NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2006-0006-3039
Environmental Protection Services, Inc
Wheeling, West Virginia

March 2007

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

PREFACE

The Hazard Evaluation 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 employers 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 Manuel Rodriguez and Ayodele Adebayo of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Andrea Markey and Scott Brueck. Analytical support was provided by Ardith Grote, Division of Applied Research, and Technology (DART), and Clayton Laboratories. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at Environmental Protection Services, Inc., (EPS) and the OSHA Regional Office. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

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

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at Environmental Protection Services, Inc. (EPS), Wheeling, West Virginia. The request asked NIOSH to evaluate exposures to dust, smoke, and fumes generated while recycling transformers, some of which contained polychlorinated biphenyls (PCBs). NIOSH investigators conducted site visits at EPS during February and July 2006.

What NIOSH Did

- We took air samples for metals and PCBs.
- We took wipe samples on surfaces and analyzed them for PCBs.
- We took bulk samples of transformer oil for PCBs.
- We looked at work activities.
- We spoke with employees about their work-related exposures and health concerns.

What NIOSH Found

- We found overexposure to copper and lead in the metal sorting/baling area.
- One personal breathing zone air sample was above the NIOSH recommended exposure limit (REL) for PCBs.
- Some work surfaces were contaminated with PCBs.
- Some respirators were not worn properly.
- A complete respirator program was not in place.
- We saw unsafe work practices: (1) moving compressed gas cylinders by the valve cap; (2) working under a shear that had not been turned off; and (3) storing sodium metal near water.
- Except for two workers with a history of work-related rash, no employees that we spoke with had any work-associated health effects or concerns.

What EPS Managers Can Do

- Use engineering controls or change work practices to reduce exposures to copper, lead, and PCBs.
- Provide employees with proper respiratory protection until you can make the above changes.
- Comply with the OSHA respiratory protection and lead standards.
- Do not transport compressed gas cylinders by the valve cap. Use a cradle boat when transporting cylinders with a crane.
- Do not allow employees to work under energized equipment without lockout/tagout.
- Do not allow eating, drinking, or smoking in the work areas.
- Clean PCB-contaminated surfaces.
- Modify the canopy hood used for cutting open transformers to a back- or side-draft hood.
- Do not store or allow employees to handle sodium (ingots) near a water source.

What EPS Employees Can Do

- Wear your respirators correctly.
- Do not eat, drink, or smoke in work areas.
- Wash hands before eating, drinking, or smoking.
- Always wear gloves when handling PCBs.
- Comply with safety procedures.

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

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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at Environmental Protection Services (EPS), Inc. Wheeling, West Virginia. The request asked NIOSH to evaluate exposures to dust, smoke, and fumes generated while recycling transformers, some of which contained polychlorinated biphenyls (PCBs). During an initial site visit to the EPS facility on February 15–16, 2006, we observed the transformer recycling processes, looked at potential worker exposures, and randomly selected eight persons for confidential interviews to discuss their concerns about work exposures and adverse health outcomes. On July 10–13, 2006, we took personal breathing-zone (PBZ) and area air samples for PCBs and metals, collected surface wipe samples and bulk samples of transformer oil for PCB analysis, and ash from incinerated materials for PCB and metal analysis.

We found that a worker sorting and baling metal was exposed to copper and lead over the NIOSH recommended exposure limit-time weighted average (REL-TWA) and Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) -TWA of 1 milligram per cubic meter (mg/m^3) and 0.05 mg/m^3, respectively. One PBZ air sample collected on a worker in the PCBX^{SM} trailer was above the NIOSH REL for PCBs of 0.001 mg/m^3. Some workers were wearing respirators inappropriately and had not been fit tested. Some work surfaces were contaminated with PCBs above 100 micrograms per square meter ($\mu g/m^2$), a guideline used by NIOSH investigators based on the results of previous evaluations. We observed several unsafe work practices including lifting gas cylinders by the valve cap, working beneath an energized overhead shear without lockout/tagout, and storing sodium ingots near a water source.

We did not find any health effects suggestive of PCB exposure. At one time all EPS employees were tested for serum PCB but currently only workers in the enclosed decontamination area are tested. EPS management referred one person with an elevated serum PCB level for medical evaluation. Our review of the EPS OSHA 300 Logs of Work-Related Injuries and Illnesses did not identify any health effects suggestive of PCB or metals exposure.

NIOSH investigators determined that a health hazard exists for some employees from exposure to lead, copper, and PCBs; improper use of respirators; and unsafe work practices. Recommendations are provided for engineering controls and modification of work practices to reduce employee exposures to metals and PCBs. NIOSH investigators also recommended that EPS management review procedures for handling gas cylinders, storing and handling sodium ingots, and working on energized equipment.

Keywords: NAICS 562920 (Materials Recovery Facility) PCEs, metals, dust, transformers, recycling, sodium, fumes, copper, lead, safety, respirators.

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INTRODUCTION

In October 2005, NIOSH received a confidential employee request for a health hazard evaluation (HHE) at Environmental Protection Services, Inc., (EPS), Wheeling, West Virginia. The requestors were concerned about dust, smoke, and fumes generated while recycling transformers and about the potential safety hazard posed by storing sodium in a facility equipped with a sprinkler system. We conducted an initial site visit to EPS on February 15–16, 2006, during which we held an opening conference with EPS management and employee representatives, conducted a facility walk-through, observed the transformer recycling processes, reviewed pertinent environmental sampling, medical, and work-related injury and illness records, and interviewed employees. On February 16, 2006, we held a closing conference to brief management and employee representatives about observations made during the site visit. Based on observations of tasks performed by workers and potential exposures we determined that further evaluation, including environmental sampling, would be necessary.

We conducted a follow-up visit to EPS Inc., on July 10–13, 2006. During the visit, we conducted personal breathing zone (PBZ) and area air sampling for polychlorinated biphenyls (PCBs) and metals. We collected bulk oil samples from transformers for PCB analyses, bulk samples of ash from incinerated materials for metals and PCBs analyses, and surface wipe samples for PCBs analysis. On July 13, 2006, we held a closing conference during which we summarized our activities and observations and provided preliminary recommendations. Two observations that we considered serious safety hazards were working under an energized shear without lockout/tagout and gas cylinders being lifted by the valve cap with an overhead crane. These observations were discussed during the closing conference. On July 26, 2006, we sent EPS management and the requestors a letter informing them of our concerns about the two safety hazards. In a letter dated July 27, 2006, EPS management replied that they had conducted a thorough review of procedures for working on energized equipment and transporting cylinders with all employees. On October 6, 2006, we sent EPS and the requestors an interim letter in which we provided preliminary PBZ air sampling results and recommendations to reduce worker exposures to copper and lead. On October 17, 2006, we held a conference call with EPS management to discuss the October 6, 2006 letter, and in a letter dated October 26, 2006, EPS management stated that they would be conducting additional PBZ sampling in the metal sorting/baling and torching areas. In addition, EPS mentioned that they had implemented our recommendations to wet down the scrap metal to reduce aerolization of the ash, upgraded respiratory protection for Metal Sorters/Balers, and were conducting medical evaluations for employees who used respirators.

BACKGROUND

EPS recycles transformers, bushings, capacitors, and other electrical equipment, some of which may contain PCBs. The company operates 24 hours per day, 7 days per week, and has 52 employees to staff three shifts. The recycling facility is a one-story metal building divided into three tank areas, four PCB storage areas, a PCB decontamination area (referred to as the Cage), the furnace and metal sorting area, and the conveyor line where electrical equipment is disassembled for recycling. To contain any potential spills, dikes ranging from 2 to 9 inches in height separate the different work areas. The company operates two mobile trailers (called PCBX℠ trailers) used for dechlorinating and cleaning oil containing PCBs in a closed loop system. EPS employees also use the PCBX℠ trailers to dechlorinate and clean oil in energized transformers at remote sites. EPS also provides a transformer dismantling service.

Job classifications include PCB Cage Operators, Metal Sorters/Balers, Line Teardown Production Workers, Maintenance Workers, PCBX℠ Rig Operators, and Furnace Operators. There are many other specialized jobs within the production area such as the Small Shear Operator, the Checking-in Person (who collects oil samples for PCB analysis), the Crusher Operator, the Pumper/Dumper (who pumps oil out of transformers), and Crane Operators. All employees wear hard hats; safety glasses; steel toe shoes; nitrile, rubber, leather, or Kevlar™ gloves; and work uniforms provided and laundered by the company.

Transformers, bushings, capacitors and other electrical equipment arriving at the EPS facility are initially sorted according to their PCB content. Equipment containing oil with less than 50 parts per million (ppm) is treated as non-PCB oil, oil with 50–499 ppm of PCBs is considered PCB contaminated, and greater than 500 ppm is considered PCB containing. In addition, transformers containing oil with greater than 50 ppm of PCBs are marked with color-coded tags (orange for 50–499 ppm, and red for >500 ppm PCBs). Oil containing 500 ppm of PCBs or greater is processed through the PCBX^{SM} trailer for dechlorination, while oil containing greater than 14,500 ppm of PCBs is shipped to another waste treatment facility.

Oil-containing equipment is placed on a conveyor line where an employee pumps out the oil. The drained equipment is disassembled, and the cases are crushed. The parts are placed in large metal bins and heated in an incinerator to 1200 ºF for 2.5 hours. The heated bins are then removed from the furnace and allowed to cool. The incinerator operates 24 hours a day.

After bins with metal parts are removed from the furnace, Metal Sorters/Balers sort the scrap by hand according to metal composition, then toss or carry the sorted metal scrap to the baler for shipping. Metal Sorters/Balers are required by EPS to wear N95 filtering facepiece respirators because the incinerated scrap is covered with a fine ash, which easily becomes airborne during the sorting process.

Two employees in the Cage remove oil from transformers and capacitors and disassemble the equipment. Any transformers containing oil with greater than 500 ppm of PCBs are disassembled in the Cage. In order to remove the internal components (because most transformer cases are sealed) the top section is cut off using an oxyacetylene or plasma torch. These transformers contain oil with PCBs and the exterior surface of the transformer case may be painted with paint containing lead or other metals. Because they are potentially exposed to PCBs and metal fumes, Cage workers receive biological monitoring for PCBs and wear air purifying elastomeric half-mask respirators with combination organic vapor (OV) + P100 cartridges

Maintenance workers repair machines and other equipment and may occasionally cut transformer cases with a torch prior to removing the oil, which may contain 50 to 499 ppm of PCBs. In addition, they may make parts for machines and repair equipment such as presses and shears. Workers performing welding operations wear air purifying elastomeric half-mask respirators with combination OV + P100 cartridges.

The PCBX^{SM} Operators receive 55-gallon drums containing sodium ingots coated with oil and kept in a nitrogen atmosphere. The ingots are hand transferred to a grinder where they are mixed with oil and then ground into a slurry that is used in the PCBX^{SM} dechlorinating process. The PCBX^{SM} Operators wear a flame retardant suit, leather gloves, and a face shield when transferring sodium ingots into the grinder.

METHODS

PCBs

During the first shift we collected PBZ and general area air samples for PCBs. Samples were collected from a Crane Operator, a Check-in Person, a Crusher Operator, a PCBX^{SM} Operator, a Furnace Operator, a Maintenance Worker, and a Metal Sorter/Baler. Full-shift air samples were collected on XAD-2 adsorbent tubes with a glass fiber filter at a flow rate of 0.2 liters per minute (L/min). We also collected samples of bulk oil from transformers and ash from incinerated scrap metal and submitted them for PCB analysis. The samples were analyzed by gas chromatography using an electron capture detector (GC/ECD) per NIOSH Manual of Analytical Methods (NMAM) Method 5503.[1]

Wipe samples from the lunchroom, employees' locker rooms, and surfaces with a high potential for skin contact were obtained for PCB analysis. The United States Environmental Protection Agency (USEPA) classifies a surface as high contact if workers routinely touch it, such as a control panel on a machine or computer keyboards. Where the surface was flat, a 10-centimeter (cm) by 10 cm template was used to collect the sample. The sampling process consisted of using a cotton gauze pad soaked with hexane and wiping the surface in an "S" pattern from top to bottom and then from left to right. A template was not used on keyboards so sample results are only a qualitative indication of surface contamination. The gauze pads were placed in a glass container and submitted for laboratory analysis per NIOSH Method 5503.

Metals

We collected PBZ air samples for metals on a Metal Sorter/Baler, and general area samples in the baling, furnace, and torching areas. Full-shift samples were collected on 37 millimeter (mm) diameter, 0.8 micron (µm) pore size mixed cellulose ester filters at a flow rate of 2.0 L/min and analyzed per NMAM method 7300. Four bulk samples of ash from a container with incinerated material were also analyzed for metals.

Medical

We randomly selected eight persons from an employee roster for confidential medical interviews to discuss their concerns about work exposures and adverse health outcomes.

Other Issues

During the facility walk-through we observed work practices, personal protective equipment use, engineering controls, and potential safety hazards. We also reviewed the OSHA 300 Log of Work-Related Injuries and Illnesses, previous industrial hygiene sampling records, and biological monitoring records.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially 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),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) threshold limit values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

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.

PCBs

The NIOSH REL for PCBs is 0.001 milligrams per cubic meter (mg/m^3), determined as a TWA for up to a 10-hour workday, 40-hour workweek.[5] The REL was based on the finding of adverse reproductive effects in experimental animals, that PCBs are carcinogens in rats and mice (and potential human carcinogens in the workplace), and the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject the worker to possible liver injury. The OSHA PELs for PCBs are 1.0 mg/m^3 for airborne PCBs containing 42% chlorine and 0.5 mg/m^3 for PCB products containing 54% chlorine, expressed as 8-hour TWA concentrations. The OSHA PELs also have a "skin" notation, which refers to the potential contribution to overall exposure by the cutaneous route, including the mucous membranes and eyes, by either airborne or direct skin contact with PCBs.

Results of several investigations of PCB surface contamination in office buildings during the 1980s indicated that there was a "background" level of surface contamination in the range of 50 to 100 micrograms per square meter ($\mu g/m^2$). Therefore, NIOSH investigators recommended at that time that PCB contamination not exceed 100 $\mu g/m^2$ on surfaces that workers may be routinely touch with unprotected skin. It is likely that current background levels may be lower now due to the general decrease in use of PCBs. Additional information on PCBs and their health effects is provided in Appendix 1.

Metals

Inorganic lead is hazardous through inhalation and ingestion. Once lead enters the bloodstream, it is circulated to the brain, kidneys, liver, skin, and skeletal muscle. Lead is also deposited in the bones; it is estimated that lead may remain in the body for 5 to 10 years. Symptoms of acute lead overexposure are usually gastrointestinal and/or neurological, and include abdominal pain, constipation, nausea, headache, stupor, coma, and renal failure. Symptoms of chronic overexposure include anemia, fatigue, irritability, insomnia, memory problems, distal motor neuropathy, loss of libido and infertility in men, and menstrual disturbances and spontaneous abortions in women.[6] The NIOSH REL and OSHA PEL for lead are 0.050 mg/m^3 averaged over an 8-hour period. OSHA has an action level (AL) for lead of 0.030 mg/m^3 averaged over an 8-hour period. Exposure to lead in general industry is covered by OSHA substance specific standard 29 Code of Federal Regulations (CFR) 1910.1025 Lead. This standard has specific requirements that employers must comply with whenever an employee is exposed to lead over the AL. Additional information on the toxicology and evaluation criteria for lead is provided in Appendix 2.

The NIOSH REL for copper dust is 1.0 mg/m^3, determined as a TWA for up to a 10-hour workday, 40-hour workweek. OSHA has a PEL for copper dust of 1.0 mg/m^3 averaged over an 8-hour period. For copper fumes, such as from welding operations, the NIOSH REL and OSHA PEL are reduced to 0.1 mg/m^3. These exposure limits are intended to reduce irritation of the eyes, skin, and respiratory tract.[7]

Sodium reacts vigorously with moisture in air or tissues to form sodium hydroxide and hydrogen, which can explode or ignite. If sodium is inhaled or comes in contact with the skin or the eyes, it may cause serious burns and tissue damage.[8] There are no occupational exposure limits for sodium. Handling sodium requires use of personal protective equipment such as a face shield, dry moleskin mitts, and apron to prevent skin contact.[9] To prevent an unwanted reaction sodium must be stored either in an inert atmosphere (oxygen- and moisture-free such as nitrogen or argon), or under a liquid hydrocarbon such as mineral oil or kerosene.

RESULTS

PCBs

We collected nine PBZ and 15 area air samples for PCBs. Aroclor® 1242 (trade name for oil containing PCBS with 42% chlorine) was the only PCB detected in the air samples. Air sampling results for PCBs are provided in Table 1. Five area samples and one PBZ sample were above the NIOSH REL of 0.001 mg/m^3, but below the OSHA PEL of 1 mg/m^3 for Aroclor® 1242. Three of the five area samples that were over the NIOSH REL were collected about 20 feet from the torching area. PCBs were not detected in any of the four bulk samples submitted for anlysis.

We collected 21 surface wipe samples from high contact surfaces, and four exceeded the surface contamination guideline of 100 µg/m^2 for PCBs used by NIOSH investigators. PCB contamination was also found on computer keyboards. Sample results were reported as µg/sample by the laboratory. We used a 10 cm by 10 cm template to collect the surface samples, therefore the results were multiplied by 100 so they could be reported in µg/m^2 units. Wipe sampling results for PCBs are provided in Table 2. Aroclor® 1242, 1254, and 1260 were detected, and surface concentrations ranged from 129 to 6550 µg/m^2. The highest PCB concentrations were found on the computer keyboard and desk in the Cage area, followed by the computer keyboard at the Check-in Counter, the table and computer keyboard by the furnace, and the bench in the locker room. Due to the irregular surface, templates were not used for the computer keyboard samples; therefore, the sample results for the keyboards are provided as a qualitative indication of surface contamination.

Metals

Air sampling results for metals are provided in Table 3, and bulk sample results for metals in the ash samples are provided in Table 4. A Metal Sorter/Baler had a PBZ concentration of 27 mg/m^3 of copper (full-shift TWA, a concentration which was 27 times greater than the NIOSH REL-TWA and OSHA PEL-TWA of 1.0 mg/m^3). This employee also had a full shift TWA concentration of lead of 0.056 mg/m^3, which was above the NIOSH REL and OSHA PEL of 0.050 mg/m^3. Area air samples for metals were collected near the furnace, baling, and torching areas, and the results were below applicable occupational exposure limits. Four bulk samples of ash in the bin from which the worker baled and sorted metal contained 20% to 80% copper.

Medical

Except for two individuals who reported a past history of truncal rash, none of the remaining employees we interviewed had work-associated health effects or concerns. Management informed us that all employees were previously tested for serum PCB annually for 6 years but that this practice had been replaced by a targeted screening that involved only employees who worked in the Cage. In 2004, an employee who worked in the Cage had an elevated level of blood PCB. This person was referred for medical care and reassigned to tasks with less potential for exposure to PCB. Subsequent testing revealed a normalization of blood PCB level. Our review of OSHA 300 Logs of Work-Related Injuries and Illnesses revealed musculoskeletal injuries and lacerations.

Other Issues

PPE and Ventilation

During the evaluation, we noticed the incorrect use of filtering facepiece respirators. One employee's N95 filtering facepiece respirator was missing a strap. Another employee wearing the same type of respirator had facial hair, and neither employee had been fit tested to determine if the respirator fit properly, nor received a medical evaluation to determine if they were medically fit to use that type of respirator. The employees wore nitrile gloves with inner cotton linings or Kevlar® gloves.

Based on our visual observations, the canopy exhaust hood over the oxyacetylene and plasma torching operation in the PCB Storage Area B was inadequately controlling emissions generated when the transformer cases were cut open. The overhead system pulled the fumes through the worker's breathing zone and did not effectively capture all the fumes, allowing contaminants to disperse throughout the facility. Transformer cases were also torched in the Cage area without local exhaust ventilation, and some Cage workers expressed concerns about these torching emissions. Torching operations were not performed in the cage area during our evaluation.

The PCBX^{SM} trailer had exhaust lines from the diesel-fired boiler that vented inside the facility. During winter when the overhead doors are closed, carbon monoxide and other trailer exhaust contaminants could accumulate in the facility.

Safety

We observed the following work practices that could result in serious injuries and/or property damage:

- Employees lifting and transporting gas cylinders with a crane by hooks attached to the valve protection cap. If the cylinder were to disengage from the cap, the cylinder would fall and the valve could break off, turning the cylinder into a projectile.
- An employee was observed entering an energized shear to remove scrap metal without ensuring the machine was properly safeguarded through lockout/tagout. Inadvertent energization or startup of the shear could have injured the employee.
- Sodium is transferred by hand to a grinder in a facility with a sprinkler system. If a fire activated the sprinkler system while an employee was transferring sodium, serious injury and property damage could result from a chemical reaction between sodium and water. EPS provided NIOSH investigators a material safety data sheet (MSDS) for sodium, which under the section labeled Handling and Storage states, "Store in segregated area of fire resistant, watertight building, without sprinklers, steam, water lines, skylights, or potential for flooding."

Following receipt of our interim letter on July 26, 2006, notifying the company of our observations regarding the improper transport of compressed gas cylinders and employees working beneath an energized shear, EPS management reportedly briefed employees on proper procedures for transporting gas cylinder and working on energized equipment.

DISCUSSION

In addition to one PBZ air sample for PCBs, airborne concentrations for five area air samples were above the NIOSH REL-TWA, indicating the potential for workers who remain in those areas to be overexposed to PCBs. Some workers cut transformer cases with a torch under a canopy hood, which drew the contaminants through the workers' breathing zone. There is a potential for PCB exposure by inhalation and skin contact because some transformers contain PCBs. Workers may also be exposed to metal fumes from lead-based paints because the paint is not removed prior to cutting the case with a torch. A side-draft or back-draft hood would be preferable to the canopy hood because it would draw the contaminants laterally rather than vertically through the workers' breathing zone.

A Metal Sorter/Baler was overexposed to copper (27 mg/m^3) during a sampling period of 510 minutes. EPS requires that Metal Sorters/Balers wear N95 filtering facepiece respirators. However, the workers were not fit tested and had not received a medical evaluation prior to wearing the respirators. Additionally, some of the N95 respirators had been altered by cutting off a strap. Assuming that these workers wore their N95 filtering facepiece respirators correctly (and that they fit properly), this type of respirator only has a maximum use concentration (MUC)[1] for copper of 10 mg/m^3, making it inadequate for this exposure situation. The minimum level of respiratory protection required for an airborne copper concentration of 27 mg/m^3 would be an air-purifying full-facepiece respirator or powered air-purifying respirator with a tight fitting facepiece, equipped with high efficiency filters, or a supplied-air respirator with a full facepiece. Use of the MUC assumes that workers are medically cleared, correctly fit-tested, trained, and included in an ongoing respiratory protection program.

Even if workers in the metal sorting/baling operation were provided with the proper respiratory protection, OSHA requires that employers implement controls to reduce exposures. The OSHA lead standard, 29 CFR 1910.1025, has other requirements that the employer must comply with such as periodic air sampling and biological monitoring. Airborne exposures to hazardous metals may be reduced by wetting or vacuuming the ash prior to sorting. On the day of our exposure monitoring, the Metal Sorter/Baler was sorting metal from a tray that primarily contained copper cores. It is possible that air sample results may differ when other materials are sorted and baled. Additional PBZ air monitoring should be performed to properly characterize this activity.

During the initial facility walk-through we observed a worker removing small porcelain bushings (about 18 inches long) from the transformer by using a hammer. This employee's work station was approximately 20 feet from the baling operation. The worker was covered with dust, and we observed airborne dust during the process. However, this individual was not wearing respiratory protection. Workers performing this task could potentially be exposed to crystalline silica. We had scheduled this task for evaluation but there were no workers performing this task during our evaluation.

CONCLUSIONS

- Some EPS employees are overexposed to PCBs, lead, and/or copper.
- EPS was not complying with all the requirements of the OSHA respiratory protection standard as outlined in OSHA standard 29 CFR 1910.134, Respiratory Protection.
- Unsafe work practices at EPS may result in serious injuries.
- The canopy hood used during torching operations cannot adequately protect workers from metal fumes and other contaminants.

RECOMMENDATIONS

Based on sample results and observations made during this HHE, NIOSH investigators offer the following recommendations to help improve health and safety:

1. Implement engineering and/or administrative controls to reduce Metal Sorters'/Balers' exposures to copper and lead below the NIOSH REL and OSHA PEL. Wetting or vacuuming the ash after incineration may be possible solutions. Once controls are implemented, the company should conduct additional PBZ sampling for metals on Metal Sorters/Balers and other

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1 The MUC is calculated by multiplying the assigned protection factor (10 for a filtering facepiece respirator) by the applicable occupational exposure limit for copper of 1 mg/m^3.

employees working near the metal sorting operation.

2. Provide Metal Sorters/Balers with a higher level of respiratory protection until engineering controls are implemented to reduce their exposures to copper below the applicable occupational exposure limits. Based on the airborne copper concentration measured during this survey, the minimum level of respiratory protection is an air-purifying full-facepiece respirator or powered air-purifying respirator with a tight fitting facepiece, equipped with N100, R100, or P100 filter(s), or a supplied-air respirator with a full facepiece. The employer must also comply with the requirements in 29 CFR 1910.134, Respiratory Protection, which includes medical evaluations, fit testing, and training, among other elements. After implementing engineering controls such as wetting the ash, conduct additional PBZ air sampling for metals. It is possible that after implementing engineering controls workers may require a lower level of respiratory protection, or no respiratory protection. Sufficient sampling should be conducted to properly characterize representative exposures since the ash composition may vary considerably in content of copper and other metals.
3. Conduct additional PBZ air sampling for lead. OSHA requires that the employer sample quarterly for lead until two consecutive measurements, taken at least 7 days apart, are below the OSHA AL of 0.03 mg/m^3, at which time the employer may discontinue monitoring for that employee. The OSHA lead standard, 29 CFR 1910.1025, also requires notifying each employee sampled within 15 working days after the receipt of the results either individually in writing or by posting the results in an appropriate location accessible to affected employees. If any sample results exceed the OSHA AL, periodic sampling must continue as indicated by the standard.
4. Write procedures for transporting gas cylinders and lockout/tagout, and train employees on the procedures. OSHA standard 29 CFR 1910.253 paragraphs (b)(5)(ii)(A and C) state that when transporting cylinders by a crane or derrick, a cradle, boat, or suitable platform shall be used and that slings or electric magnets shall not be used for that purpose. Furthermore, where cylinders are designed to accept valve-protection caps, the caps shall not be used for lifting cylinders.
5. Store sodium containers in a separate fire-resistive building with no sprinkler system or nearby source of water such as water lines. Move the sodium-grinding operation to the separate facility.
6. Conduct additional PBZ and area air sampling for PCBs throughout the facility, PCBX^{SM} trailer, and in the Cage area and torching station while torching transformers with oil containing PCBs. In addition to PCBs, sample for metals during torching operations. Metals may be present in the paint on the transformer cases. Until it can be demonstrated through PBZ air sampling that employees are not exposed to PCBs over the NIOSH REL-TWA, employees should be provided respiratory protection consisting of an air-purifying half-mask respirator with organic vapor cartridges in combination with any R- or P-series filters. Implement a cartridge change-out schedule in accordance with the OSHA respiratory Protection standard to determine how often the cartridges need to be changed.
7. Clean high contact industrial surfaces contaminated with PCBs in accordance with the USEPA regulation 40 CFR Part 761.125 and resample to verify cleanliness, or have workers wear clean gloves when in contact with these surfaces (desks, keyboards, control panels).

8. Prohibit workers from eating, drinking, or smoking in the work area, and educate workers on the importance of washing their hands before eating or smoking.
9. Modify the canopy hood used for cutting transformer cases to avoid drawing metal fumes through the workers' breathing zone. A possible modification is a cross-draft slotted hood that exhausts contaminants laterally away from the workers' breathing zone. If a slotted hood is used, hinged panels can also be placed at each end of the hood and pulled forward around the transformer to help enclose it and improve the hood's capture efficiency. Another option is a flexible duct welding hood that can be positioned near the point of contaminant generation. A ventilation engineer who can provide recommendations on the proper design and required air flow to properly control contaminants may also be consulted.
10. Provide employees with neoprene or butyl rubber gloves when handling PCBs.
11. Route the exhaust tubing from the PCBX[SM] trailer outside to prevent the accumulation of carbon monoxide and other chemicals from the PCBX[SM] process.

REFERENCES

1. NIOSH [2006]. NIOSH manual of analytical methods (NMAM®). 4th ed. Schlecht PC, O'Connor PF, eds. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 94–113 (August, 1994); 1st Supplement Publication 96–135, 2nd Supplement Publication 98–119; 3rd Supplement 2003–154. [http://www.cdc.gov/niosh/nmam/]

2. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

3. ACGIH® [2006]. 2006 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

4. CFR [2003]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

5 NIOSH [2005]. NIOSH pocket guide. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2005-149.

6. LaDou J [1990]. Occupational medicine. Norwalk, CT: Appleton & Lange, pp. 306-310.

7. NIOSH [1978]. Occupational health guideline for copper dusts and mists. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

8. Lewis RJ [1997]. Hazardous chemicals desk reference. 4th ed. New York, NY: John Wiley & Sons, Inc.

9. DuPont [2000]. Material safety data sheet, sodium. Wilmington, DE: DuPont Chemical Solutions Enterprise.

TABLES

Table 1 Air Sampling Results for PCBs HETA 2006-0006-3039 Environmental Protection Services Wheeling, West Virginia July 11-12, 2006					
Sample Number [a]	**Job Description or Location**	**Sample Date**	**Sample Volume (Liters)**	**Sample Time (Minutes)**	**Full Shift TWA Concentration mg/m³ [b]**
PCB-P1	Maintenance worker	07/11/06	92	458	Trace [c]
PCB-P2	Crane Operator	07/11/06	92	463	Trace
PCB-P3	Check-in Operator	07/11/06	92	461	Trace
PCB-P4	Crusher Operator	07/11/06	77	390	Trace
PCB-P5	Metal Sorter/Baler	07/11/06	97	486	ND [d]
PCB-A25	Pumping station	07/11/06	86	434	Trace
PCB-A26	By small shear	07/11/06	96	485	Trace
PCB-A27	By furnace	07/11/06	97	491	ND
PCB-A28	By PCBX℠	07/11/06	96	487	0.002
PCB-A29	Processing rig	07/11/06	117	584	Trace
PCB-A31	Teardown area	07/11/06	100	502	Trace
PCB-A32	Torching area	07/11/06	97	493	0.003
PCB-A33	Near torching area	07/11/06	457	493	0.004
PCB-P6	Check-in Operator	07/12/06	95	480	Trace
PCB-P7	Maintenance worker	07/12/06	93	467	Trace
PCB-P8	Crane Operator	07/12/06	92	469	Trace
PCB-P13	PCBX℠ Operator	07/12/06	110	567	0.002
PCB-A34	By small shear	07/12/06	463	468	0.002
PCB-A35	Production line	07/12/06	91	461	Trace
PCB-A36	By furnace	07/12/06	92	468	Trace
PCB-A90	Silicon loading dock	07/12/06	89	455	ND
PCB-A100	Torching area	07/12/06	95	485	0.003
PCB-A110	By large shear	07/12/06	96	480	Trace
PCB-A120	Inside PCBX℠ trailer	07/12/06	95	476	Trace
NIOSH Recommended Exposure Limit-Time Weighted Average (TWA)					0.001
OSHA Permissible Exposure Limit-TWA [e]					1.0
Minimum Detectable Concentration (MDC) [f]					0.0005
Minimum Quantifiable Concentration (MQC) [g]					0.002

[a] P before a sample number indicates a personal breathing zone sample; A indicates an area sample.
[b] mg/m³ = milligrams per cubic meter.
[c] Trace = Concentration was between the MDC and MQC. Since the MQC was higher than the NIOSH REL, some sample results reported as Trace may have been above the REL.
[d] ND = Not detected; concentration was below the MDC.
[e] Only Aroclor® 1242 was detected in all samples.
[f] The MDC was calculated by dividing the analytical method limit of detection (LOD) by an air sample volume of 0.094 m³.
[g] The MQC was calculated by dividing the analytical method limit of quantitation (LOQ) by an air sample volume of 0.094 m³.

Table 2 **Wipe Sample Results for PCBs** **HETA 2006-0006-3039** **Environmental Protection Services** **Wheeling, West Virginia** **July 11, 2006**		
Sample Number	**Location**	**Surface Concentration µg/m² [a]**
PCB-W93	Cafeteria sink counter	ND [b]
PCB-W94	Vending machine	ND
PCB-W95	Cafeteria table	ND
PCB-W96	Cafeteria table	ND
PCB-W97	Table by furnace	163
PCB-W98	Computer keyboard by furnace	129[c]
PCB-W99	Control panel PCBX[SM] trailer	ND
PCB-W100	Laboratory counter	260
PCB-W101	Bench men's locker room	143
PCB-W102	Locker men's locker room	43
PCB-W103	Door knob men's locker room	ND
PCB-W104	Desk check-in area	ND
PCB-W105	Faucet men's locker room	ND
PCB-W106	Computer keyboard check-in area	324[c]
PCB-W107	Desk top Cage	6550
PCB-W108	Computer keyboard Cage	2940[c]
PCB-W109	Work table tear down area	86
PCB-W110	Sink counter lunch room	ND
PCB-W111	Vending machine	ND
PCB-W112	Table cafeteria	ND
PCB-W113	Table cafeteria	ND
Guideline for routinely contacted surfaces used by NIOSH investigators		100 $\mu g/m^2$

[a] $\mu g/m^2$ = micrograms per square meter. Sample results were reported by the laboratory as µg per sample. Because the sampled area was 100 cm^2, the results were multiplied by 100 for comparison with the guideline for surface contamination of 100 $\mu g/m^2$ used by NIOSH investigators' This level is based on background contamination found on surfaces in office environments during previous evaluations for PCBs.
[b] ND = PCBs were not detected in the sample.
[c] On non-smooth surfaces (such as keyboards/door knob) a template could not be used. Sample results are provided as a qualitative indication of PCBs contamination.

Table 3 Air Sampling Results for Metals HETA 2006-0006-3039 Environmental Protection Services Wheeling, West Virginia July 11-12, 2006						
Sample Number	**Job Description or Location**	**Sample Date**	**Sample Volume (L)**	**Sample Time (Min)**	**Full Shift TWA Concentration, mg/m^3 [a]**	
					Copper	**Lead**
MET-P55/56[b]	Metal Sorter/Baler	07/11/06	1014	510	27	0.056
MET-A61	By torching area	07/11/06	972	491	Trace[c]	ND[d]
MET-A62	By furnace	07/11/06	985	500	0.006	ND
MET-A64	By Metal Sorter/Balers	07/12/06	914	471	0.081	Trace
NIOSH Recommended Exposure Limit-Time Weighted Average					1.0	0.050
OSHA Permissible Exposure Limit- Time Weighted Average					1.0	0.050
OSHA Action Level						0.030
Minimum Detectable Concentration (MDC)[e]					0.001	0.0008
Minimum Quantifiable Concentration (MQC)[f]					0.003	0.0027

[a] mg/m^3 = milligrams per cubic meter
[b] Two samples (MET-P55 and MET-P66) were collected during the employees work shift and time weighted averaged to determine his full shift exposure.
[c] Trace = Concentration was between the MDC and MQC.
[d] ND = Not detected; concentration was below the MDC.
[e] The MDC was calculated by dividing the analytical method limit of detection (LOD) by an air sample volume of 1 m^3.
[f] The MQC was calculated by dividing the analytical method limit of quantitation (LOQ) by an air sample volume of 1 m^3.

Table 4 Ash Analysis for Metals HETA 2006-0006-3039 Environmental Protection Services Wheeling, West Virginia July 11, 2006		
Sample Number	Copper (mg/kg)[a]	Lead (mg/Kg)
ASHM1	250000	9300
ASHM2	400000	630
ASHM3	530000	2000
ASHM4	830000	1500

[a] mg/kg = milligrams per kilogram.

Laboratory analyses of the ash samples were performed for 27 elements. While other metals were present in the bulk samples, only copper and lead were detected in the air samples at concentrations above their respective OSHA PEL or NIOSH REL.

APPENDIX 1: POLYCHLORINATED BIPHENYLS

General

Polychlorinated biphenyls (PCBs) are mixtures of up to 209 chlorinated compounds that were manufactured in the United States from 1929 to 1977 and marketed under the trade name Aroclor.[1] The PCB mixtures marketed under different trade names are often characterized by a four-digit code number. The first two digits denote the type of compound, ("12" indicating biphenyl), and the latter two digits give the weight percentage of chlorine, with the exception of Aroclor 1016. In other commercial preparations the number code may indicate the approximate mean number of chlorine atoms per PCB molecule (Phenoclor, Clophen, Kanechlor) or the weight percentage of chlorine (Fenclor). PCB mixtures found in the environment differ in composition from the commercial mixtures because of partitioning, biotransformation, and bioaccumulation.[2]

PCBs found wide use because they are heat stable; resistant to chemical oxidation, acids, bases, and other chemical agents; and stable to oxidation and hydrolysis in industrial use. Additionally they possess favorable dielectric properties; have low solubility in water, low flammability, low vapor pressure at ambient temperatures; and display viscosity temperature relationships suitable for a wide range of industrial applications. PCBs have been used commercially for insulating fluids in electrical equipment, hydraulic fluids, heat transfer fluids, lubricants, plasticizers, and components of surface coatings and inks.[3]

Dietary PCB ingestion, the major source of population exposure, occurs especially through eating fish, thus PCB residues are detectable in various tissues of persons without known occupational exposure to PCB. In past years, reported mean whole blood PCB levels have ranged from 1.1 to 8.3 parts per billion (ppb), and mean serum PCB levels ranged from 2.1 to 24.2 ppb, for persons without known occupational exposure.[4] Mean serum PCB levels among workers in one capacitor manufacturing plant studied by the National Institute for Occupational safety and Health (NIOSH) ranged from 111 to 546 ppb, or approximately 5 to 22 times the background level in the community. Mean serum PCB levels among workers in transformer maintenance and repair typically range from 12 to 51 ppb, considerably lower than among workers at capacitor manufacturing plants.[5]

In addition to dietary exposure, current exposures to PCBs may result from handling or recycling items containing PCBs. Other exposures may occur when transformers catch fire, or when capacitors that contain PCBs in old fluorescent lamps overheat. Leaks from capacitors and transformers, and poor handling of wastes in production facilities, lead to widespread dispersion of PCBs into the environment.

Health Effects

Exposure to PCBs may occur through inhalation, ingestion, or skin contact. PCBs are lipid soluble and primarily deposit in adipose tissue, the liver, and kidneys. Exposures to high concentrations of PCBs may cause skin conditions such as acne and rashes. Chronic inhalation exposure to PCBs has been reported to result in respiratory tract symptoms, such as cough and tightness of the chest, gastrointestinal effects including anorexia, weight loss, nausea, vomiting, abdominal pain, mild liver effects, and effects on the skin and eyes such as chloroacne, skin rashes, and eye irritation. Tests exist to measure PCB levels in blood, body fat, and breast milk. However the tests cannot determine when or how long persons were exposed or whether they will develop health effects.

NIOSH considers PCBs potential occupational carcinogens. The Department of Health and Human Services (DHHS) has concluded that PCBs may reasonably be anticipated to be carcinogens. The United States Environmental Protection Agency (USEPA) and International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans. In 1996 at the direction of Congress, EPA completed a reassessment of PCB carcinogenicity, which was peer reviewed by 15 experts on PCBs who agreed that PCBs are probable human carcinogens. The reassessment concluded that the type of PCBs likely to be bioaccumulated in fish and in sediments is the most carcinogenic mixture.[6]

PCB toxicity is complicated by the presence of highly toxic impurities, especially the polychlorinated dibenzofurans (PCDF),[7] which vary in amount depending on the manufacturer[8] and percent chlorination,[9] and which are found in increased concentration after incomplete pyrolysis of the PCB.[10,11] Furthermore, different animal species, including humans, vary in their pattern of biologic response to PCB exposure.[12]

In an update of a cohort mortality study among workers exposed to PCBs in an electrical capacitor manufacturing plant in Indiana, NIOSH investigators found an association between employment at the plant and melanoma and cancer mortality.[13] In another cohort mortality study of 14,458 electrical capacitor manufacturing workers exposed to PCBs, NIOSH investigators concluded that a strong exposure response relationship exists between cumulative PCB exposure and mortality from prostate cancer, and that to their knowledge their study was the first to show that relationship. The authors also concluded that the study provided suggestive evidence of excess mortality risk from myeloma, stomach cancer among men, and ovarian cancer with long term occupational exposure to PCBs.[14] In a retrospective mortality study of 17,321 workers at three electrical capacitor plants, NIOSH investigators found data suggestive of neurodegenerative disease in women exposed to PCBs.[15] It should be noted that during capacitor manufacturing the PCB oils were heated, causing them to vaporize and settle on surfaces. The study also reports that other investigators found a high prevalence of PCBs in blood of 1000 breast cancer cases and controls on Long Island in the late 1990s.

Airborne Exposure

The NIOSH recommended exposure limit (REL) for PCBs is 0.001 mg/m^3 determined as a time weighted average (TWA) for up to a 10-hour workday, 40-hour workweek.[16] This REL was based on the findings of adverse reproductive effects in experimental animals, on the conclusion that PCBs are carcinogens in rats and mice (and therefore potential human carcinogens in the workplace) and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject the worker to possible liver injury.[17] The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) is 1 mg/m^3 for airborne PCB containing 42% chlorine and 0.5 mg/m^3 for chlorodiphenyl products containing 54% chlorine, determined as 8-hour TWA concentrations (29 CFR 1910.1000). The OSHA PEL includes a "skin" notation, which refers to the potential contribution to overall exposure by the cutaneous route, including the mucous membranes and eyes, by either airborne or direct skin contact with PCB.

Surface Exposure

Results of several investigations of PCB surface contamination in office buildings conducted during the 1980s indicate that there was a "background" level of surface contamination in the range of 50 to 100 micrograms per square meter (µg/m^2).[18,19,20,21] Therefore, for surfaces in the occupational environment that may be routinely contacted by the unprotected skin, NIOSH investigators have recommended that PCB contamination not exceed 100 µg/m^2 (the lowest feasible level considering background contamination). It is expected that current background levels of PCBs in office buildings will be lower due to restrictions on the use of items containing PCBs.

References for Appendix 1

1. ATSDR [2001]. ToxFAQsTM for polychlorobiphenyls (PCBs). Atlanta GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry.

2. EPA [2000]. Polychlorinated biphenyls (PCBs) (Aroclors). U.S. Environmental Protection Agency. [http://www.epa.gov/ttn/uatw/hlthef/polychlo.html]. Date accessed January 31, 2007.

3. ATSDR [2000]. Toxicological profile for polychlorobiphenyls (PCBs). Atlanta GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry.

4. Landrigan PJ [1980]. General population exposure to halogenated biphenyls. In: Kimbrough RD, ed. Halogenated biphenyls, terphenyls, naphthalenes, dibenzodioxins, and related products. Amsterdam: Elservier/North Holland Biomedical Press, p. 267.

5. Smith A, Schloemer J, Lowry L, Smallwood A, Ligo R, Tanaka S, Stringer W, Jones M, Hervin R, Glueck C [1982]. Metabolic and health consequences of occupational exposure to polychlorinated biphenyls (PCBs). Br J Ind Med 39:361.

6. EPA [2006]. Polychlorinated biphenyls (PCBs). U.S. Environmental Protection Agency. [http://www.epa.gov/ttn/uatw/hlthef/polychlo.html]. Date accessed: January 31, 2007.

7. Vos JG, Koeman JG [1970]. Comparative toxicologic study with polychlorinated biphenyls in chickens, with special reference to prophyris, edema formation, liver necrosis, and tissue residues. Tox App Pharm 17:656.

8. Vos JG, Koeman JH, van der Mass HL, ten Noever de Brauw MC, de Vos RH [1970]. Identification and toxicological evaluation of chlorinated dibenzofuran and chlorinated naphthalene in two commercial polychlorinated biphenyls. Fd Cosmet Toxicol 8:625.

9. Bowes GW, Mulvihill MJ, Simoneti BRT, Burlingame AL, Risebrough RW [1975]. Identification of chlorinated dibenzofurans in American polychlorinated biphenyls. Nature 94:125.

10. Buser HR, Bosshardt HP, Rappe C [1978]. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of PCBs. Chemosphere 7:109.

11. Buser HR, Rappe C [1977]. Formation of polychlorinated dibenzofurans (PCDFs) from the pyrolysis of individual PCB isomers. Chemosphere 8:157.

12. Vos JG [1969]. Toxicology of PCBs for mammals and for birds. Env Health Perspect 21:29.

13. Ruder AM, Hein MJ, Nilsen N, Waters MA, Laber P, Davis-King K, Prince MM, Whelan E [2006]. Mortality among workers exposed to polychlorinated biphenyls (PCBs) in an electrical capacitor manufacturing plant in Indiana. Environ Health Perspect 114:1: p. 22.

14. Prince MM, Ruder AM, Hein MJ, Waters MA, Whelan E, Nilsen N, Ward EM, Schnorr TM, Laber P, Davis-King K [2006]. Mortality and exposure response among 14,458 electrical capacitor manufacturing workers exposed to polychlorinated biphenyls (PCBs). Environ Health Perspect 114:10: p. 1513.

15. Steenland K, Hein MJ, Cassinelli RT, Prince MM, Nilsen N, Whelan E, Waters MA, Ruder AM, Schnorr TM [2006]. Polychlorinated biphenyls and neurodegenerative disease mortality in an occupational cohort. Epidemiology 17:1: pp. 8-13.

16. NIOSH [1986]. Current intelligence bulletin 45: polychlorinated biphenyls (PCB's): potential health hazards from electrical fires or failures. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No.86-111.

17. NIOSH [1977]. NIOSH criteria for a recommended standard: occupational exposure to polychlorinated biphenyls. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 77-225.

18. NIOSH [1987]. PCB exposures following fluorescent light ballast burnout. Appl Indus Hyg 3:R-24.

19. NIOSH [1987]. Health hazard evaluation and technical assistance report. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-112-1819.

20. NIOSH [1987]. Health hazard evaluation and technical assistance report. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-472-1832.

21. NIOSH [1987]. Health hazard evaluation and technical assistance report. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 87-166-1835.

APPENDIX 2: LEAD

Occupational exposure to lead occurs via inhalation of lead-containing dust and fume, and ingestion from contact with lead–contaminated surfaces. Symptoms of lead poisoning include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort (colic), fine tremors, and “wrist drop.”[1,2,3] Exposure to lead over time can cause harm gradually, with no obvious symptoms or clinical effects. Chronic exposure to lead may damage the kidneys, or cause anemia, hypertension, infertility and reduced sex drive in both sexes, and impotence. Exposure to lead before or during pregnancy can alter fetal development and cause miscarriages. The developing nervous system of the fetus is particularly vulnerable to lead toxicity.[4]

A person’s lead exposure can readily be determined by biological monitoring. The blood lead level (BLL) is the best indication of recent exposure to and current absorption of lead.[5] Measurement of zinc protoporphyrin (ZPP) level in blood is a good indicator of chronic lead exposure because the toxic effect of lead on heme synthesis in red blood cells causes elevated ZPP levels. Persons without occupational exposure to lead usually have a ZPP level of less than 40 micrograms per deciliter (µg/dL).[6] Elevated ZPP levels due to lead exposure may remain months after the exposure. Because other factors, such as iron deficiency, can also cause an elevated ZPP level, the BLL is a more specific test in the evaluation of occupational exposure to lead.

The Occupational Safety and Health Administration (OSHA) has established a permissible exposure limit (PEL) for lead in air (PbA) of 50 micrograms per cubic meter (µg/m^3) of air as an 8–hour time weighted average (TWA). This PEL is intended to maintain worker BLLs below 40 µg/dL.[7,8] OSHA has also established an action level for PbA of 30 µg/m^3 as an 8–hour TWA. OSHA requires that employers provide protective measures to employees exposed above the action level, such as medical surveillance including BLL and ZPP sampling and analysis. Medical removal protection is required when an employee's BLL reaches 50 µg/dL.

In 1997, the National Institute for Occupational Safety and Health (NIOSH) concluded that the 1978 NIOSH recommended exposure limit (REL) of 100 µg/m^3 as an 8-hour TWA did not sufficiently protect workers from the adverse affects of exposure to inorganic lead, and in 2000, established an REL of 50 µg/m^3 as an 8-hour TWA.[9,10] NIOSH conducted a literature review of the health effects data on inorganic lead exposure and found evidence that some of the adverse effects on the adult reproductive, cardiovascular, and hematologic systems, and on the development of children of exposed workers can occur at BLLs as low as 10 µg/dL.[4] At BLLs below 40 µg/dL, many of the health effects would not necessarily be evident by routine physical examinations, but represent early stages in the development of disease.

In recognition of the toxic effects of lead, voluntary standards and public health goals have established lower occupational exposure limits to protect workers and their children. The American Conference of Governmental Industrial Hygienists (ACGIH®) threshold limit value (TLV®) for PbA is 50 µg/m^3 as an 8-hour TWA, with worker BLLs to be controlled to ≤30 µg/dL.[11] A national health goal is to eliminate all occupational exposures which result in BLLs greater than 25 µg/dL.[12]

References for Appendix 2

1. Hernberg S, Dodson WN, Zenz C [1988]. Lead and its compounds. In: Occupational medicine. 2nd ed. Chicago, IL: Year Book Medical Publishers.

2. Landrigan PJ, Froines JR, Mahaffey KR [1985]. Body lead burden: summary of epidemiological data on its relation to environmental sources and toxic effects. In: Dietary and environmental lead: human health effects. Amsterdam: Elsevier Science Publishers.

3. Proctor NH, Hughes JP, Fischman ML. [1991]. Lead. In: Chemical hazards of the workplace. 3rd ed. Philadelphia, PA: J.B. Lippincott Company, pp 353–357.

4. Sussell A, Ashley K, Burr G, Gittleman J, Mickelsen L, Nagy H, Piacitelli G, Roscoe R, Whelan E [1998]. Protecting Workers Exposed to Lead-Based Paint Hazards: A Report to Congress. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-112. January 1998–revised with minor technical changes.

5. NIOSH [1978]. Occupational exposure to inorganic lead. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 78–158.

6. Lauwerys RR, Hoet P [1993]. Industrial chemical exposure: guidelines for biological monitoring, 2nd ed. Ann Arbor, MI: Lewis Publishers, p. 62.

7. Code of Federal Regulations. OSHA lead standard for general industry. 29 CFR, Part 1910.1025. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

8. Code of Federal Regulations. OSHA construction industry lead standard. 29 CFR, Part 29 CFR 1926.62. Washington, DC. U.S. Government Printing Office, Office of the Federal Register.

9. 62 Fed. Reg. 206 [1997]. National Institute for Occupational Safety and Health; occupational exposure to inorganic lead: request for comments and information.

10. NIOSH [2005]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Publication No. 2005-149.

11. ACGIH® [2006]. 2006 TLVs® and BEIs®. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

12. DHHS [2000]. Healthy people 2010-conference edition; National health promotion and disease objectives. Washington, DC: U.S. Department of Health and Human Services. [www.health.gov/healthypeople/Document/default.htm].

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