

HEALTH CONSULTATION

Mercury Vapor Investigation at a Pawn Shop Conducting Precious Metal Reclamation Muskegon County, Michigan

Prepared by:

Michigan Department of Community Health
Under A Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Summary

An employee of a pawn shop in Muskegon County, Michigan contacted the Michigan Department of Community Health (MDCH) with her concerns regarding gold and silver items being melted down at the pawn shop to reclaim precious metals. This refining activity was being conducted without appropriate controls or safeguards. The employee reported that dental amalgams were melted occasionally. When heated, dental amalgams can release high concentrations of mercury vapor. The MDCH toxicologist was concerned that there could be potentially harmful exposure to mercury vapor and other metal fumes during the refining process and asked the Michigan Occupational Safety and Health Administration (MIOSHA) to investigate. The MDCH toxicologist also directed the employee and shop manager to have their blood tested, to determine any recent exposure.

MIOSHA conducted employee exposure monitoring while the shop manager melted several gold and silver items. Mercury was released during the process but concentrations near the melting furnace did not exceed occupational limits. Mercury was not detected in the breathing zone. The blood-testing results were similar to an average adult, suggesting no excessive or recent exposure.

MDCH has reached the following conclusions about the precious metal reclamation activities at the pawn shop:

- ✓ *The manager and employee at the pawn shop were not exposed to mercury air concentrations of concern in the 48 hours preceding the employee's complaint to MDCH nor during the employee exposure monitoring conducted by MIOSHA. Blood mercury analytical results were similar to the average U.S. adult population. Real-time mercury vapor monitoring of the indoor air at the shop showed no exceedances of MIOSHA exposure limits or MDCH screening levels.*
- ✓ *Customers of the pawn shop likely were not exposed to mercury air concentrations of concern, either at the shop or at home (as a result of bringing merchandise home). Note that this conclusion holds true only if the melting that was conducted during MIOSHA's investigation was typical of conditions during other refining instances. There was no mercury detected in the breathing zone. Also, there were no porous items or children's toys (which could act as secondary sources) for sale at the shop.*
- ✓ *Melting precious metals and dental amalgams can release potentially harmful, or lethal, levels of mercury vapors. Although the MIOSHA investigation in this case did not detect mercury in the breathing zone, the data indicated that there were short-term but significant mercury emissions near the furnace at various points during the refining process. Reports from other incidents have shown that exposure to high concentrations of mercury vapor can harm one's health irreversibly and cause death.*

Next Steps:

- Businesses conducting, or interested in conducting, small-scale refining can consult with the MIOSHA Division of Consultation, Education, and Training to ensure a safe working environment.
- MDCH will develop a fact sheet regarding the health issues surrounding small-scale refining and post it to its website (www.michigan.gov/mdch-toxics).

Purpose and Health Issues

MDCH conducted this health consultation under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR conducts public health activities (assessments/consultations, advisories, education) at sites of environmental contamination and concern. ATSDR is primarily an advisory agency. Therefore, its reports usually identify what actions are appropriate to be undertaken by the regulatory agency overseeing the site, other responsible parties, or the research or education divisions of ATSDR. As such, ATSDR recommendations may not encompass all types of federal and state requirements from a regulatory perspective. The purpose of a health consultation is not to evaluate or confirm regulatory compliance but to determine if any potentially harmful exposures are occurring or may occur in the future.

Background

On March 19, 2013, an employee of a Muskegon County pawn shop contacted the Michigan Department of Community Health (MDCH) Toxics Hotline with questions regarding gold and silver being melted down in her work place. The caller reported that the manager of the shop was refining metal items (jewelry, coins, flatware and dental amalgams) to reclaim the gold and silver in them and sell the ingots. The caller alleged that the furnace in which the melting took place was located within three feet of her desk and that the only “exhaust” system for the fumes was a window fan. She reported noticing an odor during the process and experiencing throat irritation, a cough, headache, nausea, diarrhea, and lethargy. When asked about joint pain (associated with metal fume fever), she replied that she was *not* experiencing that symptom.

MDCH immediately became concerned that toxic metals, such as lead and mercury, could be released during the refining process and that workers and customers could be exposed to very high air concentrations of these metals. (People have been killed by acute exposure to mercury vapors released when dental amalgams were melted down under conditions similar to the process described at the pawn shop [MMWR 1991].) MDCH explained these concerns and urged the employee, who was not feeling well that day and staying home, to have her blood analyzed for heavy metals. The caller agreed to do so and offered to recommend to the shop manager that he have his blood tested as well.

MDCH then alerted the Michigan Occupational Safety and Health Administration (MIOSHA) General Industry Safety and Health Division to refer the case to them (since this was primarily worker exposure). MIOSHA made arrangements to conduct real-time indoor air testing for mercury. MDCH also alerted the Poison Control Center (PCC), the local health department (Public Health Muskegon County), the U.S. Environmental Protection Agency (EPA), the Michigan Department of Environmental Quality (MDEQ), and the Region 5 Agency for Toxic Substances and Disease Registry (ATSDR) office, if assistance from those agencies became necessary as the case progressed.

Discussion

Health Outcome Data

Both the employee and the shop manager had their blood tested for mercury (and lead, but no other heavy metals were analyzed) on March 20, 2014, within 48 hours of the last reported

refining activity conducted at the pawn shop. Blood testing is recommended when exposure to high levels of mercury within the past three days is suspected (ATSDR 2014).¹ A blood lead concentration mainly reflects recent (within a few months) exposure and does not necessarily characterize the total body burden and slow elimination of lead in bone, where it is stored (ATSDR 2007).

MDCH compared the blood results to the National Health and Nutrition Examination Survey (NHANES) data reported in the *Fourth National Exposure Report on Human Exposure to Environmental Chemicals* (2013). The participants recruited for NHANES sampling are selected to be representative of “the civilian, noninstitutionalized population in the United States based on age, gender, and race/ethnicity” (CDC 2009).

The blood mercury concentration results were less than or equal to 2 micrograms per liter ($\mu\text{g/L}$). This is not greatly higher than the geometric mean of 1.04 $\mu\text{g/L}$ for blood mercury in adults, reported in the *Fourth National Report on Human Exposure to Environmental Chemicals* (2013). This suggests that excessive exposure to mercury vapors or fumes had *not* occurred during the recent refining at the pawn shop.

The blood lead concentration results were 1 to 2 micrograms per deciliter ($\mu\text{g/dL}$). This is not greatly higher than the geometric mean of 1.23 $\mu\text{g/dL}$ for blood lead in adults, reported in the *Fourth National Report on Human Exposure to Environmental Chemicals* (2013). This suggests that excessive exposure to lead fumes had *not* occurred during the recent refining at the pawn shop.

Environmental Data

Industrial hygienists from MIOSHA conducted employee exposure monitoring at the pawn shop on April 2, 2013. (The delay in scheduling an immediate inspection was due to the shop manager being out of town.) They instructed the manager to melt down silver and gold scrap jewelry under the conditions that he normally did so. They sampled for various airborne metals using a filter cassette attached to a personal sampling pump.² They also monitored for mercury vapor using a Jerome® Model 431-X real-time mercury vapor analyzer, which measures in micrograms per cubic meter ($\mu\text{g/m}^3$). A bulk sample of the slag from the melted silver was submitted for metals analysis (LARA 2013).³

The exposure monitoring lasted almost two hours. No metals, other than mercury, were detected in the air samples. Mercury vapor concentrations were generally non-detect ($< 1 \mu\text{g/m}^3$), although there were some short-term spikes, which usually returned to non-detect within one or two minutes. Table 1 shows the description of the process when mercury was detected and the resulting mercury vapor concentration. The MIOSHA staff also took several readings with the

¹ The Poison Control Center recommended that urine also be tested for mercury levels, to determine if there had been on-going exposure (more than 72 hours before the last known refining activities). The individuals did not have their urine tested.

² Metals sampled for in air were beryllium, cadmium fume, chromium metal, cobalt fume, copper fume, iron oxide fume, lead fume, manganese fume, molybdenum, silver, and zinc oxide fume (LARA 2013).

³ Metals analyzed for in the slag were aluminum, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, and zinc (LARA 2013).

Table 1. Description of refining process and resulting mercury vapor concentration (in micrograms per cubic meter [$\mu\text{g}/\text{m}^3$]) during employee exposure monitoring at a pawn shop in Muskegon County, Michigan. Air concentration of mercury returned to non-detect ($< 1 \mu\text{g}/\text{m}^3$) usually within two minutes. (Source: LARA 2013)

Melting area, fume generated during first addition of silver scrap. Reading taken 6-12 inches from the top of the melt furnace.	42
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Melting area, while pouring melted silver into a mold.*	136
Melting area, dumped silver bar out of the mold.*	11
Melting area, checking the empty silver mold.*	34
Melting area, fume generated during first addition of gold. Reading taken 6-12 inches from top of melt furnace.	28
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Melting area, empty silver mold.*	4

*The time frame of the silver being poured into the mold to the last detection of mercury from the empty silver mold was 17 minutes. The next reading of the mold was 13 minutes later and was non-detect (not shown in the table).

Jerome® of the pawn shop manager’s breathing zone during the monitoring. All of those readings were non-detect ($< 1 \mu\text{g}/\text{m}^3$; LARA 2013).

The level for mercury vapor that is considered Immediately Dangerous to Life and Health (IDLH) is $10,000 \mu\text{g}/\text{m}^3$. (The IDLH value is based on effects that might occur as a consequence of a 30-minute exposure. Note that the 30-minute period is *not* meant to imply that workers should stay in the work environment any longer than necessary but that every effort should be made to exit immediately [NIOSH 2013].) Based on the mercury vapor readings in Table 1, there was no immediate danger to life or health during the melting operation.

The MIOSHA time-weighted average (TWA) exposure limit for mercury vapor is $50 \mu\text{g}/\text{m}^3$. The TWA is defined as “the employee’s average airborne exposure in any 8-hour workshift of a 40-hour workweek that shall not be exceeded” (LARA 2014). Although one mercury vapor reading in the melting area during the exposure monitoring at the pawn shop exceeded $50 \mu\text{g}/\text{m}^3$, the air concentration dropped in the next reading and remained below the TWA exposure limit for all subsequent readings in the melting area. Note that the readings taken in the breathing zone, which would be a more appropriate indicator for exposure than near the melt furnace, were all non-detect ($< 1 \mu\text{g}/\text{m}^3$).

Where MIOSHA regulations do not apply, MDCH uses a screening level of $3 \mu\text{g}/\text{m}^3$ when considering reoccupancy of a non-residential structure (e.g. school, healthcare settings, office buildings) after a liquid mercury release has been cleaned up (ATSDR 2012). The pawn shop case was not a liquid release, but rather an air release. However, the MDCH screening level can

still be used. While the mercury vapor concentrations in the melting area sometimes exceeded the MDCH screening level, the readings occurred during an active melt, which would not happen all the time. Additionally, most of the readings in the melting area and all of the readings taken in the breathing zone were non-detect ($< 1 \mu\text{g}/\text{m}^3$).

The items melted during the exposure monitoring did not include dental amalgams. The shop manager confirmed with MDCH that he would occasionally melt down amalgams to extract the silver. Staff from another state health department indicated that they would expect the mercury indoor air concentration to increase 10 to 100 times if amalgams were melted (H. Nehls-Lowe, Wisconsin Department of Health Services, personal communication, 2013). In a Michigan home where dental amalgams were melted down, indoor air mercury concentrations, measured 11 to 18 days after the last refining, were as high as $786 \mu\text{g}/\text{m}^3$ in the basement, where the melting had occurred, and $912 \mu\text{g}/\text{m}^3$ on the first floor, due to the ventilation system distributing the vapors throughout the house. The home's four adult occupants all died as a result of the exposure (MMWR 1991). Although about 80 pounds of mercury were recovered using a vapor recovery system, the house remained too contaminated for occupancy and was demolished (J. Kimble, U.S. Environmental Protection Agency, personal communication, 2014).

The slag that was analyzed for metal content contained small percentages of aluminum, cadmium, cobalt, copper, iron, lead, manganese, nickel, and zinc. (The MIOSHA laboratory was unable to analyze for mercury.) MIOSHA staff advised the pawn shop manager of his obligations to inform and train his employees about cadmium and lead, according to the rules pertaining to the standards for those metals (LARA 2013). The shop manager disclosed to MDCH during a telephone interview that he would bag up the slag and send it on for further refining, since it could contain a very small amount of gold. (The laboratory analysis of the slag did not look for gold [LARA 2013].)

During the investigation of this case, MDCH alerted the local wastewater treatment plant, in case the pawn shop manager was disposing of any waste down the drain. No alarms had been triggered at the plant regarding mercury contamination.

Toxicological Evaluation

Inhalation of mercury vapor is the primary route of exposure to elemental mercury. Inhaled vapor is almost completely absorbed by the lungs (75-80%). Neither liquid mercury nor mercury vapor has an odor; therefore, there is no warning of hazardous concentrations without air monitoring (ATSDR 1999, 2014).

Symptoms of acute toxicity following high-level exposure to mercury vapor occur within hours of the exposure. Symptoms include cough, sore throat, shortness of breath, racing heartbeat, increased blood pressure, metallic taste, nausea, vomiting, diarrhea, headache, weakness, and visual disturbances. The respiratory effects might resolve or can progress to pulmonary edema, respiratory failure, and death. The kidneys eliminate mercury from the body and may show toxic effects. Some of the symptoms that occur following short-term, high-level exposure may be of long-term duration. Chronic exposure to lower concentrations of mercury vapor can also result in some of these symptoms, including permanent damage to the central nervous system and kidneys (ATSDR 1999, 2014).

The data collected by MIOSHA during its exposure monitoring indicated that mercury air concentrations were not above levels of concern, neither for the employees nor for any customers coming into the pawn shop during a melt like that conducted during the monitoring. Therefore, no harm would be expected under these conditions. However, more frequent refining activities or melting dental amalgams could cause air concentrations of mercury to increase to potentially harmful levels. Additionally, a window fan is not an appropriate means of clearing metal fumes from the work area and has no controls to prevent emissions of mercury to ambient air.⁴ Metal reclamation practices without appropriate training or controls to prevent human exposure can pose a human health hazard.

Children's Health Considerations

Children are usually more susceptible to the toxic effects of mercury vapor exposure. This is because they breathe more air per body weight than adults, resulting in a higher internal dose than adults would have in the same atmosphere. Also, depending on their age, their blood-brain barrier and immune systems may not be sufficiently mature to counter mercury's toxicity. Some children (about one in 500) can develop a non-allergenic hypersensitivity to mercury vapor called acrodynia. The symptoms of this syndrome include profuse sweating, dangerously high blood pressure, light sensitivity, pink and peeling palms and soles, and behavioral changes (ATSDR 1999).

MDCH and Public Health Muskegon County were concerned that there could be porous items or children's toys sold at the pawn shop that could absorb the mercury vapors and slowly release them (as secondary sources), potentially exposing purchasers of these items and their families. The county health department went to the pawn shop on March 28, 2013, to investigate these concerns. They reported seeing no porous items or children's toys at the shop. Instead, items noted included hand and power tools, hunting and fishing equipment, video games and movies, dog crates, and jewelry. These items are not likely going to act as secondary sources of mercury in this case.

Outreach Considerations

During a discussion with MDCH, the pawn shop manager stated that there likely is a common misconception among artisanal refiners that if there is no smoke coming from the crucible (melting furnace), then the melting is occurring as desired. However, he reported that he did not realize there could be mercury vapor emissions coming from the crucible, even when smoke was absent. This presents an opportunity for outreach to small-scale refiners, either commercial or home-based precious-metal reclamation operators, to ensure that they are aware of the health risks in these activities and protective actions they can take. MIOSHA has shown an interest in working with MDCH in developing health education in this area.

The Michigan Department of Environmental Quality (MDEQ) expressed concern that, depending on the process used by small-scale refiners, acid waste and rinse water might be

⁴ An unannounced inspection of the pawn shop on August 7, 2013 by the MDEQ Air Quality Division revealed that the furnace is exempt from the Rule 282(a)(iv) requirements to obtain an air use permit, since the furnace has a capacity less than 1,000 pounds (its capacity is 30 ounces) and does not use chlorine, chloride, fluoride or ammonium-based flux (MDEQ, unpublished data, 2013).

generated which would need proper handling and disposal, per environmental regulations. Additionally, Best Management Practices issued by MDEQ under Public Act 503 of 2008 state that dental amalgam waste must be sent to a recycler who reclaims the mercury from the waste (G. Scott, MDEQ Water Resources Division, personal communication, 2013).

Mercury is also used in small-scale gold mining. Persons involved in or near this activity can be exposed to mercury vapors. The Alaska Department of Health and Social Services has developed a fact sheet called “Mercury, Gold Mining, and Health” that discusses these concerns.⁵ The EPA has a similar fact sheet, discussing the need to reduce mercury air emissions from gold processing shops.⁶

Conclusions

MDCH has reached the following conclusions about the precious metal reclamation activities at the Muskegon-county pawn shop:

- ✓ *The manager and employee at the pawn shop were not exposed to mercury air concentrations of concern in the 48 hours preceding the employee’s complaint to MDCH nor during the employee exposure monitoring conducted by MIOSHA.* Blood mercury analytical results were similar to the average U.S. adult population. Real-time mercury vapor monitoring of the indoor air at the shop showed no exceedances of MIOSHA exposure limits or MDCH screening levels.
- ✓ *Customers of the pawn shop likely were not exposed to mercury air concentrations of concern, either at the shop or at home (as a result of bringing merchandise home).* Note that this conclusion holds true only if the melt that was conducted during MIOSHA’s investigation was typical of conditions during other melting instances. There was no mercury detected in the breathing zone. Also, there were no porous items or children’s toys (which could act as secondary sources) for sale at the shop.
- ✓ *Melting precious metals and dental amalgams can release potentially harmful, or lethal, levels of mercury vapors.* Although the MIOSHA investigation in this case did not detect mercury in the breathing zone, the data indicated that there were short-term but significant mercury emissions near the furnace at various points during the refining process. Reports from other incidents have shown that exposure to high concentrations of mercury vapor can harm one’s health irreversibly and cause death.

Recommendations

1. MDCH recommends that people and businesses conducting small-scale refining educate themselves on and use health-protective practices, to ensure the safety of the operator and bystanders (children, neighbors, other employees, customers).
2. MDCH recommends that people not melt dental amalgams.
3. MDCH recommends that people and businesses interested in small-scale refining educate themselves on and comply with regulations regarding properly handling waste generated by the process, to prevent environmental contamination.

⁵ See <http://www.epi.hss.state.ak.us/eh/MercuryGoldMiningFactsheet.pdf>.

⁶ See <http://www2.epa.gov/sites/production/files/2014-05/documents/asgm-fact-sheet.pdf>.

Public Health Action Plan

- Businesses conducting, or interested in conducting, small-scale refining can consult with the MIOSHA Consultation, Education, and Training Division to ensure a safe working environment.
- MDCH will develop a fact sheet regarding the health issues surrounding small-scale refining and post it to its website (www.michigan.gov/mdch-toxics).

MDCH will remain available as needed for future consultation at this site.

If any citizen has additional information or health concerns regarding this health consultation, please contact MDCH's Division of Environmental Health at 1-800-648-6942.

REPORT PREPARATION

This Health Consultation for the “Mercury Vapor Investigation at a Pawn Shop Conducting Precious Metal Reclamation, Muskegon County, Michigan” was prepared by the Michigan Department of Community Health, Division of Environmental Health, Toxicology and Response Section, under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR).

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