimens for mercury, lead, and arsenic. Cold vapor atomic absorption spectrophotometry was used for mercury analysis,[5] anodic stripping voltammetry for lead,[6] and for arsenic a colorimetric procedure that includes arsine generation followed by complexation with silver diethyldithiocarbamate.[7] The limits of detection were 2.5 μg/L for mercury, 5 μg/L for lead, and 20 μg/L for arsenic. Urine creatinine concentration was used to normalize urine metal values, i.e. to adjust for urinary concentration.

Laboratory C used the cold-vapor atomic absorption technique of Magos and Clarkson[8] for mercury analysis in urine and blood. The absolute limit of detection was 0.5 nanogram. Creatinine values were used to normalize urine metal values.

V. EVALUATION CRITERIA

A. Environmental 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 Recommended Exposure Limits (RELs),[9] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[10] and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards.[11] The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily 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 required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet 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 (**STEL**) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Substance-specific Environmental Criteria and Toxicology

1. Mercury

Mercury exists in three forms: elemental mercury, inorganic mercury, and organic mercury. Organic mercury compounds are divided into two groups, alkyl mercury compounds and phenyl mercury compounds. The suspect source of mercury exposure in this investigation was paint on the boiler. Phenyl mercuric acetate (PMA), an organic mercury compound in the phenyl mercury group, has been used as a preservative in paints. Previous studies of workers show that exposure to PMA is probably in the form of mercury vapor, which is inhaled and absorbed through the respiratory tract.[12] PMA can also be absorbed through the gastrointestinal tract and the skin, although dermal exposure is small.[13]

Once inside the body, phenyl mercury compounds, such as PMA, are rapidly transformed to inorganic mercury. The pathways for elimination of PMA from the body follow those for the

elimination of inorganic mercury. The toxic effects of phenyl mercury compounds, including PMA, are similar to inorganic mercury compounds rather than to the more toxic alkyl mercury compounds.

Based on studies of experimental or accidental exposures to mercury vapor, the amount of mercury found in whole blood following initial distribution to body tissues is approximately 2% of the total dose (per liter of whole blood) [Clarkson 1988, p. 202]. There are two phases of elimination from the blood: an initial rapid phase, and a slower phase. The half-life of inorganic mercury in blood has been estimated to be from 2 to 3 days in the early phase and from 15 to 28 days in the late phase. The initial rapid phase of elimination from the blood has been reported to account for about 90% of the mercury initially deposited in the blood.[14] A concentration of 20 μg/L is considered an acceptable level of mercury in whole human blood.[15]

Metallic, inorganic, and phenyl mercury are excreted mainly in the feces and urine. Excretion of elemental or inorganic mercury in the urine does not occur until six months following low exposure, or as little as 10 days following high exposure.[16] More of the total body burden of mercury is excreted in urine following chronic exposure (58%) than following brief exposure (13%). Urine mercury concentrations in unexposed persons are nearly always less than 10 μg/L.[15]

Most information available on human health effects of mercury is from studies of workers with chronic exposures and therefore is not directly applicable in this health hazard evaluation due to the relatively short duration of the job. Reports in the literature of health effects following brief exposure to mercury share two common factors: heat and enclosed spaces. These conditions would facilitate vaporization and increased respiratory exposure to mercury. A metal fume fever-like syndrome, including chills, nausea, general malaise, tightness in the chest, and respiratory symptoms, has been described following brief exposure to mercury vapor via inhalation.[17,18] Pneumonitis, bronchitis, chest pain, dyspnea, and coughing have also been reported in a group of eight workers who were exposed to large quantities of mercury following an accidental rupture of a mercury boiler. Concentrations of mercury were not measured at the time of the incident, but five days later, air mercury levels ranged from 0.4 to 0.8 mg/m^3. Acute mercurial pneumonitis was also reported in another incident, in which the four affected workers had cleaned a storage tank.[19]

There are infrequent reports in the scientific literature of gastrointestinal symptoms associated with acute exposure to mercury. Loss of appetite, abdominal cramps, mild diarrhea, and painful and bleeding gums were reported for two weeks following an acute exposure to mercury vapor.[20] Nausea and vomiting have also been reported following this type of exposure. The toxicity of phenyl mercury following ingestion is thought to be low, based on case reports of high exposures with only minor gastrointestinal symptoms.[21]

NIOSH recommends that exposure to mercury vapor be limited to 50 $\mu g/m^3$ determined as a TWA exposure for up to a 10-hour workday.[9,12] The ACGIH recommends a TLV of 50 $\mu g/m^3$ for mercury vapor as an 8-hour TWA, and notes that absorption of mercury through the cutaneous route including the mucous membranes and eyes, either by airborne or, more particularly, by direct contact with the substance may increase the overall exposure.[10] The OSHA PEL for mercury vapor is 50 $\mu g/m^3$ as an 8-hour TWA.[11]

2. Sulfur dioxide and particulate sulfates

Inhalation of sulfur dioxide causes irritation of the eyes, nose and throat, rhinorrhea (runny nose), choking, and cough. These symptoms have been reported at concentrations of 10 ppm to 50 ppm (27 to 133 mg/m^3), for 5- to 15-minutes. Adaptation occurs, and symptoms subside with continued exposure for most workers.[17]

The NIOSH REL for SO_2 is 5 mg/m^3 as a TWA for up to 10 hours, and 10 mg/m^3 as a 15-minute (STEL).[22] The OSHA PEL for SO_2 is 5 mg/m^3 as an 8-hour TWA and 10 mg/m^3 as a 15-minute (STEL).[11] The ACGIH TLV for SO_2 is 5.2 mg/m^3 as an 8-hour TWA, and 13 mg/m^3 as a 15-minute (STEL).[10]

The term sulfate particulates covers a range of substances including, among others, zinc ammonium sulfate, ferric sulfate, zinc sulfate, and ammonium sulfate. Although sulfates are considered irritants, the sulfate ion itself is not an irritant and sulfate particulates vary in irritant potency. The relative ranking of the different forms of sulfate particulate depends on the biologic effect being considered. There are no environmental evaluation criteria for sulfate particulates.[23]

3. Lead

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on

food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women. There is some evidence that lead can also impair fertility in occupationally exposed men.[24,25]

The OSHA PEL for lead in air is 50 $\mu g/m^3$ calculated as an eight-hour TWA for daily exposure.[11] The OSHA lead standard (29 CFR 1910.125) also requires semi-annual blood lead monitoring of employees exposed to 30 $\mu g/m^3$ or more of lead. An employee whose blood lead level is 40 $\mu g/dl$ or greater must be retested every 2 months and be removed from a lead-exposure job if the average blood lead level is 50 $\mu g/dl$ or more over a 6-month period. A blood lead level of 60 $\mu g/dl$ or greater, confirmed by retesting within 2 weeks, requires immediate medical removal. Workers on medical removal should not be returned to a lead-exposure job until their blood lead level is confirmed to be below 40 $\mu g/dl$. The standard also recommends that the blood lead levels of employees planning to have children be kept below 30 $\mu g/dl$. Removed workers are entitled to retention of wages, benefits, and seniority for up to 18 months until their blood levels decline to below 40 $\mu g/dl$.[24]

4. Arsenic

Acute, low-level inhalation exposures have resulted in irritation of the upper respiratory tract. Ingestion of food and drink contaminated with low levels of arsenic has been reported to cause burning lips, difficulty swallowing, abdominal pain, nausea, vomiting, and diarrhea.[17] Absorption of large amounts of arsenic is fatal. Oral exposure to arsenic can result in a characteristic pattern of skin abnormalities, which may ultimately progress to skin cancer. Inhalation of arsenic dust or fume increases the risk of lung cancer.[20]

NIOSH considers inorganic arsenic to be a potential occupational carcinogen.[9] NIOSH policy for worker exposures to potential occupational carcinogens is that exposures should be controlled to the lowest feasible limit or below the analytical limit of quantitation (LOQ). The LOQ for inorganic arsenic is 0.002 mg/m^3.[7,9] The OSHA PEL for inorganic arsenic is 0.01 mg/m^3 as an 8-hour TWA[11] and the ACGIH TLV is 0.2 mg/m^3 as an 8-hour TWA.[10]

5. Iron oxide dust and fume

Inhalation of iron oxide fume or dust is associated with an asymptomatic pulmonary condition termed siderosis. Siderosis can produce chest X-ray patterns indistinguishable from fibrotic pneumoconiosis; however, studies have failed to demonstrate a reduction in pulmonary function.[26]

The ACGIH recommends a TLV of 5.0 mg/m^3 (as Fe) for an 8-hour TWA,[10] while the OSHA PEL for iron oxide is 10 mg/m^3.[11] The NIOSH REL for iron oxide is 5 mg/m^3 for up to a 10-hour TWA.[9]

6. Welding fume/metals

Metal fume fever is an acute respiratory disease that is caused by inhalation of metal oxide fumes. Symptoms resemble those of influenza, including fever, chills, nausea, muscle aches, weakness, headache, and cough, lasting from 6 to 24 hours. Resistance to the illness increases with repeated exposure, but absence from exposure quickly results in loss of resistance. This syndrome is common on Mondays, following a weekend without exposure. Although zinc oxide is the most common exposure reported to cause metal fume fever, many other metals have also been implicated, including copper, magnesium, aluminum, antimony, cadmium, copper, iron, manganese, nickel, selenium, silver, and tin. Pneumonitis and pulmonary edema have also been frequently reported following exposure to metal fumes.[26,27]

An exposure limit for total welding emissions cannot be established because the composition of welding fumes and gases varies for different welding processes and because the various components of a welding emission may interact to produce adverse health effects. NIOSH therefore recommends that exposures to all welding emissions be reduced to the lowest feasible concentrations using state-of-the-art engineering controls and work practices. Exposure limits for individual chemical or physical agents are to be considered upper boundaries of exposure.[26]

7. Nickel

Metallic nickel compounds can cause sensitization dermatitis.[17] NIOSH considers nickel to be a potential carcinogen, as nickel refining has been associated with an increased risk of nasal and lung cancer.[22] While NIOSH has established an REL for nickel of 0.015 mg/m^3 for up to a 10-hour TWA, exposures should be kept to the lowest feasible level due to the carcinogenic potential of this metal.

VI. RESULTS

A. Industrial Hygiene

The order in which the industrial hygiene sampling results are presented below corresponds to the order in which the analytical methods are presented in Section IV (Evaluation Design and Methods).

1. Analyses of metal casing for mercury content

   Three analyses of the metal casing surrounding boiler #3 were performed at the NIOSH laboratories and all three analyses failed to show the presence of mercury. The acid solution placed on the painted casing and then injected into a mercury detector tube did not cause a color change on the indicator tube indicating no detectable mercury. No detectable concentrations of airborne mercury vapors were found in any of the short-term Hydrar tube samples collected during the simulations of oxyacetylene cutting operations on the painted metal casing. The mercury detector tube measurements made during the metal oxyacetylene cutting process also showed no detectable airborne levels of mercury vapor above an LOD of 0.1 mg/m^3.

2. Analyses of boiler insulation for mercury content

   One of two bulk samples of insulation collected from behind the metal-casing of boiler #3 contained 0.24 μg/gram (by weight) of mercury and the other sample did not contain mercury.

3. Analyses of bulk paint samples for mercury content

   Laboratory analysis of the two bulk samples of paint obtained on the NIOSH follow-up survey in June 1989 revealed no detectable mercury or arsenic. However, the samples did contain 1300 and 1400 μg of lead/gram of paint.

4. Analyses of coal & fly ash for mercury content

   Two bulk samples of fly ash and coal were analyzed for mercury content. The analytical results of the coal samples revealed 0.11 and 0.25 μg of mercury/gram of coal. Analysis of the 2 fly ash samples showed mercury concentrations of 0.11 μg of mercury/gram of fly ash in one sample and no detectable concentrations of mercury in the second bulk fly ash sample.

5. Analyses of fly ash for silica content

Two bulk material samples of fly ash submitted for qualitative analysis showed quartz (SiO_2), magnetite (Fe_3O_4) and mullite ($Al_6Si_2O_{16}$) mineral patterns. Both diffraction patterns also indicated the presence of amorphous materials. However, sieving tests indicated that neither of the samples contained particles in the respirable size range (<10 um in diameter).

6. Sulfur dioxide & particulate sulfate sampling

Results of sulfur dioxide and particulate sulfate sampling are presented in **Table I**. Sulfur dioxide concentrations for the three PBZ air samples collected were 0.61 mg/m^3, 4.73 mg/m^3, and 9.17 mg/m^3. The NIOSH REL for SO_2 is 5 mg/m^3 as a TWA for up to a 10-hour workshift, the ACGIH TLV and OSHA PEL for SO_2 are 5 mg/m^3 as an 8-hour TWA. One of three samples exceeded the NIOSH REL, the ACGIH TLV, and the OSHA PEL.

As noted in Table I, the sulfate particulate concentrations for the three PBZ samples were 0.35 mg/m^3, 0.46 mg/m^3, and 1.63 mg/m^3. There are no existing evaluation criteria for sulfate particulates.

7. Metal sampling

May 1989

Levels of metals generated during oxyacetylene cutting of the painted boiler casing showed that three (**arsenic, iron, and lead**) of 31 metals included in the analyses exceeded the applicable environmental criteria during the May 1989 survey. These results are presented in Table II and are summarized below.

Airborne arsenic concentrations ranged from 0.005 mg/m^3 to 0.020 mg/m^3. All six PBZ air samples exceeded the NIOSH REL (0.002 mg/m^3) and four of six exceeded the OSHA PEL (0.01 mg/m^3). NIOSH considers arsenic to be a potential occupational carcinogen.

Airborne iron concentrations ranged from 0.60 mg/m^3 to 5.8 mg/m^3. One of the six PBZ air samples exceeded the NIOSH REL and ACGIH TLV (5 mg/m^3, as Fe) for iron oxide dust and fume; none exceeded the OSHA PEL (10 mg/m^3).

Airborne lead concentrations ranged from 0.16 mg/m^3 to 1.3 mg/m^3. All six PBZ air samples exceeded the NIOSH REL (<0.1 mg/m^3), the OSHA PEL (0.05 mg/m^3), and the ACGIH TLV (0.15 mg/m^3).

The highest detectable concentration for three other metals were between 10% and 40% of the most stringent environmental criteria: nickel=40%, copper=29%, and aluminum=16%. All other metals included in the analyses were less than 10% of the environmental criteria. It should be noted that NIOSH considers nickel to be an occupational carcinogen.

June 1989

Levels of metals generated during oxyacetylene cutting of the boiler casing after hydroblasting and/or sandblasting of painted surfaces showed that one (arsenic) of 31 metals included in the analyses exceeded the applicable environmental criteria during the June 1989 survey. The results of these analyses are presented in Table III and are summarized below.

Airborne arsenic concentrations ranged from nondetectable (less than the analytical LOD) to 0.011 mg/m^3. Five of 9 PBZ air samples contained arsenic and all five exceeded the NIOSH REL (0.002 mg/m^3), with 1 of 9 exceeding the OSHA PEL (0.01 mg/m^3). Airborne iron concentrations ranged from 0.02 mg/m^3 to 1.0 mg/m^3. None of the nine PBZ air samples exceeded the NIOSH REL, ACGIH TLV, or OSHA PEL. The highest concentration found was 20% of the NIOSH REL. Airborne lead concentrations ranged from nondetectable to 0.002 mg/m^3. Lead was detected on 6 of the 9 PBZ air samples and all 6 samples were below the NIOSH REL, the OSHA PEL, and the ACGIH TLV. The highest concentration found was 10% of the OSHA PEL (0.05 mg/m^3).

The highest detectable concentration of nickel was 14% of the NIOSH REL; all other metals included in the analyses were less than 10% of the environmental criteria.

8. Respirable particulate and free silica sampling

Two samples collected during the oxyacetylene cutting of the boiler casing were analyzed for respirable particulate and free silica. The integrity of 1 of the 2 samples was questionable and therefore will not be reported. The other sample showed a concentration of 3.6 mg/m^3 of respirable particulate and no detectable concentrations of either quartz or cristobalite.

9. General-area and personal-breathing-zone sampling for mercury

Full-shift PBZ and general-area samples for airborne mercury were collected on June 6, 1989. The sample results showed that 6 of 11 PBZ samples collected on boilermakers, insulators, and laborers contained trace quantities (< 0.0008 mg/m^3) of mercury, and 3 general-area air samples contained no detectable quantities of mercury.

The results of 5 full-shift PBZ samples collected from boilermakers for airborne mercury on June 27, 1989, showed no detectable quantities of mercury above an LOD of 0.006 mg/m^3.

10. Mercury sampling using direct reading instrumentation

The results of mercury sampling, using the Jerome Instrument Corporation Gold Film Mercury Vapor Analyzer Model 411, showed the presence of mercury, but the data were inconclusive due to the potential for positive interferences when using this instrument in extreme heat. According to conversations with a representative of Arizona Instruments (formerly Jerome Instrument Corporation), this instrument reacts to temperature extremes.[28]

11. Analyses of drinking water samples for mercury content

The results of all drinking water samples collected at the Albright Power Station and those collected off-site at the Kingwood Mining Company were less than the Reporting Limit for mercury established by the EPA, Office of Drinking Water, Technical Support Division.

12. Other hazards identified

In addition to the chemical hazards reported above, the NIOSH investigators observed several safety hazards during the initial survey of May 23-24, 1989. These hazards included electrical hazards from standing water within the asbestos enclosure, tripping hazards from electrical cords and airlines, unstable scaffolding, head bump hazards from the scaffolding, and lack of safety boots with metatarsal guards. At the closing conference on May 24, 1989, which was attended by representatives of the Albright Power Station, contractors, and the union, the NIOSH investigators recommended that these hazards be addressed and corrected.

B. Medical Results

The 36 workers who participated in the survey were all male, ranging in age from 21 to 58 years. Thirty-three were

boilermakers, two were insulators, and one was an electrician. Twenty-two of these workers were involved in burning through the metal casing of the old boiler, using oxyacetylene torches; three were involved in carrying and stacking and generally helping those who were burning; four worked as foremen; one worked as a union steward; and six performed other tasks.

Fifteen of the 36 workers who were interviewed met the case definition, having at least three of the following symptoms: cough, shortness of breath, chest tightness or pain, chills, headache, nausea, and bloody sputum. **(Table IV)** Results of heavy metal blood tests from the local hospital were available for 19 workers for the time period May 20, 1989 to June 15, 1989. **(Table V)** Blood lead and arsenic levels were within the expected range for the general adult population. Mercury levels ranged from less than 1 μg/dL to 83.9 μg/dL. Eleven of 19 blood mercury levels exceeded the general population upper limit of 20 μg/L.

No mercury was detected in the 26 spot urine specimens collected from workers by NIOSH investigators on May 23rd and 24th and analyzed by Laboratory B (a NIOSH contract laboratory). Seven of the spot urine specimens were also tested for arsenic and lead; no arsenic or lead were detected. During the follow-up visit, nine 12- to 24-hour urine specimens were collected from participants, and split specimens of these were tested for mercury in two different laboratories, Laboratory B and Laboratory C (a University laboratory). No elevated levels of mercury were detected. The 7 blood specimens collected by NIOSH investigators on June 6 and 7, 1989, were all negative for mercury.

During the initial visit, several of the workers suspected that their illness was caused by an exposure related to burning the metal casing of the boiler with an oxyacetylene torch. To test this hypothesis, those workers who burned casing were compared to those who performed other tasks. Limiting this analysis to the 33 men who were currently working at the time of the NIOSH site visits, those who burned casing appeared twice as likely to meet the case definition as those who performed other tasks (Rate ratio [RR] = 2.21, 95% confidence interval [CI] 0.73-6.70) **(Table VI-A)**. Workers who burned casing appeared three times as likely to have elevated mercury levels as those who performed other tasks (RR = 2.67, 95% CI 0.47-15.11) **(Table VI-A)**. Elevated blood mercury levels were three times as common among workers who met the case definition (RR = 2.96, 95% CI 1.12 - 7.85) **(Table VI-B)**.

VII. DISCUSSION

This report describes the results of two NIOSH health hazard evaluations at the Albright Power Station, Albright West Virginia.

Both requests mentioned worker exposures to heavy metals; the first request also described an outbreak of acute illness among workers involved in a renovation/asbestos removal project on the #3 boiler. The NIOSH evaluations focused on characterizing the illnesses and identifying occupational exposures that might have occurred and could explain these illnesses.

The symptoms reported by workers (coughing, chest tightness, chills, etc.) are similar to those associated with metal fume fever, a syndrome experienced by welders that is associated with exposure to fresh fume of several metals. The symptoms of metal fume fever, however, typically occur on the first day of the work week, following a weekend or longer period of no exposure to metal fumes. During this outbreak, workers tended to become ill towards the end of the week, or after two weeks of exposure. This pattern indicates that the illness was not typical of metal fume fever and might be related to an exposure to substances other than, or in addition to, welding fumes.

The symptoms described are not specific; that is, they could be due to many causes, both occupational and non-occupational. Sulfur dioxide and mercury exposure may cause respiratory symptoms similar to those found in this evaluation.

Based on results of blood specimens collected by a local hospital, mercury exposure was considered as a possible cause of the workers' illnesses. Blood and urine samples collected by NIOSH, however, did not contain mercury. Possible explanations for these discrepant findings are discussed below.

Mercury should be detected in the blood for a brief period following exposure, but it may disappear from the blood after only a few days if exposure has ceased. Excretion of mercury in the urine following brief exposure may be delayed. It is possible that the specimens collected by NIOSH were obtained too soon for mercury to appear in the urine.

Mercury may have been underestimated in the specimens collected by NIOSH due to absorption of mercury by the container used for sampling. This is unlikely, however, because collection procedures included addition of hydrochloric acid to the specimen containers to prevent adherence to the container.

Potential contamination of specimens (from the workplace, or at the laboratory) could account for the appearance of mercury in the blood samples analyzed by Laboratory A. Blood tubes from the same lot as those used for the specimens from the workers at Albright were checked by this laboratory and did not contain mercury. A reagent (ESA Metexchange) used in the heavy metal analysis was found to contain mercury raising the possibility that contamination of blood could have occurred during testing. (Previous lots of this reagent had tested negative for mercury, 0.0028% by weight mercuric ion). Laboratory A

took steps to eliminate the contamination and reanalyzed the blood specimens. The original results were confirmed, leading the laboratory to conclude that the original results were accurate. Laboratory A also pointed out that all samples received during the same time period as the Albright samples were analyzed using the same reagent and most were in the normal range.

Elevated mercury levels may have been caused by dietary exposures (eating mercury-contaminated fish, for example). Information on such exposures was unavailable prior to the initial blood sampling by the local hospital, but during the NIOSH evaluation, only one worker reported fish consumption.

The factors considered above do not definitively refute the positive findings of mercury exposure based on the blood samples collected by the hospital. Further evidence suggesting a relationship between illness and mercury exposure, possibly from mercury-containing paint on the boiler, comes from epidemiologic analyses of data collected by NIOSH during worker interviews. These analyses suggested that workers who performed a particular job task (burning through the boiler casing with oxyacetylene torches) were more likely to become ill and to have elevated blood mercury levels than workers who performed other tasks. Workers who met the symptom-based case definition were three times as likely as non-cases to have elevated mercury levels.

In an effort to evaluate potential mercury exposures, environmental monitoring for mercury vapor was conducted and bulk samples of possible sources of mercury exposure were collected during the NIOSH evaluations. Although overexposures to airborne mercury were not documented, trace concentrations were found in 6 of 11 PBZ air samples collected on June 6, 1989. Mercury was also detected in bulk samples of coal, fly ash, and boiler insulation. Mercury was not detected in three separate analyses of samples from the painted boiler casing, nor in air samples collected at NIOSH during a simulated procedure where samples of boiler casing were cut using oxyacetylene torches. Mercury was also not detected in PBZ air samples collected on the follow-up survey of June 27, 1989, after the painted coating had been removed from the boiler.

Unfortunately, exposure monitoring data are not available prior to the NIOSH evaluations. It should be noted, however, that Combustion Engineering hired a consulting firm to conduct an industrial hygiene evaluation in June, 1989. The consultant's report indicated that low levels of mercury vapor were detected during a simulation of oxyacetylene cutting on a sample of painted boiler casing but not during cutting on casing which did not contain paint.[29] In this simulation, a plastic enclosure approximately 4 feet by 4 feet was used. The consultant also collected bulk samples of various materials to be analyzed for mercury content. A bulk sample of a high efficiency

particulate air (HEPA) filter used in the negative air filtration units of the asbestos containment enclosure and samples of paint chips showed the presence of mercury.

While there appears to be a discrepancy in the results of the simulated oxyacetylene cutting process conducted by NIOSH as compared with the consultant, the differences in the findings might be explained by differences in the simulation procedure itself, i.e., in the fact that the consultant's work was performed in a small enclosure as opposed to in a larger, more open area. Another possible explanation might be that mercury was present in some painted sections of the boiler and not in others, or possibly the level of mercury varied in some sections. In any case, however, repeated sampling conducted by NIOSH at the actual worksite failed to show significant levels of mercury in PBZ air samples obtained in May and June, 1989. The trace levels of mercury found in some of the PBZ air samples would not be expected to give rise to either elevated mercury levels in urine or blood samples or to notable health effects. It should be noted that if high mercury exposures were present in the enclosure prior to NIOSH involvement, the respirators worn at the time would not have provided protection from mercury vapor exposures.

The NIOSH surveys also included evaluations of sulfur dioxide and other metal exposures during oxyacetylene cutting operations. Overexposures to various metals including iron, lead, and arsenic were documented during the May 23-24, 1989 survey. One of three air samples showed overexposure to sulfur dioxide. Subsequent environmental monitoring conducted after the paint coating on the boiler had been removed showed lower airborne concentrations of lead, arsenic, and iron, with a few of the samples exceeding the exposure criteria for arsenic.

VIII. CONCLUSIONS

Epidemiologic analyses of job tasks suggest that the reported illnesses during the first evaluation were work-related. Evidence concerning the exact cause of these illnesses, however, is inconsistent. Although elevated blood mercury levels were reported for some workers seen at a local hospital, elevated mercury levels were not found in blood and urine samples collected by NIOSH investigators on two visits. The absence of mercury in urine collected during the NIOSH visits could result from the delayed appearance of mercury in urine following acute exposure. Because no explanation for the discrepant findings regarding blood specimens could be found, the hospital's finding of elevated blood mercury can not be discounted. Although environmental sampling did not document overexposures to mercury, mercury was detected in bulk material samples and in trace concentrations in some PBZ air samples. It is possible that a source of mercury was present at the time of the illnesses but was no longer present at the time of the NIOSH investigation. One likely source would have been the boiler casing

paint. Mercury is used as an anti-fouling agent in some paints. Sections of the boiler may have contained varying amounts of paint or differing paints. If high airborne mercury levels were present prior to the NIOSH evaluations, the type of respirators worn in May 1989 when the illnesses occurred would not have provided protection against mercury vapor.

Airborne sulfur dioxide, lead, arsenic, and iron oxide dust and fume concentrations exceeded the environmental criteria during the May 1989 survey. While respirators were worn by employees, not all employees wore the type that would have provided protection against sulfur dioxide.

IX. RECOMMENDATIONS

In future oxyacetylene cutting or welding operations performed within an asbestos enclosure (or similar operations), several precautions should be taken to insure that employees will be protected from exposure to metal fumes and vapors, which are generated during heating of the paint coating and metal surfaces.

1. Paint coatings and metal boiler casings should be assessed for mercury, lead, and other metal content. Employees should be informed of the results and should be protected from exposure to any potential health hazards identified by the analyses.

2. Paint coatings should be removed from the metal surfaces by hydroblasting and/or abrasive blasting prior to oxyacetylene cutting or other welding techniques. The welding of metals coated with protective materials containing mercury compounds will produce mercury vapor or dust containing mercury compounds. Employees involved in blasting operations should be properly protected from mercury, lead, silica, or any other identified hazards.

3. Sampling for airborne contaminants should be performed during oxyacetylene cutting or welding operations to determine if mercury, lead, or other metals are released in concentrations which may require special respiratory protection and/or the use of portable exhaust ventilation units.

4. A comprehensive respiratory protection program should be established and strictly enforced for the protection of the employees. The program should require prior medical certification of fitness for all contract employees required to wear respirators on the job. In addition, quantitative fit-testing of negative pressure respirators should be required. If airline respirators are provided, negative pressure fit tests without the air in the supply mode, as well as irritant smoke tests with the air in the

supply mode, would be beneficial in evaluating a "proper" fit. The complete respirator policy should conform in all respects to the OSHA requirements as specified in 29 CFR 1910.134.[30]

5. Contractors should be required to have a comprehensive and effective occupational health program addressing potential exposures. As part of this program, the contractor should have sufficient staff with working knowledge, expertise, and guidance as to the following: a) the training, technical consultation, and standardized methods necessary to conduct valid and reliable environmental sampling and analysis of any identified hazards, b) the limitations (sensitivity, specificity, limits of detection and quantification) of sampling methods, c) the assessment of risk identified by sampling and analytical programs, d) the communication of information to occupationally exposed workers about their level of risk, e) the procedures to determine whether to implement a control program, and f) the criteria for choosing between alternative control measures. This program should conform in all respects to the OSHA Hazard Communication Program requirements as specified in 29 CFR 1910.1200.[31]

6. Several safety hazards were observed during the initial survey and the NIOSH investigators recommended that these hazards be addressed and corrected. These hazards included electrical hazards from standing water within the asbestos enclosure, tripping hazards from electrical cords and airlines, unstable scaffolding, head bump hazards from the scaffolding, and lack of safety boots with metatarsal guards.

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4. Chempower Incorporated, Akron, Ohio.
5. Combustion Engineering, Albright Power Station, Albright, West Virginia.
6. Power Piping Company, Pittsburgh, Pennsylvania.
7. OSHA Region III.

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

TABLE I

PERSONAL-BREATHING-ZONE AIR CONCENTRATIONS OF SULFUR DIOXIDE (SO_2) AND SULFATE PARTICULATES DURING OXY-ACETYLENE CUTTING OPERATIONS

CHEMPOWER INC.
ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA
HETA 89-252

May 24, 1989

(mg/m^3)[a]			Airborne Exposure Levels	
Job Description (Sample Location)	Sample Period	Sample Volume (liters)	SO_2	Sulfate[b] Particulates
Boilermaker (Level #1)	7:59am-3:47pm	468	4.73	0.46
Boilermaker (Level #2 1/2)	8:48am-3:33pm	405	0.61	0.35
Boilermaker (Level #2)	8:38am-3:31pm	413	9.17	1.63
NIOSH REL			5.0	

a - Milligrams per cubic meter of air (mg/m^3).

b - There is no environmental criteria for sulfate particulates.

REL - NIOSH Recommended Exposure Limit as a TWA for up to a 10-hour workshift, 40-hour/week

TABLE II

RESULTS OF PERSONAL-BREATHING-ZONE SAMPLING FOR AIRBORNE METALS

CHEMPOWER INC.
ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA
HETA 89-252

MAY 24, 1989

Job Description	Sample Time (Minutes)	Contaminant Concentration (mg/m^3)[a]		
		Arsenic	Iron	Lead[b]
Foreman	416	0.005	0.60	0.16
Boilermaker (Cutting & Carrying)	454	0.006	0.97	0.27
Boilermaker (Cutting)	209[c]	0.017	5.8	1.3
Boilermaker (Cutting)	400	0.014	2.3	0.67
Boilermaker (Cutting & Carrying)	388	0.020	1.5	0.34
Boilermaker (Cutting)	471[d]	0.012	2.2	0.39
NIOSH Recommended Exposure Limit (REL)		0.002	5.0	0.1
OSHA Permissible Exposure Limit (PEL)		0.01	10.0	0.05
ACGIH Threshold Limit Value (TLV)		0.2	5.0	0.15

a - contaminant concentrations are expressed as a time-weighted average over the entire sample in milligrams per cubic meter (mg/m^3).

b - Evaluation criteria for iron (Fe) are for iron oxide dust and fume as Fe.

c - sample pump quit, fault light indicated minimum sample time.

d - the sample concentration reported is a minimum concentration, sample filter was on backwards at end of sample period, but front was loaded indicating filter was on correctly at one beginning of sample period.

TABLE III

RESULTS OF PERSONAL-BREATHING-ZONE SAMPLING FOR AIRBORNE METALS

COMBUSTION ENGINEERING/ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA
HETA 89-293

JUNE 27, 1989

Job Description	Sample Time (Minutes)	Contaminant Concentration (mg/m^3)[a]		
		Arsenic	Iron[b]	Lead
Boilermaker (No Cutting Done)	505	ND	0.21	0.001
Boilermaker (No Cutting Done)	504	ND	0.019	ND
Boilermaker (Rigging)	482	ND	0.27	ND
Boilermaker (Cleanup & Some Cutting)	450	ND	0.14	ND
Boilermaker (Cleanup & Some Cutting)	450	0.004	0.25	0.002
Boilermaker (Cutting Super Heat Crossover Pipe)	524	0.003	0.14	0.001
Boilermaker (Cutting Super Heat Crossover Pipe)	524	0.002	0.18	0.001
Boilermaker (Cutting Super Heat Crossover Pipe)	513	0.005	0.33	0.001
Boilermaker (Cutting Super Heat Crossover Pipe)	512	0.011	1.0	0.002
NIOSH Recommended Exposure Limit (REL)		0.002	5.0	0.1
OSHA Permissible Exposure Limit (PEL)		0.01	10.0	0.05
ACGIH Threshold Limit Value (TLV)		0.2	5.0	0.15

a - contaminant concentrations are expressed as a time-weighted average over the entire sample in milligrams per cubic meter (mg/m^3).

b - Evaluation criteria for iron (Fe) are for iron oxide dust and fume as Fe.

ND - nondetectable.

TABLE IV

SYMPTOMS of 36 EMPLOYEES

CHEMPOWER INC.
ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA
HETA 89-252

MAY - JUNE 1989

Symptom	Number Affected	Percent Affected
odd taste	27	(74%)
eye irritation	25	(70%)
cough	17	(47%)
headache	17	(47%)
chest tightness	12	(33%)
nausea	11	(31%)
shortness of breath	8	(22%)
chills	8	(22%)
blood-tinged sputum	6	(17%)

TABLE V

RESULTS OF HEAVY METAL BLOOD ANALYSES
FROM LOCAL HOSPITAL

CHEMPOWER INC.
ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA
HETA 89-252

Date drawn	Mercury (μg/L)	Lead (μg/L)	Arsenic (μg/L)	Case
5/20	83.9	14	<1	Y
5/20	73.3	6	<1	Y
5/21	81.8	7	<1	Y
5/21	39.8	3	<1	Y
5/24	7.4	11	<1	Y
5/26	51.2	21	<1	Y
5/30	36.7	20	<1	Y
6/02	19.8	3	<1	N
6/05	46.5	10	<1	N
6/05	50.7	13	<1	Y
6/05	21.5	14	<1	N
6/05	8.8			N
6/05	<1			N
6/06	6.9	8	<1	N
6/07	15.9	4	<1	N
6/07*	21.0	13	<1	Y
6/07	6.4	4	<1	N
6/08	21.0	6	<1	N
6/15	4.6			N

*repeat on 6/16: 1.9

TABLE VI

CHEMPOWER, INC.
ALBRIGHT POWER STATION
ALBRIGHT, WEST VIRGINIA
HETA 89-252

A. Frequency of illness and elevated mercury levels by job task[1,2]

	Task		
	Burning	Other	Rate Ratio
	No. (%)	No. (%)	(95% CI)[3]
Illness	9/19 (47%)	3/14 (21%)	2.21 (0.73-6.70)
Elevated mercury	10/15 (66%)	1/4 (25%)	2.67 (0.47-15.11)

B. Frequency of elevated mercury levels by case status[1,2]

	Case	Non-case	Rate Ratio
	No. (%)	No. (%)	(95% CI)[3]
Elevated mercury	8/9 (89%)	3/10 (30%)	2.96 (1.12-7.85)

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[1] Illness defined by symptom-based case definition (see text for full description)
[2] Elevated mercury levels reported by local hospital
[3] Taylor series 95% confidence limits
[1] Taylor series 95% confidence limits