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Dawn Tharr Column Editor

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Case Studies

Characterization of Occupational and Residential Lead Exposure at a Stained-Glass Studio

Dawn Tharr, Column Editor

Report by Beth Donovan

Introduction

At the request of the owners of a stained-glass window-making studio in the Midwest, the National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation to assess lead exposure during the process of stained-glass window making. The artists own and operate a small stained-glass window-making studio that is adjoined to their house. Occasionally they will hire part-time employees or contract their work to other studios but most often do all the work themselves. Lead exposure from working with leaded "came," the malleable support that holds the pieces of glass together, lead/tin solder, and possible lead contamination in their home were the primary concerns.

The NIOSH investigator visited the studio on five days, two during the glass cutting and leading process, and three during the soldering, leading, and whiting processes. Personal breathing zone (PBZ) and general area (GA) air samples were collected in and outside of the studio and in the adjoining house. Surface wipe samples were taken in the studio and the house. Vacuum samples of the carpets were also taken in the house. Bulk samples of the whiting agent were collected before and after its use. Soil samples were collected around the house and the studio on the first and fifth days of sampling. All of these samples were analyzed for lead. In addition, the air samples collected during soldering were also analyzed for zinc.

Background

Stained-glass window-making began as a hobby for the owners, but it has now expanded into a full-time job. Their garage has been converted into a studio, complete with work tables, grinding wheels, a sink, two small, flexible ventilation ducts, and a separate whiting room with a through-the-wall exhaust fan. After the glass is cut into the appropriate pieces, it is assembled and joined with the lead came, a process called leading. The came is cut and molded to cover the edges and join the pieces of glass. Once all the came is in place, the junctures are joined with a lead/tin solder, using a copper/zinc flux and a soldering iron. Both sides of the window are soldered. The excess flux and the writing on the glass must then be cleaned off the window by a process called whiting. A mixture of talc, linseed oil, turpentine replacement, cement black color, and lead-free Japanese drier are rubbed over the window. Then the mixture is manually scrubbed over the surface with a metal bristle brush. More talc is added as the mixture is brushed over the window surface. When the window is clean, the remaining powder is brushed off with a soft bristle brush, and the window is ready to have supports added and placed into the window frame.

The artists have implemented several hygiene practices in their studio. There are two flexible ducts connected to exhaust fans that are used for local exhaust ventilation during soldering. In the whiting room there is a through-the-wall axial fan preceded by an electrostatic filter. An adhesive mat is used at both doorways to decrease the migration of lead dust out of the studio on shoe bottoms. A laundry room near the door that connects the studio to the house is used as a changing room to change into and out of studio clothes. Studio clothes, which are not worn anywhere outside of the studio, are washed separately from other clothes. Work shoes do not leave the studio; they are left at the door. There is no eating permitted in the studio, nor are the dog or child allowed into it. Latex gloves are worn during the entire process except for the initial cutting of the glass and discarded before leaving the studio. There is also a small sink in the studio for washing hands.

Evaluation Methods

Sampling was conducted at the studio over five days, two during the glass cutting and leading process, two during the leading and soldering, and one when both the soldering and whiting processes were occurring. PBZ and GA air samples were collected in and outside of the studio and in the house. The air samples were collected on mixed cellulose ester filters using flow rates of either 2.0 L/min or 3.0 L/min. The higher flow rate was used for short-term sampling during specific activities. Surface wipe samples were taken in the studio and the house using NIOSH Wipe Sampling Method 9100. A 100 cm^2 area was wiped three times (horizontal S-curve wipes, vertical S-curve wipes, and finally horizontal S-curve wipes again) with Wash 'N Dry® towelettes. Vacuum samples of the carpet surfaces were also taken in the house. Preweighed polyvinyl chloride filters with small nozzle attachments were connected to a pump calibrated to 3.0 L/min. The carpet surface was vacuumed in the same way that the other surfaces were wiped (three sets of S-curve wipes over a 100 cm^2 area). Bulk samples of the whiting agent were collected before and after its use. Soil samples were collected around the house and studio on the first and fifth days of sampling. Blood samples were taken on the fifth day of sampling and analyzed for lead and zinc protoporphyrins concentrations.

All of the samples were analyzed for lead. In addition, the air samples collected during soldering were also analyzed for zinc. The bulk samples were also analyzed for calcium and magnesium.

Results and Discussion

Air Samples

The GA samples from the studio, the house, and outside the studio were all <0.1 μg/m³. Outside of the whiting room, during the whiting process, a trace concentration between 0.1 and 0.4 μg/m³ was detected. Quantifiable lead concentrations were measured during the leading/assembling process, the soldering process, and the whiting process. The leading measurements ranged from trace (detectable but not quantifiable) to 5.0 μg/m³. The highest concentration was measured on the fifth day of sampling.

The lead concentrations during soldering ranged from trace to 2.0 μg/m³. On the fifth day of sampling, the ventilation during one hour of soldering was altered and a PBZ sample was collected. Instead of the flexible exhaust duct being placed on the table at the point of soldering, it was suspended above the worker's head. Thus, the fumes from the soldering that were usually observed to exit via the exhaust duct could be seen accumulating over the work table. (The worker was wearing a respirator during this experiment.) The lead concentration measured after this ventilation alteration was 5.0 μg/m³. This value is not significantly higher than the concentrations measured with the usual ventilation or during the leading/assembling process. The zinc level was also measured on the PBZ samples because the flux contained zinc. When the duct was on the table, the zinc levels ranged from none detected to 0.005 mg/m³. When the ventilation was altered, the zinc concentration was 1.67 mg/m³ but it was still well below the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and NIOSH recommended exposure limit of 50 μg/m³.[1] The lack of any significant increase in lead exposure when the ventilation was altered was not surprising because it would be unlikely that the soldering iron is hot enough to volatilize the lead in the came or the solder.

The measured lead levels were highest during the whiting process. The full-shift PBZ samples measured 60 μg/m³, and two task-specific PBZ samples (taken only during whiting) had concentrations of 70 and 80 μg/m³, respectively. These levels are above the OSHA PEL of 50 μg/m³.[2]

Surface Wipe Samples

The surface wipe samples are recorded in milligrams per square meter (mg/m²). The values may be compared to the U.S. Department of Housing and Urban Development (HUD) recommendation of 2.15 mg/m² (200 μg/ft²) for floor surfaces. The HUD recommendation is not based on health effects nor is it for a workplace surface. Thus, it should only serve as a reference rather than as a standard that should be met in a workplace.[3]

All of the wipe samples from the house were "none detected" or "trace." The levels from the studio ranged from 1.2 to 1600 mg/m² of lead. The concentrations were highest on the small studio table that was used for storage of the glass pieces before assembly and for assembled windows, ranging from 29 to 1600 mg/m². The large studio table where glass cutting, assembling, and soldering was done had the next highest concentrations, ranging from 3.5 to 270 mg/m². The floor samples had the lower concentrations—7.9 to 170 mg/m² on the floor between the two tables and 1.2 to 3.7 mg/m² on the hall floor that leads to the house. The whiting table had concentrations that ranged from 5.4 to 140 mg/m². The studio was not cleaned on or before any of the sampling days. It is usually not cleaned during a project, only after its completion.

Bulk Samples

Three bulk samples of the whiting agent were collected, one of the powder before use and two after use. Because there is no lead in the contents before use (which was confirmed by the first bulk sample), the second and third samples serve as an indication if any lead dust is added to the mixture as it is being used during the whiting process. There was no lead detected in the mixture before use. The second bulk sample was of a mixture that had been used weeks earlier and was left out on the table. It had a concentration of 420 μg of lead per gram of mixture (μg/g). The third sample was collected immediately after use and it had a concentration of 1100 μg/g. This indicates that lead dust is generated during the whiting process. It is probably scraped from the came when the window is scrubbed with the metal bristle brush. The calcium and magnesium concentrations were the same before and after use.

Carpet Dust Vacuum Samples

All of the carpet dust vacuum samples collected on the first and third days of sampling were below the minimal quantifiable concentration (<4600 μg/m²), and most were below the minimal detectable concentration (<1000 μg/m²). On the last (fifth) day of sampling, one sample was below the minimal quantifiable concentration (<1700 μg/m²), and three were below the minimal detectable concentration (<500 μg/m²).

Soil Samples

Composite soil samples were collected around the house and around the studio at near (0 to 3 feet) and far (10 to 20 feet) locations for lead analysis. On the first day of sampling, the samples around the house contained 73 μg/g of soil and 53 μg/g of soil for the near and far samples, respectively. The near and far samples around the studio were 58 μg/g and 62 μg/g, respectively. The values were not much different on the fifth day of sampling. They were trace (<35 μg/g), 57 μg/g, 68 μg/g, and 110 μg/g, respectively, for the near house, far house, near studio, and far studio samples. Because these four composite samples are spot samples, they should not be used to characterize the surface soil lead levels of the whole yard. These levels do suggest that the lead levels in the soil around the studio are not drastically different than the levels around the house.

Blood Lead Levels

The two full-time workers at the studio had had their blood lead levels (BLLs) checked in the past and their levels were always less than 10 μg/dl of blood. The BLLs collected by a NIOSH investigator on the fifth day of sampling were also less than 10 μg/dl. One worker had a BLL of 1.8 μg/dl and a zinc protoporphyrin (ZPP) level of 34 μg/dl. The other had a BLL of 2.1 μg/dl and a ZPP of 31 μg/dl. Although the air sample during the whiting process suggested a high worker exposure to lead, this process only occurred on the fifth day of sampling, the same day the blood samples were collected. The potential dose of lead from whiting had probably not been absorbed into the bloodstream yet.

Conclusions

Inhalation of lead dust and fume and ingestion resulting from hand-to-mouth contact with lead-contaminated food, cigarettes, clothing, or other objects are the major routes of worker exposure to lead. The surface samples in the studio suggest that lead dust does accumulate, but the air samples and BLLs indicate that personal lead exposures are low, except during the whiting process when there is a potential overexposure. The results indicate that the ventilation and hygiene practices employed by the artists are minimizing their exposures to lead and are preventing the contamination of their house with lead. The ventilation is simple and the hygiene practices are straightforward; others in the trade could probably benefit by using similar techniques.

Recommendations

1. Because the lead dust levels during the whiting process are greater than the OSHA PEL, it is recommended that an appropriate respirator be worn. The Mine Safety and Health Administration/NIOSH approved half-face respirator with an organic vapor cartridge used by the artists is not sufficient. A dual cartridge, high efficiency particulate air filter and organic vapor should be used. Respirators need to be properly fit-tested to ensure that there is a leak-proof seal. Protection is not certain without proper fit testing.

   Also, anyone who wears a respirator should be determined medically fit to wear one. Any part-time employees also should be properly fit-tested and medically tested before using a respirator.
2. The ventilation and hygiene practices should be continued and could probably benefit others in the trade.

References

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3. U.S. Department of Housing and Urban Development: Lead-based Paint: Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing. HUD, Washington, DC (September 1990).

Editorial Note: Beth Donovan is with the Hazard Evaluations and Technical Assistance Branch of NIOSH. More information is available in the Health Hazard Evaluation Report No. 92-0029-2392 available through NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway (MS R-9), Cincinnati, Ohio 45226; by telephoning 1-800-35-NIOSH, or by facsimile 513-533-8573.