NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #98-0285-2989
Vermont Housing & Conservation Board
Montpelier, Vermont

December 2005

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

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Aaron Sussell of HETAB, and Gregory Piacitelli of the Surveillance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). We gratefully acknowledge the assistance of Joanee LaTuchie, Vermont Housing and Conservation Board, and Ellen Tohn, National Center for Lead-Safe Housing (now Alliance for Healthy Homes), for arranging the residential demonstration project and Joseph Rodriguez, Hi-Tech Coatings, Inc. for his cooperation during the project. Assistance was provided by John McKernan and Mazan Abbas (Surveillance Branch) in conducting the field work and by Gregory Burr for report preparation. Analytical support was provided by Data Chem Laboratories, Salt Lake City, Utah. Desktop publishing was performed by Shawna Watts and Robin Smith. Editorial assistance was provided by Ellen Galloway.

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

Highlights of the NIOSH Health Hazard Evaluation

Residential Lead-Based Paint Removal and Surface Preparation

The National Institute for Occupational Safety and Health (NIOSH) received a request from the Vermont Housing and Conservation Board in 1998 to evaluate worker exposures to lead-contaminated dust when removing residential lead-based paint and preparing surfaces with lead-based paint for repainting.

What NIOSH Did

- We measured exposures to lead dust during three paint removal/surface preparation methods.
- We collected air samples and settled dust samples during four trials for each method.
- We collected bulk paint samples from the exterior siding of the house and analyzed them for lead content.

What NIOSH Found

- All sections of siding that were worked on were coated with lead-based paint.
- The lead dust levels were high during dry scraping/power sanding without a properly functioning HEPA vacuum system.
- Lead dust levels were lower during dry scraping/manual sanding.
- Lead dust levels were lowest during dry scraping/power sanding with a properly functioning HEPA vacuum system and wet scraping/manual sanding.
- All of the paint removal and surface preparation methods created high levels of lead in settled dust zero to 6 ft from the siding of the house.

What Lead Abatement Managers Can Do

- Use power sanders for lead-based paint removal/surface preparation only if the sander is used with a properly-functioning HEPA vacuum dust collection system.
- Use respirators to control worker exposures to lead during dry scraping and power sanding.
- Where possible use wet scraping and manual sanding instead of dry scraping/manual sanding.
- Place heavy plastic drop cloth on the ground extending out 10 ft to 20 ft from all areas of work on lead-based paint.

What the Lead Abatement Employees Can Do

- Follow recommended work practices for lead-safe renovation work.
- See your doctor for a blood lead level test periodically.

CDC Workplace Safety and Health

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #98-0285-2989

NIOSH

Health Hazard Evaluation Report 98-0285-2989
Vermont Housing & Conservation Board
Montpelier, Vermont
December 2005

Aaron L. Sussell
Gregory M. Piacitelli

SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request in 1998 from the Vermont Housing and Conservation Board (VHCB) to evaluate worker exposures to lead-contaminated dust and the dispersion of dust to surroundings associated with exterior paint removal and surface preparation. The VHCB arranged a demonstration project that included three paint removal/surface preparation methods performed by a Vermont licensed lead abatement contractor. The objective was to determine which method produced the least amount of dust exposure and dispersion. A NIOSH site visit was made in August 1998; the sampling results were provided to the VHCB in 1999.

During the demonstration project workers removed exterior lead-based paint from clapboard siding of a single-family wood-frame house using three methods: dry scraping with manual sanding, wet scraping with manual sanding, and dry scraping with power sanding. NIOSH investigators conducted task-based sampling during four trials per method. Trials took place on different sections of the painted siding. Samples collected during each were for personal breathing zone (PBZ) and area airborne lead (PbA) (both NIOSH Manual of Analytical Methods [NMAM] Method 7105), lead in paint, and lead in the dispersed surface dust (PbS). PbS samples were collected using stationary dustfall collectors, each containing a clean unfolded pre-moistened hand wipe (Wash n' Dri®) centered in the tray. Eight PbS samples were collected in two rows on the ground at zero, 6, 10, and 20 feet perpendicular to the siding.

The mean lead concentration measured in painted surfaces was 18.7% (range for section means 4.8% – 27%). The highest PBZ PbA exposures were measured during dry scraping/power sanding with an improperly functioning (80%-blocked) HEPA vacuum dust collection system: 820 and 1600 micrograms per cubic meter (μg/m^3) as task-based time-weighted averages (TWA) over 1-2 hours. PBZ PbA concentrations during dry scraping/manual sanding were lower, ranging from 29 to 160 ug/m^3, and dry scraping/power sanding with a properly functioning HEPA vacuum system and wet scraping/manual sanding produced the lowest PBZ PbA results, ranging from 3.5 to 53 μg/m^3, task-based TWA. The area PbA results at 10 ft from the work surfaces were low, ranging from 0.16 to 8.2 μg/m^3. For all three methods, mean concentrations of PbS measured on the ground at zero ft and 6 ft from the house foundation ranged from 1300 to 7,600,000 μg/ft^2. After statistically controlling for distance, method, paint Pb concentration and the percent paint removed from substrate in a linear model, distance was significantly associated with PbS (p-value= < 0.0001).

NIOSH investigators found that worker exposures to lead during dry scraping/power sanding without functional dust collection controls were a health hazard. Worker exposures during wet scraping/manual sanding were relatively low, but could be a health hazard if the activity is performed 8 hours or more. After paint removal, high concentrations of lead in settled dust were found at distances of zero to 10 ft from the work surfaces. Recommendations included (1) use effective engineering controls on power sanding equipment to limit lead dust exposure and dust dispersion to surroundings; (2) use respirators to reduce worker exposure to lead dust during dry scraping and power sanding until engineering and/or administrative controls are effective in reducing exposures below the OSHA PEL; and (3) use good hygiene practices.

Keywords: NAICS 238320 (House painting), lead, lead abatement, paint removal, sanding, scraping, dust

Table of Contents

INTRODUCTION

In 1998 the National Institute for Occupational Safety and Health (NIOSH) received a request from the Vermont Housing and Conservation Board (VHCB) for an evaluation of worker exposures to lead-contaminated dust and the dispersion of dust to surroundings associated with several exterior lead-based paint (LBP) surface preparation methods. In collaboration with the National Center for Lead-Safe Housing, VHCB arranged a demonstration project that included three paint removal/surface preparation methods. The project took place at a single-family home near Montpelier, Vermont. The house was selected because it had deteriorated exterior LBP and the owner was willing to participate in the demonstration. The work was performed by a Vermont licensed lead abatement contractor. One NIOSH site visit was made for this evaluation in August 1998. The sampling results were provided to VHCB in 1999.

BACKGROUND

The Vermont Housing and Conservation Board is an independent, state-supported funding agency that provides grants, loans, and technical assistance to nonprofit organizations, municipalities and state agencies for the development of perpetually affordable housing and for the conservation of important agricultural land, recreational land, natural areas and historic properties in Vermont. VHCB administers grant funds from the U.S. Department of Housing and Urban Development (HUD) for lead hazard reduction in housing owned by non-profit housing organizations, private landlords, and homeowners. The focus of this VHCB program is on pre-1978 housing that contains high levels of lead-based paint and has young children residents. The eligible units must have at least one bedroom and not be intended primarily for occupancy by the elderly. Since 1995, more than 600 apartments and homes throughout Vermont have been made lead-safe through the Lead Paint Hazard Reduction Program administered by VHCB.

A number of federal and state regulations to address lead-based paint hazards in private housing have resulted from a 1992 U.S. law known as Title X of the Residential Lead–Based Paint Hazard Reduction Act of 1992.[1] In 1995, Vermont enacted legislation to address lead-based paint hazards in rental housing and child care facilities (Act 165). The Act prohibited the use of many common paint preparation techniques considered hazardous to workers and/or the occupants of the property during lead hazard reduction work. At the time of this evaluation wet scraping was the only acceptable method for paint removal. The Occupational Safety and Health Administration (OSHA) also regulates residential lead work in Vermont. The OSHA lead in construction standard [29 CFR 1926.62 (1993)] requires that when employers engage in certain "trigger tasks" (e.g., dry manual scraping and sanding), they must presume hazardous worker exposures and provide workers with the specified levels of respiratory protection, protective work clothing, and equipment until they document through an exposure assessment that the measures are not necessary.[2]

VHCB had found that it was difficult to remove some types of deteriorated exterior LBP with wet hand scraping alone. VHCB wanted NIOSH to evaluate the levels of lead-contaminated dust or paint chips generated by several methods for removing exterior LBP.

METHODS

The purpose of the study was to compare worker and area airborne lead (PbA) exposures and lead in surface dust (PbS) levels resulting from three LBP removal methods. The methods, commonly used by home renovators, painters, and lead abatement workers to remove paint and prepare exterior surfaces with LBP for repainting, were categorized by NIOSH investigators as dry scraping/manual sanding, dry scraping/power sanding, and wet scraping/manual sanding. These methods, each a combination of two tasks, are defined in Table 1. Dry scraping/manual sanding and wet scraping/manual sanding differed only in whether the surface was misted with water using hand spray bottles prior to scraping. The third method was a 5-

inch random orbital power sander provided with local exhaust ventilation, consisting of a commercial-grade high-efficiency particulate air-filter (HEPA) vacuum.

The demonstration project took place at a rural location near Montpelier, Vermont, on the exterior of a 1½-story wood frame house with clapboard siding, approximately 80 years old, with deteriorated LBP. Twelve trials of approximately 1-hour duration were done to evaluate the three paint removal methods – four trials per method. Clapboard siding on the north, east, and west sides of the house (the south side was not included because almost all of the original paint had already fallen off) was divided into 10 sections about 10 feet (ft) in width, which were marked with vertical lines from foundation to the roof line. The three methods were randomly assigned to nine sections of the house to control for variations in paint condition and paint lead concentration between sections of siding. Section locations and their corresponding paint conditions are shown in Figure 1, and the assignments used for the method trials are shown in Table 2. Figure 2 shows the field sampling set up. Sections designated for paint removal extended from the foundation to the roof line except on the north side of the house (main entry location), where one section (3) was the clapboard siding below the porch roof, and two sections (4, 10) were adjacent halves of the wood shingle siding above the porch roof. Section 10 was not used because the paint was not deteriorated and was very hard to remove.

The participating contractor, who provided two workers, was licensed in Vermont for lead abatement and lead hazard reduction work. The two workers were sampled simultaneously, but on nonadjacent sections of the house to reduce cross-contamination of the PbA and PbS samples. The workers used ladders and scaffolding to access areas on the second story level. The duration of the 12 trials was approximately 1 hour (hr) so that the settled dust measurements would be comparable between trials (mean trial duration: 1.00 hr, range: 0.80–1.43 hr). However, in practice paint removal for some sections required longer periods due to equipment problems and time required to move ladders and plastic sheeting. Workers began removing paint at the top of each section and worked down toward the foundation.

Prior to the start of work, VHCB had done a lead inspection on the house and determined that all exterior siding was coated with LBP. VHCB scheduled the paint removal work so that the occupants could be relocated during the demonstration project to prevent their exposure to lead dust. The site preparation done by the contractor included sealing all exterior windows and doors from the outside with 6-mil polyethylene (poly) plastic sheeting. The poly sheeting was extended 20 ft out from the house foundation on the three sides where paint was disturbed, and was rolled up at the end of each work day.

Environmental Sampling

One personal breathing-zone (PBZ) air sample was collected during each trial while a worker removed paint from a section of the house. Two area air samples were collected during each trial to assess the LBP dust dispersion and potential exposure of bystanders. The area sampling pumps were placed immediately abutting the exterior siding (zero ft) and 10 ft out along a line perpendicular to the siding. The area samples were collected 1.5 to 5 ft above the ground (depending on available horizontal surfaces or hooks), and 6 ft downwind of the section midpoint, if the wind direction was roughly parallel to the exterior siding.

Air samples were collected and analyzed using NIOSH Method 7105 (graphite furnace atomic absorption spectrophotometry), modified for microwave digestion of the samples.[3] The flow rate used for the sampling pumps was 4.0 liters per minute (Lpm); pumps were calibrated in the field pre- and post-sampling. The limits of detection (LODs) for lead in air samples ranged from 0.05 to 0.07 micrograms per sample (µg/sample), depending on the dilution factor. The limit of quantitation (LOQ) for all samples was 0.2 µg /sample. Air concentrations are reported in micrograms per cubic meter (µg/m^3).

Eight PbS samples were collected during each trial. Samples were collected using stationary dustfall collectors, which consisted of commerciallyavailable 6"x9"x2" plastic trays (EKCO Consumer Plastic Inc®, Model 514-1, sold at K-Mart®), each containing a clean unfolded pre-moistened hand wipe (Wash n' Dri®) centered in the tray (the hand wipes are 5.5"x8" unfolded). Just before paint removal on a section of the house started, eight dust collectors were arranged on the ground in two rows perpendicular to the house foundation. One row extended out from the section midpoint and the other was located parallel to it, at 6 ft horizontal distance in the direction closest to downwind (a portable wind vane was used to determine wind direction). Each row had a dust collector at zero, 6, 10 and 20 feet out from the house foundation. The hand wipes were kept moist during dust sampling by misting them every 10–15 minutes with water from a hand spray bottle (settled dust did not stick to the hand wipes if they were allowed to dry). The collectors were picked up approximately 15 minutes after the work ceased for each section. The hand wipes were then folded inward and transferred to 50 mL plastic centrifuge tubes with gloved hands or tweezers. No attempt was made to transfer dust that had fallen in the tray but not on the hand wipes. Between trials the trays were washed with soap and water. Results are reported in micrograms per square foot ($\mu g/ft^2$). PbS samples were analyzed for lead using NIOSH Method 7082, modified for digestion of hand wipes.

Three bulk paint samples were collected from siding or wood trim in each designated section of the house. For each sample a measured area of paint was removed from a known surface area by (1) scoring all layers of the paint with an approximately 1-inch diameter laboratory hole cutter (designed for cutting holes in rubber stoppers), (2) heating the paint gently with a heat gun to soften it, and (3) scraping all paint off within the scored area using a stainless steel paint scraper. The paint chips were collected on a piece of paper and transferred to 50 mL plastic centrifuge tubes. Paint samples were analyzed for lead using NIOSH Method 7082, modified for digestion of paint films.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff use environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, this may increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[4] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[5] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[6] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm

[Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

TWA exposure criteria refer to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Lead Exposure

Occupational exposure occurs via inhalation of lead-containing dust and fume and ingestion from contact with lead-contaminated surfaces. Symptoms of lead poisoning include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort (colic), fine tremors, and "wrist drop."[7,8,9] 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 blood lead level (BLL) is used as the best indication of recent exposure to, and current absorption of lead.[10] Measurement of zinc protoporphyrin (ZPP) levels in blood can be a good indicator of the toxic effect of lead on heme synthesis in red blood cells. Elevated ZPP levels due to lead exposure, which may remain months after the exposure, are an indicator of chronic lead intoxication. Persons without occupational exposure to lead usually have a ZPP level of less than 40 micrograms per deciliter (μg/dL).[11] Because other factors, such as iron deficiency, can cause an elevated ZPP level, the BLL is a more specific test in the evaluation of occupational exposure to lead.

In the OSHA lead standards for general industry and construction, the PEL and Action Level for PbA is 50 and 30 μg/m^3 (both 8-hour TWAs), respectively. These limits are intended to maintain worker BLLs below 40 μg/dL; medical removal is required when an employee's BLL reaches 50 μg/dL.[12,2] After concluding that its 1978 REL of 100 μg/m^3 as an 8-hour TWA did not sufficiently protect workers from the adverse affects of exposure to inorganic lead, [13] NIOSH adopted the OSHA PEL. However, NIOSH has conducted a literature review of the health effects data on inorganic lead exposure and finds evidence that some of the adverse effects on the adult reproductive, cardiovascular, and hematologic systems, and on the development of children of exposed workers can occur at BLLs as low as 10 μg/dL.[14] At BLLs below 40 μg/dL, many of the health effects would not necessarily be evident by routine physical examinations, but represent early stages in the development of disease. In recognition of this, voluntary standards and public health goals have established lower BLL exposure limits to protect workers and their children. The ACGIH TLV® for PbA is 50 μg/m^3 as an 8-hour TWA, with worker BLLs to be controlled to ≤30 μg/dL. A national health goal is to eliminate all occupational exposures that result in BLLs greater than 25 μg/dL.[15]

Lead in Surface Dust and Soil

Lead contamination in dust and soil, which is commonly found in the U.S. due to the past use of lead in gasoline and paints, and from industrial emissions, is a health risk to children. Lead-contaminated surfaces may also be a source of occupational exposure for workers. Lead exposure may occur either by direct hand-to-mouth contact, or indirectly through contamination of hands, cigarettes, cosmetics, or food.

Generally there is little or no correlation between surface lead levels and employee PBZ exposures in the workplace. The amount of lead ingested in contaminated work areas depends on the effectiveness of administrative controls, personal hygiene practices, and available facilities for maintaining personal hygiene. There are no federal occupational standards that set limits for surface or soil lead contamination. EPA has defined a dust–lead hazard as a surface in a residential dwelling or child–occupied facility that contains a lead loading equal to or greater than 40 µg/ft^2 (equivalent to 0.43 mg/m^2) on floors or 250 µg/ft^2 (equivalent to 2.7 mg/m^2) on interior window sills, based on wipe sample results.[16] EPA has defined a soil–lead hazard as bare soil on a residential real property or on the property of a child–occupied facility that contains total lead equal to or exceeding 400 parts per million (ppm) (ppm is equivalent to micrograms per gram [µg/g] for soil) in a play area or average of 1,200 ppm in the rest of the yard based on soil sample results.[16]

RESULTS AND DISCUSSION

The 30 paint sampling results were approximately normally distributed, with an overall mean concentration of 18.7% lead by weight (standard deviation [SD]=6.50). The mean paint lead concentrations for nine sections of the house varied from 4.8% to 27% (see Table 3). Section 10, which was not used for paint removal, had a mean paint lead concentration of 18%. Except for section 9, which was 4.8%, the mean paint lead concentrations for sections of the house worked on ranged from 17% to 27% lead. All of the mean lead concentrations were well above the federal action level for lead-based paint of 0.5% lead by weight, but were fairly typical for exterior paint on an 80-yr-old house in the northeastern U.S. In addition to the paint removal method used, mean paint lead concentration is one of the most important factors in determining the amount of lead-containing dust produced by removal of residential lead-based paint.[17] The amount of paint deterioration on each section of the house used was qualitatively rated before surface preparation work began, all of the sections used were rated as having either moderate or minimal deterioration. Minimal deterioration meant that 100% of the surface was coated with paint. Moderate deterioration meant some paint (estimated to be 2% to 20%) had fallen off the surface.

As shown in Table 3, the highest PBZ PbA exposures occurred during dry scraping/power sanding. The task-based PbA exposures during this method were highly variable, ranging from 3.5 to 1600 µg/m^3, TWA over the approximately 1 to 2 hours of actual work time. Part of the variability was due to a problem with the HEPA vacuum equipment. Near the beginning of the third trial for the dry scraping/power sanding method, we discovered that the HEPA vacuum canister inlet was about 80% blocked (apparently the inlet had been clogged by carpet fibers and debris during use at a previous job). The contractor immediately replaced the vacuum with another HEPA vacuum for completion of most of the third trial and all of the fourth trial. The lower PBZ PbA exposures for this method were associated with (1) removing minimally-deteriorated paint (we estimated that only 5% was removed) with the lowest percent lead content (4.8%) with the power sander and the partially-blocked HEPA vacuum; and (2) removing moderately-deteriorated paint with higher lead content (17%) with the power sander and a properly functioning HEPA vacuum. The highest PBZ PbA exposures during dry scraping/power sanding occurred when removing moderately-deteriorated higher lead content paint (20%–21%) while using a random-orbital power sander connected to the 80%-blocked HEPA vacuum. It should be noted that the two highest PBZ exposures (820 and 1600 ug/m^3) would exceed the OSHA PEL for lead of 50 µg/m^3, TWA over an 8-hour workday, even assuming that no additional paint scraping or sanding was performed during the day. Due to the variability of exposures during dry scraping/power sanding, even if HEPA vacuum equipment is used, employers should provide respirators for personal protection until it can be shown that the exposures on a job are well controlled and below the PEL.

The remaining paint removal techniques produced lower lead exposures. PbA concentrations during dry scraping and manual sanding ranged from 29 to 160 µg/m^3, TWA over approximately 1 hour of actual work time. The lowest PBZ PbA exposures were measured during wet scraping combined with manual sanding, ranging from 4.7 to 53 $\mu g/m^3$, TWA over the actual work time of 1 to 2 hours.

The area PbA results at 10-ft distance from the work surfaces (downwind from section midpoint, if there was measurable wind) ranged from none detected (estimated concentration 0.16 $\mu g/m^3$) to 8.2 $\mu g/m^3$. The highest area levels at 10 ft, 15 $\mu g/m^3$ and 8.2 $\mu g/m^3$, occurred during trials for dry scraping/power sanding and wet scraping/manual sanding, respectively. Area PbA levels during the other three trials for wet scraping/manual sanding were very low, however. Area PbA collected zero ft from work surfaces were highly variable, ranging from 0.4 to 3400 $\mu g/m^3$. The area PbA results at zero ft were lower than the respective PBZ sample results for nine trials and higher than the PBZ samples during three trials. The zero-ft area PbA results of 3400 $\mu g/m^3$ and 35 $\mu g/m^3$ during dry scraping/power sanding were significantly higher than the PBZ sample results, 1600 $\mu g/m^3$ and 3.5 $\mu g/m^3$, respectively. The area PbA results were collected to estimate the exposures of bystanders observing the work. These results indicated that bystanders should stay at least 10 ft away from paint removal and surface preparation to avoid high PbA exposures.

The results obtained for 64 lead in settled dust (PbS) samples collected during paint removal are presented in Table 4. The distribution of results approximated log normal, so the PbS data were log-transformed prior to statistical analyses. No significant difference was found between the midpoint and the matched 6 ft-downwind samples (p-value = 0.19), so only midpoint PbS results are presented here. As shown in Table 4, the geometric mean concentrations for PbS collected at distances of 6, 10, and 20 feet from the surface where the paint was being removed all showed a sharp decline (up to 99%) when compared to the PbS levels measured at the foundation of the house. This reduction in PbS levels occurred regardless of the type of work task or the section of the home being treated. This suggests that for the paint removal methods demonstrated in this project, many of the LBP particles generated by either scraping or sanding were aerodynamically large and settled out of the air quickly. The mean differences in PbS concentrations between any paired distances (zero vs. 6 ft, 10 vs. 20 ft, 6 vs. 10 ft, etc) were statistically significant (ANOVA, p-values from <0.0001 to 0.001). After statistically controlling for distance, method, paint Pb concentration and the percent paint removed from substrate in a linear model, only distance was significantly associated with PbS (p-value= < 0.0001, df 1). For all three methods, high mean concentrations of PbS were measured on the ground at zero ft and 6 ft from the house foundation (range: 1300 to 7,600,000 ug/ft^2). At all distances except zero ft, dry scraping/power sanding resulted in higher PbS levels than the other methods, and a high mean PbS level was measured at 10 ft from the work surface (3100 ug/ft^2). These outdoor PbS levels collected with the dustfall collectors are not directly comparable to the HUD lead dust clearance standards, which refer to wipe sample results, or to the EPA residential bare soil guideline, which refers to bulk soil sample results. However, the mean lead concentrations in settled dust at zero and 6 feet for all methods, and at 10 ft for dry scraping/power sanding were very high, and likely would create a health hazard to young children occupying the residence if the lead-containing dustfall measured was allowed to fall on the ground rather than contained and wrapped up in poly sheeting, and taken off site for proper disposal.

CONCLUSIONS

- The highest PbA exposures occurred during dry scraping/power sanding conducted without a properly functioning HEPA vacuum system. These exposures represent a health hazard to unprotected workers and bystanders within 10 ft of the work.
- PbA exposures during dry scraping/power sanding were significantly lower when the random-orbital sander was connected to a properly functioning HEPA vacuum (dust collection system). With a properly functioning HEPA vacuum system the PbA

exposures for this method were among the lowest of the three methods evaluated.

- PbA exposures during dry scraping/manual sanding approached the OSHA Action Limit for lead of 30 µg/m^3, and could exceed the OSHA PEL of 50 µg/m^3 if scraping and sanding was performed continuously for up to an 8-hour workday.
- PbA exposures during wet scraping/manual sanding were lower, but could exceed the OSHA PEL of 50 µg/m^3 if this task was performed throughout an entire 8-hour work day.
- For all of the methods demonstrated, area PbA levels at a distance of at least 10 ft from the work surfaces were low, and do not represent a health hazard for short-term (one- to several-hour) airborne lead exposures of bystanders.

RECOMMENDATIONS

The following recommendations are based on the findings of this investigation and are offered to improve the safety and health of workers involved in scraping and sanding on lead-containing surfaces.

1. Use power sanding equipment only when it is provided with effective dust collection equipment to limit lead dust exposure. To ensure proper functioning and dust collection, thoroughly inspect hoses and inlets of HEPA vacuum, or other dust collection equipment, prior to each use on the job site. Publications developed by NIOSH provide guidance on controls for hand sanders. These include the following:
 Control of Wood Dust from Orbital Hand Sanders (http://www.cdc.gov/niosh/hc9.html); and Control of Wood Dust from Random Orbital Hand Sanders (http://www.cdc.gov/niosh/hc8.html).

2. Use respirators to reduce worker exposure to lead dust during dry scraping and power sanding until it can be shown that engineering and/or administrative controls effectively reduce exposures below the NIOSH REL. As a minimum they should be NIOSH-approved half-mask respirators with an N100 filter designation.

3. Use wet scraping/manual sanding instead of dry scraping/manual sanding whenever feasible to reduce or eliminate potentially hazardous worker lead exposures.

4. Develop a written respiratory program. This program should include the following components: respirator selection, medical evaluation, fit testing, respirator use, respirator maintenance and care, filter identification, training and information, program evaluation, and recordkeeping.

5. Use poly sheeting to cover the ground at least 10 ft out from foundation for manual sanding methods, and at least 20 ft from foundation for power sanding methods to protect surroundings from lead contamination during lead-based paint removal. Avoid paint removal on windy days. Use cleanup techniques that minimize dust generation at the end of the refinishing project, including HEPA vacuuming of all surfaces.

6. Use good hygiene practices, such as washing hands prior to eating or drinking and changing or laundering work clothes before returning home to reduce the possibility of para-occupational or "take-home" lead dust exposures.

7. To prevent unnecessary hazards lead exposures among bydstanders, residents, neighbors, and other observers, establish a resticted entry parimeterm, at least 10 ft from the active work surfaces, and if possible establish a larger restricted area, particularly for young children, who are at greatest risk of exposure to lead–based paint dust on surfaces.

REFERENCES

1. Residential Lead–Based Paint Hazard Reduction Act of 1992, Public Law 102–550, from U.S. House Report 102–1017, October 28, 1992.

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

3. NIOSH [1994]. NIOSH manual of analytical methods, 4th edition. Eller, P and Cassinelli, ME, Eds. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94–113.

4. 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.

5. ACGIH [2004]. 2004 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

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

7. Hernberg S, et al. [1988]. Lead and its compounds. In: Occupational medicine. 2nd ed. Chicago, IL: Year Book Medical Publishers.

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

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

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

11. Lauwerys RR and Hoet P [1993]. Industrial chemical exposure: guidelines for biological monitoring, Second Edition. Ann Arbor, MI: Lewis Publishers, p. 62.

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

13. 62 Fed. Reg. 206 [1997]. National Institute for Occupational Safety and Health: occupational exposure to inorganic lead: request for comments and information.

14. Sussell A, et al. [1998]. Protecting workers exposed to lead–based paint hazards: a report to Congress. 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. 98–112. January 1998–revised with minor technical changes.

15. DHHS [2000]. Healthy people 2010–conference edition; National health promotion and disease objectives. Washington, DC: U.S. Department of Health and Human Services. Available on the internet at: www.health.gov/healthypeople/Document/default.htm

16. 66 Fed. Reg. No. 4 [2001]. U.S. Environmental Protection Agency: Lead-based paint hazards, January 5, 2001. (To be codified at 40 CFR Part 745)

17. Sussell A, Hart C, Wild D, and Ashley K [1999]. An evaluation of worker lead exposures and cleaning effectiveness during removal of deteriorated lead-based paint. Applied Occ and Env Hygiene, 14:177-185.

Table 1. Exterior Lead Based Paint (LBP) Removal/Surface Preparation Methods Evaluated

Vermont Housing and Conservation Board, Montpelier, Vermont

HETA 98-0285-2989

Method	Work Description
Dry scraping/manual sanding	A hand scraper with a (replaceable) 2-inch tungsten-carbide blade is used to remove loose and peeling paint, followed by dry hand sanding with coarse sandpaper to smooth edges.
Dry scraping/power sanding	A hand scraper with a (replaceable) 2-inch tungsten-carbide blade is used to remove loose and peeling paint, followed by power sanding with a pneumatic 5-inch diameter five hole random orbital sander attached to a commercial-grade HEPA vacuum. The sander is used to smooth edges, not remove the remaining paint.
Wet scraping/manual sanding	Before scraping, a hand-held spray bottle is used to wet surfaces with a water mist. A hand scraper with a (replaceable) 2-inch tungsten-carbide blade is used to remove loose and peeling paint, as surfaces are kept wet with periodic misting with water. The scraping is followed by wet hand sanding with coarse sandpaper to smooth edges. The hand sanding block is dipped frequently in water keep sandpaper wet.

Table 2. Assignments for Trials of Three Paint Removal/Surface Preparation Methods

Vermont Housing and Conservation Board, Montpelier, Vermont

HETA 98-0285-2989

House section	Worker	Day	Method
1	A	1	Dry scraping/manual sanding
1	A	2	Dry scraping/manual sanding
2	A	1	Wet scraping/manual sanding
2	A	3	Dry scraping/power sanding
3	B	2	Wet scraping/manual sanding
4	B	2	Wet scraping/manual sanding
4	B	3	Dry scraping/manual sanding
5	B	1	Dry scraping/manual sanding
6	B	1	Wet scraping/manual sanding
7	A	2	Dry scraping/power sanding
8	A	2	Dry scraping/power sanding
9	B	2	Dry scraping/power sanding

Table 3. Personal Breathing-Zone and Area Air Sample Results for Lead during Paint Removal/Surface Preparation Vermont Housing and Conservation Board, Montpelier, Vermont HETA 98-0285-2989

Task	Day	Section of house*	Mean Paint Pb (%)	Treated Area (ft^2)†	% of Existing Paint Removed	Actual Work Time (min)	PBZ PbA‡ μg/m^3		Area PbA μg/m^3	
							Task TWA§	Estimated 8-hr. TWA**	0 ft Task TWA	10 ft Task TWA
Dry scraping/manual sanding	1	5	24	29	30	56	160	18.7	42	0.07
	1	1	17	48	10	60	83	10.3	9.1	*0.13*††
	2	1	17	63	10	60	120	15	15	0.40
	3	4	19	24	5	62	29	3.8	17	0.17
Dry scraping/power sanding	2 [A]	7	20	103	50	126	1600	420	3400	15
	2 [B]	8	21	53	50	64	820	109	17	0.08
	2 [A]	9	4.8	45	10	53	3.5	0.39	35	*0.16*††
	3 [C]	2	17	36	50	59	7.4	0.91	2.6	*0.16*††
Wet scraping/manual sanding	1	2	17	40	10	60	4.7	0.59	0.4	*0.16*††
	1	6	27	39	20	55	50	5.7	4.8	0.43
	2	3	18	53	10	75	53	8.3	13	8.2
	2	4	19	23	90	67	7.5	1.1	12	*0.15*††
Occupational Exposure Criteria:										
Occupational Safety and Health Administration Permissible Exposure Limit (PEL)								**50**		
NIOSH Recommended Exposure Limit (REL)								**50**		

*** See Figure 1 for location.**
†Treated area refers to the amount of painted surface area that was scraped and/or sanded.
‡PbA = Lead in air concentration, expressed in micrograms per cubic meter.
§Task TWA= PbA concentration calculated for the actual work time.
****8-hr. TWA = PbA concentration estimated for an 8-hour work day, *assuming no additional lead exposure during the day*.**
††None detected result; the LOD/$2^{(0.5)}$ and sample volume were used to calculate an estimated value.

[A] Used a 5-inch disk random orbital sander attached to Nilfisk VT-60® high efficiency particulate air (HEPA) filter vacuum with ~80% blocked hose.
[B] Used a 5-inch disk random orbital sander attached to Nilfisk VT-60® HEPA vacuum with ~80% blocked hose (5 min) and then Nilfisk GM-80 HEPA vacuum (29 min).
[C] Used a 5-inch disk random orbital sander attached to Nilfisk GM-80® HEPA vacuum.

Table 4. Mean Results for Lead in Settled Dust during Paint Removal/Surface Preparation
Vermont Housing and Conservation Board, Montpelier, Vermont
HETA 98-0285-2989

	Perpendicular distance from exterior siding, ft			
Paint Removal Method	**0**	**6**	**10**	**20**
Dry Scraping and Manual Sanding[A]	3,400,000	3,800	580	17
Dry Scraping and Power Sanding[B]	4,300,000	6,300	3,100	321
Wet Scraping and Manual Sanding[B]	7,600,000	1300	110	56

All results are mean PbS, ug/ft^2; samples collected in dustfall collectors during the tasks.

[A]PbS results are geometric means for three trials on different siding sections.

[B]PbS results are geometric means for four trials on different siding sections.

Figure 1. Site Layout with Designated Areas and Paint Condition

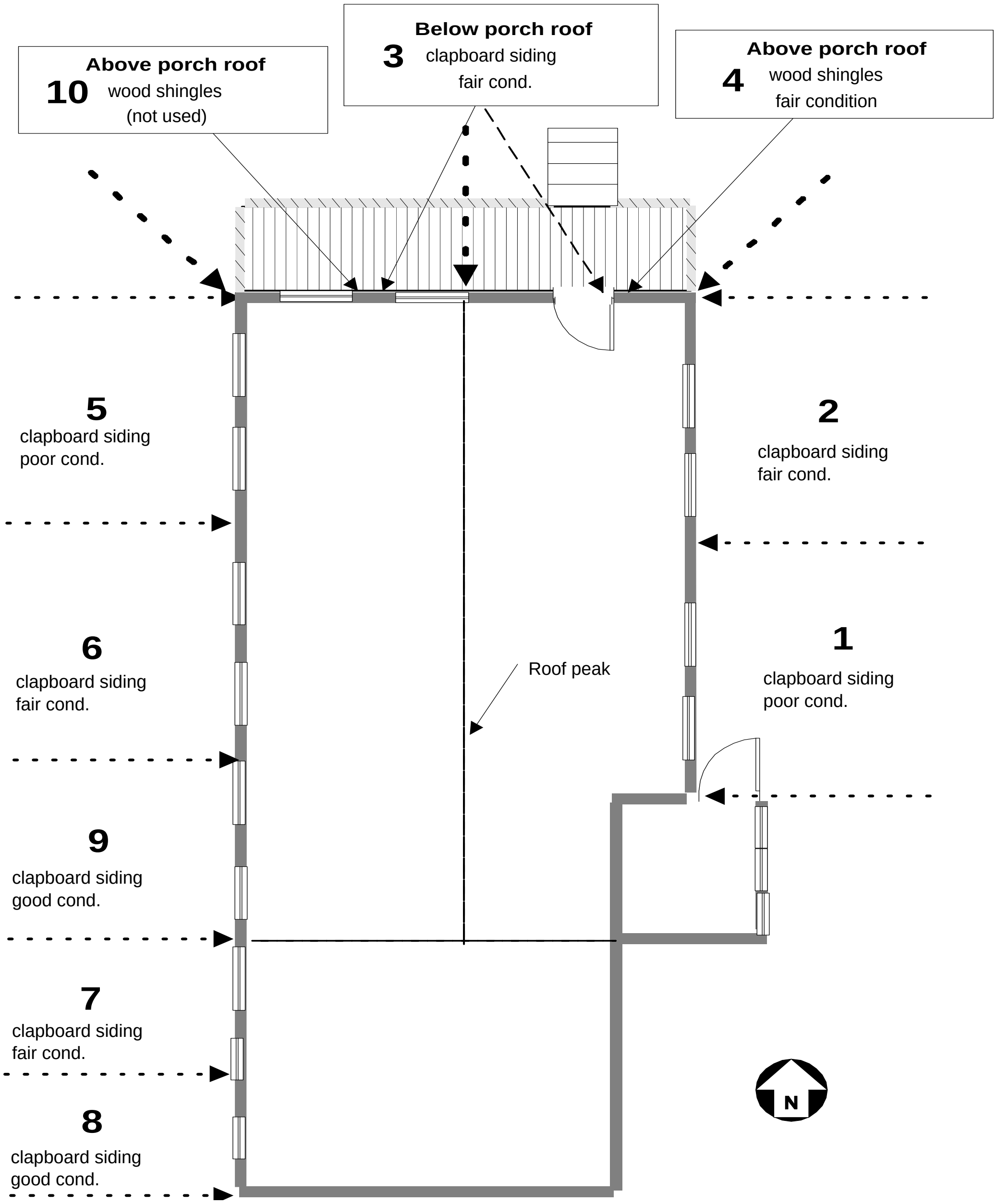

Figure 2. Sampling Set Up during a Paint Removal Method

A

B

A) PbA and PbS sampling while a worker performs the dry scraping/power sanding method. B) Collection of a PbS sample with dustfall collector.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226-1998

National Institute for Occupational Safety and Health
NIOSH

**Delivering on the Nation's promise:
Safety and Health at work for all people
through research and prevention**

To receive NIOSH documents or information
about occupational safety and health topics
contact NIOSH at:

1-800-35-NIOSH (356-4674)
Fax: 1-513-533-8573
E-mail: pubstaft@cdc.gov
or visit the NIOSH web site at:
http://www.cdc.gov/niosh

S A F E R • H E A L T H I E R • P E O P L E™