



NIOSH HEALTH HAZARD EVALUATION REPORT:

**HETA # 2002-0351-2903
Bechtel-Jacobs Co., LLC
Piketon, Ohio**

July 2003

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

The NIOSH logo, consisting of the word "NIOSH" in a bold, italicized, sans-serif font. The "N" is significantly larger and more prominent than the other letters.

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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 (OSHA) 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.

HETAB 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 NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Mark M. Methner, Ph.D., CIH of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Melissa Finley and Chad Dowell of DSHEFS. Analytical support was provided by DataChem Laboratories. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of the X-747H Scrap Yard

In July 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management and union of U.S. Enrichment Corporation (USEC) to evaluate worker exposure to inorganic arsenic fume during torch-cutting operations in the X-747H scrap yard.

What NIOSH Did

- We took wipe samples for arsenic on various surfaces that workers could come in contact with.
- We talked to employees and management personnel.
- We looked at the current arsenic control plan and historical air and urine data.
- We watched current work practices and checked exposure control equipment and procedures.

What NIOSH Found

- Wipe samples collected on “clean” respirators had measurable levels of arsenic.
- The local exhaust ventilation system used to control torch cutting fumes needs improvement and regular maintenance (e.g., hole found in duct).
- The ventilation hood was positioned too far from torch and did not provide effective fume capture.
- Workers need to wear respirators at all times when working within the arsenic control area.

What Bechtel-Jacobs Co., LLC Managers Can Do

- Improve the respirator cleaning procedure.
- Develop and a more effective respirator washing procedure.

- Improve the wipe testing technique to ensure media, laboratory, and field blank samples do not become contaminated with arsenic.
- Improve the current ventilation system by moving the exhaust hood closer to the fume and by installing a flange on the hood to increase fume capture.
- Improve the testing and maintenance of the ventilation system.
- Continue to monitor air and urine levels of arsenic.
- Require all workers to wear respirators inside the arsenic control area.

What the Bechtel-Jacobs Co., LLC Employees Can Do

- Wear a respirator and other protective equipment at all times while working in the arsenic control area.
- Make sure facial hair is shaved daily to ensure a good seal while the respirator is worn.
- Move the fume capture hood 1-2 feet from the torch.
- Use an appropriate solution to clean each respirator after use and prior to submitting it for mechanical washing and sanitization by the on-site respirator washing facility.



What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2002-0351-2903



**Health Hazard Evaluation Report 2002-0351-2903
Bechtel-Jacobs Co., LLC
Piketon, OHIO
July 2003**

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SUMMARY

On July 26, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a joint management/union request for a Health Hazard Evaluation (HHE) to evaluate worker exposure to inorganic arsenic fume during torch-cutting of steel process equipment in the X-747H scrap yard at U.S. Enrichment Corporation (USEC). The facility, located in Piketon, Ohio, formerly operated a gaseous diffusion process for uranium enrichment. The HHE request was submitted after routine air sampling and urinalysis indicated excessive worker exposure to arsenic.

On October 29, 2002, NIOSH investigators conducted an opening conference with labor and management officials and collected surface wipe samples to identify sources of arsenic contamination. Objects/areas sampled included table top/seating surfaces, coveralls, overshoe covers, respirators, and a welder apron and glove. Arsenic sample values ranged from non-detectable (ND) up to 16 micrograms (μg)/wipe sample. The highest value was obtained from the outside face piece of a freshly "cleaned" respirator stored in a sealed plastic bag. Arsenic sample results and interim recommendations were distributed in a letter to management and labor officials on December 11, 2002.

Upon inspection of the local exhaust ventilation used for fume control, a number of deficiencies were identified. We also observed that the standard operating procedures for respirator use were not strictly adhered to.

A potential health hazard was identified from respiratory, dermal, and ingestion exposure to arsenic. Recommendations include continued airborne and urine monitoring for arsenic, a quantitative evaluation of the respirator cleaning procedure, strict adherence to the respiratory protection program, and improved local exhaust ventilation.

Keywords: SIC 7389 (Business Services, not elsewhere classified), Scrap Steel Cutting on a contract or fee basis, torch cutting, welding fume, process equipment, gaseous diffusion, uranium enrichment, arsenic (CAS# 7440-38-2).

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INTRODUCTION

On July 26, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) of worker exposure to inorganic arsenic from oxy-acetylene torch-cutting operations in the X-747H scrapyards at the former uranium enrichment gaseous diffusion plant. This plant, located in Piketon, Ohio, is currently operated by U.S. Enrichment Corporation (USEC) under a contract with the U.S. Department of Energy. The main purpose of the scrapyards operation is size reduction of process equipment prior to shipment to an offsite location. This joint request was submitted by the bargaining unit at this site, Local 5-689 of the Paper, Allied-Industrial, Chemical & Energy Workers International Union (PACE) as well as management from the Bechtel-Jacobs Co., LLC (BJC). BJC's responsibility at the site is that of a health and safety subcontractor. Job titles of concern included: welders, firewatch personnel, maintenance mechanics, laborers, chemical operators and vehicle drivers. A total of 27 workers make up the scrapyards workforce.

This gaseous diffusion plant came under the jurisdiction of the Department of Labor's Occupational Safety and Health Administration (OSHA) from the Department of Energy (DOE) as a result of the Energy Policy Act of 1992.¹ This act mandated that on July 1, 1993, DOE-owned gaseous diffusion plants be transferred to the USEC, a congressionally-established government-owned corporation.

NIOSH investigators conducted a site visit on October 29, 2002, where opening and closing conferences regarding HHE activities were held with management and labor representatives and wipe sampling for inorganic arsenic was performed. A subsequent survey (December 10, 2002) was conducted to observe work practices and equipment usage. An interim report presenting the arsenic wipe sampling results was distributed to BJC and PACE Local 5-689 on December 11, 2002.

BACKGROUND

The USEC facility in Piketon, Ohio, was one of two uranium enrichment production facilities in the United States. The other facility was the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. Both operate under contract to the USEC. Each plant utilized the gaseous diffusion process to enrich uranium from a natural state of 0.7% ²³⁵Uranium up to higher concentrations of ²³⁵U, which historically ranged from 2% to greater than 97%. Recently, the Piketon facility has begun dismantling components of the gaseous diffusion process cascade.²

Historical Uranium Enrichment Process:

Production of enriched uranium at Piketon began in 1955. The two gaseous diffusion plants (Piketon and PGDP) were operated in a complementary mode. The Paducah facility performed the initial enrichment of uranium up to about 1% to 2% ²³⁵U. This material served as a feedstock for Piketon. Both the Piketon and PGDP facilities utilized the same feed materials supplied by the uranium conversion facilities. The uranium enrichment process used uranium in the form of gaseous uranium hexafluoride (UF₆). The uranium enrichment process used at Piketon, also referred to as gaseous diffusion, employed a physical separation process. Lighter molecules of UF₆ containing the ²³⁵U atom or isotope diffused more rapidly through a porous barrier in the system, leaving behind a gas stream with a slightly higher concentration of UF₆ molecules containing the ²³⁸U atom. The degree of isotope separation at any one stage of the process was very small because of the small difference in molecular weight of the two UF₆ isotopes (349 vs 352).

The process equipment was an assembly of thousands of separative stages. The separative equipment consisted of a compressor, converter, and motor which comprised a stage arrangement, and 8 to 12 of these stages comprised a cell. Ten to twenty cells formed a functional unit. These cells were linked together in series completing the formation of the "cascade" for uranium enrichment. The facilities'

several thousand stages were housed in three interconnected buildings. Each cascade building had two floors, each floor covering approximately 1.5 million square feet.^{3,4} The overall configuration resulted in a flow of increasingly enriched UF₆ (²³⁵U) toward the top of the process, while depleted UF₆ (²³⁸U) flowed toward the bottom or "tail" end of the process.

UF₆ was delivered to and shipped from the facility in the solid phase. Because UF₆ is a solid at room temperature, the diffusion plant was operated at temperatures and pressures that maintained the material in the gaseous state. Product withdrawal involved the condensation of gaseous UF₆ into cylinders for shipment.

Process Contaminant Sources

Various contaminants and "light" gases entered the process from a variety of sources over time. Acidic gases (e.g., fluorine and chlorine trifluoride) entered the cascade through process equipment maintenance activities. Chlorofluorocarbons (CFCs) from the cascade cooling system equipment also escaped into the process equipment. Contaminants in process feed materials and from uranium decay, may also have contributed to the presence of chemical contaminants.

The UF₆, in gaseous or liquid form, is extremely reactive with water and is slightly corrosive to most common metals. It is incompatible with organic materials such as lubricating oils.⁵ Arsenic and arsenic-containing compounds were not among the chemicals historically evaluated in the feed UF₆ analyses, within process samples, in tests of purged process equipment for residual gases, or in the gases from the process released to the atmosphere. Arsenic-containing materials present within the uranium enrichment process equipment were first discovered when blocked copper instrument lines from the X-25-7-2 cell in the X-326 building were opened, revealing a pale yellow-white viscous material similar to butter or taffy.⁶ The material released a green smoke upon exposure to atmospheric moisture. The remaining residue was highly hygroscopic. Analyses of the

material by the on-site laboratory indicated that the original deposit may have been chlorylarsenic hexafluoride (ClO₂·AsF₆) or arsenic tetrachloride-arsenic hexafluoride [AsCl₄+][AsF₆-]. The hygroscopic reaction product was identified as arsenic oxide, (As₂O₅). A second deposit in cell X-27-1-15 appeared as a light green material that released a white smoke upon exposure to atmospheric moisture. This second deposit, when immersed in water in the lab, reacted vigorously while forming an acidic solution (pH = 2). The laboratory reported that the compounds contained high levels of copper and chlorine. Although this second deposit differed in some respects from the first deposit in the X-25-7-2 instrument line, the material was also considered to potentially be ClO₂·AsF₆ or [AsCl₄+][AsF₆-].⁷

X-ray diffraction analyses were performed by the on-site laboratory on the solids remaining from these initial samples. A crystalline material was identified as hydrogen arsenate (H₅As₃O₁₀) and copper arsenate (Cu₂As₂O₇). A solid material from a valve in cell X-25-7-2 and a copper tube from X-27-1-15 was identified as Cu₂As₂O₇. The copper instrument lines were acting as a "getter" for the arsenic,⁸ absorbing and combining with the gaseous arsenic contaminants.⁹

Laboratory personnel at PGDP indicated that the facility was probably seeing arsenic pentafluoride (AsF₅) complexed with HF, a metal, or other compound.⁶ A high AsF₅ concentration was identified in the cascade process equipment in the X-326 building in the vicinity of high CFC concentrations, near the top end of the cascade process. The highest concentration of AsF₅ identified inside of the process equipment was 3800 parts per million (ppm) at the X-25-7-9 cell in X-326.¹⁰ This level represents an arsenic concentration of several hundred milligrams of arsenic per cubic meter (mg/m³) of gas. This conversion to a milligram value for arsenic assumes cell operating conditions of an internal pressure of 1.2 pounds per square inch absolute, a 200°F operating temperature, and an average process power consumption of 1900 Megawatts.⁶

Arsenic could have entered the cascade process in one of two ways - as an impurity in the UF₆ feed material or during fluorination of uranium tetrafluoride (UF₄) or uranium octoxide (U₃O₈) with arsenic-contaminated fluorine (F₂). In the latter case, arsenic could have been present in the fluoride-bearing ore used to produce the HF and F₂. However, on-site generated F₂ was considered to be arsenic-free, even if arsenic had been present in the HF received by the site, because in-line trapping would have removed any arsenic prior to F₂ use. Process engineers determined that arsenic entered the cascade process as an impurity in the UF₆ feed material supplied during the 1980's. The site began testing PGDP-supplied UF₆ for arsenic contamination, and the supplier took actions that reduced the arsenic contamination by 1990.¹⁰

Arsenic compounds were also considered to reside in solid uranyl fluoride (UO₂F₂) deposits within the cascade equipment. These deposits would have volatilized during the course of cell treatments to remove uranium residues.¹¹ The facility sought to identify other locations and equipment throughout the cascade process that may have had potential for arsenic contamination and worker exposures. The potential presence of arsenic in sludges from heavy metal recovery and microfiltration in the decontamination building was also a concern. However, the facility determined that this material did not present a hazard because the material was not likely to become airborne and contained a very low concentration of arsenic (less than 0.003% by weight).¹²

Current X-747 H Scrapyard Operations:

The main purpose of the scrapyard operation is size reduction of excess metallic cascade process equipment. Currently, equipment and related process piping are being removed from various buildings throughout the facility. These pieces of equipment range in size from a few inches to over 10 feet in diameter. Once removed from the facility, each piece is trucked to the X-747H scrapyard where it is stored outdoors until the workers initiate size reduction activities. A total of 27 workers conduct activities

within the scrapyard. The workforce consists of 7 welders, 8 maintenance mechanics, 4 laborers, 5 chemical operators, and 3 vehicle drivers. Two to four cutting operations can be conducted simultaneously during a typical work shift, and the time spent in the cutting area can vary from 60-180 minutes. It is anticipated that when operations cease, the scrapyard will have handled approximately 6000 tons of metal.

One method of size reduction involves the use of a mechanical shearing device that cuts equipment up into smaller pieces, based on the thickness of the metal. This method is usually employed on equipment that is relatively small or flat. Other pieces of equipment, mostly irregularly shaped objects, are cut into pieces with an oxy-acetylene torch operated by a welder. During torch cutting, one welder serves as the cutter while another welder serves as "firewatch." These duties are typically rotated every 20-30 minutes. Small forklift trucks carry each piece from the scrapyard and place the piece on a concrete pad that serves as a level surface to prevent large, odd-shaped pieces from tipping over. A mechanic and/or laborer assists the welder by using a crowbar to move the object being cut. A chemical operator assists the welder by positioning a local exhaust ventilation (LEV) apparatus equipped with a high efficiency particulate air (HEPA) filter close to the source of fume generation. This apparatus, called a "gulper" consists of a rectangular 10"x20" hood (unflanged) equipped with a metal spark arrester grill, connected by a 6" flexible plastic duct to a fan motor assembly designed to move air at 2100 cubic feet per minute (CFM). The hood assembly is attached to a telescoping arm that was fabricated on site. This apparatus is on wheels and can be maneuvered anywhere on the pad or in the adjacent building. Once all pieces are cut, the welder, mechanic and chemical operator leave the pad and remove their respirators. At this time, the forklift driver enters the pad and begins picking up the pieces of scrap. The forklift driver makes numerous runs from the pad to special metal boxes that serve as a shipping container for the scrap. The scrap boxes are then weighed and sealed prior to shipment. Cutting operations usually occur two to four times during a typical work shift if weather permits. During inclement weather,

materials are cut inside a covered structure equipped with a series of 6 “gulpers” that are intended to provide general building exhaust ventilation. These devices are HEPA filtered prior to being exhausted outdoors.

According to BJC, size reduction efforts in the scrapyards began in July 2000. Approximately 1 year later, metal fume air samples indicated that arsenic was present in quantities that approached and sometimes exceeded the OSHA Action Level of 5.0 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). Since surface levels of arsenic were inconsistent and unpredictable, BJC implemented an “Arsenic Control Plan” to reduce worker exposure. Also implemented at this time was a worker medical monitoring program which included a physical examination by an off-site occupational physician in tandem with urinalysis for inorganic/organic arsenic. Urine samples are compared to the American Conference of Governmental Industrial Hygienists (ACGIH) Biological Exposure Index (BEI) value of 35 micrograms per Liter ($\mu\text{g}/\text{L}$). BEIs represent the levels of substances that are most likely to be observed in specimens collected from healthy workers who have been exposed to substances at the TLV. BJC has conducted routine breathing-zone air sampling for metal fumes during cutting operations as well as end-of-week urine samples which were analyzed for inorganic as well as organic arsenic species (monomethylarsonic acid and dimethylarsinic acid).

The presence of radioactive contaminants and the generation of welding fumes necessitated the use of personal protective equipment (PPE). This protective equipment included full-face air purifying respirators with HEPA P-100 filter cartridges; anticontamination (anti-C) coveralls; flame retardant head, shoulder, and shoe covers; total body coveralls; safety shoes; leather welding aprons; and leather gloves and latex undergloves.

METHODS

The overall approach to evaluate the arsenic hazard included the following: (1) meeting with workers and

labor and management officials to discuss their concerns; (2) collecting wipe samples from various objects that workers routinely come in contact with to semi-quantitatively test for the presence of arsenic; (3) observing all work practices to identify actions that may lead to arsenic exposure; (4) reviewing site-specific air and urine sampling data for accuracy and completeness; (5) evaluating the respirator cleaning/maintenance program; and (6) visually evaluating the use of LEV to control welding fumes.

Wipe samples for inorganic arsenic were collected during the first site visit according to NIOSH Method 9100. During the wipe sampling effort, Ghostwipes® (pre-moistened towelettes) were used to swab various surfaces. On irregularly shaped objects such as respirator facepieces, no attempt was made to accurately determine the surface area wiped. The goal of the wipe sampling was to semi-quantitatively test for the presence of arsenic.

The outside of all sample containers were screened for radiological contamination by BJC prior to shipment, and by DataChem Laboratories, Salt Lake City, Utah, upon receipt. All wipe samples were digested and analyzed for arsenic according to NIOSH Method 7901 modified for microwave digestion. Each sample was prepared for analysis according to the following procedure: (1) Transfer sample to a clean microwave digestion vessel; (2) add 10 milliliters (mL) of 1:1 (volume:volume) ASTM type II water: concentrated nitric acid; (3) seal vessel, place in a microwave oven, and run until the program is completed; and (4) transfer an aliquot of the sample to a 25 mL volumetric flask and dilute to an appropriate volume with ASTM type II water. These samples were analyzed using a Perkin-Elmer Zeeman 5100 Graphite Furnace Atomic Absorption (AA) Spectrophotometer. The analytical limit of detection (LOD) was calculated to be 0.1 microgram per wipe ($\mu\text{g}/\text{wipe}$) while the limit of quantitation (LOQ) was documented as 0.4 $\mu\text{g}/\text{wipe}$. Media blank samples were submitted for analysis along with field samples. No arsenic was detected on any of the 3 blank samples.

Based on the results obtained during the NIOSH wipe sampling effort, the BJC industrial hygienist and the

USEC jointly conducted additional wipe sampling of newly issued respirators to quantify removable surface contamination levels of inorganic arsenic at the X-747H Scrapyard project on December 12, 2002. Thirteen newly-issued full-facepiece air-purifying respirators (FFAPR) were randomly selected from issued stocks at the X-747H Don/Doff Trailer respirator storage area. The FFAPRs had all been recently washed, assembled, inspected, and sealed in bags at the X-103 USEC respirator cleaning facility. FFAPRs were removed from their sealed bags and carrying case and wipe samples were collected over various surfaces of the FFAPRs, which included a combination of the exterior of the facepiece, the entire interior of the facepiece, the filter cartridge holder interior, and the circumference of the inner facepiece seal. Samples were collected using Ghostwipe® pre-wetted wipe media, and were collected using the wipe sample protocols of NIOSH Method 9100. Wipe media were immediately placed into labeled capped vials following wiping. Field and media blank samples were also collected.

Measurements of dimensions of the interior and exterior surfaces of a medium and large-sized FFPAR were taken to estimate surface wipe areas. The dimensions were found to be relatively equal for both sizes. Wipe surface areas could only be estimated because of uneven contours of facepieces, and the irregular shapes of most facepiece surfaces.

These wipe samples were analyzed by the on-site USEC X-710 laboratory using a modified version of NIOSH Method 7300, for analysis of elemental metals by inductively coupled plasma-atomic absorption spectroscopy (ICP-AAS). An analytical lowest concentration reportable (LCR) of 0.170 µg As/wipe was reported on lab results forms, and was the value reported for wipe samples on which inorganic arsenic was non-detectable. Wipe sampling results were not blank-corrected.

On December 10, 2002, the NIOSH investigator observed all activities related to the scrapyard operation - work practices, PPE usage and Don/Doff procedures, equipment use and maintenance, housekeeping procedures and personal hygiene practices - to estimate the relative contribution each

activity had contributed, singly or in combination, to potential exposure to arsenic. Observations were documented via digital photographs and written records which were later reviewed prior to assessing the condition of the X-747H scrapyard workplace and making recommendations to reduce/eliminate potential exposure to arsenic.

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, which potentially increases 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),¹³ (2) the ACGIH® Threshold Limit Values (TLVs®),¹⁴ and (3) the OSHA Permissible Exposure Limits (PELs).¹⁵ Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91-596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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 STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Biological Effects of 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.¹⁶ Arsenic is absorbed primarily via inhalation and ingestion. Oral ingestion from contaminated hands may result in absorption of toxicologically significant amounts of arsenic.¹⁷

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.¹⁸ The biological half-life of arsenic in humans is 24 to 36 hours.¹⁹ If a worker's exposure on following days is similar, the arsenic concentration in urine remains more or less the same.

Sources of non-occupational arsenic exposure to arsenic are drinking water, food and polluted air.²⁰

Cigarette smoking is also a source of arsenic exposure (12 to 42 µg/cigarette).²¹ Therefore, arsenic can be found in the urine of people who have no occupational exposure to arsenic. Concentrations of inorganic arsenic and its metabolites in the urine of the general population are usually below 10 µg/L (generally equivalent to microgram per gram [µg/g] creatinine) in European countries, but slightly higher in the United States.¹⁶ Biological monitoring by urinalysis is of little value in determining whether or not workers' arsenic exposures exceed the NIOSH REL, because as normal levels of arsenic in urine could easily mask the contribution of occupational exposures near the REL. The NIOSH REL (ceiling limit) is 2 µg/m³, and the OSHA PEL-TWA is 10 µg/m³. Both NIOSH and OSHA [29 CFR 1910.1018] consider inorganic arsenic to be a potential occupational carcinogen.¹⁴ The ACGIH has proposed a BEI for arsenic of 35 µg/L for inorganic arsenic and its metabolites in urine measured in workers at the end of the workweek.¹⁸ The current ACGIH TLV-TWA of 10 µg/m³ for arsenic and inorganic compounds is based on the prevention of systemic effects due to the inhalation of arsenic and its inorganic compounds and the clinical and epidemiological evidence for inorganic arsenic to cause lung and skin cancer.¹⁹

The OSHA inorganic arsenic standard, 29 CFR 1910.1018, does not include a quantitative value for inorganic arsenic surface contamination. The standard's housekeeping provision does state that "all surfaces shall be maintained as free as practicable of accumulations of inorganic arsenic."

RESULTS

Arsenic Wipe Samples

NIOSH Wipe Sampling Findings

Of the 11 samples collected, 5 were found to contain detectable levels of arsenic ranging from 0.6 to 16 µg/wipe (See Table 1). All field blank samples were below the LOD of the instrument. It should be noted that these data are semi-quantitative; the investigators did not measure the surface area of the irregularly

shaped objects. Also, laboratory studies to validate the collection efficiency of the wipe sampling method using Ghostwipe® for arsenic were not performed.

BJC Wipe Sampling Findings

Based on the NIOSH results, BJC initiated their own wipe sampling effort. The highest level of inorganic arsenic surface contamination, measured at 0.098 µg As/in² (or 2.45 µg As per wipe), was found on the interior of the filter cartridge housings of FFAPR ID # UV10058. The inner facepiece seal of this same respirator had an arsenic surface contamination level of 0.090 µg As/in², (or 2.58 µg As per wipe). On visual inspection, this respirator had no distinguishable discoloration or soiling. For reference, the floor area of the Don/Doff Trailer where samples were collected had inorganic arsenic surface contamination of 0.13 µg As/in² (or 2.03 µg As per wipe).

According to the BJC industrial hygienist, detectable levels of inorganic arsenic were found for all 13 wipe samples collected from various FFAPR surfaces. Nine of the 13 results were less than the Practical Quantitation Limit (PQL) of the analytical method, but greater than or equal to the analytical LOD. Detectable inorganic arsenic, however, was also found on field and media blanks, making interpretation of these findings difficult.

DISCUSSION

The BJC wipe sampling results agree with the findings of the NIOSH wipe sampling effort in which the exterior of a newly-issued FFAPR had inorganic arsenic surface contamination. However, the actual magnitude of the contamination remains in disagreement. For the BJC sampling, the mean level of inorganic arsenic surface contamination from the exterior face pieces of three FFAPRs was 0.0087 µg As/in² (or 1.1 µg As per wipe). However, due to the fact that media and field blank samples contained arsenic, sometimes at levels higher than other measurements, the validity of the data is suspect. The presence of arsenic in the blanks must be addressed before any future wipe sampling efforts are

conducted. Blank samples could be contaminated by improper handling of the media before, during or after the sample has been collected or could be an artifact of the laboratory analysis. As with all sampling media, meticulous care must be exercised to avoid inadvertent contamination.

Procedures related to the appropriate Donning/Doffing of PPE were found to be loosely enforced. Some workers were seen removing their respirator immediately upon stepping off the outdoor concrete cutting pad, and thus respiratory protection is non-existent during the walk back to the Don/Doff trailer. If an unprotected worker was to pass by an ongoing cutting operation, and be in a downwind position relative to the plume, the potential for exposure becomes plausible.

The LEV system used to control the welding fume was found to be in poor working order. A hole was found in the flexible duct leading to the air handler. Also, the unflanged hood appeared to provide little fume control. This was probably due to partial clogging of the spark arrester grating that was applied to the face of the hood. Finally, the positioning of the hood was, on occasion, too far away from the source of the fume. The gulper operator did not keep up with the pace of the welder during flame cutting. On multiple occasions, a visible plume rose vertically into the breathing zone of the welder and was not captured by the LEV.

CONCLUSIONS

After reviewing the large amount of documentation related to the BJC arsenic control plan, conducting wipe sampling, and observing work practices, we concluded the following:

1. Wipe sampling found arsenic on “freshly-cleaned” respirators. Despite the fact that the current respirator cleaning and sanitizing operation is fully consistent with the recommended respirator cleaning practices from Annex A of ANSI Z88.2-1992, American National Standard for Respiratory Protection, an improvement in effectiveness appears warranted. The washing solutions’ pH of 14 may inhibit the complete removal of arsenic surface contamination.

2. Procedures related to the appropriate Donning/ Doffing of PPE were loosely enforced. Workers should not Doff any of their PPE until they reach the Don/Doff trailer. Torch-cutting fumes could easily be transported towards unprotected workers if meteorological conditions are correct (e.g., worker downwind without a respirator).

3. The LEV system used to control the welding fume was in poor working order; a hole was found in the flexible duct leading to the air handler. Also, the unflanged hood appeared to provide little fume control, probably due to partial clogging of the spark arrester grating on the face of the hood. At times, the hood was located approximately 1-2 feet away from the torch. Other times it was located approximately 6 feet from the torch.

RECOMMENDATIONS

Arsenic exposure should be reduced and maintained below an airborne concentration of $2 \mu\text{g}/\text{m}^3$. The frequency and type of monitoring (air and urine sampling) for arsenic should continue as currently scheduled.

It is necessary that BJC validate their wipe sampling/analytical method so that results can be accurately interpreted. The mechanical washing of each respirator should be conducted with a suitable detergent (e.g. EscaTech D-lead) that has been deemed effective at removing arsenic as well as sanitizing.

Inspections of respirator assemblies by the wearer should be conducted each time a respirator is used. Each wearer should be familiar with inspection criteria and also personal hygiene issues that could adversely affect the sealing properties of the respirator (e.g., facial hair). Respirator wearers identifying an inspection deficiency should report this to their front-line manager and remove the respirator from service.²²

Regular inspection of the LEV components (hood, grate, ducting and fan motor assembly) is necessary to ensure full operational characteristics. Appropriate

flanging around the perimeter of the exhaust hood attached to the LEV can increase capture velocity by nearly 40%.²³ Spark arresting filters were partially clogged, a situation which would reduce the capture efficiency of the hood.

The LEV should be positioned as close as possible to the cutting torch (within 1-2 feet).²³ A possible alternative would be an overhead canopy-style hood system that would take advantage of the natural convective properties of the fume plume. By using an articulating arm that would allow the hood to be placed directly over the plume, capture efficiency would be greatly enhanced. However, one possible disadvantage of the overhead canopy style hood is that welders may end up positioning their head between the source of the fume and the LEV.

The current arsenic control plan, including monitoring workers via air and urine sampling, should continue to evaluate the effectiveness of the recommended changes made in equipment and work practices.

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Table 1
 Bechtel-Jacobs Company, LLC
 Piketon, OH
 October 29, 2002
 Arsenic Wipe Samples

Sample Location	Mass of Inorganic Arsenic (Micrograms/wipe)
Break Trailer - table top	ND
Break Trailer - bench seat	ND
Don/Doff Trailer - bench seat	ND
Don/Doff Trailer - clean welder coverall	ND
Don/Doff Trailer - clean rubber overshoe cover	ND
Don/Doff Trailer - outside face piece of clean respirator	16
Don/Doff Trailer - inside face piece of clean respirator	1
Welder Leather Storage area - outside of recently used respirator	0.6
Welder Leather Storage area - inside of recently used respirator	ND
Welder Leather Storage area - welder leather apron (outer surface)	0.7
Outdoor cutting pad - welders glove stored inside toolbox (palm surface)	2

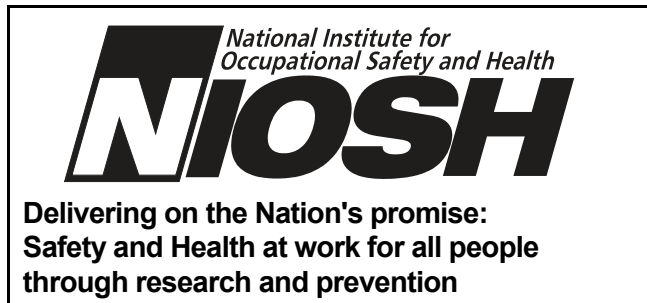
Limit of Detection: 0.1 micrograms per wipe.

Limit of Quantitation: 0.4 micrograms per wipe

ND: None Detected (Below 0.1 micrograms per wipe)

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