# HETA 95-0393-2633
# Clinch River Power Plant
# Cleveland, Virginia

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**Dino A. Mattorano**

# 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, technical and consultative assistance 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.

# ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Dino A. Mattorano, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Max Keefer, CIH; John Decker, CIH; and Chris Reh, M.S. Analytical support was provided by the Measurement Research Support Branch, NIOSH, Cincinnati, Ohio; and Data Chem Laboratories, Salt Lake City, Utah. Desktop publishing by Kate Marlow.

Copies of this report have been sent to employee and management representatives at the Clinch River Power Plant; the Building and Construction Trades Department, American Federation of Labor and Congress of Industrial Organizations; representatives of Babcock and Wilcox Construction Company, and the Centers to Protect Workers' Rights; and the OSHA Regional Office.  Single copies of this report will be available for three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

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**Health Hazard Evaluation Report 95-0393-2633**
**Clinch River Power Plant**
**Cleveland, Virginia**
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**Dino A. Mattorano**

# SUMMARY


In September 1995, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) at the Clinch River Power Plant near Cleveland, Virginia. The evaluation was requested by the Building and Construction Trades Department of the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO). The request raised concerns about exposures to arsenic, other heavy metals, and silica encountered by workers during rebuilding of coal-fired boilers. Health effects mentioned in the request included respiratory diseases and skin irritation.

On September 25-28, 1995, NIOSH conducted a site visit at the Clinch River Power Plant. Full-shift personal breathing zone (PBZ) air samples were collected from 29 workers (25 boilermakers and 4 laborers) on both September 26 and 27. NIOSH investigators collected 48 PBZ air samples for heavy metals, 9 PBZ air samples for respirable dust and silica, 8 hand wipe samples, and 12 bulk fly ash samples. During the sampling period, boilermakers removed secondary inlet and secondary outlet boiler elements and removed and replaced portions of the steel boiler casing, exposing them to fly ash and fumes from air arc gouging, welding, and torch cutting. Laborers maintained walkways and prepared work areas by dry sweeping and vacuuming, primarily exposing them to fly ash. Employees worked six, 10-hour workdays (equal to a 60-hour workweek). Because of this increase in hours worked per week, the PBZ air sample results are compared to adjusted occupational exposure limits calculated by the Brief and Scala model.

In general, the highest PBZ air sample concentrations of arsenic, beryllium, cadmium, nickel, lead, and respirable dust were found during sample periods where boilermakers performed job tasks inside the boiler and outside the boiler on the steel boiler casing. Six samples were above the NIOSH recommended exposure limits (REL) of 2 $ug/m^3$ (15 minute ceiling limit). One PBZ air sample measured arsenic concentrations above the adjusted U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) and the adjusted American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLV®) of 5.6 $\mu g/m^3$. Beryllium concentrations ranged from less than 0.02 to 0.37 $\mu g/m^3$ with the highest concentration found while workers torch cut on the boiler casing. One sample was above the adjusted NIOSH REL of 0.28 $ug/m^3$. Thirty-eight percent (16 of 42) of the samples were above the adjusted NIOSH RELs for nickel of 8.4 $\mu g/m^3$, and 19 % (8 of 42) of the samples were above the adjusted ACGIH proposed TLV for nickel of 28 $\mu g/m^3$ in the ACGIH Notice of Intended Changes, and Cristobalite silica was detected in one PBZ air sample at a concentration of 0.03 $mg/m^3$, which was above the adjusted NIOSH REL and ACGIH TLV of 0.028 $mg/m^3$. Bulk sample analysis revealed that settled dust collected from working surfaces on the exterior and interior of the boiler contained metals that were identified in the PBZ air samples. The grayish scale/slag that was forcibly remove from the boiler elements contained approximately 40 times the concentration of arsenic when compared to settled dust and fly ash collected at various sites inside and outside the boiler. Air arc gouging, welding, oxygen/acetylene torch cutting, or grinding on or near the scale greatly increases the potential for the generation of airborne particles.

A small percentage of the PBZ air samples for arsenic and nickel exceeded adjusted exposure criteria while boilermakers removed secondary inlet and secondary outlet boiler elements and removed and replaced portions of the steel boiler casing.  One PBZ air sample detected cristobalite silica.  Bulk sample analysis revealed that the grayish boiler element scale/slag contained approximately 40 times the concentration of arsenic when compared to settled dust and fly ash collected at the power plant. Because of these observations, there appears to be a potential for a health hazard to exist at job sites where similar activities take place.  Recommendations are made to reduce worker exposures to these contaminants through the use of engineering controls and improvements in housekeeping procedures.

Keywords: SIC 4911 (Electric services) electricity generation, coal-fired power plant, coal-fired power station, fly ash, arsenic, heavy metals, crystalline silica, lead, beryllium, nickel, boilermakers, welding, air arc gouging, torch cutting, boiler elements.

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# INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) conducted a site visit at the Clinch River Power Plant on September 25-28, 1995, in response to a health hazard evaluation (HHE) request by the Building and Construction Trades Department of the American Federation of Labor and Congress of Industrial Organizations (AFL-CIO). The request raised concerns about exposures to arsenic, other heavy metals, and silica encountered by workers during the rebuilding of coal-fired boilers. Health concerns mentioned in the request included respiratory diseases and skin irritation.

On September 25, 1995, the NIOSH evaluation began with an opening conference attended by representatives from the American Electric Power System (AEP), Appalachian Power Company (APCO), Clinch River Power Plant, Boilermakers (BM) Union Local 45, and Babcock and Wilcox (B&W) Construction Company to discuss the purpose and scope of the HHE. Following this meeting, a walk-through inspection of boiler unit #1 was conducted to identify specific work areas and job tasks of the boilermakers and laborers and to devise a sampling scheme. On September 26 and 27, personal breathing zone (PBZ) air samples were collected for metals, respirable dust, and silica. Bulk fly ash samples and hand wipe samples were also collected. On February 16, 1996, an interim letter was sent to the individuals represented at the opening conference and the Centers to Protect Workers' Rights reporting the environmental monitoring results and preliminary recommendations. This final report reiterates those results and expands on the recommendations made earlier by NIOSH investigators.

# BACKGROUND

The Clinch River Power Plant (CRPP) is located on the banks of the Clinch River near Cleveland, Virginia. It is owned by APCO, one of seven operating companies in AEP. Construction of the three 235 Megawatt units began in 1958 and was completed by 1961. CRPP has a generating capacity of 705 Megawatts and an annual coal consumption of approximately 1.6 million tons. At the time of the NIOSH investigation, CRPP was burning coal mined in Toms Creek, Cane Patch, and Clinchfield, Virginia.

Each unit has seven coal pulverizers that can grind approximately 29,600 pounds of coal per hour to face powder consistency. The pulverized coal is mixed with hot air supplied by two force draft fans (2,000 horsepower per fan, 572,000 cubic feet per minute) and injected into the boiler through the burners. The pulverized coal is ignited with fuel oil on the burner side of the boiler. The boilers (steam generators) are 10 stories high and constructed of several thousand feet of water-wall tubes, refractory brick, and steel wall casing with an exterior insulation liner that is covered with aluminum panels. Inside the boiler, there are several thousand feet of boiler elements (water tubes). The secondary superheater (inlet and outlet), reheat superheater (inlet and outlet), primary superheater (inlet and outlet), and economizer boiler elements are located on the gas side of the boiler. Water circulating through both the water-walls and boiler elements is heated at extremely high temperatures and converted to steam at a pressure of approximately 2,000 pounds per square inch and a temperature of 1,050 degrees Fahrenheit (°F). The steam is delivered through thick-walled alloy steel pipes at 1.6 million pounds of steam per hour to each pair of turbines. The turbine shafts are attached to large electric magnets that are spun inside coils of heavy copper conductors, thus generating electricity.

In September 1995, boiler unit #1 was shut down for maintenance. In general, CRPP and B&W Construction Company planned to remove and replace the boiler elements (from economizers to the secondary inlet superheaters) and portions of the rear boiler casing. Sixty-one contract employees (36 on the day shift and 25 on the night shift) worked at CRPP during the outage. The focus of this HHE was on the thirty-two boilermakers and the four laborers who worked the day shift.

Prior to entering boiler unit #1, interior surfaces were cleaned with high pressure water. During air monitoring, boilermakers removed the secondary inlet and secondary outlet boiler elements and removed and replaced portions of the boiler casing on the south wall. Laborers maintained walkways and prepared work areas by dry sweeping and vacuuming. According to the contractors, initial clearance air monitoring results were below the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for arsenic. Therefore, contract employees were not required to use respiratory protection. However, workers were observed wearing 3M™ 6200 half-face air-purifying respirators with 3M 2040 (dust, fume, radionuclides, asbestos) replaceable high efficiency particulate air filters or disposable dust/mist particulate respirators, at their own discretion. Contract workers issued 3M 6200 half-face air-purifying respirators had respirator fit tests and were in a respiratory protection program. The boiler outage was on a strict time schedule. Thus, employees worked six 10-hour workdays, which equates to a 60-hour workweek. Because of this increase in hours worked per week, the PBZ air sample results are compared to adjusted occupational exposure limits.

# EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 even though 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 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)[1], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVS®)[2] and (3) the U.S. Department of Labor, OSHA permissible exposure limits (PELs)[3].
In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVS, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

Evaluation criteria for chemical substances are usually based on the average PBZ exposure to the airborne substance over an entire 8- to 10-hour workday during a 40-hour workweek, expressed as a time-weighted average (TWA). Personal exposures are usually expressed in parts per million (ppm), milligrams per cubic meter ($mg/m^3$), or micrograms per cubic meter ($\mu g/m^3$). To supplement the 8-hr TWA where there are recognized adverse effects from short-term exposures, some substances have a short-term exposure limit (STEL) for 15-minute peak periods; or a ceiling limit, which is not to be exceeded at any time. Additionally, some chemicals have a "skin" notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

## Arsenic

Exposure to inorganic arsenic can produce dermatitis (skin inflammation), keratoses (horny growths on the skin), peripheral neuropathies (diseases of the nerves of the extremities), peripheral vascular diseases (diseases of the arteries and veins of the extremities), and cancer of the skin, liver, and lungs. Arsenic is absorbed primarily via inhalation and ingestion. Ingestion from hand to mouth contact may result in absorption of toxicologically significant amounts of arsenic.[4]

Inorganic arsenic is eliminated from the body through metabolism and urinary excretion. The total amount excreted in urine accounts for about 60% of the absorbed amount. Inorganic arsenic metabolites appear in urine shortly after the start of exposure. The concentration rises slowly during the first days of the exposure, and then levels off. If a worker's exposure on following days is similar, the arsenic concentration in urine remains more or less the same.

The NIOSH REL (15-minute ceiling limit) is 2 $\mu g/m^3$, and the OSHA PEL is 10 $\mu g/m^3$ as an 8-hr TWA (maximum of 40 hours per week). The ACGIH TLV for inorganic arsenic is 10 $\mu g/m^3$ as an 8-hr TWA, with the designation of confirmed human carcinogen. The ACGIH Biological Exposure Index (BEI®) for arsenic is 50 micrograms per gram ($\mu g/g$) of creatinine for inorganic arsenic metabolites in urine measured in workers at the end of the workweek. Since arsenic concentrations in urine are dependent on urine output, they are normalized with reference to creatinine concentration in the sample. Creatinine is usually excreted from the body in urine at a constant rate. Both NIOSH and OSHA consider inorganic arsenic to be a potential occupational carcinogen. NIOSH and ACGIH recommend that occupational exposures to arsenic be lowered to the lowest feasible concentration.

Sources of non-occupational exposure to arsenic are drinking water, food, and polluted air.[5] Cigarette smoking is also a source of exposure to arsenic (12 to 42 $\mu g$/cigarette).[6] Therefore, arsenic is found in the urine of people who have no occupational exposure. Concentrations of inorganic arsenic and its metabolites in the urine of the general population are usually below 10 micrograms per liter ($\mu g/L$) in European countries, but slightly higher in the United States.[7]

## Beryllium

Beryllium may cause dermatitis, acute pneumonitis (lung inflammation), and chronic pulmonary granulomatosis (berylliosis - multiple nodular inflammatory lesions) in humans.[8] Various parts of the respiratory tract may be involved, with inflammation of the mucus membrane of the nose, throat, trachea, and bronchi and pneumonitis.[9] The pneumonitis may be fulminating (rapid worsening) following high exposure levels, or less severe, with gradual onset, from lesser exposures.[8, 10] A variety of beryllium compounds and some of its alloys have induced malignant tumors of the lung in rats and monkeys and osteogenic sarcoma (disease of the bone) in rabbits. Epidemiologic studies are strongly suggestive of a carcinogenic effect in humans.[11] The NIOSH REL is 0.5 $\mu g/m^3$, the ACGIH TLV is 2 $\mu g/m^3$, and the OSHA PEL is 2 $\mu g/m^3$, expressed as TWAs over an 8- to 10- hr workday (maximum of 40 hours per week).

NIOSH and ACGIH recommend that occupational exposures to beryllium be lowered to the lowest feasible concentration. It is important to note that ACGIH has changed the carcinogenicity designation for beryllium from a suspected human carcinogen (A2) to a confirmed human carcinogen (A1).

## Cadmium

Exposure to cadmium produces a wide variety of effects involving many organs and systems. Although acute health effects from overexposure to cadmium have been reported, currently, in most occupational settings, chronic effects are of greater concern.

Cadmium poisoning has been reported from acute overexposure to cadmium oxide fumes; the principal symptom is respiratory distress due to chemical pneumonitis and edema.[8] In one situation with a very high level of exposure (40-50 mg/m$^3$ for 1 hour), death was reported.[8]

Long-term occupational exposure to cadmium is most strongly associated with an increased occurrence of lung cancer, kidney damage, and chronic obstructive lung disease.[12] The total amount of cadmium exposure affects the risk of developing disease. This risk increases as the number of years and the level of cadmium exposure increase.

The kidney is thought to be the organ most sensitive to the toxic effects of cadmium. Kidney damage caused by cadmium exposure occurs when cadmium accumulates in the kidneys. The damage can progress over time and is irreversible. Chronic lung injury develops in workers in relation to the time and level of exposure. Effects on the lung occur quite slowly. The exposure level at which these effects occurs is unknown. The level of exposure linked with lung damage, however, is thought to be above that which causes kidney damage.

NIOSH considers cadmium to be a potential human carcinogen.[13] Two types of cancer have been of concern -- lung and prostate cancer. Although the evidence linking overexposure to cadmium with lung cancer is strong, the evidence linking cadmium exposure with prostate cancer is weaker.[14]

Although NIOSH considers cadmium to be a potential occupational carcinogen, an REL has not been established. The ACGIH TLV and OSHA PEL for cadmium are 10 and 5 ug/m$^3$, respectively, as an 8-hr TWA.

## Lead

Chronic lead exposure has resulted in nephropathy (kidney damage), gastrointestinal disturbances, anemia, and neurologic effects.[8] These effects may be felt as weakness, fatigue, irritability, high blood pressure, mental deficiency, or slowed reaction times. Exposure also has been associated with infertility in both sexes and fetal damage.[15] The OSHA PEL for lead is 50 µg/m$^3$, while the current ACGIH TLV is 50 µg/m$^3$. ACGIH has designated lead as an animal carcinogen.[2] The U.S. Public Health Service has established a national public health goal to eliminate all occupational exposures that result in BLLs greater than 25 **µ**g/dL by the year 2000.[16] NIOSH supports the Public Health Service goal and recommends that to minimize the risk of adverse health effects, employers and workers should continually strive to reduce workplace lead exposures.

## Nickel

Nickel is one of the most common causes of allergic contact dermatitis ("nickel-itch").[17] The condition has been seen in various occupations including hairdressers, nickel platers, and jewelers. Once a worker is sensitized to nickel, the sensitivity persists after the exposure is removed.[8] The major route of exposure to nickel and nickel compounds is through inhalation.[18] Inhalation exposures have been associated with cancer of the lung and of the nasal sinuses in workers employed in nickel refineries and smelters.[19] Although not common, other health effects of nickel inhalation exposures include nasal irritation, damage to the nasal mucosa, perforation of the nasal septum, loss of smell, pneumoconiosis, and allergic asthma.

The NIOSH REL and OSHA PEL for nickel metal as an 8- to 10-hour (maximum of 40 hours per week) TWA are 15 $\mu g/m^3$ and 1000 $\mu g/m^3$, respectively.[1,3] NIOSH considers nickel to be a potential occupational carcinogen and therefore, recommends that exposures be reduced to the lowest feasible concentration. ACGIH has reported in the Notice of Intended Changes (for 1996) a TLV for nickel of 50 $\mu g/m^3$ with an A1 designation (confirmed human carcinogen).[2]

## Titanium Dioxide

Titanium dioxide is a mild pulmonary irritant generally considered to be a nuisance dust.[8] In the lungs of workers processing titanium dioxide pigment, dust deposit findings indicate that titanium dioxide is a minor pulmonary irritant. Rats repeatedly exposed to concentrations of 10 to 328 million particles per cubic foot of air for up to 13 months showed small focal areas of emphysema, attributable to large deposits of dust.[8] There was no evidence that titanium dioxide produced any specific lesion.

A two year research study where rats were exposed to 250 $mg/m^3$ of titanium dioxide resulted in the development of squamous cell carcinomas in 13 of 74 female rats and in 1 of 77 male rats, as well as an increase in bronchoalveolar adenomas, another type of tumor. No excess tumor incidence was noted at 50 $mg/m^3$. The authors of that study questioned the biologic relevance of these tumors to humans, given the extremely high exposure concentrations, the unusual histology and the location of the tumors, and the absence of metastasis (spread of disease from one part of the body to another).[20] The NIOSH REL is 0.2 $mg/m^3$. Also NIOSH considers titanium dioxide to be a potential occupational carcinogen and recommends that exposures be reduced to the lowest feasible concentration.[1, 20] The ACGIH TLV for titanium dioxide is 10 $mg/m^3$ as an 8-hour TWA.[2] The OSHA PEL is 15 $mg/m^3$ as an 8-hour TWA.[3]

## Unusual Work Schedules

The above evaluation criteria are based on 8- to 10-hour workdays and 40-hour workweeks. During this outage, employees worked six 10-hour workdays, which equates to a 60-hour workweek. Because of this significant increase in hours worked per week, consideration should be given to modifying the evaluation criteria. The rationale for adjusting occupational exposure limits for unusual work schedules is to assure, as much as possible, that persons on these schedules are placed at no greater risk of injury or discomfort than persons who work a standard 8-hour workday, 40-hour workweek.[21] As a tentative guide, The Brief and Scala Model cited in the ACGIH TLV booklet is intended to apply to work schedules longer than 8-hour workdays or 40-hour workweeks.[22] For example, the ACGIH TLV for arsenic is 10 $\mu g/m^3$. When adjusting this exposure limit based on hours worked per week,

$$\frac{40}{h} \times \frac{168 - h}{128} = \text{TLV™ reduction factor}$$

h = hours worked per workweek

the adjusted exposure limit is 5.6 $\mu g/m^3$. This formula can be used with OSHA PELs and NIOSH RELs. The PBZ sample results in Tables 1 and 2 are compared to adjusted exposure limits calculated according to the above formula.

# METHODS

## Metals

Full-shift PBZ air samples were collected from 29 workers (25 boilermakers and 4 laborers) on both September 26 and 27, 1995, while they worked on boiler unit #1. Over these two days, NIOSH investigators collected 48 PBZ air samples for heavy metals, 9 PBZ air samples for respirable dust and silica, 8 hand wipe samples, and 12 bulk fly ash samples. In some cases, consecutive PBZ air samples were collected during any one work shift to prevent particulate overloading.

Air samples for metals were collected on 37-millimeter (mm), 0.8 µm pore size cellulose ester membrane filters in clear cassette holders. The filters were attached via flexible Tygon® tubing to personal sampling pumps and the sampling trains were calibrated at a flow rate of 2 liters per minute (Lpm). The samples were analyzed for 28 elements using NIOSH analytical method 7300.[23] The method was modified for microwave digestion and standard matrix matching of samples. A Thermo Jarrell Ash ICAP-61 inductively coupled plasma (ICP) emission spectrometer controlled by a Digital DEC Station 333c personal computer was used for all measurements. The analytical limits of detection (LOD) for arsenic, beryllium, cadmium, lead, and titanium were 0.05, 0.02, 0.01, 0.08, and 0.06 µg/filter, respectively; which equates to minimum detectable concentrations (MDC) of 0.04, 0.02, 0.008, 0.07, and 0.05 µg/m$^3$, respectively, using a 1200 liter sample volume. The analytical limit of quantitation (LOQ) for arsenic, beryllium, cadmium, lead, and titanium were 0.17, 0.06, 0.02, 0.27, and 0.19 µg/filter, respectively; which equates to minimum quantifiable concentrations (MQC) of 0.14, 0.05, 0.02, 0.23, and 0.16 µg/m$^3$, respectively, using a 1200 liter sample volume. It is important to note that the PBZ air sample results at the end of this document report titanium as titanium dioxide for comparison with the evaluation criteria.

Bulk fly ash samples were collected from areas in and around boiler #1. The exterior samples where collected from surfaces representative of areas where employees worked. The samples were collected in glass vials, labeled, and shipped to the analytical laboratory, and analyzed for selected metals using NIOSH method 7300 as described above. The analytical LODs for arsenic, beryllium, cadmium, lead, and titanium were 0.3, 0.08, 0.02, 0.5, and 0.3 µg/g, respectively. The LOQs for arsenic, beryllium, cadmium, lead, and titanium were 0.72, 0.26, 0.04, 1.6, and 0.76 µg/g, respectively.

Hand wipe samples were collected to quantitatively identify metal contaminants on workers' hands. The hand wipe samples were collected on Wash'n Dri ® moist disposable towelettes and analyzed for selected metals using NIOSH analytical method 7300 as described above. The LODs and LOQs were the same as for the PBZ samples reported above. The employee hand wipe samples were collected in three steps. NIOSH investigators supplied the towelettes to the workers. They were instructed to unfold the towelette completely and wipe both hands including palms, the back of the hand, the cuticles, the fingers, and between the fingers continuously for thirty seconds. They were then instructed to place the towelette into a Zip-Lock™ plastic bag held by the NIOSH investigator which was then sealed.

## Respirable Particulate and Silica

The respirable particulate and silica samples were collected on tared 37 mm, 5 µm pore size polyvinyl chloride (PVC) membrane filters mounted in 10 mm nylon Dorr-Oliver cyclones. The filters were attached via flexible Tygon tubing to personal sampling pumps and the sampling trains were calibrated at a flow rate of 1.7 Lpm. The samples were weighed by gravimetric analysis according to NIOSH analytical method 0600[23] with two modifications. The filters were stored in an environmentally controlled room to reduce the stabilization time between tare weighings from 8-16 hours to 5-10 minutes, and the backup pads and filters were not vacuum desiccated. The instrumental precision of the weighings was ± 0.02 milligrams (mg).

After the gravimetric analysis, the samples were analyzed for crystalline silica (quartz and cristobalite) using X-ray diffraction. NIOSH analytical method 7500[23] was used with the following modifications: (1) filters were dissolved in tetrahydrofuran rather than being ashed in a furnace; and (2) standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure. The LODs for quartz and cristobalite for this method were 0.01 mg/sample and 0.02 mg/sample, respectively; which equates to MDCs of 0.008 and 0.02 mg/m$^3$, respectively, using a sample volume of 1200 liters. The LOQ for both quartz and cristobalite for this method were 0.03 mg/sample which equates to MQCs of 0.03 mg/m$^3$, using a sample volume of 1200 liters.

# RESULTS

On September 26, boilermakers removed thirty-one elements (secondary outlet) from the interior of boiler unit #1 and a large section of the exterior boiler casing on the element side of the boiler (rear or south wall). Six to seven workers were inside the boiler for the entire work shift except during lunch and the morning and afternoon breaks. During the 10-hour work shift, workers air arch gouged and torch cut the elements, and then rigged them with cable so the elements could be hoisted out of the boiler. Because the elements were removed one at a time, air arch gouging and torch cutting was intermittent but continued most of the day. Immediately outside the boiler, two or three workers, along with two tug operators, raised the elements out of the boiler and lowered them to ground level (turbine floor). At this point, another group of three to five workers, including a forklift operator, loaded the elements onto a forklift, moved them to the yard, and placed them onto a trailer. On the exterior wall, eight to ten workers removed portions of the steel boiler casing by air arch gouging, torch cutting, and grinding. There was also limited amounts of shielded metal arch welding (SMAW), or “stick welding,” conducted while preparing this area for a new casing. Laborers maintained walkways and prepared work areas by dry sweeping and vacuuming throughout the work shift.

On September 27, boilermakers removed thirty-seven elements (secondary inlet) and several element supports from the interior of the boiler and prepared and installed the steel boiler casing on the exterior of the boiler. Six to seven workers were inside the boiler for the entire work shift except during lunch and the morning and afternoon breaks. Until early afternoon, workers removed boiler elements as described earlier. During the rest of the day, three workers removed the element supports by air arch gouging. Visual observations of this activity identified high levels of airborne dust and fume which appeared to be much higher than previous activities observed during the NIOSH visit. On the exterior wall, eight to ten workers prepared and installed the steel boiler casing. Job tasks included torch cutting, grinding, and stick welding. Grinding and torch cutting were conducted intermittently throughout the work shift. Stick welding was conducted continuously throughout the entire 10-hour work shift. Laborers maintained walkways and prepared work areas by dry sweeping and vacuuming throughout the work shift.

Full-shift PBZ air samples were collected from boilermakers working inside the boiler removing boiler elements, on the exterior of the boiler raising the elements out of the boiler and lowering them to the turbine floor, moving the elements from the turbine floor to the plant yard, and removing and replacing the steel boiler casing on the south wall of unit # 1. Also during this time, full-shift PBZ air samples were collected from laborers maintaining walkways and preparing work areas outside the boiler. One worker’s PBZ air samples for both sample days was eliminated from the data sets because of suspected tampering. Another air sample was removed from the data set because the filter cassette broke off of the sample train and the exact sampling time period was not known. Lastly, the boilermakers and laborers worked six 10-hour work shifts (60-hour workweek) and the evaluation criteria are based on a 40-hour workweek. This is a 50% increase in hours worked per week. As mentioned in the Evaluation Criteria section of this report, the exposure limits should be adjusted to reflect the significant increase in hours worked per week, as was done in this report.

## Metals

The PBZ air sample results for metals are presented in Tables 1 and 2. Only the results for the metals with the greatest toxicological significance and found at the highest concentration are presented. The tables are divided into two categories, ***boilermakers*** and ***laborers***. The boilermaker category was then subdivided into two other categories based on job task location, ***interior of boiler*** and ***exterior of boiler***.

Arsenic concentrations ranged from less than 0.04 to 5.7 $\mu g/m^3$. The highest concentrations were found during sample periods where job tasks such as torch cutting (oxygen and acetylene) on the boiler casing and air arch gouging on boiler elements and element supports were performed. Six samples were above the NIOSH REL of 2 $ug/m^3$ (15 minute ceiling limit). One sample was above the adjusted OSHA PEL and ACGIH TLV of 5.6 $\mu g/m^3$. Beryllium concentrations ranged from less than 0.02 to 0.37 $\mu g/m^3$ with the highest concentration found while workers torch cut on the boiler casing. One sample was above the adjusted NIOSH REL of 0.28 $ug/m^3$. Berylium air samples were below the adjusted OSHA PEL and ACGIH TLV of 1.1 $ug/m^3$. Cadmium concentrations ranged from less than 0.008 to 0.36 $\mu g/m^3$ with the highest concentrations found while workers cut the boiler elements by air arch gouging or torch cutting. Samples were below the adjusted ACGIH TLV of 5.6 $ug/m^3$ and the adjusted OSHA PEL of 2.8 $ug/m^3$. Lead concentrations ranged from less than 0.07 to 3.3 $\mu g/m^3$. The highest concentration was found while workers torch cut on the boiler casing. Samples were below the adjusted OSHA PEL and ACGIH TLV of 28 $ug/m^3$. Nickel concentrations ranged from less than 0.3 to 358.0 $\mu g/m^3$. The highest concentrations were found while workers performed various tasks inside the boiler. Approximately 38% (16 of 42) of the samples were above the adjusted NIOSH REL for nickel of 8.4 $ug/m^3$. Nineteen percent (8 of 42) of the samples were above the adjusted ACGIH proposed TLV for nickel of 28 $\mu g/m^3$. Titanium dioxide concentrations ranged from 1.7 to 169 $\mu g/m^3$ with the highest concentrations found while workers torch cut on the boiler casing. One sample was above the adjusted NIOSH REL of 112 $ug/m^3$.

## Respirable Particulate / Silica

The respirable particulate PBZ air sample concentrations ranged from less than 0.02 to 7.0 $mg/m^3$, with a mean concentration of 1.1 $mg/m^3$. The highest concentrations were found while workers performed tasks inside the boiler, including air arc gouging boiler elements and element supports and torch cutting boiler elements. The above PBZ air samples were also analyzed for cristobalite and quartz crystalline silica. Cristobalite silica was detected in one PBZ sample at a concentration of 0.03 $mg/m^3$. This concentration was above the adjusted NIOSH REL and ACGIH TLV of 0.028 $mg/m^3$. Quartz silica concentrations were below the MDC of 0.008 $mg/m^3$. It is important to note that NIOSH considers crystalline silica a potential occupational carcinogen and recommends that airborne concentrations be reduced to the lowest feasible concentration.

One respirable dust sample was analyzed for metals because the worker air arc gouged boiler elements and element supports a majority of the 10-hour work shift. The highest respirable dust and arsenic concentrations collected during the survey were found in this sample with concentrations of 7.0 $mg/m^3$ and 6.2 $\mu g/m^3$, respectively. Beryllium and cadmium were not detected. Nickel, lead, and titanium dioxide concentrations were 24, 1.3, and 10.3 $\mu g/m^3$, respectively. It should be noted that evaluation criteria for metals are based on total particulate matter; therefore, the above sample, which represents only the respirable fraction, will not be compared to the criteria. However, air arch gouging can produce airborne particulate matter greater than the respirable fraction and actual airborne concentration of arsenic and other metals may have been higher.

## Bulk Samples

The bulk sample analytical results are presented in Table 3. Samples are divided into two categories, ***interior of the boiler*** and ***exterior of the boiler***. The analysis revealed that settled dust collected from working surfaces on the exterior and interior of the boiler contained metals that were identified in the PBZ air samples. When compared to bulk samples collected from another power plant which burns eastern-bituminous coal, the arsenic, nickel, and lead concentrations at CRPP were lower. Beryllium and cadmium concentrations were similar.[24]

## Hand Wipe Samples

Hand wipe samples were collected to quantitatively identify metal contaminants on workers' hands. The hand wipe sample results revealed that workers may be exposed to low levels of arsenic, beryllium, cadmium, lead, nickel, and other metals through ingestion. Of the eight workers for which hand wipes were collected, six washed their hands before a hand wipe sample was collected. The mean arsenic, beryllium, cadmium, lead, and nickel concentrations of the workers that washed their hands were 3.1, trace, 2.3, 4.2, and 23 µg/wipe, respectively. The mean arsenic, beryllium, cadmium, lead, and nickel concentrations of the workers that did not wash their hands were 4.8, trace, 1.5, 7.8, 32 µg/wipe, respectively.

# DISCUSSION / CONCLUSION

In general, the highest PBZ air sample concentrations of arsenic, beryllium, cadmium, nickel, lead, and respirable dust were found during sample periods where boilermakers performed job tasks inside the boiler or outside the boiler on the steel boiler casing. PBZ air sample concentrations for arsenic, lead, nickel, and titanium dioxide were higher on the second day of air monitoring which was most likely due to the noticeable increase of air arch gouging inside the boiler. Six PBZ air samples contained arsenic concentrations above the NIOSH REL of 2 ug/m$^3$ (15 minute ceiling limit). One PBZ air sample was above the adjusted OSHA PEL and adjusted ACGIH TLV for arsenic of 5.6 µg/m. Approximately 38% (16 of 42) of the PBZ air samples were above the adjusted NIOSH REL for nickel of 8.4 ug/m$^3$, and 19% (8 of 42) of the samples were above the adjusted ACGIH proposed TLV for nickel of 28 µg/m$^3$. Cristobalite silica was detected in one PBZ air sample at a concentration of 0.03 mg/m$^3$; this concentration was above the adjusted NIOSH REL and ACGIH TLV of 0.028 mg/m$^3$. Two respirable dust PBZ air samples were above the adjusted OSHA PEL of 2.8 mg/m$^3$ and the adjusted ACGIH TLV of 1.7 mg/m$^3$. It is important to note that NIOSH considers arsenic, beryllium, cadmium, nickel, silica, and titanium dioxide as potential occupational carcinogens.

The bulk sample analysis revealed that settled dust collected from working surfaces (areas where workers perform job tasks) on the exterior and interior of the boiler contained metals that were identified in the PBZ air samples. Effort was taken to minimize the amount of settled dust and fly ash on the interior and exterior of boiler unit #1. Before work began inside the boiler, interior surfaces were cleaned with high pressure water. Throughout the survey, laborers cleaned walkways and work areas by dry sweeping and vacuuming. An important finding regarding bulk samples involves the analysis of the boiler element scale. The grayish scale/slag that was forcibly removed from the boiler elements contained approximately 40 times the concentration of arsenic when compared to settled dust and fly ash collected at various sights inside and outside the boiler. The scale/slag is not easily aerosolized; however, air arc gouging, welding, oxygen/acetylene torch cutting, or grinding on or near the scale greatly increases the potential for the generation of airborne particles.

Hand wipe samples showed the presence of various metals even when workers washed their hands prior to sample collection. Thus, hand to mouth contact can contribute to the employees' overall metal exposure. For metals such as arsenic and lead, ingestion is a significant route of exposure, and may lead to the absorption of toxicologically significant quantities of these metals. Also, cigarette smoking itself is a source of exposure to arsenic (12 to 42 μg per cigarette).

Inside the boiler, control measures for reducing airborne concentrations include using local exhaust ventilation, opening the stack dampers to create a natural draft (please refer to Appendix A at the end of this report), and operating the induced draft fans (if applicable). Outside the boiler, control measures include local exhaust ventilation, good work practices, and improved housekeeping procedures.

As mentioned earlier, contract employees did not have to use respiratory protection because initial clearance air monitoring results were below the OSHA 8-hr TWA PEL for arsenic. During the survey, however, contract workers were observed wearing half-face air-purifying respirators with dust, fume, radionuclides, and asbestos replaceable high efficiency particulate air filters, or disposable dust/mist particulate respirators at their own discretion. Contract workers issued half-face air-purifying respirators had respirator fit tests and were in a respiratory protection program. NIOSH investigators identified some deficiencies with the program. Several half-face air-purifying respirators were found on scaffolding, soot blowers, and rafters around boiler unit #1 with no protective container for the respirator. Most of these surfaces were contaminated with metals identified in the bulk settled dust sample results. If a worker dons a respiratory that has dust inside the face-piece, the dust can be inhaled which is contrary to the purpose of wearing a respirator. In addition, dust between the respirator face seal and the person's face, could cause skin irritation. Moreover, with compounds like arsenic and nickel in the settled dust and fly ash, more severe dermatological conditions may arise. Three contract workers who wore respirators had long mustaches and facial hair that appeared to adversely affected the face-to-respirator seal.

Welding, torch cutting, and air arch gouging were conducted continuously around boiler unit #1 throughout the NIOSH investigation. While observing workers' activities, NIOSH investigators found that, for the most part, these activities were not shielded to prevent optical radiation hazards. Welding shields are effective for preventing optical radiation hazards, and they should be used throughout the plant when conducting welding, torch cutting, and air arch gouging activities. It should be noted that the shields should be arranged so that ventilation is not restricted. On a few occasions, sparks and hot metal were observed falling through the grated floors of the power plant down several floors creating a safety hazard for workers below. In one instance, fire-retardant fabric was put down over the metal-grated floors to contain the sparks and hot metal pieces. This is an effective control measure that should routinely be used.

# RECOMMENDATIONS

Based on the air, bulk, and hand wipe sample data, the NIOSH investigators determined that a health hazard from exposures to metals in the settled dust and fly ash existed at the Clinch River Power Plant during the rebuilding of boiler unit #1. The following recommendations are offered to improve the health and safety conditions for boilermakers and laborers during further rebuilding of boilers.

1. Workers' exposures to arsenic and other heavy

metals in settled dust and fly ash should be reduced through the use of engineering controls. Engineering controls include using local exhaust ventilation, opening the stack dampers to create a natural draft (if possible), and operating the induced draft fans (if applicable) to ventilate the boiler during rebuilding processes. For arsenic, the requirements outlined in the OSHA regulation (29 CFR 1926.1018,)[25] should be followed. This standard includes provisions for periodic exposure monitoring, implementation of engineering and work practice controls where overexposure occurs, use of respiratory protection while engineering controls are being implemented or when controls are not sufficient to reduce employee exposures to or below the OSHA PEL, provision of clean protective clothing and lunchroom facilities, establishment of a medical surveillance program, and employee notification, education, and training.

2. Housekeeping procedures should be improved. The bulk sample results revealed that settled dust and fly ash collected from the interior and exterior of the boiler are similar, except for the boiler element scale which has much higher arsenic concentration. By removing settled dust and fly ash from working surfaces before work begins, the potential for airborne exposures can be reduced. However, while vacuuming is an effective cleaning measure, dry sweeping should be avoided because it can greatly increase airborne concentrations of dust and fly ash. When removing settled dust and fly ash, dry methods (shoveling and sweeping) should be replaced with wet methods and/or high efficiency particulate air vacuum-cleaning methods to minimize aerosolization of settled dust.

3. If worker exposures can not be reduced through the use of engineering controls and improved housekeeping procedures, then respiratory protection should be used. Although a respiratory protection program was in place, certain elements, (e.g., respirator storage, employee training, and facial hair) were deficient. The respirator protection program should, at a minimum, comply with the requirements described in 29 CFR 1910.134.[26] Publications developed by NIOSH can also be referenced when developing an effective respirator program including the NIOSH Respirator Decision Logic and the NIOSH Guide to Industrial Respiratory Protection.[27, 28]

4. The hand wipe sample results revealed that employees are exposed to arsenic, cadmium, lead, and other heavy metals through ingestion. Smoking and eating in areas where exposures to settled dust and fly ash can occur should be eliminated. Workers should be required to thoroughly wash their hands and face prior to eating or other activities that would increase hand-to-mouth contact.

5. Welding, torch cutting, and air arc gouging should be shielded to eliminate optical radiation hazards and prevent the sparks and hot metal from falling through the grated floors. Shields should be arranged so that ventilation is not restricted. At a minimum, work practices must conform to OSHA standards 1926.350 - 354.[29]

6. Initial clearance monitoring should not be restricted to evaluating just arsenic exposures. As was seen in these results, nickel exposures can also be present.

7. The exposure criteria should be adjusted to reflect the increase in hours worked per week. The Brief and Scala model for adjusting exposure criteria to accommodate extended work periods is one method that can be used. All employers need to be familiar with the rationale for this kind of evaluation criterion adjustment.

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## TABLE 1
## Personal Breathing Zone Air Samples for Metals
## HETA 95-0393
## September 26, 1995

**Note: Table 1 continued on next page**

| Job Task / Location (floor) | Sample time (military) | Concentrations, micrograms per cubic meter ($ug/m^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | **As** | **Be** | **Cd** | **Pb** | **Ni** | **$TiO_2$** |
| **BOILERMAKERS** | | | | | | | |
| INTERIOR OF BOILER | | | | | | | |
| air arch, rig & remove elements | 0713 - 1709 | Trace | ND | ND | Trace | Trace | 4.0 |
| rig & remove elements | 0656 - 1155 | 1.4 | Trace | 0.06 | 0.74 | 147 | 22.0 |
| torch cut, rig & remove elements | 0640 - 1712 | 1.1 | ND | 0.36 | 0.67 | 136.0 | 21.5 |
| air arch element support cables & rig elements | 0655 - 1712 | 1.4 | ND | ND | 0.81 | 186.3 | 26.2 |
| rig & remove elements | 0700 - 1707 | 0.44 | ND | 0.02 | 0.38 | 107.0 | 6.2 |
| EXTERIOR OF BOILER | | | | | | | |
| air arch & weld boiler casing / ($6^{th}$) | 0708 - 1706 | 0.42 | Trace | 0.04 | 0.70 | Trace | 9.8 |
| air arch & weld boiler casing / ($6^{th}$) | 0652 - 1715 | 0.66 | ND | 0.02 | 0.51 | Trace | 6.7 |
| grind & weld boiler casing / various floors | 0651 - 1715 | 0.51 | Trace | Trace | 0.52 | 1.4 | 7.6 |
| torch cut & grind boiler casing / ($6^{th}$) | 0702 - 1711 | 1.9 | Trace | 0.03 | 0.57 | Trace | 12.0 |
| grind & remove boiler casing / ($6^{th}$) | 0700 - 1710 | 2.0 | ND | ND | 0.37 | 1.1 | 5.4 |
| grind & remove boiler casing / various floors | 0651 - 1711 | 2.5 | Trace | 0.03 | 1.1 | 5.9 | 9.6 |
| **Minimum Detectable Concentration (MDC)** | | **0.04** | **0.02** | **0.01** | **0.07** | **0.3** | **0.09** |
| **Minimum Quantifiable Concentration (MQC)** | | **0.14** | **0.05** | **0.02** | **0.2** | **1.1** | **0.3** |
| ***Evaluation Criteria** | **NIOSH REL** | **2 C** | **0.2** | **N/A** | **56** | **8.4** | **112** |
| | **OSHA PEL** | **5.6** | **1.1** | **2.8** | **28** | **560** | **8,400** |
| | **ACGIH TLV** | **5.6, A1** | **1.1, A2** | **5.6, A2** | **28, A3** | **[ 28 ]** | **5,600** |

* Adjusted occupational exposure limit using the Brief and Scala model [22] (note: ceiling (C) limit values were not adjusted)

As = arsenic
Cd = cadmium
Ni = nickel
Trace = concentration between MDC and MQC
C = ceiling limit for a 15-minute sample
A1 = confirmed human carcinogen
A3 = animal carcinogen
Be = beryllium
Pb = lead
$TiO_2$ = titanium dioxide
ND = not detected
N/A = not available
A2 = suspected human carcinogen
[ ] = proposed TLV on the ACGIH Notice of Intended Changes

## TABLE 1 (continued)
## Personal Breathing Zone Air Samples for Metals
## HETA 95-0393
## September 26, 1995

| Job Task / Location (floor) | Sample time (military) | Concentrations, micrograms per cubic meter (ug/m³) As | Be | Cd | Pb | Ni | $TiO_2$ |
|---|---|---|---|---|---|---|---|
| **BOILERMAKERS** | | | | | | | |
| EXTERIOR OF BOILER | | | | | | | |
| move elements / (8th) | 0706 - 1714 | Trace | ND | 0.05 | Trace | 29.6 | 4.2 |
| move elements / (8th) | 1235 - 1715 | Trace | ND | Trace | ND | 22.5 | 4.3 |
| move elements / (8th) | 0703 - 1710 | 1.2 | Trace | 0.14 | 0.59 | 7.1 | 33.6 |
| move elements / (8th) | 0705 - 1716 | Trace | Trace | ND | 0.25 | 10.6 | 5.8 |
| move elements / (7th & 8th) | 0705 - 1710 | Trace | ND | ND | ND | Trace | 4.4 |
| move elements / (turbine floor) | 1440 - 1641 | Trace | ND | ND | ND | ND | 2.1 |
| move elements / (turbine floor) | 0711 - 1707 | Trace | ND | 0.03 | Trace | ND | 2.3 |
| forklift operator / (turbine floor) | 0639 - 1705 | ND | ND | ND | Trace | ND | 2.0 |
| move elements in power plant yard | 0653 - 1705 | ND | ND | ND | ND | ND | 1.7 |
| move elements in power plant yard | 0653 - 1654 | ND | ND | ND | ND | 1.2 | 2.0 |
| tug operator / (8th) | 0659 - 1705 | Trace | ND | ND | Trace | 3.4 | 4.1 |
| tug operator / (10th) | 1204 - 1707 | ND | ND | ND | ND | Trace | 1.7 |
| **LABORERS** | | | | | | | |
| EXTERIOR OF BOILER | | | | | | | |
| sweep & vacuum walkways and prepare work areas | 0657 - 1711 | Trace | Trace | 0.17 | Trace | Trace | 14.2 |
| sweep & vacuum walkways and prepare work areas | 0801 - 1709 | Trace | ND | ND | Trace | ND | 3.4 |
| sweep & vacuum walkways and prepare work areas | 0654 - 1615 | Trace | ND | ND | Trace | ND | 3.8 |
| **Minimum Detectable Concentration (MDC)** | | **0.04** | **0.02** | **0.01** | **0.07** | **0.3** | **0.09** |
| **Minimum Quantifiable Concentration (MQC)** | | **0.14** | **0.05** | **0.02** | **0.2** | **1.1** | **0.3** |
| ***Evaluation Criteria** | **NIOSH REL** | **2 C** | **0.2** | **N/A** | **56** | **8.4** | **112** |
| | **OSHA PEL** | **5.6** | **1.1** | **2.8** | **28** | **560** | **8,400** |
| | **ACGIH TLV** | **5.6, A1** | **1.1, A2** | **5.6, A2** | **28, A3** | **[ 28 ]** | **5,600** |

* Adjusted occupational exposure limit using the Brief and Scala model[22] (note: ceiling (C) limit values were not adjusted)

Trace = concentration between MDC and MQC
C = ceiling limit for a 15-minute sample
A1 = confirmed human carcinogen
A3 = animal carcinogen

ND = not detected
N/A = not available
A2 = suspected human carcinogen
[ ] = proposed TLV on the ACGIH Notice of Intended Changes

# TABLE 2
# Personal Breathing Zone Air Samples for Metals
# HETA 95-0393
# September 27, 1995

| Job Task / Location (floor) | Sample time (military) | Concentrations, micrograms per cubic meter (ug/m$^3$) | | | | | |
|---|---|---|---|---|---|---|---|
| | | As | Be | Cd | Pb | Ni | $TiO_2$ |
| **BOILERMAKERS** | | | | | | | |
| INTERIOR OF BOILER | | | | | | | |
| air arch, rig & remove elements (air arch | 0654 - 1709 | 2.1 | Trace | 0.35 | 1.3 | 358.0 | 32.0 |
| air arch elements and element supports (all day) | 0700 - 1705 | 4.5 | ND | ND | 1.5 | 52.1 | 26.7 |
| EXTERIOR OF BOILER | | | | | | | |
| weld boiler casing/ (6$^{th}$) | 1130 - 1711 | 2.1 | Trace | ND | 1.2 | 15.6 | 36.0 |
| weld boiler casing/ (6$^{th}$) | 0826 - 1708 | 1.2 | Trace | 0.12 | 1.2 | 14.4 | 32.6 |
| grind & weld boiler casing/ | 0656 - 1710 | 0.61 | Trace | 0.03 | 0.60 | Trace | 10.42 |
| torch cut & grind on boiler casing / | 0633 - 1712 | 0.44 | Trace | ND | 0.34 | 4.9 | 5.9 |
| torch cut on boiler casing / (6$^{th}$) | 0705 - 1707 | 5.7 | 0.37 | 0.04 | 3.3 | 7.3 | 169.0 |
| torch cut & grind boiler casing / various floors | 0826 - 1445 | 0.45 | Trace | 0.06 | 0.40 | 9.2 | 9.4 |
| grind on boiler casing / various floors | 0658 - 1706 | 1.1 | Trace | 0.07 | 0.7 | 10.0 | 13.6 |
| move elements / (8$^{th}$) | 0652 - 1711 | 1.4 | Trace | 0.07 | 0.65 | 61.4 | 17.9 |
| move elements / (8$^{th}$) | 0702 - 1706 | 0.42 | Trace | 0.13 | 0.22 | 7.9 | 6.5 |
| move elements / (8$^{th}$) | 0628 - 1710 | 0.65 | Trace | 0.05 | 0.43 | 17.9 | 14.5 |
| tug operator / (8$^{th}$) | 0648 - 1708 | 0.36 | Trace | Trace | Trace | 9.4 | 4.7 |
| tug operator / (10$^{th}$) | 0640 - 1705 | Trace | ND | Trace | Trace | 1.3 | 2.4 |
| forklift operator / (turbine floor) | 0650 - 1310 | 0.28 | ND | ND | Trace | ND | 2.9 |
| **LABORERS** | | | | | | | |
| EXTERIOR OF BOILER | | | | | | | |
| sweep & vacuum walkways and prepare work areas | 0659 - 1707 | 0.43 | Trace | ND | 0.41 | 1.8 | 15.4 |
| **Minimum Detectable Concentration (MDC)** | | **0.04** | **0.02** | **0.01** | **0.07** | **0.3** | **0.09** |
| **Minimum Quantifiable Concentration (MQC)** | | **0.14** | **0.05** | **0.02** | **0.2** | **1.1** | **0.3** |
| ***Evaluation Criteria** | **NIOSH REL** | **2 C** | **0.2** | **N/A** | **56** | **8.4** | **112** |
| | **OSHA PEL** | **5.6** | **1.1** | **2.8** | **28** | **560** | **8,400** |
| | **ACGIH TLV** | **5.6, A1** | **1.1, A2** | **5.6, A2** | **28, A3** | **[ 28 ]** | **5,600** |

* Adjusted occupational exposure limit using the Brief and Scala model[22] (note: ceiling (C) limit values were not adjusted)

Trace = concentration between MDC and MQC
C = ceiling limit for a 15-minute sample
A1 = confirmed human carcinogen
A3 = animal carcinogen

ND = not detected
N/A = not available
A2 = suspected human carcinogen
[ ] = proposed TLV on the ACGIH Notice of Intended Changes

**TABLE 3**
**Bulk Samples**
**HETA 95-0393**
**September 27, 1995**

| Description - Location | Concentrations, micrograms per gram of sample (ug/g) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **As** | **Be** | **Cd** | **Ni** | **Pb** | **Al** | **Cr** | **Fe** | **V** | **Zn** | **$TiO_2$** |
| INTERIOR OF BOILER | | | | | | | | | | | |
| grayish scale/slag - scraped from boiler element (secondary outlet elements) | **1600** | 6 | 2 | 53 | 16 | 17000 | 190 | 24000 | 93 | 73 | 340 |
| grayish scale/slag - scraped from boiler element (secondary outlet elements) | **1500** | 3 | 1 | 21 | 12 | 8700 | 140 | 12000 | 60 | 44 | 170 |
| grayish scale/slag - scraped from boiler element (secondary inlet elements) | **1400** | 10 | 2 | 74 | 34 | 32000 | 270 | 26000 | 210 | 75 | 730 |
| brownish clay-like material - refractory brick removal area, rear water wall | 75 | 2 | 0.1 | 76 | 14 | 14000 | 81 | 18000 | 49 | 32 | 560 |
| brownish gray, clinker ash - refractory brick removal area, rear (south) water wall | 1.3 | 0.4 | 0.6 | 87 | ND | 5500 | 13 | 1100 | ND | 65 | 15 |
| EXTERIOR OF BOILER | | | | | | | | | | | |
| settled dust - on wooden bench outside access porthole, east side of boiler | 44 | 3 | 3 | 100 | 30 | 22000 | 130 | 26000 | 64 | 1400 | 780 |
| settled dust - on access porthole, southeast side of boiler | 40 | 3 | 2 | 32 | 27 | 30000 | 52 | 24000 | 66 | 110 | 940 |
| settled dust - south access porthole on east side of boiler, floor 6½ | 42 | 3 | 64 | 46 | 15 | 46000 | 240 | 29000 | 58 | 370 | 910 |
| settled dust - on I-beam 6th floor, west side of boiler, southeast corner | 19 | 3 | 0.3 | 21 | 6 | 17000 | 49 | 22000 | 46 | 160 | 650 |
| settled dust - exterior wall of boiler, 6th floor west corner | 27 | 3 | 0.1 | 33 | 12 | 17000 | 70 | 33000 | 52 | 30 | 790 |
| settled dust - exterior wall of boiler, 7th floor east corner | 56 | 6 | 0.4 | 45 | 47 | 39000 | 90 | 38000 | 130 | 79 | 1600 |
| settled dust - on soot blower, east side of boiler, floor 6½ | 27 | 3 | 1 | 37 | 10 | 23000 | 51 | 19000 | 61 | 240 | 830 |

Al = aluminum As = arsenic Be = beryllium Cd = cadmium Cr = chromium Fe = iron
Ni = nickel Pb = lead V = vanadium Zn = zinc $Ti0_2$ = titanium dioxide

# APPENDIX A

A letter was sent to NIOSH on February 23, 1996, from an AEP representative in response to the NIOSH interim letter dated February 16, 1996. In the NIOSH interim letter, the first recommendation was to reduce workers' exposures to arsenic and other heavy metals in fly ash through the use of engineering controls, such as operating the induced draft (ID) fans to ventilate the boiler. According to the letter from AEP, boiler unit #1 at the CRPP does not have ID fans. This information contradicts information that was acquired during the site visit. However, if the unit does not have ID fans then they cannot be used. Another concern AEP expressed in the letter was that if the fans were operating then the unit is considered in-service and state and federal air pollution laws would come into play. According to officials from the Virginia Department of Environmental Quality and the federal Environmental Protection Agency, Emissions Standards Division, if the unit is shut down for rehabilitation (no fuel consumption), then the unit is not considered to be in-service even if the ID fans are operating.[1, 2] Lastly, AEP stated in the letter that it is not unusual to open the stack damper to generate a natural draft during rehabilitation work inside the boiler. However, because the unit shared a common stack with another unit that was in service, the stack damper were not opened for the reason that a backflow problem could arise. In any event, because unit # 1 shared a stack with another unit (which was in service) and does not have ID fans then these control methods would not be acceptable in this situation. In future boiler rehabilitation, opening the stack dampers and operating the ID fans (if applicable) can be used to help reduce exposures to metals and other airborne contaminants. It would be a good idea to check with the local Department of Environmental Quality concerning these issues as the regulation may differ from state to state.

## References


1. Faggert S [1996]. Telephone conversation on December 17, 1996, between S. Faggert, Virginia Department of Environmental Quality and D. Mattorano, Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluation, and Field Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

2. Eddinger J [1996]. Telephone conversation on October 10, 1996, between J. Eddinger, Emission Standards Division, U.S. Environmental Protection Agency and D. Mattorano, Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluation, and Field Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

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