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People Working Cooperatively
Cincinnati, Ohio

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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SUMMARY

In 1993, a management request was received from People Working Cooperatively, a nonprofit organization in Cincinnati, Ohio, for an evaluation of worker lead exposures during renovation of homes with lead–based paint (LBP). The organization provides home repair and weatherization services to low–income homeowners, primarily in pre–1960 homes. Lead exposures of full–time professional home renovators, and of part–time volunteers who worked a few days per year in an annual Paint–a–Thon event, were assessed in 18 homes. Potentially hazardous lead exposures were measured during exterior dry scraping and wet scraping of LBP, with maximum exposures of 120 and 63 micrograms per cubic meter ($\mu g/m^3$), respectively. These tasks were performed only by volunteers during home painting. Exposures during all the other tasks, including general repair, weatherization, scraping/painting (mostly applying new paint), window replacement, demolition, and plumbing were low (range: 0.1 – 16 $\mu g/m^3$), as were 13 full–shift personal exposures which included break periods, initial set–up, and clean–up (geometric mean [GM] = 3.6 $\mu g/m^3$, range: 0.2 – 12 $\mu g/m^3$). Blood lead levels (BLLs) for full–time workers ranged up to 17.5 micrograms per deciliter (µg/dL), with a GM of 5.2 µg/dL; the GM for volunteers was 3.2 µg/dL. All 49 painted work surfaces sampled in 15 homes had detectable amounts of lead (GM = 1.05, range: 0.0022 – 58% lead [Pb]). Sixty–five percent (32) of the work surfaces had an average lead concentration >0.5%, the Federal definition of lead–based paint. Sampling results indicated that chemical spot test kits, when used by industrial hygienists, are highly sensitive (100% positive) in screening for high levels (>9%) of lead in painted work surfaces, and somewhat less so (88% positive) for lower lead levels (>0.5%). Mean paint lead concentrations were correlated with mean worker exposures during renovation, both by house (r = 0.875) and by work surface (r = 0.898). Average surface lead loadings measured on floors in homes undergoing renovation (2045 micrograms per cubic foot [$\mu g/ft^2$]), and in vehicles of full–time workers (310 $\mu g/ft^2$) and volunteers (140 $\mu g/ft^2$) were relatively high. Further study is needed to assess the prevalence and degree of childhood lead exposure caused by renovation and remodeling work in homes with LBP.

Worker lead exposures during wet and dry scraping of lead–based paint are potentially hazardous. The workers evaluated infrequently performed these tasks, however, and the other lead exposures measured during home renovation were low. No full–shift air or blood lead levels indicating excessive occupational exposure were measured. However, average surface lead levels potentially hazardous to young children were measured in homes undergoing renovation and in the workers' personal vehicles.

Keywords: SIC 1521 (General Contractors-Single-Family Houses), remodeling, lead exposure, lead–based paint, home renovation, construction, chemical test kits

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BACKGROUND

Title X of the Residential Lead–Based Paint Hazard Reduction Act of 1992 directs national efforts to protect workers and occupants from lead hazards during lead abatement and renovation work in pre–1978 housing.[1] In 1993, the management of People Working Cooperatively (PWC), a Cincinnati, Ohio, nonprofit organization, requested a National Institute for Occupational Safety and Health (NIOSH) evaluation of worker lead exposures during renovation of homes with lead–based paint (LBP). The organization provides general home repair and weatherization services to low–income homeowners, primarily in pre–1960 homes. At the time of the NIOSH field visits (June 1993 to June 1994), PWC had 95 full–time employees, about 75 of whom were field personnel. PWC had a safety manager and provided training in safe work practices and lead hazards to its full–time employees. The organization also had a volunteer program in which community volunteers participated in two annual home repair events, one of which was a "Paint–a–Thon" for repainting clients' homes.

The primary purpose of the NIOSH study was to characterize worker lead exposures during home renovation in homes with LBP. Secondary objectives were: (1) to determine the concentrations of lead in painted surfaces, (2) evaluate the usefulness of chemical spot test kits for screening for lead in paint, (3) determine the correlation (if any) between paint lead concentrations and worker air lead exposures, and (4) determine the potential for lead exposures among workers' families from lead contamination of workers' vehicles.

Seven NIOSH field visits were made from June 1993 to June 1994. An interim report with environmental and medical results was sent to PWC in November 1994, and workers were provided individual notification letters with medical results.

METHODS

All of the home repair and renovation tasks performed by PWC were initially reviewed and categorized with respect to the potential for worker lead exposure. Activities selected for environmental monitoring were those expected to result in lead exposures due to disturbance of lead–containing paint or plumbing. NIOSH investigators observed the work practices used during a variety of tasks, and a self–administered questionnaire was used to collect information about the workers' work histories, hygiene practices, and potential lead–related symptoms. Lead exposures of both full–time professional home renovators and part–time volunteers, who worked a few days in an annual Paint–a–Thon, were assessed in 18 Cincinnati homes.

Personal breathing zone (PBZ) and area air samples, surface wipes, and bulk paint chip samples were collected during renovation projects. The personal air monitoring included both full–shift and task–based sampling, with emphasis on the latter; sampling periods (range: 12 – 504 minutes) included on–site work breaks. Area air samples were located in areas representative of the exposures of nearby workers and bystanders. Air samples were collected at the rate of 2.0 liters per minute (L/min) with personal sampling pumps which had been calibrated immediately before sampling. Air samples were prepared and analyzed by NIOSH Method 7082 (flame atomic absorption spectrophotometry), and if no lead was detected, the samples were subsequently analyzed by NIOSH Method 7105 (graphite furnace atomic absorption spectrophotometry).[2] When no lead was detected in an environmental sample, ½ the respective limit of detection (LOD) was used to calculate a numerical value. These estimated lead concentrations were used in the data analyses.

All full–time employees and Paint–a–Thon volunteers were invited to participate in a medical evaluation, which included the questionnaire mentioned above, and blood tests for lead, zinc protopor-phyrin (an increase of which can result from lead's interference with the formation of heme), and markers of kidney damage (another toxic effect of lead). Informed written consent was obtained from all participants. Blood lead analyses were performed at the Centers for Disease Control and Prevention (CDC's) National Center for Environmental Health by graphite furnace atomic absorption.[3] The other tests were done by a commercial laboratory.

Paint chip samples were collected in 15 of the 18 homes evaluated. One to six samples per work surface were collected by donning clean vinyl gloves and using a stainless steel paint scraper to remove an area approximately 2 cm x 2 cm of the paint to bare wood. The paint chip samples were transferred to sealable plastic bags or glass vials and analyzed for percent lead by weight using NIOSH Method 7082, modified for microwave digestion of paint.[2] In cases where multiple paint chip samples were collected from a work surface, the mean value was used for data analyses. Chemical spot tests for lead (Lead Check™Swabs, HybriVet Systems, Inc., Natick, MA) were performed in situ on surfaces immediately adjacent to 41 of the surfaces from which paint chip samples were collected. The participating NIOSH industrial hygienists were instructed to expose all paint layers on the substrates by making V–shaped cuts with a stainless steel knife before applying the spot test solution.

Surface wipe samples were collected in homes and workers' vehicles during renovation. Hard–surface floors and window wells were sampled in homes. Samples were collected from the center of the drivers' side floor in vehicles owned by 20 full–time workers and 11 part–time volunteers. Floor surfaces in the vehicles included both carpet and rubber mats. Wipe samples were collected and analyzed according to NIOSH Method 9100.[2] All samples were collected with pre–moistened towelettes (Wash'n Dri,® Softsoap Enterprises, Inc, Chaksa, MN) which have been found to be free of lead contamination and result in good analytical recoveries of lead dust.[4] Sampling templates cut from 8.5– x 11–inch plastic transparencies were used to define 10– x 10–cm surface areas for sampling; a new template was used for each sample.

EVALUATION CRITERIA

General Guidelines

To evaluate occupational exposures, NIOSH investigators use NIOSH Recommended Exposure Limits (RELs),[5] American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[6] and Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[7] These criteria are designed to provide exposure levels to which most workers may be exposed over a working lifetime without experiencing significant adverse health effects. However, because of variation in individual susceptibility, a small percentage of workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre–existing medical conditions, or possible interactions with other workplace agents, medications being taken by the worker, or other environmental conditions.

Lead Exposure

Occupational exposure to lead occurs via inhalation of dust and fume, and ingestion from contact with lead–contaminated hands, food, cigarettes, and clothing. Symptoms of lead poisoning include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort (colic), fine tremors, and "wrist drop."[8,9,10] Overexposure to lead may also result in damage to the kidneys, anemia, high blood pressure, infertility and reduced sex drive in both sexes, and impotence. An individual's blood lead level (BLL) is a good indication of recent exposure to, and current absorption of lead.[11]

Under the OSHA interim final rule for lead in the construction industry (29 CFR 1926.62), the PEL for airborne exposure to lead is 50 micrograms per cubic meter (µg/m^3) (8–hour time–weighted average [TWA]) and medical removal is required if an employee's BLL reaches 50 micrograms per deciliter (µg/dL).[12] NIOSH has concluded that the OSHA standard should prevent the most severe symptoms of lead poisoning, but that it does not protect workers and their children from all of the adverse effects of lead.[13] The ACGIH TLV for lead is 50 µg/m^3 (8–hour TWA), with worker BLLs to be controlled to ≤30 µg/dL.[14] A national health goal for the year 2000 is to eliminate all occupational exposures which result in BLLs greater than 25 µg/dL.[15]

Surface Lead Levels

Lead contamination is widespread in U.S. urban environments due to the common use of lead in gasoline, paints, and industry during the last century. Studies have found a significant correlation between resident children's BLLs and house dust lead levels.[16] To protect young children, the U.S. Department of Housing and Urban Development (HUD) and the U.S. Environmental Protection Agency (EPA) recommend the following limits for residential surface lead levels: uncarpeted floors, 100 micrograms per square foot (µg/ft^2); interior window sills, 500 µg/ft^2, and window wells, 800 µg/ft^2.[17,18] There are no established occupational limits for surface lead levels, however, since no useful correlation between workplace surface lead levels and adult lead exposures has been established.

RESULTS

Results of 77 task–based personal air samples are summarized in Table 1. Potentially hazardous lead exposures were measured during exterior dry scraping and wet scraping of LBP, with maximum exposures of 120 and 63 µg/m^3, respectively. The geometric means (GMs) for exposures during exterior dry and wet scraping tasks were low, 9.1 and 6.7 µg/m^3. These tasks were performed only by volunteers during the Paint–a–Thon. Exposures during all the other tasks including general repair, weatherization, scraping/painting (mostly applying new paint), window replacement, demolition, and plumbing were low (range: 0.03 – 16 µg/m^3). Results for 13 full–shift (greater than 360 minutes) personal samples, which included break periods, initial set up, and clean up, were low (GM = 3.2 µg/m^3, range: 0.05 – 12 µg/m^3, see Table 2). Results for 37 area air samples were lower than the corresponding personal sample results for each task (overall GM = 0.6, range: 0.1– 25 µg/m^3); the highest was during exterior dry scraping of LBP.

Sixty–eight (72%) of the full–time employees participated in the medical evaluation. On the basis of their questionnaire responses, we determined that 47 (63%) of the participants were field personnel. Fifty–three employees, 39 of whom were field personnel, had a blood lead test. Ten persons, all field personnel, had a BLL of 10 µg/dL or greater. This represents 19% of all tested employees and 26% of the field personnel. Four employees (8% of all tested employees, 10% of field personnel) had BLLs of 15 µg/dL or greater; the highest was 17.5 µg/dL. Geometric mean BLL for all full–time workers tested was 5.2 µg/dL; of these employees, the GM was 6.3 µg/dL for field personnel and 2.7 µg/dL for office personnel. The distribution of BLLs indicates that PWC field workers had somewhat more lead exposure than the general U.S. adult population (<7% with BLLs ≥10 µg/dL, <2% with ≥15 µg/dL, and GM <4 µg/dL),[19] but none of the BLLs exceeded any current occupational exposure criterion. Since none of the BLLs were in the range that would account for either symptoms or abnormalities in the other blood tests, neither the results of those tests nor the questionnaires were analyzed for this report.

Thirty–three Paint–a–Thon volunteers participated in the evaluation; 20 had at least one blood lead test. Fourteen had both pre– and post–shift tests. Cross–shift change in BLL ranged from a decrease of 3.5 µg/dL to an increase of 5.3 µg/dL. The mean change was +0.4 µg/dL, which is not significantly different from zero ($t = 0.59$, $p > 0.5$). The largest change was from 18.8 to 24.1 µg/dL. This occurred in a person whose current (at the time of the survey) occupation and history of work at PWC could not be ascertained from his questionnaire because of incomplete and contradictory information. The other 19 volunteers tested had BLLs (using the highest where there were two) that ranged from 1.6 to 13.7 µg/dL, with all but one being less than 10 µg/dL. The GM BLL among the 20 volunteers (using the average value if there were both pre– and post–shift results) was 3.2 µg/dL. Thus, although one volunteer had an elevated (by general population standards) BLL, the overall distribution of the volunteers' BLLs was consistent with that of the general U.S. adult population, and there was no cross–shift pattern demonstrating substantial worksite exposure to lead.

A total of 126 paint chip samples were collected from 49 painted work surfaces in 15 homes; all had detectable amounts of lead (GM = 1.05, range: 0.0022 – 58% lead [Pb]). Sixty–five percent (32) of the work surfaces tested had an average lead concentration ≥0.5%. Chemical spot tests on immediately adjacent areas were performed for 41 (84%) of these work surfaces; the results (positive or negative) are compared to the average paint lead concentrations obtained by laboratory analysis in Figure 1. Spot test results were 100% positive (22/22) for surfaces with ≥ 9% Pb, and 88% positive (30/34) for surfaces with >0.5% Pb. One of 7 samples with results <0.5 % Pb had a positive spot test result. Mean paint lead concentrations were well correlated with mean worker exposures by house ($r = 0.875$, see Figure 2), and by work surface ($r = 0.898$, see Figure 3).

Results for wipe samples are presented in Table 3. Twelve surface dust samples, collected on floors in six homes during renovation, on average had lead loadings hazardous to children (average for floor samples = 2045 micrograms per cubic foot [µg/ft^2]), and both window wells sampled had very high loadings. Lead levels in full–time workers' vehicles (average = 310 µg/ft^2) were higher than those in volunteers' vehicles (average = 140 µg/ft^2), although the difference narrowly missed statistical significance ($p = 0.06$, Student's t–test, one tail).

DISCUSSION

Workers renovating pre–1960 homes in Cincinnati have a high risk of encountering LBP. The majority of the painted work surfaces had lead concentrations greater than Federal definition for LBP (≥0.5% Pb), and all of the surfaces had detectable amounts of lead, a condition which triggers requirements of the OSHA construction lead standard.

Potentially hazardous worker exposures were measured during exterior dry and wet scraping of LBP, although on average the exposures for these tasks were low. Wet scraping (misting surfaces with water during scraping) resulted in somewhat lower worker exposures than dry scraping. The principal mitigating factor for exposures during paint scraping in this study is that all of the work took place outdoors. A previous NIOSH evaluation found that workers who perform manual scraping of LBP indoors have higher exposures.[20] Similarly, the use of power tools to remove LBP would have generated much more dust and therefore greatly increased worker lead exposures. Another mitigating factor was PWC management attention to worker lead exposures, including provision of worker training about lead hazards.

The results suggest that PWC workers generally have low lead exposures during home renovation tasks. Lead exposures during the other home renovation tasks, including sweeping debris, power washing, drilling, general repair, demolition, plumbing, and window replacement appeared to be nonhazardous for these workers. However, the number of workers and homes sampled was inadequate to conclude that hazardous exposures could never occur during these tasks. Blood lead testing indicated some occupational lead exposure among PWC workers, but their BLLs were below current occupational exposure criteria. There was no evidence that Paint–a–Thon volunteers had biologically significant occupational lead exposure at PWC worksites. The relatively low BLL results are consistent with the air sampling results.

Paint lead levels appeared to be correlated with worker lead exposures, both by house and by work surface. However, the results should be interpreted with caution. In contrast to the results here, two previous NIOSH studies of worker exposures during residential LBP abatement found only very weak correlations between paint lead concentrations and personal lead exposures.[20,21] In this study, the correlation may appear stronger than it really is because of the regression line being "anchored" by data points at the ends of the distribution. In both cases (Figures 2 and 3), there are relatively few data points in the middle concentration ranges.

The results indicate that chemical spot test kits, when used by industrial hygienists, are highly sensitive in screening for high levels ($\geq$ 9% Pb) of lead in painted work surfaces and reasonably sensitive for levels > 0.5%. However, a previous NIOSH study found that potentially hazardous worker exposures can occur during paint scraping indoors even when average paint lead levels are less than 0.5% Pb.[20] NIOSH currently recommends quantitative laboratory or field analysis for accurately determining lead concentrations in paint.[13]

Average surface lead levels measured in homes undergoing renovation, and in workers' and volunteers' vehicles, represent a potential health hazard to young children. This study did not determine whether the surface lead levels in the homes were preexisting or caused by the renovation work. However, a New York study suggests that home renovation and remodeling is an important source of childhood lead poisoning.[22] The results suggest that lead contamination of workers' vehicles may have been due to ineffective hygiene practices at the worksites, since full-time workers had higher levels than part-time volunteers. A NIOSH study of New Jersey construction workers found that children of lead–exposed construction workers are more likely to have elevated BLLs than those of neighbor children.[23] Further study is needed to assess the prevalence and degree of childhood lead exposure caused by renovation and remodeling work in homes with LBP.

RECOMMENDATIONS

1. Due to the relatively high prevalence of LBP in the Cincinnati homes in which PWC works, painted surfaces should be assumed to contain LBP unless quantitative analysis shows otherwise.

2. To protect themselves, and occupants of the residences, renovators working in homes with LBP should follow the requirements and recommendations of OSHA, HUD, EPA, and other appropriate agencies. Recommended sources of information (and phone numbers to order the documents) are:

> Guidelines for the Evaluation and Control of Lead–Based Paint Hazards in Housing HUD, 1995. (available from the HUD USER at 800–245–2691).
>
> Reducing Lead Hazards When Remodeling Your Home. EPA, 1994. (available from the National Lead Information Center at 800–424–LEAD).
>
> Lead–Based Paint, Operations & Maintenance Work Practices Manual for Homes and Buildings. National Institute of Building Sciences, 1995. (available at 202–289–7800).

These documents describe safe work practices including: (1) isolating work areas from other areas of the house; (2) prohibiting occupants and bystanders from entering the work area; and (3) performing specialized daily and final clean–up of work areas and tools. PWC should consider sending some field personnel to state-certified training courses required for lead abatement workers and supervisors.

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Table 1. Task–based Personal Air Sampling Results

Task	No. samples	Lead Conc. (µg/m^3)	
		GM	Range
Dry scraping (exterior)	15	9.1	0.2 –120
Wet scraping (exterior)	7	6.7	0.7 – 63
Demolition	4	6.0	3.5 –11
Window replacement	8	5.6	2 – 16
Plumbing	6	1.5	*0.04*[A] – 11
Other[B]	11	0.4	*0.03*[A] – 2.7
General repair	10	0.5	*0.1*[A] – 4.7
Scraping/painting	9	0.4	*0.04*[A] – 14
Weatherization	7	0.2	*0.05*[A] – 2.1
Total	77		

[A] None detected results for which ½ the LOD was used to calculate numerical values.

[B] Drilling holes, power washing, sweeping, sawing boards.

Table 2. Full–shift Personal Air Sampling Results

Job Title	Primary Task	Time (min)	Lead Conc. (µg/m^3)
Volunteer	Wet scraping	504	0.9
Volunteer	Wet scraping	502	3.3
Repair technician	Demolition	465	3.7
Volunteer	Scraping	437	10.0
Volunteer	Scraping/painting	417	12.0
Volunteer	Scraping	412	1.5
Generalist 2	Demolition	411	11.1
Volunteer	Scraping/painting	411	4.3
Crew leader	Demolition	409	9.0
Installer	Weatherization	407	*0.05*[A]
Repair technician	Demolition	390	3.5
Volunteer	Scraping	386	2.0
Volunteer	Wet scraping	361	12.0

[A] None detected result for which ½ the LOD was used to calculate numerical value.

Table 3. Surface Sampling Results for Vehicles and Homes

Surfaces sampled	No. Samples	Lead Conc. ($\mu g/ft^2$) Mean	Range
Floors in volunteers' vehicles	11	140	*5*[A] – 490
Floors in workers' vehicles	20	310	*4*[A] – 1900
Floors in homes[B]	12	2045	*14*[A] – 14,000
Window wells in homes[B]	2	—	69,000 – 120,000

[A] None detected results for which ½ the LOD was used to calculate numerical values.

[B] Samples collected during renovation work.

Figure 1. Paint Lead Testing: Chemical Spot Test vs. Laboratory Results

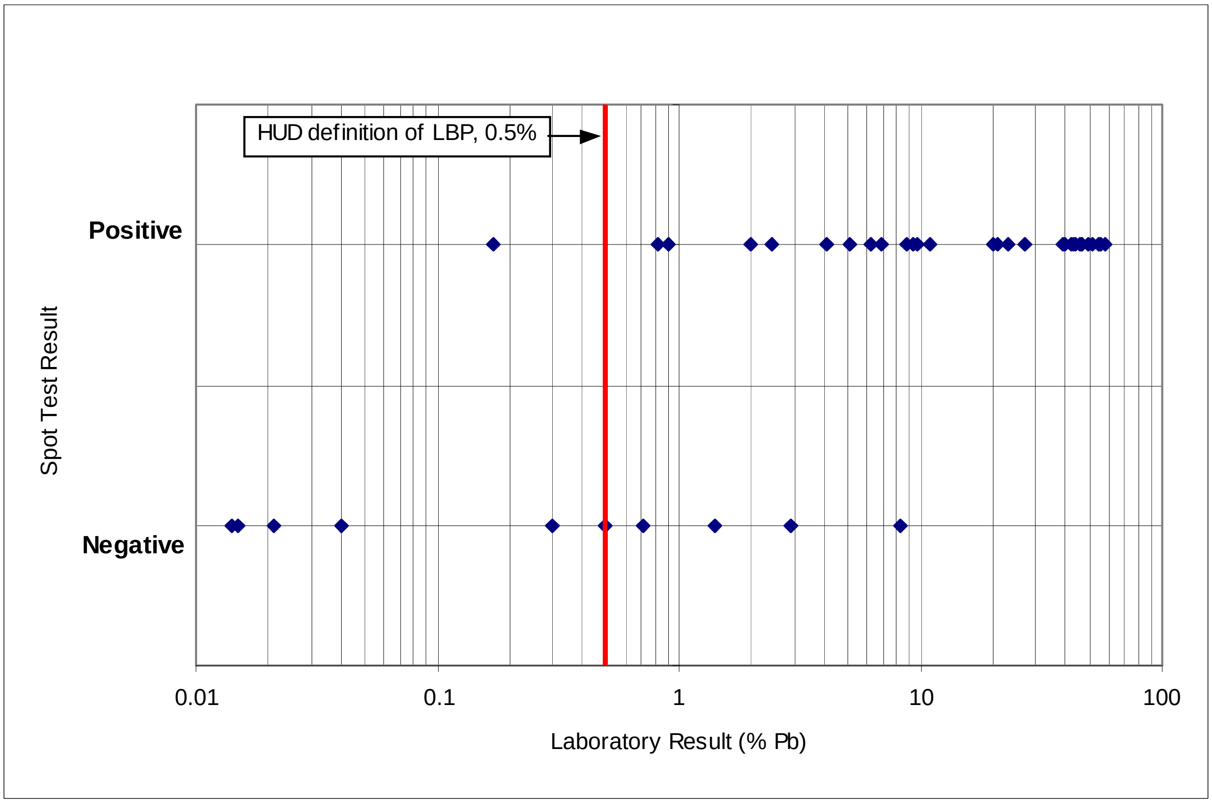


Figure 2. Correlation Between Surface and Air Lead for 15 Houses

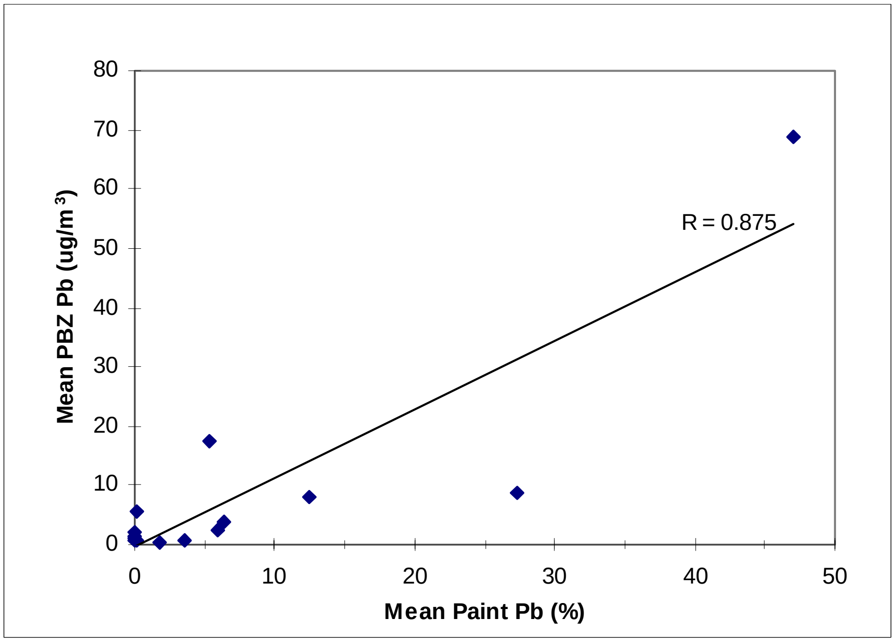
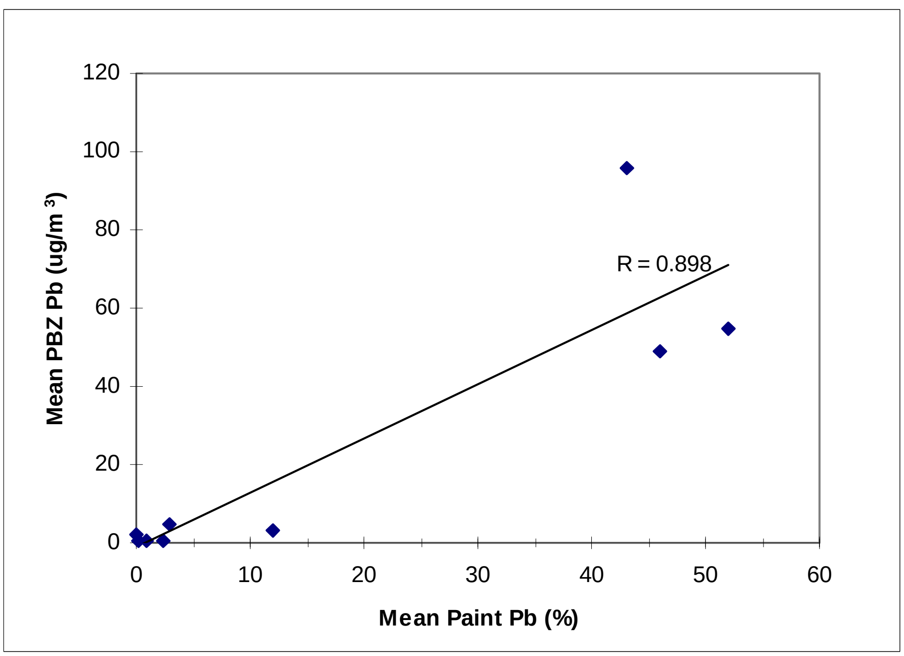


Figure 3. Correlation Between Surface and Air Lead for 10 Work Surfaces



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