Evaluation of respiratory concerns at a coal and copper slag processing company

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Report No. 2013-0016-3258
August 2016

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation.

Highlights of this Evaluation

In September 2012, the National Institute for Occupational Safety and Health received a management request for a health hazard evaluation at a coal slag processing facility in Illinois. Management submitted the health hazard evaluation request as part of a settlement with the Occupational Safety and Health Administration. The Occupational Safety and Health Administration inspected one of the company's coal processing facilities in 2010 and identified multiple health and safety violations and a suspected cluster of pneumoconiosis in four former workers. As part of the settlement, the company requested a health hazard evaluation to determine if cases of pneumoconiosis were present in current workers and assess dust hazards.

What NIOSH Did

- We reviewed medical surveillance data from the company's five coal processing facilities.
- We visited two coal slag processing facilities in September 2014 and one copper slag processing facility in July 2015.
- We collected air samples during coal and copper slag processing that were analyzed for dust, silica, and metals.
- We collected bulk samples that were analyzed for silica and metals.
- We conducted in-person interviews with current workers to understand work history and respiratory symptoms.

We evaluated airborne exposures during coal and copper slag processing. We took air samples for the analysis of dust, silica, and metals to investigate respiratory concerns. Overall, copper slag processing produced higher levels of dust, silica, and metals compared to coal slag processing, but both processes posed health risks. We recommend employee exposure monitoring and a formal respiratory protection program.

What NIOSH Found

- No additional abnormal chest x-rays consistent with pneumoconiosis in current workers, as of August 2013.
- Personal air samples for dust were generally low and below applicable published occupational exposure limits at all three facilities.
- Workers' airborne exposure to silica was low at both coal slag processing facilities.
- Two of the six employees sampled at the copper slag processing facility were exposed to silica levels that exceeded the American Conference of Governmental Industrial Hygienists' threshold limit value.
- Overall, workers' airborne exposures to metals were low and below applicable

published occupational exposure limits at both coal slag processing facilities.

- Workers' airborne exposure to arsenic was high at the copper slag processing facility. Five of the six employees sampled were exposed to arsenic that approached or exceeded the Occupational Safety and Health Administration permissible exposure limit.
- The screen house presented the highest risk for exposure to dust, silica, and metals at all facilities.
- Respiratory protection was provided at all three facilities, but use was not required.
- There was no running water or hand washing stations at the copper slag processing facility.
- Carcinogens, suspect carcinogens, and other toxic elements were identified in bulk samples from all facilities.

What the Employer Can Do

- Due to extremely high levels of dust, silica, and metals inside the screen house, continue to restrict workers from entering the screen house during operation. Entry should only occur in the morning before operation when machines are off.
- Establish a mandatory respiratory protection plan that adheres to the requirements of the Occupational Safety and Health Administration's Respiratory Protection Standard (29 CFR 1910.134). Require mandatory use of respirators, at least as protective as an N95 disposable filtering-facepiece respirator during the following tasks or in the following locations:
    - During any tasks that involve going near the screen houses (outside or inside);
    - During quality control checks;
    - When the baggers fill a super sack; and
    - When operating a forklift to fill a super sack.
- Educate workers on the proper use of respirators and ensure they understand potential hazards (e.g., dust, silica, metals) in the workplace and how to protect themselves.
- At all facilities, conduct employee exposure monitoring to determine employee exposure to crystalline silica. Review the new Occupational Safety and Health Administration regulations for occupational exposures to crystalline silica to ensure compliance.
- Encourage employees to report new or ongoing respiratory symptoms, particularly those with a work-related patterns, to their personal physician.
- Provide employees with personal protective clothing (long-sleeve shirt, work pants, and boots), a change out station, and storage for clean and dirty clothing to reduce take-home exposures of dust and metals from dirty clothing. Employees should not take

dirty work clothing home; make arrangements to wash the work clothing.

- At the copper slag facility, install a potable water hand washing station to improve hygienic conditions and reduce the possibility of ingesting copper slag dust and metals.
- At the copper slag facility, conduct employee exposure monitoring to determine employee exposure to arsenic. Review the requirements of the Occupational Safety and Health Administration Inorganic Arsenic Standard [29 CFR 1910.1018] to ensure compliance.

What Employees Can Do

- Use respiratory protection, particularly when performing tasks near the screen house, quality control check areas, and bagging.
- Wash hands before and after eating, smoking, or bathroom breaks.
- Change out of work clothes before leaving the job site. Do not bring work clothing home.
- Report new or ongoing respiratory symptoms, particularly those with a work-related patterns, to your personal physician.

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Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
As	Arsenic
Be	Beryllium
Cd	Cadmium
Cr	Chromim
CFR	Code of Federal Regulations
Co	Cobalt
Cu	Copper
EHS	Environmental Health and Safety
EPA	Environmental Protection Agency
Fe	Iron
HHE	Health hazard evaluation
ILO	International Labor Organization
IOM	Institute of Occupational Medicine
LPM	Liters per minute
<LOD	Below limit of detection
$\mu g/m^3$	Microgram per cubic meter
mg/m^3	Milligrams per cubic meter
mg/kg	Milligram per kilograms
Mn	Manganese
Ni	Nickel
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
Pb	Lead
PEL	Permissible exposure limit
Pt	Platinum
PVC	Polyvinyl carbonate
QC	Quality control
REL	Recommended exposure limit
STEL	Short-term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
Ti	Titanium
V	Vanadium

Summary

In September 2012, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from the management of a coal slag processing company to investigate respiratory concerns related to dust exposure. The management submitted the health hazard evaluation request as part of a settlement with the Occupational Safety and Health Administration (OSHA). OSHA inspected one of the company's coal slag processing facilities in Illinois in June 2010 and identified multiple safety and health violations, which resulted in various citations and fines. OSHA also identified a cluster of four suspected cases of pneumoconiosis in former workers.

In August 2013, we reviewed the company's medical surveillance records for any evidence of additional cases of pneumoconiosis in current workers. We did not identify additional abnormal chest x-rays consistent with pneumoconiosis in current coal slag processing workers, who had relatively short tenure. In September 2014, we performed a comprehensive industrial hygiene survey at the facility where former workers were diagnosed with pneumoconiosis and a second coal slag processing facility; both located in Illinois. In July 2015, we performed another comprehensive industrial hygiene survey at the company's recently opened copper slag processing facility in Montana. At all facilities, we collected bulk samples for the analysis of silica and metals, and personal and area air samples for the analysis of dust, silica, and metals. Carcinogens, suspect carcinogens, and other toxic elements were identified in bulk samples from all three facilities. Area air sampling results from all facilities indicated multiple areas for potential exposure to dust, silica, and metals. Overall, personal exposure to dust, silica, and metals were low and below applicable occupational exposure limits at the two coal slag processing facilities. Two of the six samples collected on workers at the copper slag processing facility exceeded the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value for silica. All workers that were directly involved in copper slag processing approached or exceeded the OSHA permissible exposure limit for arsenic, a known health hazard. Our recommendations included employee exposure monitoring for silica (all facilities) and arsenic (copper slag processing facility) and a formal respiratory protection program (all facilities).

Introduction

In September 2012, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from the management of a coal slag processing company to investigate respiratory concerns related to dust exposure. The management submitted the health hazard evaluation request as part of a settlement with the Occupational Safety and Health Administration (OSHA). OSHA inspected one of the company's coal slag processing facilities in Illinois in June 2010 and identified multiple safety and health violations, which resulted in various citations and fines. OSHA also identified a cluster of four suspected cases of pneumoconiosis in former workers. As part of the settlement with OSHA, the company was instructed to contact NIOSH "to perform a study of the health effects on employees of their exposure to dust at their worksite."

In August 2013, NIOSH reviewed the company's medical surveillance records for evidence of additional cases of pneumoconiosis in current workers. In September 2014, NIOSH performed a comprehensive industrial hygiene survey at the facility where former workers were diagnosed with pneumoconiosis (Facility A) and a second coal slag processing facility (Facility B). Both facilities were located in Illinois. In July 2015, NIOSH performed a comprehensive industrial hygiene survey at the company's recently opened copper slag processing facility (Facility C) in Montana.

In June 2014, the first interim letter was sent after reviewing the company's medical surveillance data. In April 2015, the second interim letter was sent after visiting two coal slag processing facilities in Illinois. In December 2015, the third interim letter was sent after visiting the copper slag processing facility.

Background

OSHA Investigation

An OSHA investigation in 2010 uncovered a case cluster of suspected pneumoconiosis in four former workers at a coal slag processing facility (Facility A) in Illinois [Fagan et al. 2015]. The suspected pneumoconiosis cases were considered attributable to occupational exposure to coal slag dust. Medical records including medical and occupational histories, physical examinations, pulmonary function tests, chest x-ray readings, and physicians' assessments and diagnoses for three of the four former workers were obtained by an OSHA medical officer. Three of the four workers were interviewed by the medical officer and described respiratory symptoms that began months to years before the end of their employment at the facility. The OSHA compliance officer on-site noted that workers entered "dusty areas," specifically screening and crushing areas, with no respiratory protection. Air sampling from the investigation resulted in multiple personal total dust samples from a plant operator and maintenance workers that exceeded the OSHA permissible exposure limit (PEL) of 15 milligrams per cubic meter (mg/m^3). One personal respirable crystalline silica (quartz) sample from a maintenance worker exceeded the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV®) of 0.025 mg/m^3 and approached the NIOSH recommended exposure limit (REL) and new OSHA PEL of 0.050 mg/m^3 (50 micrograms per cubic meter (μg/m^3)).

OSHA required the company to request a health hazard evaluation from NIOSH to determine if cases of pneumoconiosis are present in current workers and assess dust hazards during coal slag processing. Since copper slag is processed in the same manner as coal slag and occupational exposures during copper slag processing were unknown, the company requested that we conduct another comprehensive industrial hygiene survey at the company's recently opened copper slag processing facility in Montana.

Process Description

The company processed coal and copper slag granules for the abrasive blasting and roofing industries.

Coal Slag Processing (Facility A and B)

This section describes the processes for Facility A and B as of September 2014. The two facilities, Facility A and B, are outdoor facilities that opened in 1998 and 1988, respectively. Facility A employed approximately 10-20 workers, while Facility B employed approximately 5-10 workers. The exact number of workers on any given day depended on season and customer demand. Facility A produced primarily abrasive blasting granules in a variety of sizes, and product was sold in bulk (via rail car or truck), bags, and super sacks (large industrial sized bags). Facility B produced both roofing and abrasive blasting granules in a variety of sizes, and product was sold in bulk only.

The two facilities were located in close proximity to coal-fired power plants that utilized wet-bottom boiler systems. The wet-bottom boilers had a solid base with an orifice that periodically opened to drop the spent molten slag into quenching water. When the molten slag came into contact with the quenching water, the rapid cooling caused it to break apart into small, angular glass-like pellets. The water/slag mixture was transported by high pressure water lines into outdoor collection basins called 'slag ponds', where it was collected by an employee operating an excavator, who transferred the coal slag into a dump truck. The same employee operated the dump truck and transferred the coal slag to the processing facility.

Processing at both facilities involved crushing and screening coal slag, and storage of finished product granules. Bagging of finished granule product was only performed at Facility A. Coal slag material was delivered on site by truck-load or railcar and finished granule products were shipped off site by railcar or truck. In addition to receiving slag from their neighboring power plant, the facilities also received coal slag from various coal-fired power plants in other areas of the United States such as Iowa, Kentucky, and Wyoming. Each day, prior to operation, maintenance workers spent about one hour inspecting and repairing equipment, and lubricating conveyor belt rollers. After routine maintenance, a heavy equipment operator operated a front-end loader to begin transfer of coal slag material into a feed hopper which funneled material onto a conveyor belt. A primary magnet on the first conveyor belt removed metallic pieces from the coal slag, which was manually cleaned by a worker when it became overloaded. The two facilities differed slightly after this stage of slag processing:

Facility A: Coal slag from the conveyor belt was transferred into a rotary dryer to remove moisture content. After drying, the slag was transferred by conveyor belt into an enclosed screen house, which contained a series of two screens that sifted and removed oversized coal slag for reprocessing through the crusher until the desired granule size was reached. Once the material passed through the first screen, the material entered a secondary screen. Once the material passed the secondary screen, it entered a third quality control (QC) screen that served as a backup in case the primary or secondary screens malfunctioned. Periodically, at the third QC screen, the plant operator collected final product granules to manually perform QC checks. After the QC screen, the finished product granules were transferred by conveyor belt to either the bagging station or storage silos.

Facility B: Coal slag from the conveyor belt was transferred into a rotary dryer to remove moisture content. After drying, the slag was transferred by conveyor belt into an enclosed screen house, which contained a series of two screens that sifted and removed oversized coal slag for reprocessing through the crusher until the desired granule size was reached. Once the material passed through the first screen, the material entered a secondary screen. Once the material passed the secondary screen, it was coated with oil and conveyed to final storage silos. The plant operator periodically collected granule product at the final conveyor belt to perform QC checks. The finished product granules were then transported by truck or railcar to Facility A for bagging.

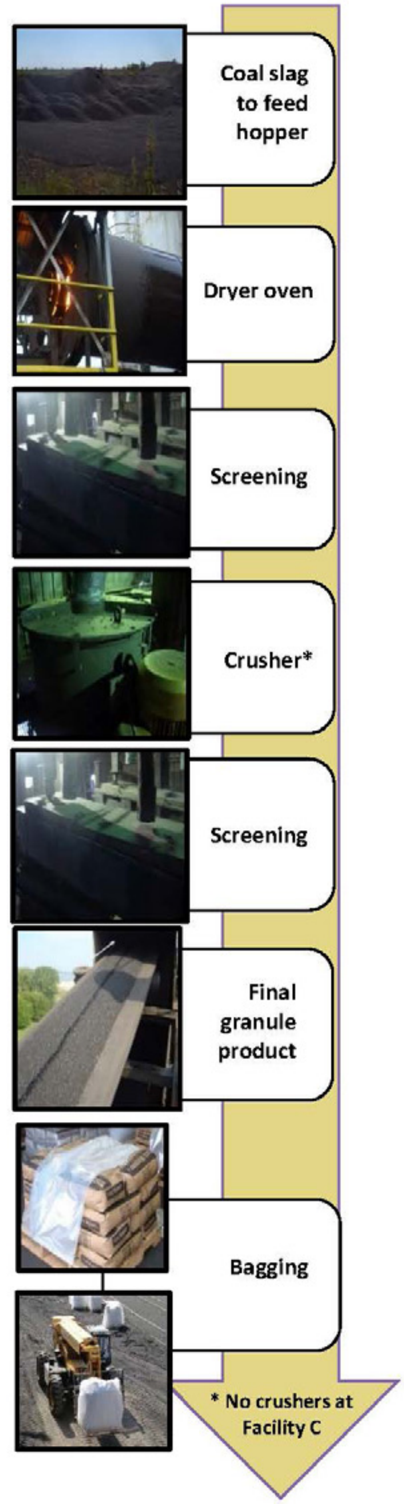

Figure 1. Generalized coal and copper slag processing flow chart

Bagging

Bagging was only performed at Facility A. The bagging station was located inside the warehouse. At the bagging station, a worker placed a bag onto the bagging chute which filled and sealed the bag automatically using compressed air. Another worker stacked the filled granule bags onto a pallet for storage inside the warehouse. When a super sack was filled, a worker operated a forklift to hold the super sack open and in place while the chute was attached to the opening of the super sack. Finished product granules were transferred into the storage silos for bulk truck pick up only.

Copper Slag Processing (Facility C)

This section describes the processes at Facility C as of July 2015. Facility C employed approximately 2-10 workers, but the exact number of workers on any given day depended on season and customer demand. Facility C produced primarily abrasive blasting granules in a variety of sizes, and product was sold in bulk (via rail car) and super sacks. If needed, prior to operation, maintenance workers inspected and repaired equipment that was used in processing or bagging.

The copper slag processing facility was constructed on an old smelting site. Smelting is the process of heating ore at high temperatures to remove impurities from the molten metal. Inside the smelter furnace, a layer of mostly iron, silica, and other impurities is formed and is known as, ‘copper slag’.

To begin the processing of copper slag to finished granule product, a heavy equipment operator operated a front-end loader to begin the transfer of copper slag material into a feed hopper which funneled material onto a conveyor belt. Copper slag from the conveyor belt was transferred into a rotary dryer to remove moisture content. After drying, the copper slag was transferred by conveyor belt into an enclosed screen house, which contained two screens that sifted and removed oversized copper slag until the appropriate size was reached. Oversized slag pieces were discarded out the side of the screen house into an oversize pile. Once the material passed through the first screen, the material entered a secondary screen. Once the material passed the secondary screen, the material was conveyed to final storage silos. There were no crushers involved in the processing of finished granule products. Approximately every hour, a worker collected granule product at the final conveyor belt to perform QC checks to ensure the appropriate granule size was met, and screens were functioning correctly. The finished product granules were stored until needed for bagging of super sacks or bulk delivery via rail car.

Bagging

During bagging, a worker opened a chute at the bottom of the finished granule product storage silo. After the storage silo chute was opened, finished product granule was transferred onto a conveyor belt that transported it into a bagging hopper. A worker operated a forklift to hold the super sack open and in place while the chute at the bottom of the bagging hopper was opened by another worker. Once the super sack was filled, two workers closed and covered it with a plastic and stapled the plastic to the bottom of the wood pallet. Filled super sacks were transported by forklift to an on-site storage area until needed for truck delivery.

Medical Surveillance and Personal Protective Equipment

There was a company-wide medical surveillance plan that contained the following elements: medical and occupational history; chest x-ray; pulmonary function test (spirometry); and a medical examination. The following hazards or hazardous materials were noted to have specific medical surveillance requirements: arsenic; beryllium; cadmium; lead; noise and hearing conservation; and silica. However, there was no attached information about these specific requirements. Workers were required to wear steel-toe boots, hard hats, and safety glasses. N95 disposable filtering-facepiece respirators were available for voluntary use. We observed workers wearing respiratory protection only at Facility C during quality control checks at the conveyor belt and during the filling of super sacks, which both generated visible dust.

Methods

The objectives for this evaluation were the following:

1. Determine whether cases of pneumoconiosis occurred in current workers;
2. Measure employee exposure to dust, silica, and metals;
3. Characterize elemental composition of coal and copper slag;
4. Identify process areas or machines that present the highest risk for exposure to dust, silica, and/or metals;
5. Identify potential work-related respiratory health problems; and
6. Recommend controls to reduce or eliminate workplace hazards.

Review of Medical Surveillance Data

To determine whether cases of pneumoconiosis occurred in current workers, we reviewed the company's medical surveillance records. In August 2013, the company provided us with the names of surveillance medical providers for each of the five coal processing facilities and a list of current employees. This roster included name, plant location, hire date, job title, and birthdate for each employee. We contacted the medical providers to obtain medical records and original chest x-rays for each employee on the roster. We used the information to assess tenure, age, and job distribution among employees; all analyses were conducted in JMP 10.0.2 (SAS Institute, Cary, NC). For employees with a chest x-ray, we calculated work tenure by subtracting the date of hire from the date of the chest x-ray and age by subtracting birth date from the date of the chest x-ray. For those without an x-ray, we calculated tenure and age as of August 15, 2013, the date we received the roster.

We sent all original radiographs for B-Readings to physicians who were NIOSH certified B-Readers. Each radiograph was read by two certified physicians. X-ray B-Readings are prepared by physicians who have demonstrated competency in detecting pneumoconiosis on chest x-rays and determining the degree of abnormality in relation to standard comparison films provided by the International Labor Organization (ILO). In the case of disagreement, a third certified physician read the films to provide a median ILO score.

Industrial Hygiene Sampling

We performed an industrial hygiene survey at two separate coal slag facilities and one copper slag processing facility. We visited Facility A on September 10-11, 2014, Facility B on September 8-9, 2014, and Facility C on July 8-9, 2015. During the surveys, NIOSH industrial hygienists collected bulk material samples and sampled for airborne dust, silica, and metals. Air samples were collected on individual workers (personal) and in the areas that they occupy (area). Following the visit, bulk samples were analyzed for silica and metals, and air samples were analyzed for total, inhalable, and respirable dust; respirable silica; and metals.

In addition, real-time monitoring devices that measure airborne dust were placed in specific work areas to screen for potentially elevated levels of dust. We also offered each worker the opportunity to be interviewed with a brief health questionnaire.

Personal Air Samples
Two types of personal samplers were worn by workers during the course of their work shift over the two days at each facility. Job titles across the three facilities included maintenance, heavy equipment operator, plant hand, laborer, plant operator, plant manager, bagger, office coordinator, and environmental health and safety (EHS) manager. Personal air sampling results for individual workers were provided to workers upon their request. On the first day at each facility, we collected:

1. *Total dust and metals samples* using an open-faced, two-piece, 37-mm cassette (SKC, Inc., Eighty Four, PA) loaded with a polyvinyl carbonate (PVC) filter with air pulled through the filter at a flow rate of 2 liters per minute (LPM). Samples were weighed for total dust following NIOSH Method 0500 and then analyzed for metals following NIOSH Method 7300 [NIOSH 2003].

   On the second day at each facility, we collected:

2. *Respirable dust and silica samples* using an aluminum cyclone (SKC, Inc., Eighty Four, PA) with a two-piece, 37-mm cassette fitted with a PVC filter with air pulled through the filter at a flow rate of 2.5 LPM. This device collects respirable dust and silica in order to meet the OSHA criteria for silica sampling. Samples were weighed for respirable dust following NIOSH Method 0600 [NIOSH 2003] and then analyzed by X-ray diffraction following NIOSH Method 7500 [NIOSH 2003] for respirable crystalline silica.

Area Air Samples
Full-shift area air samples, placed in wire baskets, were collected from various locations in work areas between the three facilities. Area sample locations at Facility A included the bagging station, control room, feed hopper, QC area, and screen house (upstairs and downstairs). Area sample locations at Facility B included the baghouse, under the drying oven, control room, loading station, north of the facility, and screen house (outdoor and indoor). Area sample locations at Facility C included end of super sack bagging conveyor, super sack loading station, conveyor access shack, exit door of conveyor access shack (right and left), screen house (outdoor and indoor), QC check area, under conveyor leading to screen house, and under drying oven. Figures A1, A2, and A3 present area sample locations for each facility.

Each area basket included the following:

1. *Respirable dust and silica sample* using either a GK2.69 cyclone (BGI Inc., Waltham, MA) or an aluminum cyclone (SKC, Inc., Eighty Four, PA) with a two-piece, 37-mm cassette fitted with a PVC filter with air pulled through the filter at a flow rate of 2.5 LPM.; and

2. *Inhalable dust and metals sample* using the Institute of Occupational Medicine (IOM) sampler with a 25-mm PVC filter with air pulled through the filter at a flow rate of 2 LPM.

All samplers were connected to a Gilian GilAir-5 (Sensidyne, LP, St. Petersburg, FL) pump set at the desired flow rate. Each sampling pump was calibrated prior to and after sampling using a TSI 4100 series (TSI, Inc., Shoreview, MN) flow meter to ensure flow rate accuracy.

Some area samples were paired with real-time monitoring instruments. Real-time DustTrak DRX 8533 Aerosol Monitors (TSI Inc., Shoreview, MN) that measured total, inhalable, respirable and PM1 dust particles were placed in specific work areas to screen and identify tasks associated with potentially elevated levels of dust.

Personal total and area inhalable dust samples were collected using different sampling methods. Personal total dust samples were collected using a 37-mm cassette for comparison purposes to the OSHA PEL. Area inhalable dust samples were collected using an IOM inhalable sampler due to its greater collection efficiency compared to a 37-mm total dust cassette. The collection efficiency of a total dust cassette is greatly reduced with increasing particle size and wind speed [Werner et al. 1996; Li et al. 2000], as expected in an outdoor process.

Bulk samples of unprocessed coal and copper slag, final granule product, and settled dust were collected. The samples were collected by scooping a 50-ml plastic tube into the bulk unprocessed slag, finished granule product, or settled dust excluding large solids. The samples were dissolved and analyzed for elements and silica using NIOSH Methods 7303 and 7500 [NIOSH 2003], respectively.

Bulk and air samples were digested and analyzed for the following elements: arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni), titanium (Ti), and vanadium (V) using inductively coupled plasma atomic emission spectroscopy (ICP-AES). Platinum (Pt) was analyzed using inductively coupled plasma mass spectrometry (ICP-MS).

If samples were below the limit of detection (LOD) (the lowest limit we can detect using these methods), they have the designation "<LOD".

Questionnaire

Employees were given the opportunity to be interviewed with a questionnaire during the survey. Employees were privately interviewed by a NIOSH employee using a questionnaire that included questions on demographics, work history and respiratory symptoms. Participation in the questionnaire was voluntary.

Exposure Limits

OSHA PELs are the regulatory limits for exposure to a physical or chemical agent over an eight hour work shift. The OSHA PELs for exposure to total and respirable dust are 15 mg/m^3 and 5 mg/m^3, respectively. The old OSHA PEL for respirable crystalline silica that was in effect during our sampling is different for each individual sample [OSHA 2006]. OSHA has recently implemented a new respirable crystalline silica PEL of 0.05 mg/m^3, (50 µg/m^3) which is the same as the NIOSH REL of 0.05 mg/m^3 [NIOSH 2010; Fed Reg 2016].

NIOSH RELs are not enforceable limits; they are levels that NIOSH considers protective for worker health over a 10-hour work shift. There are no NIOSH RELs for total, inhalable, or respirable dust.

ACGIH TLVs® are not enforceable limits; they are health-based guidelines from the latest scientific and toxicological information. ACGIH is a scientific group separate from NIOSH. The TLV for respirable crystalline silica is 0.025 mg/m^3. ACGIH also provides guidelines for some substances when TLVs have not been established. For example, ACGIH recommends that respirable dust concentrations be kept below 3 mg/m^3 and inhalable dust concentrations be kept below 10 mg/m^3 [ACGIH 2015].

Results

Review of Medical Surveillance Data

Fifty-six workers were employed at the five different coal slag processing facilities as of August 2013. The average age of employees was 44.3 years (range 19.7−67.8 years). Thirty-three employees had a job title provided. These included eight (24%) baggers, three (9%) loaders, six (18%) maintenance workers, four (12%) drivers, four (12%) operators, and three (11%) laborers. The remaining employees were office coordinators or plant managers. The average work tenure of the 33 workers with hire dates recorded was 5.0 years (range 0.2−11.6 years), and half had worked less than 3.6 years (median).

We received chest x-rays on 73% of employees whose names were submitted to medical providers as having been eligible for medical surveillance x-rays. The x-ray completion rate ranged from 22%−100% at different locations. Some x-rays were accompanied by a respiratory questionnaire or physical examination findings. Rarely, records included results of breathing tests. Three employees had medical records but no chest x-ray. Only one clinical provider appeared to be sending films to certified B-Readers for evaluation, accounting for 20% of surveillance chest x-rays; none of the other x-ray interpretations had an ILO classification.

For one plant site, we received three x-rays for employees who were not on the company list of current employees eligible for x-rays. These three were included in our evaluation since they may have been hired after the August 2013 roster was sent to us. Six employees had two chest x-rays performed. One chest x-ray was of such poor quality that a determination regarding pneumoconiosis abnormalities could not be made. None of the remaining 49 evaluated x-rays had pneumoconiosis abnormalities.

Bulk Samples – Table A1

Coal Slag Facilities
Fe was the most abundant element identified in bulk samples. Most bulk samples contained

Mn, Ti, and V at levels above 100 milligrams per kilograms (mg/kg). Some bulk samples also contained Co, Cu, and Ni above 100 mg/kg. Be was detected in some unprocessed coal slag (0.22 - 4.1 mg/kg), but concentrations were <LOD in all finished product granules. Unprocessed coal slag from Illinois, Kentucky, and Wyoming contained 0.43 – 0.48% (4,300 – 4,800 mg/kg) silica. Only one finished product granule bulk sample (Facility A; Sample D) had detectable levels of silica (0.34%; 3,400 mg/kg). Settled dust collected from the warehouse and screen house at Facility A ranged from <LOD – 2.6% (<LOD – 26,000 mg/kg) silica.

Copper Slag Facility

The most abundant metals identified in bulk samples were Fe (all samples were ≥240,000 mg/kg) and As (all samples were ≥1,600 mg/kg). Cd, Co, Cu, Mn, Ni, Pb, Ti, and V were also detected. Be and Pt were not detected in any bulk sample. Unprocessed copper slags contained 0.53 and 1.5% silica (5,300 and 15,000 mg/kg), respectively. Finished product granules contained 0.55 and 0.63% silica (5,500 and 6,300 mg/kg), respectively. A sample collected from inside the screen house contained 4.9% silica (49,000 mg/kg).

Personal Air Sampling Results - Table A2 (dust and silica) and Table A3 (metals)

Coal Slag Facilities

The highest total dust levels were measured on two baggers (6.56 and 1.98 mg/m^3), an office coordinator (1.26 mg/m^3), and a plant operator (1.14 mg/m^3). Overall, personal respirable dust levels were low, with all samples < 0.5 mg/m^3. The highest respirable dust levels were measured on a maintenance worker (0.37 mg/m^3) and a bagger (0.14 mg/m^3). All personal samples for silica were <LOD. Personal samples for metals were <LOD for As, Be, Cd, Co, Pb, Ni, and Pt. The highest personal metal exposures were to Fe, but these were significantly below the OSHA PEL of 10,000 µg/m^3. Cr, Cu, Mn, Ti, and V were all present in personal air samples, but below their applicable OSHA PEL, NIOSH REL, and ACGIH TLV.

Copper Slag Facility

The highest total dust levels were measured on a plant hand (6.35 mg/m^3), a maintenance worker (1.94 mg/m^3), and a laborer (1.79 mg/m^3). Overall, personal respirable dust levels were low. All samples were less than 1 mg/m^3. The highest respirable dust levels were measured on a plant hand (0.703 mg/m^3) and a laborer (0.538 mg/m^3). The highest silica levels were observed in personal samples from a laborer (0.042 mg/m^3) and plant hand (0.031 mg/m^3), both of which exceeded the ACGIH TLV of 0.025 mg/m^3 for crystalline silica but were below the NIOSH REL and new OSHA PEL of 0.05 mg/m^3. Five of the six employees sampled had personal exposures that approached and/or exceeded the OSHA PEL for As of 10 µg/m^3. Personal samples for a laborer (17.9 µg/m^3), a maintenance worker (18.0 µg/m^3), and a plant hand (18.0 µg/m^3) all exceeded the OSHA PEL for As. Personal samples for a heavy equipment operator (9.12 µg/m^3) and a maintenance worker (9.14 µg/m^3) approached the OSHA PEL and were above the OSHA action level of 5 µg/m^3. An action level refers to an air concentration that requires additional actions to reduce exposure. The other personal air samples for Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Pt, Ti, and V were significantly below any OSHA PEL, NIOSH REL, or ACGIH TLV.

Area Air Sampling Results - Table A4 (dust and silica) and Table A5 (metals)

Coal Slag Facilities

At Facility A, the highest full-shift inhalable dust samples were located inside the screen house, upstairs (21.5 mg/m^3) and downstairs (21 mg/m^3), and outside the QC check (13.1 mg/m^3). The highest full-shift respirable dust samples were located inside the screen house, upstairs (2.29 mg/m^3) and outside the QC check (0.50 mg/m^3). At Facility B, the highest full-shift inhalable dust samples were located inside the screen house (68.1 mg/m^3), and outside the baghouse (11.3 mg/m^3). The highest full-shift respirable dust samples was located inside the screen house (0.36 mg/m^3). Measurable levels of silica (0.005 mg/m^3) were detected in the screen house at each facility. Results for all other area sampling locations were <LOD for silica.

At Facility A, measurable levels of Cr, Co, Cu, Fe, Mn, Ni, Ti, and V were observed in the screen house, upstairs. At Facility B, measurable air levels of Be, Cr, Co, Fe, Mn, Ti, and V were observed outside of the bag house, near the drying oven, and at the screen house. Most of the levels for other metals in other locations were <LOD at both facilities.

Copper Slag Facility

The highest full-shift inhalable dust levels were located at the QC check (236 mg/m^3), inside the screen house (109 mg/m^3), under the conveyor belt leading into the screen house (19.8 mg/m^3), and in the conveyor access shack (11.4 mg/m^3). The highest full-shift respirable dust levels were located inside the screen house (13.7 mg/m^3) and at the QC check (10.3 mg/m^3). The highest silica levels were measured inside the screen house (0.686 mg/m^3), at the QC check (0.43 mg/m^3), and inside the conveyor access shack (0.067 mg/m^3). Measurable levels of As, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Ti, and V were detected in all area samples. Arsenic was highest in the screen house (1,030 µg/m^3), QC check (96.9 µg/m^3), under conveyor to screen house (89.1 µg/m^3), conveyor access sack (67.7 µg/m^3), and outside the screen house (12.5 µg/m^3). Cd (23.8 µg/m^3), Fe (27,658 µg/m^3), and Pb (326 µg/m^3) were also highest inside the screen house. Pb was also elevated at the QC check (34.7 µg/m^3). Co was detected in some area samples. Be and Pt were <LOD in all samples.

Real-time Dust Monitoring

We were unable to identify any specific task that resulted in elevated levels of total and respirable dust using real-time dust monitors during coal slag processing. However, elevated dust levels were identified at the QC check area during copper slag processing. This was confirmed by the inhalable and respirable dust samples collected at this location.

Questionnaire Results

Coal Slag Facilities

All employees that participated in the industrial hygiene survey participated in the questionnaire (12/12). The average age of employees was 44, with average job tenure of 8.4 years. Five employees had held different jobs at the company throughout their employment. Half of the employees were never-smokers. Two employees reported usual cough. Four employees reported usually bringing phlegm up from their chest. One employee reported being troubled by shortness of breath. Four employees reported other symptoms or health concerns within the last 12 months including sinus irritation, runny nose, asthma, and high blood pressure. Seven employees reported working with other lung hazards.

Copper Slag Facility
All employees that participated in the industrial hygiene survey participated in the questionnaire (6/6). The average age of employees was 41, with average job tenure of 1.1 years. Four employees had held different jobs at the company throughout their employment. Two of the employees were never-smokers. One employee reported usual cough. Two employees reported usually bringing phlegm up from their chests. No one reported being troubled by shortness of breath. No one reported other symptoms or health concerns within the last 12 months. Four participants reported working with other lung hazards.

Discussion

Medial Surveillance Data
As of August 2013, we did not find additional cases of abnormal chest x-rays consistent with pneumoconiosis in current coal slag processing employees. Without a number of former workers to compare to, we could not determine the prevalence of pneumoconiosis among former workers. However, a case cluster of physician-diagnosed x-ray abnormalities in a facility that had 10 employees, and a company-wide current workforce of 56 is worrisome for a risk of occupational pneumoconiosis in employees exposed to coal slag processing dusts. OSHA felt that this pneumoconiosis was more specifically mixed dust pneumoconiosis or siderosilicosis, as both silica and iron oxide were found during their sampling.

The inhalational toxicity of coal slag dust has not yet been characterized in workers. The presence of sentinel cases of dust-related disease in coal slag workers is concerning, and suggests both the need for medical surveillance, as recommended by OSHA, and further study. Several studies in rats have demonstrated lung scarring (fibrosis) after inhalation exposure [MacKay et al. 1980; Stettler et al. 1995; Hubbs et al. 2001]. The animal experiments provide biologic plausibility for a risk of pneumoconiosis in coal slag workers, and support the need for protection and surveillance, though the exact microscopic findings and mineral burden remain unknown.

Given the long latency of all forms of pneumoconiosis, the medical surveillance findings should not be taken to mean that there is no hazard to workers at these plants or in this industry. X-ray findings often take 20 years or more to appear after initial exposure. The four cases had tenures of 20 years in three cases, and eight years in one case, a time course which would allow for development of changes visible on x-ray. Yet, the tenure of most workers that were employed as of August 2013 was less than four years, with a maximum of 11 years; thus, surveillance chest x-rays would have been unlikely to show evidence of disease in these workers, even if they were already developing illness.

The regulations for the coal miners' surveillance program have recently added spirometry (breathing tests) as a tool for detecting declining lung function in miners, because x-ray surveillance alone is not sufficient for dust-related lung diseases, which include airways diseases [Attfield and Hodus 1992; Department of Labor 2014; Wang et al. 2013]. The new silica rule also includes spirometry surveillance [Fed Reg 2013]. Of the three sentinel cases who had pulmonary function testing reported, all had abnormal findings. Though spirometry is often normal in siderosilicosis and mixed dust pneumoconiosis, it is possible to use this testing to look for airways disease and excessive decline of lung function over time, which would give another point of reference in tracking the health of employees. This type of surveillance may be useful to those employed in the coal and copper slag processing industry, especially since our sampling results indicated a silica hazard.

As of August 2013, no x-rays were available for 27% of workers, so attention to follow up of screening requirements is needed. Furthermore, most radiologists in clinical institutions evaluate chest x-rays for acute lung disease, such as pneumonia. Without special training in B-Reading or indication on the order form that the purpose of the ordered x-ray is to screen for pneumoconiosis, many radiologists will miss the subtle changes of occupational dust diseases. Since only 20% of the chest x-rays had been read by a certified B-Reader trained in the detection of pneumoconiosis, early signs of pneumoconiosis could be missed in the future. If B-Readers are not available, the minimum requirement is to specify on all order forms that the purpose of the chest x-ray is to rule out pneumoconiosis.

Bulk Samples

The collection of bulk samples was done to investigate if potentially hazardous materials are present in the coal and copper slag that may contribute to lung disease and other health problems. The bulk samples collected from our industrial hygiene surveys yielded different amounts of silica and metals. Coal slag bulk samples from different regions of the country presented slightly different results. For example, unprocessed coal slag from Illinois and Kentucky yielded detectable amounts of silica, whereas unprocessed coal slag from Wyoming was <LOD for silica. Regional differences in geology and coal formation may explain this variability [Stettler et al. 1982; Dai et al. 2014]. Conversely, elemental composition of unprocessed copper slag bulk samples were fairly uniform; likely because copper slag was from the same origin. Elemental composition of copper slag will vary depending on a number of factors including, but not limited to, ore content and origin, furnace type, and treatment and recovery processes [Gorai and Jana 2003; Stettler et al. 1988]. Elemental composition of unprocessed copper slag from the site appears to have remained unchanged over the years, since our bulk sample results were similar to previous bulk sample results reported by the U.S. Environmental Protection Agency (EPA) from samples collected in 1993 [EPA 1998]. Therefore levels of metals, most notably As, that we measured likely reflect exposures since the plant became operational in 2013.

Although unprocessed coal slag contained measurable levels of silica (0.43% – 0.46%), only one of seven bulk samples of finished product granules contained detectable levels of silica (0.34%). The relatively small amounts of silica observed in all the coal slag bulk samples support the claim that coal slag abrasives reduce silica exposure compared to silica sand and may reduce the risk of silicosis during blasting operations. Although bulk samples of unprocessed copper slag contained less than 1% silica (0.63% and 0.55%), one of the two finished granule products contained greater than 1% silica (1.5%). One possible explanation may be the different granule sizes of unprocessed granules compared to finished product granules. The larger, unprocessed granules may have been too large to be fully digested during the sample preparation and extraction steps of analysis, therefore resulting in lower concentrations overall. Copper slag has been widely used as a silica sand abrasive substitute due to its low silica content; however, based on our limited bulk analysis data, it may be prudent to evaluate the silica content of this type of abrasive material.

Personal and Area Air Samples

At all facilities, personal air samples of total and respirable dust were below their applicable OSHA PELs. However, total dust samples collected from a bagger at Facility A (6.55 mg/m^3) and a plant hand at Facility C (6.35 mg/m^3) were close to half the OSHA PEL of 15 mg/m^3. Elevated levels of total dust for the bagger at Facility A may have been due to the use of compressed air to seal the bag during bagging and its potential to make dust become airborne. Elevated levels of dust for the plant hand may have been due to elevated dust levels at the QC check area, where the employee took a QC sample approximately every hour during his work shift. The area sample for inhalable dust at the QC check had a concentration of 236 mg/m^3 and a respirable dust concentration of 10 mg/m^3 (Table A4).

No personal air samples exceeded the NIOSH REL and new OSHA PEL of 0.05 mg/m^3 (50 µg/m^3) for silica. However, two workers at Facility C exceeded the ACGIH TLV of 0.025 mg/m^3. The highest silica samples were measured on a laborer (0.042 mg/m^3) and a plant hand (0.031 mg/m^3) at Facility C. During the day of silica sampling, the laborer operated a forklift moving the super sacks back and forth at the loading area and was inside a forklift cabin for the majority of the day. Dust generation from driving the forklift on the dirt road and close proximity to the super sack as it was filled may have been a potential source of dust and silica exposure inside the forklift cabin. The forklift cabin likely was not adequately filtering or blocking dust generated from vehicle traffic and the filling of super sacks. Wet methods, such as wetting the road, may reduce dust generation from the dirt road and reduce exposure to the worker operating the forklift. During silica sampling, the plant hand was responsible for attaching super sack bags to the forklift, filling them, and covering them with a plastic for storage. Filling and covering the super sack likely contributed to the plant hand's silica exposure.

Employees who inhale very small crystalline silica particles are at increased risk of developing serious silica-related diseases. These tiny particles can penetrate deep into the lungs and cause silicosis, a disabling, non-reversible and sometimes fatal lung disease. Crystalline silica exposure also puts employees at risk for developing lung cancer and other potentially debilitating respiratory diseases such as chronic obstructive pulmonary disease. The old crystalline silica OSHA PEL, which differed per sample, was amended to improve employee protection. OSHA has implemented two new crystalline silica standards: one for general industry and maritime, and the other for construction. The new silica standards are based on extensive review of scientific evidence that shows that the current exposure limits do not adequately protect worker health. The new rule includes provisions for measuring how much silica employees are exposed to, limiting employees' access to areas with silica exposures, using effective methods to reduce silica exposures (e.g., wetting down operations, enclosing operations, using vacuums to collect dust) as well as providing medical exams to employees with high silica exposures, and training for employees about silica-related hazards and how to limit their exposure to silica. More information on OSHA's new crystalline silica standards and how it may affect these workplaces and employees is available on OSHA's website [OSHA 2016].

Employees at Facility C were exposed to high levels of Arsenic (As). Arsenic is a naturally occurring element widely distributed in the earth's crust. Exposure to higher than average levels of arsenic can occur near hazardous wastes sites. Arsenic may cause irritation to the skin, eyes, and mucous membranes. Severe symptoms may also occur; these include disturbances of the gastrointestinal system (e.g., nauseas and vomiting), nervous system (e.g., "pins and needles" in hands and feet), blood-forming system (e.g., decreased production of red and white blood cells), and cardiovascular system (e.g., abnormal heart rhythm). Ingesting or breathing in low levels of inorganic arsenic for a long time can cause skin disorders (e.g., redness; swelling; darkening of the skin; and appearance of small "corns" or "warts" on the palm of hands, soles of feet, and torso). The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans; several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs [ATSDR 2007].

Three out of six copper slag processing workers exceeded the As OSHA PEL of 10 $\mu g/m^3$. A laborer (17.9 $\mu g/m^3$), maintenance worker (18.0 $\mu g/m^3$), and a plant hand's (18.0 $\mu g/m^3$) samples were nearly double the OSHA PEL for As. A heavy equipment operator (9.12 $\mu g/m^3$) and maintenance (9.14 $\mu g/m^3$) were also very close to the OSHA PEL and well over the OSHA action level of 5 $\mu g/m^3$.

At Facility C, As was also present in all area samples, and well exceeded the OSHA PEL at the screen house (1,031 $\mu g/m^3$), QC check (97 $\mu g/m^3$), under the conveyor leading to the screen house (89 $\mu g/m^3$), conveyor access shack (68 $\mu g/m^3$), and exit door to screen house (12 $\mu g/m^3$). We observed no running water for hand washing, drinking, or bathroom use. There was a portable toilet on-site; however, there was no hand washing or sanitizing station. Ingesting arsenic-containing dust may increase the burden of As exposure to employees and was not accounted for in our air sampling results.

As stated in the OSHA Standard 29 CFR 1910.1018 *Inorganic arsenic*, if employee air monitoring is above the PEL, the employer shall repeat monitoring at least quarterly. If levels are above the action level, but below the PEL, the employer shall repeat monitoring at least every six months. The standard also states that the employer shall establish regulated areas where exposures to inorganic As are in excess of the PEL, and access to those area should be limited. Ensure that the company's requirements for medical surveillance are in accordance with the OSHA Standard 29 CFR 1910.1018 *Inorganic arsenic*. For more information on engineering control, respiratory protection, protective work clothing, equipment, medical surveillance, and other requirements, refer to OSHA Standard 29 CFR 1910.1018 *Inorganic arsenic* (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10023).

The area air samples identified specific work areas that had higher risk for exposure. Inhalable dust area air samples exceeded the OSHA PEL inside the screen house at both facilities and by the QC check at Facility A and the bag house of Facility B. The screen house, conveyor access shack, and QC check at Facility C all exceeded the new OSHA PEL for silica. OSHA PELs are specified for personal samples, and area samples cannot be used for enforcement. However, the area sample results suggest that the screen house and bag house areas have potential for high personal exposures to dust and silica.

Iron (Fe) was measured in all area samples, and highest in samples collected at the screen house at each facility. Overall, Fe was higher in area samples at the copper slag processing facility. Iron oxide exposure is associate with "siderosis," a type of pneumoconiosis which is usually not fibrotic [Chong et al. 2006]. Exposure to both iron oxide and silica or silicates is associated with mixed dust pneumoconiosis or "siderosilicosis." The OSHA investigators suggested that the four cases of pneumoconiosis in former workers at Facility A were consistent with siderosilicosis or mixed dust pneumoconiosis [Fagan et al. 2015]. During our time at each facility, we noticed that workers were not entering the screen houses and most maintenance tasks in these areas were conducted in the morning prior to turning on the equipment, per company policy. Lead (Pb) was also elevated in an area sample collected from the QC check (34.7 $\mu g/m^3$). This sample exceeded the OSHA action level of 30 $\mu g/m^3$, which indicated action must be taken to reduce exposure (29 CFR 1910.1025)

The company did not provide personal protective clothing, such as long sleeve shirts, pants or work boots and did not have a change out and storage station for dirty and clean clothes at the three facilities.

Conclusions

Despite OSHA's identifying four cases of pneumoconiosis in four former workers, we did not identify any additional cases of pneumoconiosis in short-tenured current workers during our review of medical surveillance data. Since the OSHA investigation in 2010, the company had taken steps to reduce worker exposure to dust, silica, and metals. The company restricted workers from entering the screen house area during operation and, required that they perform maintenance tasks in the morning before start up. Despite these efforts, we noted potential opportunities for exposure to dust, silica, and metals during our site visits that can be addressed through enhanced engineering controls and modified work practices.

Recommendations

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. At Facility C, install a potable water hand washing station on-site to improve hygienic conditions and reduce the risk of ingesting copper slag dust.

a. Per the OSHA *General Environmental Controls, Sanitation Standard* [29 CFR 1910.141], "potable water shall be provided in all places of employment, for drinking, washing of the person, cooking, washing of foods, washing of cooking or eating utensils, washing of food preparation or processing premises, and personal service rooms." Also, "portable drinking water dispensers shall be designed, constructed, and serviced so that sanitary conditions are maintained, shall be capable of being closed, and shall be equipped with a tap."

b. Information on general working conditions and sanitation can be found on the OSHA website (https://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9790).

2. Use wet methods, such as road wetting, during the use of the forklift to fill super sacks to reduce dust generation and dust exposure to the worker operating the forklift.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Continue performing maintenance checks and other repair tasks in the morning before operation. At this time, the screening machines and the dryer oven should be turned off.
2. Prohibit employees from entering the screen house (all facilities) and conveyor access shack (Facility C) at any time during operation. Entry should only occur in the morning before operation or when machines are off and after dust has fully settled.
3. Ensure employees understand potential hazards (e.g., dust, silica, metals) in the workplace and how to protect themselves. OSHA's *Hazard Communication Standard*, also known as the "*Right to Know Law*" [29 CFR 1910.1200] requires that employees are informed and trained on potential work hazards and associated safe practices, procedures, and protective measures. Hold a workforce presentation to share these results.
   a. Information on OSHA's *Hazard Communication Standard* can be found on the OSHA website at https://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9790
4. Conduct exposure monitoring to determine employee exposure to crystalline silica. Give special attention to employees working near high risk areas (e.g., screen and bag house). Review the new OSHA regulations for occupational exposures to crystalline silica to ensure each facility is in compliance
   a. New OSHA standards on silica –
      i. Crystalline Silica Rulemaking https://www.osha.gov/silica/

ii. OSHA's New Crystalline Silica Rule: Overview https://www.osha.gov/Publications/OSHA3683.pdf
iii. Silica Rulemaking FAQs https://www.osha.gov/silica/Silica_FAQs_2016-3-22.pdf

5. Conduct bulk sample analysis for silica and metals of both unprocessed coal and copper slag product and finished granule product if coal or copper slag is delivered from new plants or if the process changes.
6. At Facility C, conduct exposure monitoring to determine employee exposure to arsenic. Review the requirements of the OSHA *Inorganic Arsenic Standard* [29 CFR 1910.1018] to ensure each facility is in compliance.
    a. Information on OSHA's *Inorganic Arsenic Standard* can be found on the OSHA website at https://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10023

Personal Protective Equipment

Personal protective equipment is the least effective means for controlling hazardous exposures. Proper use of personal protective equipment requires a comprehensive program and a high level of employee involvement and commitment. The right personal protective equipment must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. Personal protective equipment should not be the sole method for controlling hazardous exposures. Rather, personal protective equipment should be used until effective engineering and administrative controls are in place.

1. Establish a *mandatory* respiratory protection program that adheres to the requirements of the OSHA *Respiratory Protection Standard* [29 CFR 1910.134]. Require mandatory use of respirators, at least as protective as an N95 disposable filtering-facepiece respirator. As part of the respiratory protection program, require the use of an N95 disposable filtering-facepiece respirator during the following tasks or in the following locations:
    a. During any tasks that involve going near the screen houses (outside or inside) at all facilities;
    b. During QC checks;
    c. When the baggers fill a super sack; and
    d. When operating a forklift to fill a super sack.

Details on the *Respiratory Protection Standard* and on how a company can set up a respiratory protection program are available on the OSHA website (http://www.osha.gov/SLTC/respiratoryprotection/index.html).

A NIOSH document on Respiratory Protection Recommendations for Airborne Exposures to Crystalline Silica can be found at http://www.cdc.gov/niosh/docs/2008-140/

NIOSH recommends the use of half-facepiece particulate respirators with N95 or better filters for airborne exposures to crystalline silica at concentrations less than or equal to

0.5 mg/m^3. OSHA also specifies the use of at least a 95-rated filter efficiency [29 Code of Federal Regulations (CFR) 1910.134].

2. Educate workers on the use of N95 disposable filtering-facepiece respirator. A NIOSH document showing how to put on and take off a disposable respirator correctly can be obtained at http://www.cdc.gov/niosh/docs/2010-133/pdfs/2010-133.pdf.
3. Provide employees with personal protective clothing (long-sleeve shirt, work pants, and boots), a change out station and storage for clean and dirty clothing to reduce take-home exposures of dust and metals from dirty clothing. Employees should not take dirty work clothing home; company should make arrangements to wash the work clothing.

Medical Surveillance

The purpose of a medical surveillance program is to help assure the health of employees who have workplace exposures to health hazards (e.g., dust, silica, arsenic) known to pose risk for potentially serious health conditions, illnesses, or injuries; or perform work tasks (e.g., respirator use) that require a degree of health and fitness to assure employee and/or public health and safety.

1. If not already done so, in accordance with the OSHA *Inorganic Arsenic Standard* [29 CFR 1910.1018], monitor for potential employee exposure to arsenic, special attention should be given to Facility C.

   According to the OSHA *Inorganic Arsenic Standard* [29 CFR 1910.1018],

   > *Medical examinations are to be provided for all employees exposed to levels of inorganic arsenic above the action level (5 ug/m^3) for at least 30 days per year (which would include among others, all employees, who work in regulated areas). Examinations are also to be provided to all employees who have had 10 years or more exposure above the action level for more than 30 days per year while working for the present or predecessor employer though they may no longer be exposed above the level.*
   >
   > *An initial medical examination is to be provided to all such employees by December 1, 1978. In addition, an initial medical examination is to be provided to all employees who are first assigned to areas in which worker exposure will probably exceed 5 ug/m^3 (after the effective date of this standard) at the time of initial assignment. In addition to its immediate diagnostic usefulness, the initial examination will provide a baseline for comparing future test results. The initial examination must include as a minimum the following elements:*
   >
   > *(1) A work and medical history, including a smoking history, and presence and degree of respiratory symptoms such as breathlessness,*

cough, sputum production, and wheezing;

(2) A 14” by 17” posterior-anterior chest X-ray;

(3) A nasal and skin examination; and

(4) Other examinations which the physician believes appropriate because of the employee's exposure to inorganic arsenic or because of required respirator use.

Periodic examinations are also to be provided to the employees listed above. The periodic examinations shall be given annually for those covered employees 45 years of age or less with fewer than 10 years employment in areas where employee exposure exceeds the action level (5 ug/m³). Periodic examinations need not include sputum cytology and only an updated medical history is required.

Periodic examinations for other covered employees, shall be provided every six (6) months. These examinations shall include all tests required in the initial examination, except that the medical history need only be updated.

The examination contents are minimum requirements. Additional tests such as lateral and oblique X-rays or pulmonary function tests may be useful. For workers exposed to three arsenicals which are associated with lymphatic cancer, copper acetoarsenite, potassium arsenite, or sodium arsenite the examination should also include palpation of superficial lymph nodes and complete blood count [29 CFR 1910.1018]; available at https://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10026.

Details on the specific requirements and employer responsibilities can be found on the OSHA website at https://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10023 and https://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10026.

As noted earlier, OSHA has implemented a new respirable crystalline silica PEL of 0.05 mg/m³, (50 µg/m³) which is the same as the NIOSH REL of 0.05 mg/m³. The crystalline silica standard (29 CFR 1910.1053) requires employers to limit access to high exposure areas, provide training, provide respiratory protection when controls are not enough to limit exposure, provide written exposure control plans, and measure exposures in some cases. An OSHA FactSheet describing the new OSHA's Crystalline Silica Rule for General Industry and Maritime can be found at the following link: https://www.osha.gov/Publications/OSHA3682.pdf

Medical surveillance must be offered to employees who will be exposed above the PEL for 30 or more days a year starting on June 23, 2018. Appendix B of the respirable crystalline silica standard (29 CFR 1910.1053) provides medical information and recommendations to aid physicians and other licensed health care professionals (PLHCPs) regarding compliance with the medical surveillance provisions of the respirable crystalline silica standard (https://www.osha.gov/silica/AppendixBtosect1910.1053.pdf).

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Table A1. Bulk sample results, metals and silica, all facilities, NIOSH industrial hygiene survey (mg/kg)

Bulk Location	As	Be	Cd	Cr	Co	Cu	Fe	Pb	Mn	Ni	Pt	Ti	V	Silica (Quartz)
Coal Slag Processing Facility (Facility A)														
Finished product granule A	<LOD	<LOD	1.1	76	29	51	59,000	<LOD	460	49	<LOD	7,100	190	<LOD
Finished product granule B	<LOD	<LOD	0.83	72	25	45	59,000	<LOD	440	44	0.07	5,800	180	<LOD
Finished product granule C	<LOD	<LOD	0.73	75	55	79	60,000	<LOD	460	160	0.04	6,700	190	<LOD
Finished product granule D	<LOD	<LOD	0.8	70	21	35	55,000	<LOD	480	42	0.06	4,200	160	3,400
Finished product granule E	<LOD	<LOD	0.9	78	28	47	60,000	<LOD	460	48	0.07	6,900	190	<LOD
Settled dust, screen house A	<LOD	<LOD	1.5	80	21	51	46,000	14	280	66	0.08	4,000	130	18,000
Settled dust, screen house B	20	<LOD	1.6	84	22	53	47,000	<LOD	300	68	0.07	4,200	130	12,000
Settled dust, warehouse A	<LOD	<LOD	1.8	76	24	1,300	58,000	75	500	62	0.08	5,200	140	26,000
Settled dust, warehouse B	<LOD	<LOD	0.77	76	26	35	58,000	<LOD	450	50	<LOD	5,600	170	<LOD
Coal Slag Processing Facility (Facility B)														
Bulk Location	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**V**	**Silica (Quartz)**
Slag on conveyor belt	0.3	<LOQ	<LOD	<LOD	<LOD	<LOD	4,300	<LOD	17	<LOD	0.04	61	6.9	5,100
Unprocessed slag (IL)	<LOD	0.26	<LOD	4.9	0.8	2.3	5,900	<LOD	25	<LOD	<LOD	92	5.6	4,600
Unprocessed slag (KY)	<LOD	4.1	0.95	41	16	8.1	61,000	<LOD	210	64	0.03	1,000	92	4,300
Unprocessed slag (WY)	<LOD	<LOD	<LOD	55	21	30	32,000	<LOD	150	36	<LOD	5,500	160	<LOD
Unprocessed slag (IL)	<LOD	0.22	<LOD	<LOD	0.9	<LOD	3,100	<LOD	9.8	<LOD	<LOD	44	<LOD	4,800
Settled dust; bag house	<LOD	1.7	1.5	43	15	30	51,000	16	200	100	<LOD	1,000	64	16,000
Finished product granule A	<LOD	<LOD	0.53	16	8.1	9	17,000	<LOD	73	17	0.021	1,400	44	<LOD
Finished product granule B	<LOD	<LOD	0.57	33	14	8.6	40,000	<LOD	150	35	0.02	1,900	72	<LOD
Magnet	28	<LOD	8.4	93	340	320	520,000	10	830	1,400	<LOD	260	110	8,600
Copper Slag Processing Facility (Facility C)														
Bulk Location	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**V**	**Silica (Quartz)**
Finished product granule; QC (A)	4,300	<LOD	100	190	920	6,300	330,000	2,600	3,100	37	<LOD	1,600	200	5,300
Finished product granule; QC (B)	4,300	<LOD	100	180	860	6,500	310,000	2,500	2,500	61	<LOD	1,500	210	15,000
Screen house conveyor	11,000	<LOD	240	120	770	19,000	240,000	3,100	2,300	35	<LOD	1,200	190	49,000
Unprocessed slag	2,400	<LOD	65	100	810	5,500	290,000	2,100	3,400	140	<LOD	1,300	210	5,500
Unprocessed slag	1,600	<LOD	56	69	830	4,700	270,000	1,500	2,400	21	<LOD	1,300	160	6,300
Blastnox®	2,700	<LOD	68	140	670	4,200	240,000	1,500	2,100	35	<LOD	1,700	160	<LOD

Note: mg/kg=milligrams per kilogram; <LOD=below limit of detection for the instrument used to detect the analyte; As=arsenic; Be=beryllium; Cd=cadmium; Cr=chromium; Co=cobalt; Cu=copper; Fe=iron; Pb=lead; Mn=manganese; Ni=nickel; Pt=platinum; Ti=titanium; V=vanadium; Blastnox=commercial lead stabilizing additive.

Table A2. Personal air sampling results, dust and silica, all facilities, NIOSH industrial hygiene survey (mg/m^3)

Coal Slag Processing Facility A, September 2014			
Job Title	Dust		Crystalline Silica
	Total (mg/m^3)	Respirable (mg/m^3)	Quartz (mg/m^3)
Maintenance	--	0.08	<LOD
Maintenance	--	0.37	<LOD
Maintenance	--	0.12	<LOD
Plant operator	1.14	0.07	<LOD
Plant manager	0.27	--	--
Bagger	1.97	0.14	<LOD
Bagger	6.56	--	--
Heavy equipment operator	0.34	<LOD	<LOD
EHS manager	0.62	0.06	<LOD
Office coordinator	1.26	<LOD	<LOD
Coal Slag Processing Facility B, September 2014			
Job Title	**Dust**		**Crystalline Silica**
	Total (mg/m^3)	**Respirable (mg/m^3)**	**Quartz (mg/m^3)**
Maintenance	0.34	<LOD	<LOD
Plant operator	0.21	<LOD	<LOD
Plant manager	0.12	--	--
Heavy equipment operator	0.30	<LOD	<LOD
EHS manager	0.22	<LOD	<LOD
Copper Slag Processing Facility (Facility C), July 2015			
Job Title	**Dust**		**Crystalline Silica**
	Total (mg/m^3)	**Respirable (mg/m^3)**	**Quartz (mg/m^3)**
Heavy equipment operator	0.83	0.25	0.012
Laborer	1.78	0.53	0.042
Maintenance	1.34	0.13	<LOD
Maintenance	1.94	0.32	0.013
Plant hand	6.35	0.70	0.031
Plant manager	0.34	0.03	<LOD
OSHA PEL†	*15*	*5*	*0.05*
NIOSH REL	*NA*	*NA*	*0.05*
ACGIH TLV‡	*NA*	*3*	*0.025*

Note: mg/m^3=milligram per cubic meter; NIOSH=National Institute for Occupational Safety and Health; REL=recommended exposure limit; ACGIH=American Conference of Governmental Industrial Hygienist; TLV=threshold limit value; OSHA=Occupational Safety and Health Administration; PEL=permissible exposure limit; <LOD=below the limit of detection (LOD) for the instrument used to detect the analyte; EHS=environmental health and safety.

†The new OSHA PEL for respirable crystalline silica respirable crystalline silica is 0.05 mg/m^3.

‡ACGIH does not have a TLV for inhalable or respirable dust but does provide guidelines for inhalable or respirable dust; ACGIH recommends inhalable dust concentrations be kept below 10 mg/m^3, and respirable dust concentrations be kept below 3 mg/m^3.

Table A3. Personal air sampling results, metals, all facilities, NIOSH industrial hygiene survey (µg/m³)

Coal Slag Processing Facility (Facility A)													
Job Title	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**V**
Plant Operator	<LOD	<LOD	<LOD	0.95	<LOD	3.49	134	<LOD	0.93	<LOD	<LOD	13.1	0.51
Plant Manager	<LOD	<LOD	<LOD	0.4	<LOD	<LOD	13.8	<LOD	<LOD	<LOD	<LOD	1.28	<LOD
Bagger	<LOD	<LOD	<LOD	0.9	<LOD	<LOD	155	<LOD	1.1	<LOD	<LOD	18.3	0.58
Bagger	<LOD	<LOD	<LOD	1.44	<LOD	<LOD	568	<LOD	3.93	<LOD	<LOD	59.0	1.68
Heavy Equipment Operator	<LOD	<LOD	<LOD	0.64	<LOD	<LOD	26.3	<LOD	<LOD	<LOD	<LOD	2.63	<LOD
EHS Manager	<LOD	<LOD	<LOD	0.71	<LOD	<LOD	44.9	<LOD	<LOD	<LOD	<LOD	5.03	<LOD
Office Coordinator	<LOD	<LOD	<LOD	0.55	<LOD	<LOD	57.8	<LOD	<LOD	<LOD	<LOD	4.57	<LOD
Job Title	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**Va**
Maintenance Worker	<LOD	<LOD	<LOD	0.28	<LOD	<LOD	39.1	<LOD	<LOD	<LOD	<LOD	1.39	<LOD
Plant Operator	<LOD	<LOD	<LOD	0.7	<LOD	1.18	84.0	<LOD	<LOD	<LOD	<LOD	2.57	<LOD
Plant Manager	<LOD	<LOD	<LOD	0.64	<LOD	<LOD	22.8	<LOD	<LOD	<LOD	<LOD	0.85	<LOD
Heavy Equipment Operator	<LOD	<LOD	<LOD	0.72	<LOD	<LOD	21.4	<LOD	<LOD	<LOD	<LOD	1.31	<LOD
EHS Manager	<LOD	<LOD	<LOD	0.47	<LOD	<LOD	20.3	<LOD	<LOD	<LOD	<LOD	0.66	<LOD
Job Title	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**Va**
Heavy Equipment Operator	9.12	<LOD	0.25	0.68	0.84	21.72	246	3.33	2.17	<LOD	<LOD	1.25	0.17
Laborer	**17.9**	<LOD	0.45	0.74	0.87	44.05	357	5.6	3.21	0.1	<LOD	1.91	0.31
Maintenance	**18.0**	<LOD	0.44	0.74	0.79	41.61	416	5.83	3.47	0.08	<LOD	2.08	0.29
Maintenance	9.14	<LOD	0.26	0.79	0.82	24.37	353	3.66	4.26	0.24	<LOD	1.46	0.17
Plant Hand	**18.0**	0.04	0.52	0.89	0.94	47.95	371	6.11	3.6	0.16	<LOD	1.92	0.3
Plant Manager	2.74	<LOD	0.07	0.57	0.26	9.01	57.0	1.07	0.74	<LOD	<LOD	0.35	<LOD
	10	*2*	*5*	*1,000*	*100*	*1,000*	*10,000*	*50*	*5,000*	*1,000*	*1,000*	*15,000§*	
	2†‡±	*0.5±*	*NA*	*500*	*50*	*1,000*	*5,000*	*50*	*1,000*	*15±*	*1,000*	*NA¶§*	
	10	*0.05*	*10*	*500*	*20*	*1,000*	*5,000#*	*50*	*200*	*1,500*	*1,000*	*10,000§*	

Note: µg/m³=micrograms per cubic meter; OSHA=Occupational Safety and Health Administration; PEL=permissible exposure limit; NIOSH=National Institute for Occupational Safety and Health; REL=recommended exposure limit; ACGIH=American Conference of Governmental Industrial Hygienist; TLV=threshold limit value; <LOD=below the limit of detection for the instrument used to detect the analyte. The LOD for each analyte is below any of the existing OSHA, NIOSH, or ACGIH exposure limits; As=arsenic, Be=beryllium; Cd=cadmium; Cr=chromium; Co=cobalt; Cu=copper; Fe=iron; Pb=lead; Mn=manganese; Ni=nickel; Pt=platinum; Ti=titanium; V=vanadium; Bold text indicates concentration exceeds OSHA PEL. Exposure limits are specified for personal (employee wearing sampler) samples (not area samples); NA=not applicable; †=ceiling: ceiling value should not be exceeded at any time; ‡=15-minute exposure limit that should not be exceeded at any time during a workday; ±=carcinogen: causes an increase in cancer; ¶=potential carcinogen: potential to cause an increase in cancer; #=respirable dust fraction; §=dioxide.

Table A4. Area air sampling results, dust and silica, for all facilities, NIOSH industrial hygiene survey (mg/m^3)

	Dust		Crystalline Silica
	Inhalable	Respirable	Quartz
Coal Slag Processing Facility (Facility A)			
Bagging station (Indoor)	1.25	0.16	<LOD
Control room (Indoor)	<LOD	0.06	<LOD
Feed hopper (Indoor)	<LOD	0.02	<LOD
QC check (Outdoor)	**13.1**	0.5	<LOD
Screen house, upstairs (Indoor)	**21.5**	2.29	0.005
Screen house, downstairs (Indoor)	**21.0**	0.31	<LOD
Coal Slag Processing Facility (Facility B)			
Baghouse (Outdoor)	**11.3**	0.09	<LOD
Drying oven (Outdoor)	3.71	0.04	<LOD
Control room (Indoor)	<LOD	<LOD	<LOD
Loading dock (Outdoor)	<LOD	<LOD	<LOD
Screen house (Outdoor)	4.84	0.03	<LOD
Screen house (Indoor)	**68.1**	0.36	0.005
North of slag plant (Outdoor)	0.35	<LOD	<LOD
Copper Slag Processing Facility (Facility C)			
End of super sack bagging conveyor (Outdoor)	2.19	0.10	<LOD
Super sack station (Outdoor)	1.77	<LOD	<LOD
Conveyor access shack (Indoor)	**11.4**	1.74	**0.067**
Exit door of screen house (Outdoor)	1.64	--	--
QC check (Outdoor)	**236**	**10.3**	**0.43**
Screen house (Indoor)	**109**	**13.7**	**0.686**
Right of bagging conveyor access shack (Outdoor)	0.8	0.08	0.007
Left of bagging conveyor access shack (Outdoor)	1.4	0.14	0.007
Under conveyor leading into screen house (Outdoor)	**19.8**	--	--
Under drying oven (Outdoor)	1.79	--	--
OSHA PEL [†]	*15* [#]	*NA*	*0.05*
NIOSH REL [†]	*NA*	*NA*	*0.05*
ACGIH TLV [†‡]	*10**	*3**	*0.025*

Note: mg/m^3=milligram per cubic meter; OSHA=Occupational Safety and Health Administration; PEL=permissible exposure; NIOSH=National Institute for Occupational Safety and Health; REL=recommended exposure limit; ACGIH=American Conference of Governmental Industrial Hygienist; TLV=threshold limit value; Bold text indicates concentration exceeds OSHA PEL; <LOD=below the limit of detection for the instrument used to detect the analyte. The LOD for each analyte is below any of the existing OSHA, NIOSH, or ACGIH exposure limits.

†Exposure limits are specified for personal (employee wearing sampler) samples (not area samples).

‡ACGIH does not have a TLV for inhalable or respirable dust but does provide guidelines for inhalable or respirable dust; ACGIH recommends inhalable dust concentrations be kept below 10 mg/m^3, and respirable dust concentrations be kept below 3 mg/m^3.

#OSHA confirmed that total dust measurement collected with an IOM Sampler may be used as an equivalent method when measuring an employee's exposure for comparison to the PEL.

§The new OSHA PEL for respirable crystalline silica is 0.05 mg/m^3.

Table A5. Area air sampling results, metals, all facilities, NIOSH industrial hygiene survey (µg/m³)

Coal Slag Processing Facility (Facility A)													
Location	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**V**
Bagging station	<LOD	<LOD	<LOD	0.35	<LOD	<LOD	42.4	<LOD	<LOD	<LOD	<LOD	4.58	0.32
Control room	<LOD	<LOD	<LOD	0.4	<LOD	0.6	11.5	<LOD	<LOD	<LOD	<LOD	1.08	<LOD
Feed hopper	<LOD	<LOD	<LOD	0.39	<LOD	1.05	22.6	<LOD	<LOD	<LOD	<LOD	0.92	<LOD
QC screen	<LOD	<LOD	<LOD	1.1	<LOD	<LOD	231	<LOD	1.59	1.27	<LOD	24.5	0.79
Screen house, upstairs	<LOD	<LOD	<LOD	2.9	0.55	1.33	785	<LOD	5.46	1.88	<LOD	87	2.39
Screen house, downstairs	<LOD	<LOD	<LOD	0.87	<LOD	<LOD	286	<LOD	2.14	<LOD	<LOD	34.2	0.87
Coal Slag Processing Facility (Facility B)													
Location	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**Va**
Baghouse	<LOD	0.03	<LOD	2.23	0.37	1.06	2,531	<LOD	7.74	2.08	<LOD	32.8	1.64
Drying oven	<LOD	0.03	<LOD	1.71	0.36	<LOD	1,041	<LOD	3.99	<LOD	<LOD	25.7	1.38
Control room	<LOD	<LOD	<LOD	0.51	<LOD	0.67	17.3	<LOD	<LOD	<LOD	<LOD	0.59	<LOD
Loading station	<LOD	<LOD	<LOD	0.57	<LOD	<LOD	7.19	<LOD	<LOD	<LOD	<LOD	0.16	<LOD
Screen house (Outdoor)	<LOD	0.1	<LOD	2.6	0.67	<LOD	2,602	<LOD	9.4	2.89	<LOD	60.7	3.18
Screen house (Indoor)	<LOD	0.11	<LOD	3.76	0.78	0.95	2,507	<LOD	9.69	3.53	<LOD	44.5	3.08
North of facility (Outdoor)	<LOD	<LOD	<LOD	0.41	<LOD	<LOD	44.19	<LOD	<LOD	<LOD	<LOD	1.5	<LOD
Copper Slag Processing Facility (Facility C)													
Location	**As**	**Be**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Ni**	**Pt**	**Ti**	**V**
End of super sack bagging conveyor	2.93	<LOD	0.09	0.13	<LOD	9.4	85.4	1.2	1.95	0.07	<LOD	1.83	0.11
Super sack station	2.79	<LOD	0.06	0.15	<LOD	9.4	127	1.4	2.03	0.08	<LOD	1.4	0.11
Conveyor access shack	**67.7**	<LOD	1.95	1.95	5.62	206	2,180	27.5	19.5	0.75	<LOD	11.2	1.38
Screen house (Outdoor)	**12.5**	<LOD	0.36	0.29	<LOD	37.0	178	3.98	1.65	0.1	<LOD	0.93	0.1
QC check	**96.9**	<LOD	2.73	1.37	4.6	285	1,863	34.7	17.3	0.51	<LOD	9.57	1.24
Screen house	**1,030**	<LOD	**23.8**	16.3	67.8	2,262	**27,658**	**326**	226	5.15	<LOD	138	20.1
Conveyor access shack (right)	2.56	<LOD	0.07	0.1	<LOD	7.67	64.5	1.07	0.79	0.03	<LOD	0.57	0.06
Conveyor access shack (left)	5.63	<LOD	0.15	0.28	<LOD	16.6	121	2.18	1.54	0.06	<LOD	1.1	0.09
Under conveyor to screen house	**89.1**	<LOD	2.26	1.84	7.64	169	3,113	31.1	25.4	0.37	<LOD	15.57	1.98
Under drying oven	8.98	<LOD	0.23	0.32	<LOD	20.7	193	3.04	1.8	<LOD	<LOD	1.02	0.18
OSHA PEL	*10*	*2*	*5*	*1,000*	*100*	*1,000*	*10,000*	*50*	*5,000†‡*	*1,000*	*2*	*15,000±*	*500†¶*
NIOSH REL	*2 †‡*	*0.5*	*NA*	*500*	*50*	*1,000*	*5,000*	*50*	*1,000*	*15*	*2*	*NA*	*NA*
ACGIH TLV	*10*	*0.05*	*1*	*500*	*20*	*1,000*	*5,000#*	*50*	*100*	*1,500*	*2*	*1,000±*	*50¶*

Note: µg/m³=micrograms per cubic meter; OSHA=Occupational Safety and Health Administration; PEL=permissible exposure limit; NIOSH=National Institute for Occupational Safety and Health; REL=recommended exposure limit; ACGIH=American Conference of Governmental Industrial Hygienist; TLV=threshold limit value; <LOD=below the limit of detection for the instrument used to detect the analyte. The LOD for each analyte is below any of the existing OSHA, NIOSH, or ACGIH exposure limits; As=arsenic, Be=beryllium; Cd=cadmium; Cr=chromium; Co=cobalt; Cu=copper; Fe=iron; Pb=lead; Mn=manganese; Ni=nickel; Pt=platinum; Ti=titanium; V=vanadium; Bold text indicates concentration exceeds OSHA PEL. Exposure limits are specified for personal (employee wearing sampler) samples (not area samples); NA=not applicable; †ceiling: ceiling value should not be exceeded at any time; ‡15-minute exposure limit that should not be exceeded at any time during a workday; ±carcinogen: causes an increase in cancer; ¶potential carcinogen: potential to cause an increase in cancer; #respirable dust fraction; §dioxide.

Figures

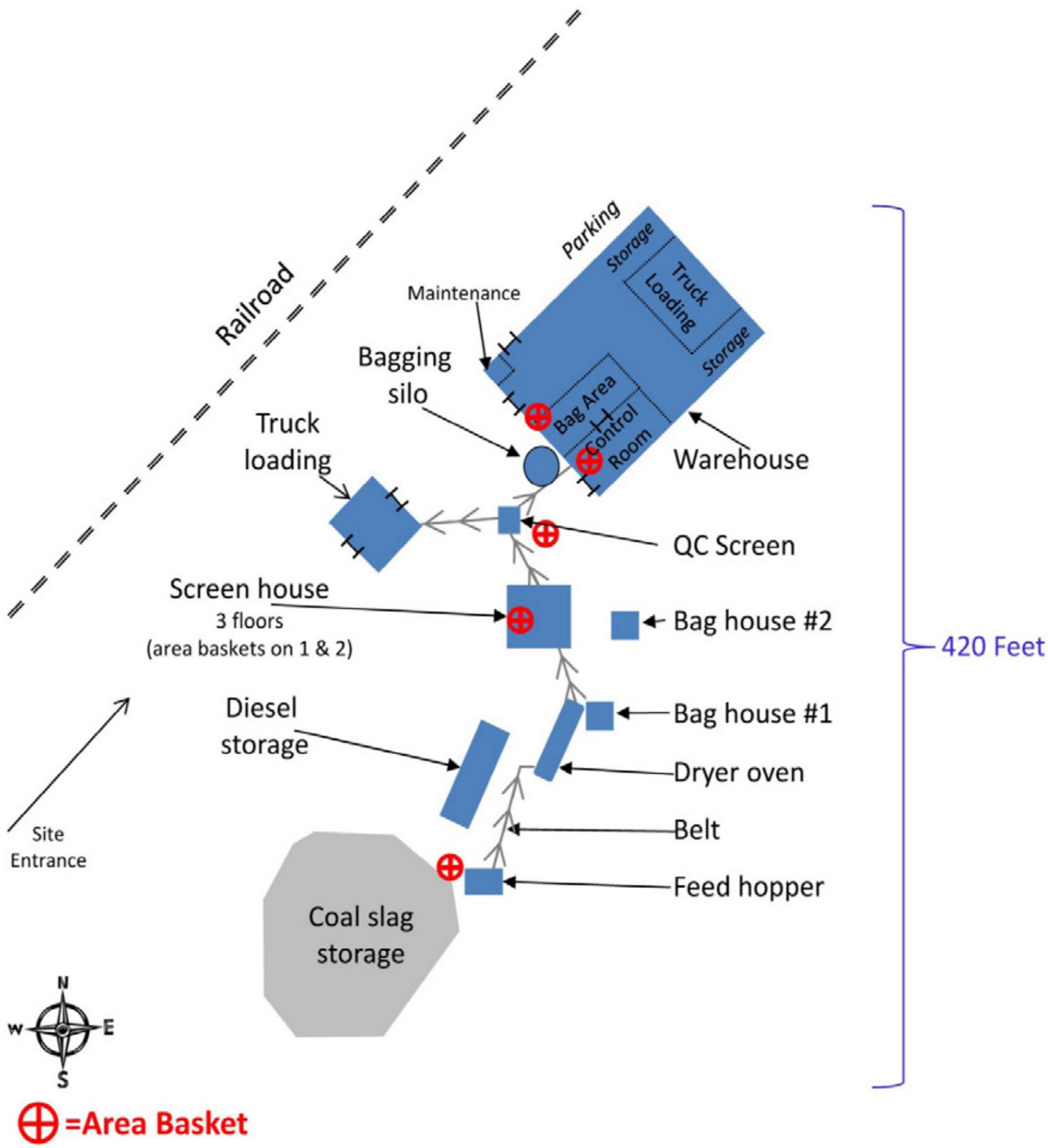

Figure A1. Facility A - Area air sampling locations, NIOSH industrial hygiene survey, September 2014.

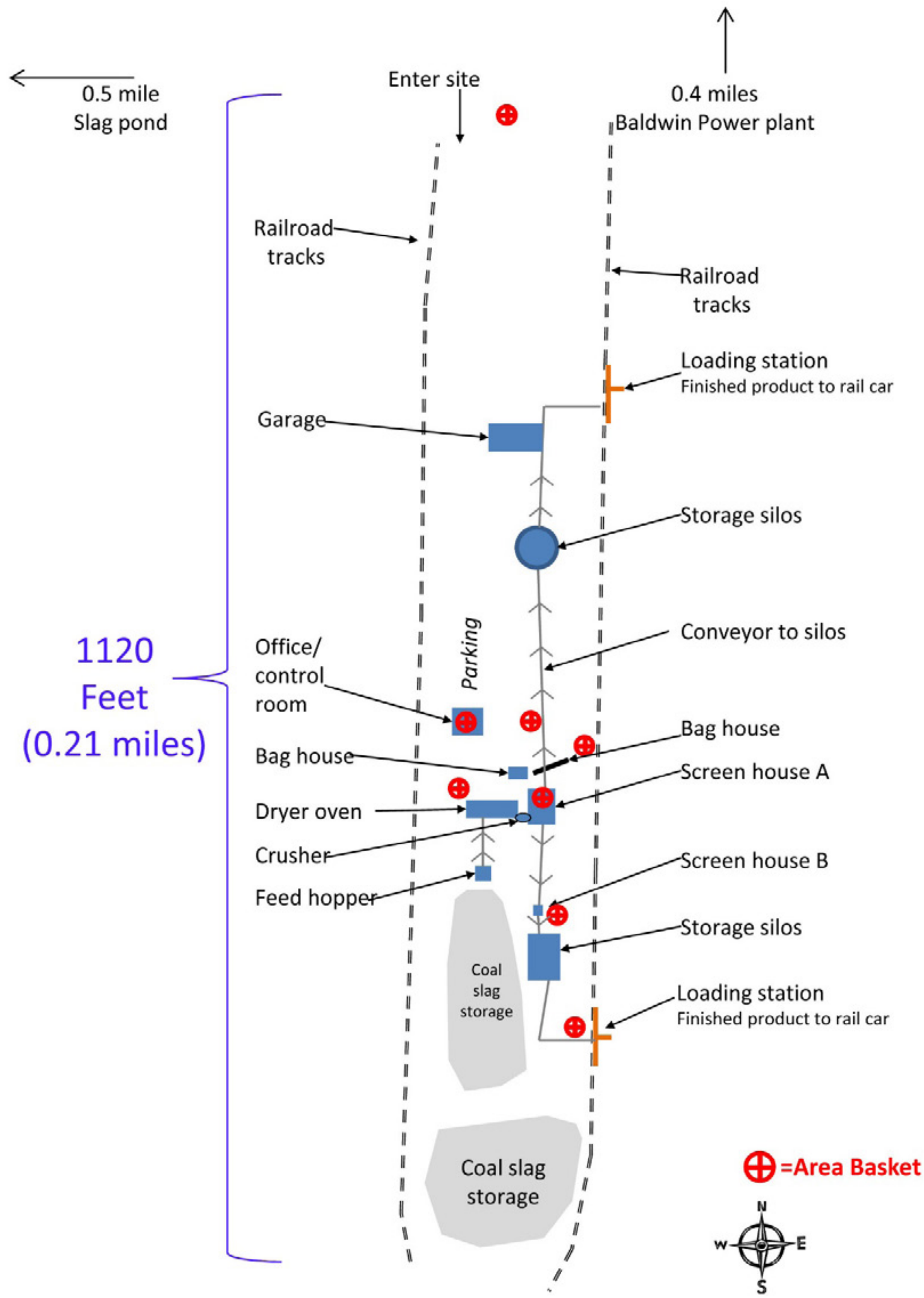

Figure A2. Facility B - Area air sampling locations, NIOSH industrial hygiene survey, September 2014.

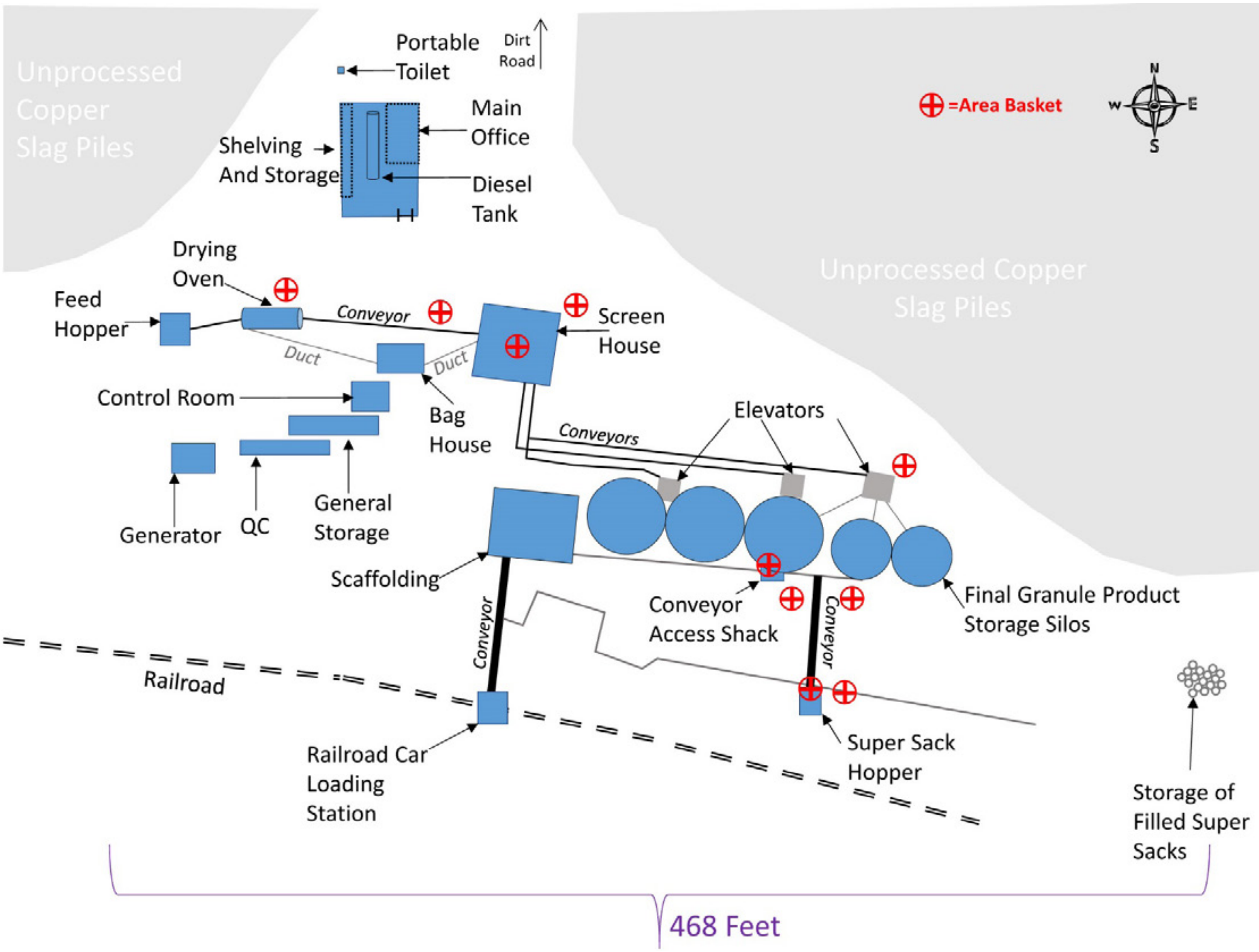

Figure A3. Facility C - Area air sampling locations, NIOSH industrial hygiene survey, July 2015.

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Keywords: NAICS 327992, coal slag, copper slag, silica, arsenic, metals, dust, pneumoconiosis

The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 (29 U.S.C. § 669(a)(6)). The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations (42 CPR Part 85).

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The recommendations in this report are made on the basis of the findings at the workplace evaluated and may not be applicable to other workplaces.

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Acknowledgments

Desktop Publisher: Tia McClelland
Data Analysis Support: Nicole Edwards

Availability of Report

This report is available at http://www.cdc.gov/niosh/hhe/reports/pdfs/2013-0016-3258.pdf.

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Recommended citation for this report:
NIOSH [2016]. Health hazard evaluation report: evaluation of respiratory concerns at a a coal and copper slag processing company. By Mugford C, Boylstein R, Armstrong Gibbs J, McCague A. Morgantown, WV: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HHE Report No. 2013-0016-3258.

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