Bull. Environ. Contam. Toxicol. (2003) 70:1165–1169

DOI: 10.1007/s00128-003-0104-3

Bulletin of Environmental Contamination and Toxicology

Airborne Exposure Concentrations of Lead, Cadmium, and Chromium During Demolition of Incinerators Inside a Building

J. H. Lange,[1] K. W. Thomulka[2]

[1] Envirosafe Training and Consultants, Inc., Post Office Box 114022, Pittsburgh, PA 15239, USA
[2] University of the Sciences in Philadelphia, 600 South 43rd Street, Philadelphia, PA 19104, USA

Received: 12 September 2002/Accepted: 9 March 2003

Exposure to lead and other metals during demolition of structures has become an important concern in the United States and other countries (Conroy et al. 1996; Ilgren 2001). Only a limited number of studies have been published on exposure to metals during demolition activities (Jacobs 1998). The US Occupational Safety and Health Administration (OSHA) has established regulations on exposure to lead. These requirements include both an action level (AL) (30 ug/m^3) and a permissible exposure limit (PEL) (50 ug/m^3) (OSHA 2001) for airborne lead. The OSHA PELs for cadmium and chromium are 5 ug/m^3 and 1.0 mg/m^3, respectively (OSHA 2001). If PELs are exceeded the workers' employer (OSHA 2001) must implement medical surveillance, personal protection and various work practices. Recently, the US Department of Housing and Urban Development (HUD) published guidelines on engineering controls and work practices for lead abatement which has commonly become part of demolition activities in the US (HUD 1995; Lange and Thomulka 2000).

This study investigated personal and area air samples for lead, cadmium and chromium during demolition of two incinerators in a building. Airborne exposure results provide historical information for demolition of incinerators.

MATERIALS AND METHODS

Airborne samples (personal and area) for lead, cadmium and chromium were collected during demolition of incinerators and associated conveyor systems inside a building in 2001. The site was located in Pennsylvania, USA and consisted of approximately two stories and a basement area. Floor area of the building was approximately 10,000 square feet. Demolition consisted of cutting with saws and torching. Pieces of the incinerator and its conveyor system were removed using bobcats and a backhoe and loaded onto flat bed trucks brought inside the building.

This project was performed in about 30 days. Sampling was not conducted each day. The number of workers on site ranged from two to

Correspondence to: J. H. Lange

four. Workers on-site elected not to use personal protective equipment (PPE), except for coveralls and gloves. All site personnel had training on lead and LBP as required by OSHA (OSHA 2001).

Samples were collected inside the work area, from workers (personal) and outside the building. Outside area samples were collected approximately 2 to 3 feet from doors. Openings to the outside consisted for two large bay doors, one garage door and two man doors. All samples were collected by one of the author's (JHL) using personal sample pumps with a 37 mm mixed ester cellulose filter that was closed face (Lange and Thomulka 2000). Personal samples were collected in the breathing zone of workers. Area samples (in the work area and outside the building) were collected between 3 and 4 feet off the ground surface. Samples were analyzed for lead, cadmium and chromium using the NIOSH 7300 method as a group and NIOSH 7105 method for lead alone. Flow rate was 1.0 lpm (nominal) as determined using a calibrated rotometer (Lange and Thomulka 2000). Sample results were reported as a task-length average.

Exposure data are reported by statistics of location (arithmetic mean – AM, geometric mean – GM) and variability (standard deviation – SD, geometric standard deviation – GSD, and range) (Lange and Thomulka 2000). Confidence interval (CI) for AM was determined using a method for non-normal populations (Daniel 1991). Distribution of the data were determined using the Shapiro-Wilk test. Outliers for data transformed (natural logarithm) and non-transformed were determined using the Grubbs test. Probability (confidence coefficient) of exceeding at least 5% of the average exposure was determined using a graphic method (Leidel et al. 1977). Samples reported below detection limits were included in calculations at its reported numerical value (Lange and Thomulka 2000). All calculations were performed at 95%.

Debris inside incinerators was evaluated using the toxicity characteristic leechate procedure (TCLP) for arsenic, selenium, chromium, cadmium, lead, silver, barium and mercury. The TCLP method employed was the Environmental Protection Agency's (EPA) SW 846 (method 1310).

RESULTS AND DISCUSSION

Exposure levels for lead, cadmium and chromium are shown in Table 1. No summary value for any metal exceeded the OSHA PEL or AL for lead. Two individual values for lead, 105.1 and 62.5 ug/m^3, exceed the OSHA PEL for this metal. No individual value exceeded the OSHA PEL for cadmium and chromium. When the upper CI is included for these metals, all values are below established PEL's. However, when the probability (confidence coefficient) for at least 5% or greater of samples (area and personal) is considered, there is a high probability of exceeding the PEL for lead and cadmium. The probability values of overexposure for area and personal lead samples were 65% and 82%, respectively. For

Table 1. Summary statistics for exposure, in ug/m^3, to lead, cadmium and chromium during demolition of incinerators

Type of Sample	Number of Samples	AM	GM	SD	GSD	Range
Lead (personal)	3	26.4 (21.2)	19.4	18.4	3.0	5.3-39.7
Lead (area)	31$^+$	20.8 (7.2)	14.1	20.4	2.6	0.7-105.1
Cadmium (area)	3	2.8 (0.8)	2.7	0.7	1.3	<2.0-3.0
Chromium (area)	3	3.1 (1.0)	3.0	0.9	1.3	<2.4-<4.2

() is CI value at 95%; + three lead samples were collected outdoors and all were below detection limits of 2.0 ug/m^3. + ten values inside the work area were above the AL, including two values above the OSHA PEL.

cadmium and chromium probabilities of overexposure are 30% and <5%, respectively. These data suggest that there is a low probability of overexposure for chromium, but a good likelihood of occurrence for the other two metals (lead and cadmium). Based on the highest values for lead, it appears that the PEL for this metal commonly exceed both the OSHA PEL and AL.

Since exceedance of the OSHA PEL for lead is suggested to occur, requirements for medical surveillance, engineering controls and PPE would apply (OSHA 2001). Even though there is a probability of exceeding the OSHA PEL for cadmium, the highest observed concentration did not exceed the occupational standard. Therefore, it can be questioned whether requirements related to protective practices for cadmium are warranted, although others (Conroy et al. 1996) have found levels above cadmium's PEL.

Lead area sample data were non-normally distributed. GSDs for lead area and personal samples support a non-normal distribution. When the data for lead area samples were transformed, a normal distribution was exhibited. Previous studies (Lange and Thomulka 2000a; Gaga et al. 2002) of lead have also suggested a non-normal distribution with the distribution following a logarithmic form. Form of distribution could not be determined for cadmium and chromium due to the small number of samples. However, airborne concentrations of these metals have also been suggested to be logarithmic (Karlsen et al 1996) as are environmental and occupational exposure samples in general (Leidel et al. 1977; Bakeas and Siskos 2002).

The variability for cadmium and chromium was low. A GSD of 1.3 is suggestive of a normal distribution (Leidel et al. 1977). Low variability is a result of a majority of the values being below the detection limit. However, for lead sample data the variability is large. A GSD of 3.0 and 2.6 represent about 83 and 78%, respectively, variability among samples. This suggests that a single sample will not likely serve as a predictor of future exposure. Although the amount of variation is common for occupational and environmental samples, it also demonstrates the need for multiple sampling and reporting of summary statistics for understanding occupational exposures.

No single value, either transformed or non-transformed, was an outlier for area samples. Other types of samples were not evaluated due to their small sample sizes.

TCLP (Table 2) results suggest that none of the metals evaluated exceed their regulatory limits. These data suggest that this debris is below limits for defining it as hazardous waste. Previous studies (HUD 1995; Lange and Thomulka 2000a) have suggested that, at least for lead, most building materials that contain LBP are not likely leechable. Data presented suggest that the other metals may likely follow a similar characteristic.

These data suggest that lead exposure during demolition commonly exceed the OSHA PEL and AL for this metal. Neither cadmium or chromium airborne concentrations exceeded the OSHA limits, although there is a probability of such exceedance for cadmium. However, such probability must be considered with caution, especially based on two of the values being below detection limits and one reportable value which is below the OSHA standard.

Based on airborne concentrations of lead (area and personal) there is a likelihood of workers having exposure over established standards. Other demolition studies (Conroy et al. 1996; Lange and Thomulka 2000) suggest that this type of work commonly result in high lead exposure.

Table 2. Toxicity characteristic leaching procedure results and EPA regulatory limits (mg/l)

Metal	Result	Regulatory Limit
Arsenic	<0.20	5.00
Selenium	<0.35	1.00
Chromium	<0.080	5.00
Cadmium	0.10	1.00
Lead	<0.40	5.00
Silver	<0.10	5.00
Barium	0.45	100
Mercury	<0.001	0.200

Such exposure may place workers in this industry at risk to lead poisoning (Conroy et al. 1996; Jacobs 1998). Since biological monitoring was not performed as part of this project, it is unknown to what extent exposure and other routes of uptake of lead impact the workers in regard to blood levels. These data warrant employment of PPE and other protective measures (engineering controls) for demolition work (Conroy et al. 1996).

Exposure concentrations in this study provide historical data associated with demolition operations for the metals lead, cadmium and chromium. Additional studies of airborne metals during demolition are warranted.

REFERENCES

Bakeas EB, Siskos PA (2002) Photochemical episodes and volatile hydrocarbons in Athens Greece. Fresenius Environ Bull 11: 312-317.

Conroy LM, Menezes-Lindsay RM, Sullivan PM, Cali S, Forst L (1996) Lead, chromium, and cadmium exposure during abrasive blasting. Arch Environ Health 1996: 51: 95-99.

Daniel WW (1991) Biostatistics: a foundation for analysis in the health sciences. Wiley and Sons, New York, NY.

Gaga EO, Tuncel PE, Tuncel SG (2002). Exposure of school children to Pb and Zn in an industrialized city of turkey. Fresenius Environ Bull 11: 249-253.

Ilgren E (2001) Health Risks from Exposures to Asbestos and Inorganic Metals due to Collapse of the World Trade Center: An Environmental Residential Survey. Indoor-Built Environ 10: 361-383.

Jacobs DE (1998) Occupational exposures to lead-based paint in structural steel demolition and residential renovations. Int J Environ Pollut 1998: 9: 1-14.

Karlsen JT, Torgrimsen T, Langard S (1996) Exposure to hazardous aerosols during manual metal arc welding on nickel-rich alloys. Occup Hyg 3: 307-310.

Lange JH, Thomulka KW (2000) Evaluation of engineering controls for airborne lead exposure during renovation/demolition of a commercial building. Indoor-Built Environ 9: 207-215.

Lange JH, Thomulka KW (2000a) Occupational exposure during lead abatement of steel surfaces by needle gun methodology. Bull Environ Contam Toxicol 64: 463-466.

Leidel NA, Busch KA, Lynch JR (1977) Occupational Exposure Sampling Strategy Manual. DEHW (NIOSH) Publication Number 77-173, National Technical Information Service Number PB-274-792. National Institute for Occupational Safety and Health, Cincinnati, Ohio.

US Department of Housing and Urban Development (1995) Guidelines for the evaluation and control of lead-based paint hazards in housing, www.hud.gov/offices/lead/guidelines/hudguidelines/index.cfm, Washington, DC.

US Occupational Safety and Health Administration (2001) Occupational Safety and Health Standards, Title 29 Code of Federal Regulations 1910 and 1926, www.OSHA.gov, US Department of Labor, Washington, DC