CDC Workplace Safety and Health

Evaluation of Exposures to Carbon Monoxide and Surface Metals in an Ohio Department of Transportation District Garage

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Health Hazard Evaluation Report
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District 8 Main Garage
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DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
NIOSH National Institute for Occupational Safety and Health

The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

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Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
AL	Action level
BEI®	Biological exposure index
BLL	Blood lead level
CO	Carbon monoxide
CO_2	Carbon dioxide
EPA	Environmental Protection Agency
°F	Degrees Fahrenheit
HEPA	High-efficiency particulate air
HHE	Health hazard evaluation
HUD	Housing and Urban Development
mL	Milliliter
ND	Non-detectable
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OCSEA	Ohio Civil Service Employees Association Union
ODOT	Ohio Department of Transportation
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PPE	Personal protective equipment
ppm	Parts per million
REL	Recommended exposure limit
RH	Relative humidity
STEL	Short term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
WEEL	Workplace environmental exposure limit
$\mu g/100\ cm^2$	Micrograms per 100 square centimeters
µg/dL	Micrograms per deciliter
$\mu g/ft^2$	Micrograms per square foot
$\mu g/m^3$	Micrograms per cubic meter

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a request from the Ohio Civil Service Employees Association for a health hazard evaluation at the Ohio Department of Transportation District 8 Main Garage in Wilmington, Ohio. NIOSH investigators were asked to address concerns about exposure to carbon monoxide and metals such as arsenic, cadmium, and lead. We conducted a site visit in October and December 2006.

What NIOSH Did

- We measured carbon monoxide when vehicles were started and driven out of the Main Garage.
- We collected surface wipe samples for metals such as arsenic, cadmium, and lead. Samples were taken from work and non-work surfaces.

What NIOSH Found

- Carbon monoxide concentrations were well below occupational exposure limits.
- Arsenic was not detected in any of the surface wipe samples.
- Low concentrations of cadmium were detected on the bench grinder workbench and chain saw sharpener workbench. Cadmium was not detected in any other surface wipe sample.
- A relatively high surface lead concentration was detected on the bench grinder workbench and chain saw sharpener workbench. Lead concentrations on other work surfaces were low.
- Lead was either not detected or was found in trace concentrations on most non-work surfaces. Low concentrations of lead were detected on the floor near the picnic tables and around the handle of a changing room locker.

What Ohio Department of Transportation Managers Can Do

- Do not permit vehicles to idle in the garage.
- Keep both garage doors open and use exhaust fans when vehicles are running in the garage.
- Clean the bench grinder and chain saw sharpener workbench surfaces at the end of each day of use.
- Establish and follow a regular cleaning schedule for other work surfaces.
- Clean the eating surfaces in the kitchen and break area each day.

What Ohio Department of Transportation Employees Can Do

- Remove personal protective equipment before using the kitchen or break areas.
- Store personal protective equipment in a clean area when not in use.
- Wash hands thoroughly before eating, drinking, or smoking to prevent ingestion of lead or other metals.
- Wipe off shoes on floor mats before entering the kitchen or other non-work areas.

Summary

On August 15, 2006, NIOSH received a request from the OCSEA for a HHE at the ODOT District 8 Main Garage in Wilmington, Ohio. The OCSEA expressed concern about workplace exposure to CO from vehicle exhaust and exposure to metals such as arsenic, cadmium, and lead that may have accumulated on work surfaces over many years of garage operation.

Carbon monoxide concentrations were well below NIOSH recommended exposure limits. High concentrations of surface lead were detected at the chain saw sharpener and bench grinder workbenches. Improved cleaning of these surfaces, storing personal protective equipment properly, and thorough hand washing before eating, drinking, or smoking are recommended.

Two NIOSH investigators walked through the worksite on October 31, 2006, to become familiar with the facility and identify potential locations of surface contamination with metals. In a follow-up site visit on December 12, 2006, they measured instantaneous CO concentrations using direct reading instruments as the vehicles started-up and left the garage at the beginning of the work shift. They also collected surface wipe samples for arsenic, cadmium, lead, and other metals in work and non-work areas.

Although only one of the two garage doors was open and only one of two exhaust fans was operating, all CO measurements were well below the NIOSH recommended ceiling limit of 200 ppm. The highest instantaneous CO concentration of 22.6 ppm occurred when a full-size pickup truck was started and driven out of the garage. Of all the CO measurements, 78% were less than 5 ppm. Because all measured CO concentrations were less than 23 ppm, it is expected that full-shift TWA concentrations would also be well below the NIOSH REL of 35 ppm.

No arsenic was detected in any of the surface wipe samples that NIOSH investigators collected. Low concentrations of cadmium were detected on the workbench near the bench grinder in the vehicle maintenance bay and on the workbench near the chain saw sharpener. Cadmium was not detected in any of the other surface wipe samples. High concentrations of surface lead were detected on the bench grinder workbench and chain saw sharpener workbench, and low concentrations were detected on the other work surfaces sampled. Lead was either not detected or was found in trace concentrations on most non-work surfaces, except for low concentrations on the floor near the picnic tables and around the handle of a changing room locker.

NIOSH investigators recommend cleaning the workbench surfaces with a HEPA filtered vacuum followed by wet cleaning of the bench surface after each day in which the chain saw sharpener or bench grinder are used. Other work surfaces should be periodically cleaned. Kitchen and break area eating surfaces should be cleaned each day. NIOSH investigators also recommend that employees store personal protective equipment in designated areas and that employees wash their hands thoroughly before eating, drinking, or smoking.

Keywords: NAICS 926120 (Regulation & Administration of Transportation Programs), vehicle repair, carbon monoxide, surface metals, lead, cadmium, arsenic

Introduction

In August 2006, NIOSH received a request from the OCSEA for an HHE at the ODOT District 8 Main Garage. The request noted concerns regarding exposure to CO from vehicle exhaust and to metals such as arsenic, cadmium, and lead. Arsenic exposure was reported to originate from insecticide spray used in the facility to control termites and other insects. The source of exposure to other metals was reported to be garage activities that may have resulted in an accumulation of metals on surfaces over many years of garage operation.

On October 31, 2006, two NIOSH investigators conducted an initial site visit. An opening conference was held with management and an employee representative to discuss the HHE request. Following the opening conference, the NIOSH investigators walked through the facility to become familiar with the facility layout, equipment, and typical work activities. A subsequent site visit was conducted on December 12, 2006, to monitor for CO during ODOT vehicle warm-up and to collect surface wipe samples for metals in the facility. Upon completion of the site visit, a closing conference was held with management and employee representatives to summarize site visit activities and provide preliminary findings.

Workplace Description

The ODOT District 8 Main Garage, which measures approximately 120 feet by 60 feet, was constructed in 1953. In the garage, workers perform vehicle repairs and preventive maintenance including engine, hydraulic, transmission, radiator, and power steering fluid changes; minor engine repairs; brake jobs; tire and wheel replacement; snowblade repairs; minor body repairs; welding; and grinding. Other activities such as chain saw sharpening, lawn mower maintenance, and road maintenance equipment repairs are also performed. Additionally, the Main Garage is used to store a small amount of cold tar patch material and some ODOT vehicles are parked in the building overnight. The site has a separate open-front building for equipment storage; a storage building for road repair aggregate material; three road-salt storage buildings; and an additional garage for overnight parking of ODOT trucks. ODOT plans to construct a new garage at this site within the next few years.

Introduction (continued)

Seventeen employees work at the District 8 Main Garage. Five of these employees, including two mechanics, one storeroom clerk, one account clerk, and the county manager usually spend their entire work shift in the Main Garage. The remaining employees are highway technicians and usually work offsite conducting snow and ice removal or treatment, grading roads, mowing grass, maintaining or replacing road signs, repairing guardrails, and patching potholes in roads. When offsite work is not necessary, highway technicians work in the Main Garage on miscellaneous jobs such as vehicle cleaning or minor repairs. All employees typically work 8-hour shifts. However, during adverse weather events, such as snowstorms, highway technicians work longer shifts.

Assessment

NIOSH investigators measured CO and collected surface wipe samples for metals on December 12, 2006. For CO monitoring, each NIOSH investigator used a TSI Q-TRAK™ Plus Indoor Air Quality Monitor, Model 8554 (TSI Incorporated, Shoreview, Minnesota) to take instantaneous real-time measurements at representative work locations throughout the Main Garage and adjoining rooms. They took 32 CO measurements in the Main Garage between 7:07 a.m. and 7:46 a.m. as ODOT vehicles were started and then driven out of the building. Additionally, eight CO measurements were taken in the front office area and two measurements were taken outdoors during that time. They monitored for CO at the beginning of the work shift because this was when ODOT vehicles were started and then driven out of the garage, and when CO concentrations would likely be the highest. The CO monitors also provided temperature, RH, and CO_2 measurements.

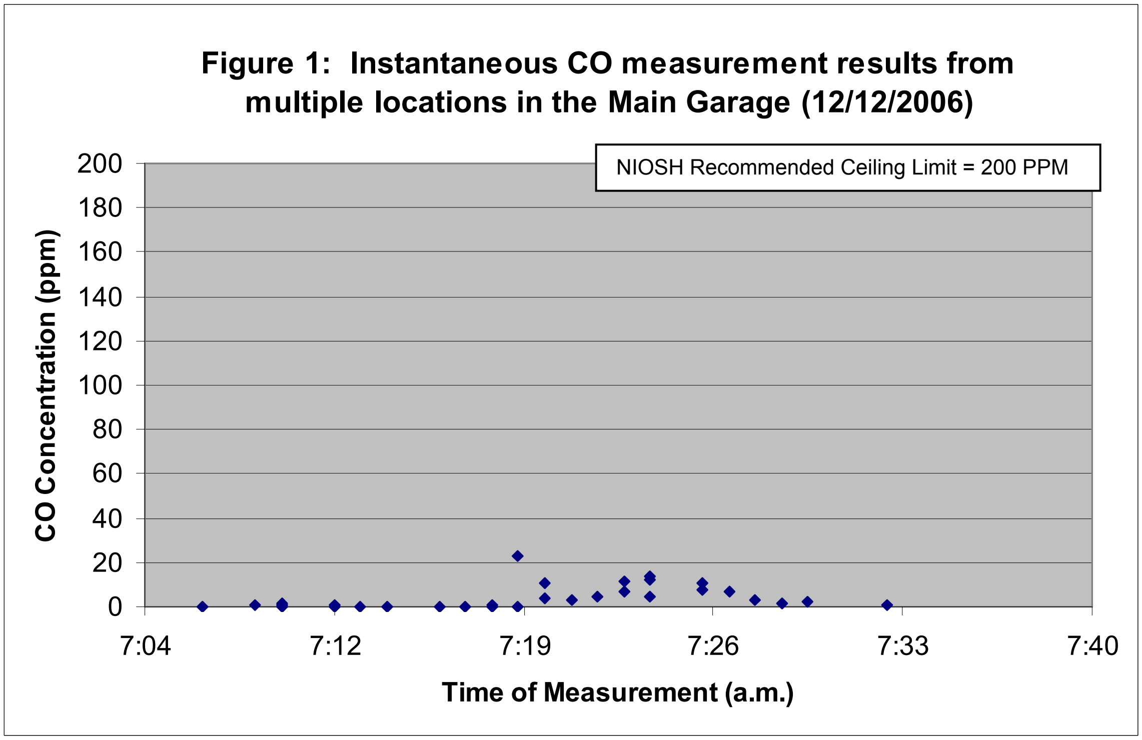
Twenty surface wipe samples for metals were taken in the facility. Samples were collected in the Main Garage work areas, eating areas, break areas, and in the front office area. Sample locations were selected to identify the presence of metals at different work areas and non-work areas, and to determine to what extent metal contaminants may have migrated from work areas to non-work areas. Surface wipe sample assessment methods used during the evaluation are explained in Appendix B. Because activities that generate air contaminants are infrequently performed and are of short duration when performed, air contaminant concentrations that exceed OELs were considered very unlikely and, therefore, air sampling was not deemed necessary.

Carbon Monoxide

During CO monitoring in the Main Garage, a diesel-powered dump truck and a gasoline-powered pickup truck were started and then driven out of the garage. Another pickup truck was moved from the garage area to the repair bay area of the building. These vehicles were operated in the building for no more than 2 minutes. General exhaust ventilation in the Main Garage was provided by one of the two 12-inch exhaust fans, located approximately 15 feet above the floor in the northwest wall. ODOT did not have information on the fan exhaust flow and NIOSH investigators were not able to measure exhaust flow because of the fan location. Passive air movement also occurred when one of the two large garage doors was opened while vehicles were running. Both large garage doors were closed when no vehicles were operating, but one of the wall-mounted exhaust fans operated continuously during the sample period. During CO measurements, the temperature in the Main Garage ranged from 62.6°F to 68.3°F, and the RH was 29% to 36%. The outside air temperature was 49.5°F, and the outside RH was 38.2%.

Instantaneous CO concentrations, measured across the Main Garage, ranged from 0 to 22.6 ppm. However, the concentration of most CO measurements was less than 5 ppm. Specifically, the concentration of 47% of the CO measurements was between 0.1 ppm and 5 ppm; and CO was not detected in 25% of the measurements. The highest concentration of CO (22.6 ppm) was measured at 7:19 a.m. shortly after a full-size pickup truck was driven out of the garage. The CO concentration declined quickly after the truck departed the garage. The CO concentration was approximately 14 ppm when another full-size pickup was moved from the main part of the garage to the repair bay. CO was not detected outside the building or in the front office. All measured CO concentrations were well below the NIOSH recommended ceiling limit of 200 ppm [NIOSH 1992]. A ceiling limit is a concentration that should never be exceeded during the work shift. Although CO measurements were only taken in the morning during vehicle start-up and departure, we would expect very similar results when vehicles return at the end of the work day.

CO measurement results from the Main Garage are summarized in Figure 1, and detailed CO measurement results are provided in Table A1 in Appendix A.



Facility management and some employees indicated that vehicles only idle inside the garage for a maximum of 2 minutes, before departing. However, one employee reported that during cold weather, vehicles may idle in the building for 5 to 10 minutes, and sometimes the garage doors remained closed as vehicles idled. On the day of the evaluation, vehicles idled for 2 minutes or less. It is likely that CO concentrations would have been higher if vehicles had idled longer, or if the garage doors remained closed while vehicles idled. Although TWA measurements were not collected, the CO concentrations for all of the instantaneous measurements were less than 23 ppm, and most were less than 5 ppm. Therefore, it is expected that full-shift TWA CO concentrations would be well below the NIOSH REL of 35 ppm.

While CO concentrations were well below OELs on the day of monitoring, a few ventilation related deficiencies were observed, which, if changed should further reduce CO concentrations. Specifically, only one of the two exhaust fans was in operation and only one of the two garage doors was open when vehicles were running.

Surface Metal Wipe Samples

NIOSH investigators noticed several possible sources for metal particles on surfaces in the Main Garage. Used vehicle fluids or lubricants, such as radiator fluid, transmission fluid, brake fluid, hydraulic oil, and engine oil, can contain residual metal contaminants. Although only performed for about an hour or less every few weeks, grinding, cutting, and welding on metal parts for vehicle repairs and sharpening of chain saw blades can generate metal particles, which could accumulate on nearby surfaces. Over time, some metal particles could migrate from surfaces in work areas to non-work areas via clothing, shoes, hands, and to a much lesser extent through the air. The building has been used as a maintenance garage since its construction in 1953, so some residual lead could be present from the use of leaded fuels prior to a phasing out of leaded fuel in the late 1980s and a complete ban by the EPA in 1996.

Because the HHE request was primarily concerned with lead, cadmium, and arsenic, this report specifically addresses surface sample results related to these metals; however, other metals were also detected in the samples. Surface sample results provided in this report should be used as an indication of relative surface contamination, i.e., a surface with 500 µg/100 cm^2 would be considered more contaminated than a surface with 50 µg/100 cm^2. Complete surface wipe sample results are provided in Table A2 of Appendix A.

Regardless of sample location, no detectable concentration of arsenic was found in any of the surface wipe samples. Additionally, our review of the product data sheet for the insecticide (Demand CS) used by Terminix to treat the building for insects indicated that arsenic was not a component. This had been a concern of the HHE requestor.

Low concentrations of cadmium were detected in the surface wipe sample collected on the workbench near the chain saw sharpener (2.5 µg/100 cm^2) and in the surface wipe sample from the workbench near the bench grinder (3.5 µg/100 cm^2). These results are not surprising because cadmium can be a minor constituent in some of the metal products that are sharpened or ground at these locations. No cadmium was detected in any other surface wipe sample.

In work areas, surface lead concentrations ranged from 5.3 to 11 µg/100 cm^2, except for a concentration of 46 µg/100 cm^2 on the workbench next to the chain saw sharpener and 720 µg/100 cm^2 on the workbench near the bench grinder in the repair area. At these workbenches, direct abrasion of metal during grinding and blade sharpening releases metal particles onto nearby surfaces. The work surfaces on both benches had noticeable amounts of dirt and debris from prior activity. This was particularly evident at the bench grinder. At the time of the evaluation, the local exhaust ventilation system in the mechanic bay was not operational. An exhaust fan in the wall of the mechanic bay was working. However, it would not be particularly effective for capturing metal particulates because of its distance from the location where grinding or cutting were done.

It is important to note that neither NIOSH guidelines nor OSHA regulations exist for lead concentrations on work surfaces against which to compare these surface wipe sample results. However, OSHA specifies in its substance-specific standards for lead, cadmium, and inorganic arsenic that all surfaces should be maintained as free as practicable of accumulations of these metals. Furthermore, the OSHA compliance directive for lead exposure in construction recommends using HUD's recommended level for acceptable decontamination of 200 µg/ft^2 for floors in evaluating cleanliness of change areas, storage facilities, and lunchrooms/eating areas. OSHA would not expect that surfaces should be any cleaner than this level [OSHA 1993].

The EPA recommends meeting the following clearance levels for surface lead loading after residential lead abatement or interim control activities: floors, 40 µg/ft^2; interior windowsills, 250 µg/ft^2; window troughs, 400 µg/ft^2 [CFR 2001]. Because children have substantially more hand-to-mouth contact than adults, these clearance levels were primarily established to prevent excessive lead exposure in children who may reside in homes following lead abatement. Because of the substantial differences between activities in a home environment and a work environment, the EPA clearance levels are not directly applicable to workplaces, nor are they legally enforceable.

When the measurable surface wipe sample results for lead were extrapolated from "100 cm^2" (the surface area NIOSH used for wipe samples) to "ft^2" (the surface area referenced by OSHA and EPA), seven of the surface wipe samples had lead concentrations above the EPA clearance levels for floors (Table 1). However, only the surface lead concentrations at the chain saw sharpener and bench grinder were greater than the EPA lead clearance levels specified for interior window sills and window troughs. Although EPA lead clearance criteria cannot be used to state that a lead hazard exists at the work site, they do provide a reasonable guideline that, when exceeded, suggests that improved cleaning is advisable for affected surfaces to prevent contamination of skin and clothes and decrease the opportunity for accidental ingestion.

None of the lead concentrations in non-work area surface wipe samples exceeded 200 µg/ft^2, which is the level OSHA refers to in its lead in construction compliance directive for evaluating the cleanliness of changing areas, storage facilities, and lunchrooms/eating areas.

Table 1: Measurable surface wipe sample results for lead (extrapolated from µg/100 cm^2 to µg/ft^2)

Sample Location	Lead (µg/100 cm^2)	Lead (µg/ft^2)
Floor between picnic table and sofa	5.4	50.2
Work bench near chain saw sharpener	46	427.4
Floor in front of chain saw sharpening work bench	11	102.2
Change room locker handle (locker #72)	9.7	90.1
Floor in middle of mechanic's bay	9.2	85.5
Work bench near bench grinder	720	6689
Floor in from of cold mix pit	5.3	49.2

NOTE: All other surface wipe sample results for lead (n=13) were non-detectable or at trace concentrations.

The relatively high lead concentrations on the work bench surfaces, particularly at the bench grinder in the mechanic bay, indicate that these two work surfaces had not been adequately cleaned.

Results and Discussion (continued)

Little evidence suggested that lead dust had substantially migrated from work areas to non-work areas (kitchen, break area, offices, and changing room). Surface lead was either non-detectable or at trace concentrations in most of the non-work areas sampled. A trace concentration means that some contaminant was detected in the sample, but the amount was too low for the lab to be able to quantify it with sufficient accuracy. However, the presence of lead on a few kitchen surfaces does underscore the importance of cleaning eating surfaces daily to prevent unnecessary exposure.

Low concentrations of lead were detected on the floor between the break area picnic tables (5.4 µg/100 cm^2) and near the handle of a locker in the men's changing room (9.7 µg/100 cm^2). Lead dust was most likely carried to these areas on the bottom of employees' shoes and dirty hands, respectively.

Lead was not detected on the picnic table surface and was measured at trace concentrations on the picnic table bench seat. However, the poor work practices NIOSH investigators observed increase the opportunity for possible contamination of these surfaces with lead or other metals. Specifically, employees had placed work shoes on one of the bench seats and dirty gloves on the table top. If shoes, gloves, or other work items have lead or other metal dust on them, the contaminants could be transferred to these surfaces.

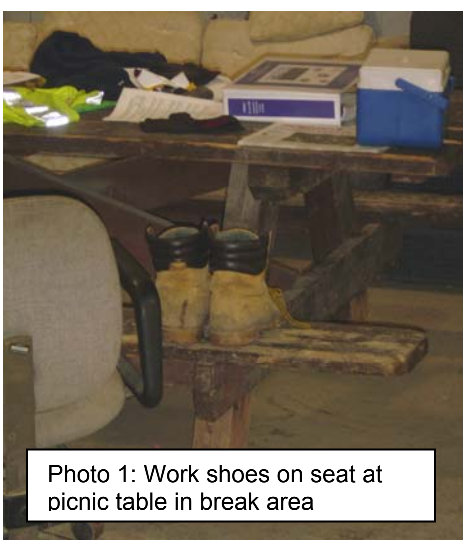


Photo 1: Work shoes on seat at picnic table in break area

Photo 2: Dirty gloves on picnic table in break area

Results and Discussion (continued)

NIOSH investigators observed a pair of safety glasses on the workbench near the chain saw sharpener during the initial walkthrough at the facility and again during the subsequent evaluation. Although only trace concentrations of lead were found on the surface wipes collected on the safety glasses, high concentrations of lead were found on the workbench. Placing safety glasses on a dirty workbench or other dirty surface during periods of non-use increases the chance of contamination and subsequent exposure when the safety glasses are later worn.

Photo 3: Safety glasses on work bench near chain saw sharpener

Conclusions

NIOSH investigators determined that CO concentrations in the Main Garage during start-up and departure of ODOT vehicles ranged from ND to 23 ppm. Similar CO concentrations would also be expected when vehicles return to the garage. These concentrations are substantially below the NIOSH recommended ceiling limit of 200 ppm. However, underutilized ventilation from exhaust fans and unopened garage doors, and lack of clearly specified and enforced vehicle start-up procedures could result in higher CO concentrations at times, particularly if vehicles idle in the garage for more than a few minutes.

NIOSH investigators found that arsenic was not detected on any surface in the Main Garage. Cadmium was detected at low concentrations on the bench grinder workbench and on the chain saw sharpener workbench, but was not detected on any other surfaces. Surface lead was either non-detectable or at trace concentrations in the kitchen and break area. In most work

Conclusions (continued)

areas, lead was detected in relatively low or trace concentrations, but investigators found a high surface lead concentration on the workbench near the chain saw sharpener and on the workbench near the bench grinder.

Based on the wipe sample results, surface concentrations of arsenic and cadmium do not pose a health risk to employees. Likewise, low or trace concentrations of lead found on most surfaces should not present a health risk to employees. However, higher concentrations found on some workbench surfaces could result in employees contaminating their hands or clothing and possibly ingesting lead. Exposure to lead by this pathway is highly dependent on surface concentration, activities, and precautions taken by the worker. Appropriate housecleaning and personal hygiene practices should substantially decrease the chance that workers would accidentally ingest lead or any other metals.

Recommendations

The following recommendations are based on carbon monoxide monitoring, surface metal sampling, discussions with employees and management, and observations made during the NIOSH investigation. They are offered to improve the workplace and reduce exposures to contaminants.

1. Keep both garage doors open and use the exhaust fans when ODOT vehicles enter, leave, or move within the garage. Do not idle vehicles in the building. Reduce CO emission from vehicles by keeping the engines properly tuned.
2. Train employees about the importance of thoroughly washing their hands prior to eating, drinking, or smoking to prevent accidental ingestion of lead or other metals. Employees should also wash their hands before using the locker room. Supervisors should make sure that employees wash their hands before breaks.
3. Use a vacuum with a HEPA filter to clean the workbench surface and surrounding area after each day the bench grinder or chain saw sharpener is used. A HEPA filter is extremely important for preventing dust from getting back into the air during vacuuming. Care must also be taken not to disperse dust into the air when emptying the vacuum. Prohibit the use of compressed air or dry sweeping to clean these work areas, as this would generate airborne dust.

Recommendations (continued)

Following vacuuming, clean the workbench surface with detergent and water. Detergents that contain tri-sodium phosphate are best for cleaning surfaces that may have lead contamination. Wet-clean the floors in the mechanic bay periodically (such as quarterly), based on the amount of repair activity. Perform regular cleaning (bi-weekly) in the change room. Using the local exhaust ventilation for the grinder, saw, or other equipment could also reduce nearby surface contamination.

4. Clean the kitchen floor, countertop, sink, tabletop, and picnic tables every day to prevent possible accumulation of surface metals at eating or food preparation areas.

5. Provide and encourage employees to use wipe-off floor mats outside break areas, offices, and employee locker rooms to reduce tracking of contaminants out of the Main Garage.

6. Do not permit employees to place dirty shoes, gloves, hats, or other PPE on kitchen or picnic tables. Provide a designated location to store PPE after use or during breaks.

7. Do not permit employees to leave PPE, such as safety glasses, on work benches where they could become contaminated by lead or other metals. Store safety glasses in a clean locker or other clean location when not in use. Safety glasses should be cleaned after each day of use.

8. Separate the picnic tables from the work areas; the location of picnic tables in the general work area increases the potential for contamination.

References

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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.

OSHA [1993]. Occupational Safety and Health Administration Instruction CPL 02-02-058-29 CFR 1926.62, Lead Exposure in Construction; Interim Final Rule: Inspection and Compliance Procedures (12/13/1993).

	Table A1. Carbon monoxide measurement results ODOT District 8 Main Garage, December 12, 2006			
	Time	Location	CO (ppm)	Note
CO Monitor #1	7:09 a.m.	Next to diesel truck (running) near entrance to offices	0.5	one garage door is open
	7:10 a.m.	Center of garage as truck was leaving	0.6	one garage door is open
	7:10 a.m.	Near south garage door	0.8	one garage door is open
	7:12 a.m.	Near north exit door	0.5	garage doors closed
	7:17 a.m.	Center of garage	0.2	garage doors closed
	7:18 a.m.	Center of garage as pick-up truck leaving	0.5	garage doors closed
	7:19 a.m.	Center of garage a few minutes after pick-up truck left	22.6	garage doors closed
	7:20 a.m.	Center of garage, toward south garage door	10.5	garage doors closed
	7:22 a.m.	In garage near entrance from office	4.9	garage doors closed
	7:23 a.m.	Center of garage	11.2	garage doors closed
	7:24 a.m.	Center of garage as pick-up truck move to repair area	14.1	garage doors closed
	7:30 a.m.	Near repair area	2.3	garage doors closed
	7:33 a.m.	Near secretary's desk in front office area	0.1	
	7:35 a.m.	In plant foreman's office	0	
	7:37 a.m.	In plant manager's office	0	
	7:45 a.m.	Outdoors	0	
CO Monitor #2	7:07 a.m.	In garage near entrance to office	0	one garage door is open
	7:10 a.m.	Next to diesel truck (running) near entrance to offices	0	one garage door is open
	7:10 a.m.	In garage near office entrance as truck leaves garage	1.8	one garage door is open
	7:12 a.m.	At entrance to repair bay	0	
	7:13 a.m.	At workbench in repair bay	0	three people in area
	7:14 a.m.	In mechanic office	0	two people in office
	7:16 a.m.	Center of repair bay	0	garage doors closed
	7:18 a.m.	In break area	0	garage doors closed
	7:19 a.m.	In break area	0	garage doors closed
	7:20 a.m.	In kitchen at stove	3.6	
	7:21 a.m.	In kitchen at sink	3.1	
	7:23 a.m.	In kitchen at table near vending machine	6.6	
	7:24 a.m.	Near break area picnic table	4.4	one pick-up truck running
	7:24 a.m.	Near break area picnic table	12.3	one pick-up truck running
	7:26 a.m.	At garage door near break area	10.7	garage doors closed
	7:26 a.m.	At garage door near cold mix	8	garage doors closed
	7:27 a.m.	At cold mix area	6.6	garage doors closed
	7:28 a.m.	At cold mix area towards office door	3.1	garage doors closed
	7:29 a.m.	Center of garage	1.2	garage doors closed
	7:33 a.m.	In garage near entrance to offices	0.6	garage doors closed
	7:34 a.m.	Near front door entrance to offices	0	
	7:35 a.m.	In plant foreman's office	0	
	7:36 a.m.	TM's room	0	
	7:37 a.m.	Secretary's office	0	
	7:40 a.m.	Outdoors	0	
	7:46 a.m.	In plant manager's office	0	
ppm = parts per million				

Table A2. Surface wipe sample results for metals[a] ODOT District 8 Main Grage, December 12, 2006										
Surface Sample No.	Sample Location	Concentration, micrograms per wipe sample[b]								
		As	Ba	Be	Cd	Cr	Co	Cu	Fe	Pb
1	Kitchen countertop (near sink)	ND	ND	Trace	ND	ND	ND	Trace	Trace	Trace
2	Kitchen tabletop	ND	ND	Trace	ND	ND	ND	Trace	7.7	ND
3	Vending machine (middle 4 buttons)	ND	1.2	ND	ND	Trace	ND	18	73	Trace
4	Kitchen floor (near water dispenser and oven)	ND	1.6	Trace	ND	Trace	ND	2.7	170	Trace
5	Kitchen refrigerator door handle	ND	Trace	ND	ND	ND	ND	3	22	ND
6	Picnic table bench seat	ND	8.6	Trace	ND	3.3	ND	21	1200	Trace
7	Picnic table top	ND	3	Trace	ND	Trace	ND	2.9	140	ND
8	Arm of sofa chair (near picnic table)	ND	Trace	ND	ND	Trace	ND	2.3	45	Trace
9	Floor between picnic table and sofa	ND	11	Trace	ND	4.2	ND	16	1500	5.4
10	Work bench near chain saw sharpener	ND	120	Trace	2.5	19	Trace	15	6900	46
11	Floor in front of chain saw sharpening work bench	ND	20	Trace	ND	7.2	Trace	15	4200	11
12	Safety glasses on chain saw sharpening bench	ND	1.8	Trace	ND	2.1	ND	3.1	490	Trace
13	Desk in stock room (near computer)	ND	ND	ND	ND	ND	ND	ND	ND	Trace
14	Handle of changing room locker	ND	7.4	Trace	ND	1.8	Trace	35	200	9.7
15	Floor in middle of mechanic's bay	ND	32	Trace	ND	16	Trace	79	5200	9.2
16	Work bench near bench grinder	ND	36	1.8	3.5	56	3.3	2300	35000	720
17	Faucet handle in unisex restroom	ND	Trace	Trace	ND	ND	ND	2.7	37	Trace
18	Computer keyboard in mechanics' office	ND	7	ND	ND	5.1	ND	9.5	610	Trace
19	Floor in front of cold mix pit	ND	8.8	Trace	ND	3.2	ND	56	1600	5.3
20	Floor in front of secretary's office	ND	Trace	ND	ND	ND	ND	Trace	26	ND

[a] For flat surfaces a 100 cm^2 surface area was wiped, for irregular surfaces a 100 cm^2 area was approximated
ND = non-detectable
Trace = concentration between the minimum detectable concentration and minimum quantifiable concentration
As = arsenic, Ba = barium, Be = beryllium, Cd = cadmium, Cr = chromium, Co = Cobalt, Cu = copper, Fe = iron, Pb = lead
[b] Lanthanum, selenium, tellurium, thallium, and zirconium were also analyzed but were not detected in any samples

Table A2 (continued). Surface wipe sample results for metals[a] ODOT District 8 Main Garage, December 12, 2006										
Surface Sample No.	Sample Location	Concentration, micrograms per wipe sample[b]								
		Mn	Mo	Ni	P	Ag	Sr	V	Y	Zn
1	Kitchen countertop (near sink)	ND	ND	ND	ND	Trace	0.68	ND	ND	Trace
2	Kitchen tabletop	ND	ND	ND	Trace	Trace	0.6	ND	ND	Trace
3	Vending machine (middle 4 buttons)	1.4	ND	4.2	ND	Trace	1.1	ND	ND	ND
4	Kitchen floor (near water dispenser and oven)	3.4	ND	Trace	38	Trace	1.2	ND	ND	32
5	Kitchen refrigerator door handle	Trace	ND	ND	Trace	Trace	0.89	ND	ND	Trace
6	Picnic table bench seat	29	Trace	5.8	56	Trace	4.6	Trace	Trace	33
7	Picnic table top	52	ND	ND	30	Trace	3.1	ND	ND	19
8	Arm of sofa chair (near picnic table)	Trace	ND	Trace	Trace	ND	1	ND	ND	24
9	Floor between picnic table and sofa	29	Trace	3.1	72	ND	7.5	Trace	0.53	41
10	Work bench near chain saw sharpener	50	ND	41	63	Trace	6.7	ND	Trace	190
11	Floor in front of chain saw sharpening work bench	38	Trace	9.1	56	ND	13	ND	Trace	88
12	Safety glasses on chain saw sharpening bench	4	ND	8.2	ND	Trace	2.1	ND	ND	44
13	Desk in stock room (near computer)	ND	ND	ND	ND	ND	Trace	ND	ND	Trace
14	Handle of changing room locker	1.7	ND	61	ND	Trace	1.1	ND	ND	240
15	Floor in middle of mechanic's bay	57	Trace	8.3	46	Trace	9.7	Trace	0.66	52
16	Work bench near bench grinder	190	7.8	89	ND	0.54	8	ND	0.77	610
17	Faucet handle in unisex restroom	Trace	ND	ND	Trace	Trace	1.4	ND	ND	21
18	Computer keyboard in mechanics' office	7.6	ND	4.2	19	Trace	3.1	ND	ND	28
19	Floor in front of cold mix pit	30	Trace	2.4	47	Trace	7.7	2.1	0.66	79
20	Floor in front of secretary's office	Trace	ND	ND	ND	Trace	Trace	ND	ND	Trace

[a] For flat surfaces a 100 cm^2 surface area was wiped, for irregular surfaces a 100 cm^2 area was approximated
ND = non-detectable
Trace = concentration between the minimum detectable concentration and minimum quantifiable concentration
Mn = Manganese, Mo = molybdenum, Ni = nickel, P = phosphorus, Ag = silver, Sr = strontium, V = vanadium, Y = yttrium, Zn = Zinc
[b] Lanthanum, selenium, tellurium, thallium, and zirconium were also analyzed but were not detected in any samples

Appendix B: Methods

Surface wipe samples were collected at several locations in the work areas and non-work areas to determine the extent of surface contamination with lead, cadmium, and arsenic. The surface wipe samples were collected with pre-moistened Palintest Dust Sampling Wipes according to the NIOSH Manual of Analytical Methods Method 9102 [NIOSH 2007]. The sample collection procedure was completed as follows: (1) identify the area to be sampled and place a disposable 10 cm by 10 cm template on the surface, (2) put on a pair of nitrile disposable gloves, (3) wipe the surface within a disposable template using three to four horizontal S-strokes, side to side so that entire surface is covered, (4) fold the exposed side of the wipe in and wipe the same area with three to four vertical S-strokes, (5) fold the wipe once more and wipe the area with three to four horizontal S-strokes, (6) fold the wipe, exposed side in and place in a sample container. A clean pair of gloves and a new template was used for each surface wipe sample. For non-flat surfaces, such as door handles or faucet handles, a template was not used and a 100 cm^2 surface area was approximated. All samples were submitted to Bureau Veritas Laboratory (Novi, MI) for analysis. The surface wipe samples were analyzed for total recoverable metals according to NIOSH Method 9102 [NIOSH 2007]. The analytical laboratory reported the sample results as micrograms of metals per wipe.

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Appendix C: Occupational Exposure Limits and Health Effects

In evaluating the hazards posed by workplace exposures, NIOSH investigators use both mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents as a guide for making recommendations. OELs have been developed by Federal agencies and safety and health organizations to prevent the occurrence of adverse health effects from workplace exposures. Generally, OELs suggest concentrations 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. However, not all workers will be protected from adverse health effects even if their exposures are maintained below these concentrations. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or 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 exposure limit. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, which contributes to the individual's overall exposure.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended STEL or ceiling values where there are health effects from exposures over the short-term. Unless otherwise noted, the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday, and the ceiling limit is an exposure that should not be exceeded at any time.

In the U.S., OELs have been established by Federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits, while others are recommendations. The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits enforceable in workplaces covered under the Occupational Safety and Health Act. NIOSH RELs are recommendations based on a critical review of the scientific and technical information available on a given hazard and the adequacy of methods to identify and control the hazard. NIOSH RELs can be found in the *NIOSH Pocket Guide to Chemical Hazards* [http://www.cdc.gov/niosh/npg]. NIOSH also recommends different types of risk management practices (e.g., engineering controls, safe work practices, worker education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects from these hazards. Other OELs that are commonly used and cited in the U.S. include the TLVs recommended by ACGIH, a professional organization, and the WEELs recommended by AIHA, another professional organization. ACGIH TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2007]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2007].

Employers should understand that not all hazardous chemicals have specific OSHA PELs, and for some agents the legally enforceable and recommended limits may not reflect current health-based information. However, an employer is still required by OSHA to protect its employees from hazards even in the absence of a specific OSHA PEL. OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause 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, NIOSH investigators encourage employers to make use of other OELs when making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminate or minimize identified workplace hazards. This includes, in order of preference, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) PPE (e.g., respiratory protection, gloves, eye protection, hearing protection).

Carbon Monoxide

CO is a colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing materials such as gasoline, natural gas, or propane fuel. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea. These initial symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. Coma or death may occur if high exposures continue [Hathaway et.al. 1996; NIOSH 1972; NIOSH 1977; NIOSH 1979; NIOSH 2005; World Health Organization 1999].

The NIOSH REL for CO is 35 ppm for an 8-hour TWA exposure, with a recommended ceiling limit of 200 ppm that should not be exceeded [NIOSH 1992]. The NIOSH REL is designed to protect workers from health effects associated with carboxyhemoglobin levels in excess of 5% [NIOSH 1992]. The ACGIH recommends an 8-hour TWA TLV of 25 ppm [ACGIH 2006]. The OSHA PEL for CO is 50 ppm for an 8-hour TWA exposure [CFR 2003].

Lead

Lead is ubiquitous in U.S. urban environments due to the widespread use of lead compounds in industry, gasoline, and paints during the past century. Occupational exposure to lead occurs via inhalation of dust and fume and via ingestion through contact with lead-contaminated hands, food, cigarettes, and clothing. Absorbed lead accumulates in the body in the soft tissues and bones. Lead is stored in bones for decades, and may cause health effects long after exposure as it is slowly released in the body.

Symptoms of lead exposure include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort (colic), fine tremors, and “wrist drop” [Hernberg et al. 1988; Landigran et al. 1985; Proctor et al. 1996]. Overexposure to lead may also result in kidney damage, anemia, high blood pressure, infertility and reduced sex drive in both sexes, and impotence. An individual’s BLL is a good indication of recent exposure to, and current absorption of lead [NIOSH 1978]. The frequency and severity of symptoms associated with lead exposure generally increase with the BLL. The overall geometric mean BLL for the U.S. adult population (ages 20–74 years) declined significantly between 1976 and 1991, from 13.1 to 3.0 µg/dL of blood. This decline is most likely due primarily to the reduction of lead in gasoline. More than 90% of adults now have a BLL of <10 µg/dL, and more than 98% have a BLL <15 µg/dL [Pirkle et al. 1994].

Under the OSHA general industry lead standard (29 CFR 1910.1025), the PEL for airborne exposure to lead is 50 µg/m^3 for an 8-hour TWA [CFR 2000]. The standard requires lowering the PEL for shifts exceeding 8 hours, medical monitoring for employees exposed to airborne lead at or above the action level of 30 µg/m^3 (8-hour TWA), medical removal of employees whose average BLL is 50 µg/dL or greater, and economic protection for medically removed workers. Medically removed workers cannot return to jobs involving lead exposure until their BLL is below 40 µg/dL. NIOSH has an REL for lead of 50 µg/m^3 averaged over an 8-hour work shift. ACGIH has a TLV for lead of 50 µg/m^3 (8–hour TWA), with worker BLLs to be controlled to or below 30 µg/dL, and designates lead as an animal carcinogen [ACGIH 2007].

The occupational exposure criteria are not protective for all the known health effects of lead. For example, studies have found neurological symptoms in workers with BLLs of 40 to 60 µg/dL, and decreased fertility in men with BLLs as low as 40 µg/dL. BLLs are associated with increased blood pressure, even at levels less than 10 µg/dL. Fetal exposure to lead is associated with reduced gestational age and low birth weight with maternal BLLs as low as 10 to 15 µg/dL. BLLs at 10 µg/dL have been associated with decreased intelligence and impaired neurobehavioral development [ATSDR 1990]. Men and women planning to have children should limit their exposure to lead.

Lead-contaminated surface dust represents a potential source of lead exposure, particularly for young children. This may occur either by direct hand-to-mouth contact, or indirectly from hand-to-mouth contact with contaminated clothing, cigarettes, or food. Previous studies have found a significant correlation between resident children's BLLs and house dust lead levels [Farfel and Chisholm 1990].

In the workplace, generally there is little or no correlation between surface lead levels and employee exposures because ingestion exposures are highly dependent on personal hygiene practices and available facilities for maintaining personal hygiene. No current federal standard provides an exposure limit for lead contamination of surfaces in the workplace. The OSHA lead standard requires maintaining all surfaces as free as practicable of accumulations of lead. Additionally, OSHA has stated in its Compliance Directive *CPL 02-02-058 - 29 CFR 1926.62, Lead Exposure In Construction; Interim Final Rule: Inspection and Compliance Procedures (12/13/1993)*, that it recommends the use of HUD's recommended level for acceptable decontamination of 200 µg/ft^2 for floors in evaluating cleanliness of change areas, storage facilities, and lunchrooms/eating areas and would not expect that surfaces should be any cleaner than this level [OSHA 1993].

The EPA currently recommends meeting the following clearance levels for surface lead loading after residential lead abatement or interim control activities: floors, 40 µg/ft^2; interior window sills, 250 ug/ft^2; window troughs, 400 µg/ft^2 [CFR 2001]. These levels have been established as achievable through lead abatement and interim control activities. They are not based on projected health effects associated with specific surface dust levels.

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Acknowledgements and Availability of Report

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