# WORKER EXPOSURES TO AIRBORNE LEAD DURING RESIDENTIAL REMODELING ACTIVITIES

## RESULTS OF FIVE SITE VISITS

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## EXECUTIVE SUMMARY

This report presents the results of air lead monitoring at a total of five sites where different types of work disturbing lead-based paint were being performed. The types of work studied included removal of lead-painted wooden shingles, dry scraping of lead-painted plaster prior to repainting, manual demolition of a lead-painted plaster ceiling and walls, removal of lead-painted windows and replacement with new windows, and outdoor hand scraping and hand sanding of lead-painted windows in preparation for repainting. All of the jobs were chosen as representative of different types of residential repair and remodeling work rather than intentional abatement of lead-based paint. Lead content of the paint ranged from less than 1 $mg/cm^2$ to more than 50 $mg/cm^2$.

The air lead samples included personal breathing zone samples for workers as well as area sampling. The lead content of paint as determined by laboratory analysis or XRF is also presented for each site monitored. The general nature of work performed is described and test results are presented separately for each site visit.

Worker lead exposures during four of the five activities monitored were well below the "Action Level" of 30 $\mu g/m^3$ set by the OSHA Interim Final Rule on Lead in Construction (29 CFR Section 1926.62), both for the work periods and when converted to an 8-hour time weighted average. The only work period readings that exceeded 30 $\mu g/m^3$ or 50 $\mu g/m^3$ were from the ceiling and wall demolition, indicating the need for respiratory protection during such work. Other activities did not appear to require respirators, based on measured air lead levels.

Many variables can affect air lead levels during work that disturbs lead paint, including nature of the work, lead content of the paint, number of workers, interior or exterior location, ventilation rate, and work practices. The available data on airborne lead levels during repair and remodeling work is very limited and generally not well documented. This report presents detailed information on the subject as a supplement to other reports. It may be useful in assessing the need for respiratory protection when similar work is performed at other sites, and in reviewing the approach to regulating lead exposures in remodeling under the OSHA Lead in Construction rule.

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# 1. INTRODUCTION

## 1.1 OSHA Regulation of Lead in Construction

Title X of the Housing and Community Development Act of 1992 required the Occupational Safety and Health Administration (OSHA) to issue a comprehensive standard governing exposures to lead in the construction industry. The OSHA rule, titled "Lead Exposure in Construction; Interim Final Rule" (generally referred to in this report as "the OSHA rule" or "the rule"), was published in 29 CFR Part 1926 Section 1926.62, and contains worker protection requirements for construction workers exposed to lead. It was adopted effective June 3, 1993, with specific requirements phased in over the next 120 days. This was the first update of OSHA's rules for lead exposure in construction since 1971. Under the previous OSHA rule, lead exposures in construction were limited to 200 micrograms per cubic meter of air ($\mu g/m^3$) computed as an 8-hour time weighted average (TWA), while under the new rule this "permissible exposure limit" (PEL) was reduced to 50 $\mu g/m^3$ and supplemented by an "action level" (AL) of 30 $\mu g/m^3$ that triggered a variety of requirements. The 25 states with OSHA-approved occupational safety and health plans were required to adopt a comparable standard within six months.

The OSHA rule "applies to all construction work where an employee may be occupationally exposed to lead." Construction work is defined in the rule as "work for construction, alteration and/or repair, including painting and decorating." Remodeling activities are included within the scope of the rule as are many other types of construction work. Note that some types of maintenance work inside buildings may instead fall under the General Industry Lead rule, at 29 CFR Section 1910.1025, which has the same AL and PEL but differs in several other respects.

Lead has historically been used in a variety of construction products, but its most extensive use has been in lead-based paints. While the use of lead paint inside homes and apartments began to decline by the 1950's, and paint containing more than 0.06 percent lead by weight in the dry film has been prohibited for residential use since 1978, a survey published in 1990 by the U.S. Department of Housing and Urban Development estimated that 75 percent of the pre-1980 housing stock contained lead paint on interior surfaces, exterior surfaces or both.[1] As a result, remodeling work involving lead paint is commonplace.

The OSHA rule calls for performing an "exposure assessment" including an "initial monitoring" of airborne lead levels for all covered workplaces or operations (i.e., all construction activities involving lead). Whenever lead exposures are above the action level, the rule further requires worker training, blood lead testing and annual medical examinations, and whenever lead exposures are above the PEL it requires respiratory protection, shower facilities, warning signs, work practice controls, engineering controls and a written compliance program. During the period when an exposure assessment is being performed, specified respiratory protection is generally required for a series of listed activities. For example, during "(m)anual demolition of structures (e.g., dry wall), manual scraping, manual sanding, heat gun applications, and power tool cleaning with dust

[1] *Comprehensive and Workable Plan for the Abatement of Lead-Based Paint in Privately Owned Housing: Report To Congress*, U.S. Department of Housing and Urban Development, December 7, 1990. Note that HUD defines lead-based paint as containing at least 1.0 $mg/cm^2$ of lead, or 0.5 percent lead by weight. The OSHA rule does not define lead-based paint and may apply below these thresholds.

collection systems", employees are required to wear half-mask air-purifying respirators unless and until air monitoring results demonstrate that exposures in that particular workplace are below the action level.

The rule contains one exception to the requirement for initial air monitoring. Section 1926.62(d)(3)(iv) provides that:

> Where the employer has objective data, demonstrating that a particular product or material containing lead or a specific process, operation or activity involving lead cannot result in employee exposure to lead at or above the action level during processing, use or handling, the employer may rely upon such data instead of implementing initial monitoring.

However, under Section 1926.62(d)(3)(iv)(B), such "objective data" may not be substituted for initial monitoring of a list of tasks performed where lead-based paint is present, including those listed above as requiring half-mask air-purifying respirators (manual demolition, scraping, sanding, etc.).

Despite concern about lead exposure during construction work, little information is available to document actual worker exposures during specified types of activities that are commonly performed during remodeling of homes and apartments.[2] The National Association of Home Builders commissioned the NAHB Research Center, Inc., to gather additional data by performing air monitoring during different types of remodeling activities and reporting the results. It was intended that this information would be useful either as objective data documenting activities with exposures below the AL and the PEL, or as evidence that particular activities could lead to exposures exceeding the AL or the PEL. The preamble to the Lead in Construction Rule also indicates (at 58 F.R. 26596) that OSHA recognizes "the limited amount of firm data available at the time of promulgation of [the Lead in Construction] standard", and intends to consider further data "in a forthcoming rulemaking on a permanent final rule for lead exposures in the construction industry."

[2] Data on airborne lead levels during abatement of residential lead-based paint was published by the HUD Office of Policy Development and Research in *The HUD Lead-Based Paint Abatement Demonstration (FHA)*, HUD-1316-PDR, August 1991. Additional information appears in *Health Hazard Evaluation Report - HETA 90-070-2181 - HUD Lead-Based Paint Abatement Demonstration Project*, National Institute for Occupational Safety and Health, February 1992. By contrast, the present study was intended to focus on exposures during typical remodeling work involving lead-based paint, not during intentional abatement or removal of lead-based paint. Results from site monitoring outside of an abatement context appear in reports from Site Visits #24 (revised February 1993) and #25 (January 1993), prepared by CONSAD Research Corporation for OSHA. A summary of exposure data for all types of workers available to OSHA when the Lead Exposure in Construction Rule was announced appears in the May 4, 1993 *Federal Register*, Vol. 58, No. 84, at pp. 26590 - 26627. Additional information and analysis appears in *Economic Analysis of OSHA's Interim Final Standard for Lead in Construction, Final Report* (April 1993), prepared for OSHA by CONSAD Research Corporation.

## 1.2 Overview of the Site Visits

During the course of this project, air lead monitoring was performed at a total of five job sites. The jobs during which monitoring was performed included:

1. removal of lead-painted wood shingles on a single-family house
2. surface preparation (dry hand scraping) of lead-painted walls inside an apartment in preparation for repainting,
3. manual demolition of lead-painted plaster on wood lath in a single-family home,
4. removal of lead-painted windows in a single-family home and replacement with new windows, and
5. outdoor dry hand sanding and scraping of lead-painted windows in a single-family home in preparation for repainting.

The monitoring studies included collecting air samples from the breathing zones of workers using portable air pumps; collection of paint samples and laboratory analysis for lead content; and documentation of the work procedures. Air samples were analyzed for lead by NIOSH 7082 (atomic absorption, flame) or NIOSH 7105 (atomic absorption, graphite furnace), and paint samples by EPA 7420 (atomic absorption, flame). Specific test methods and laboratories used for air and paint sample analysis are identified in the individual write-ups.

The five jobs that were monitored would be regulated in different ways under the Lead in Construction Rule. All five would require air monitoring to be performed as part of the initial assessment, and objective data, if available, could be substituted for such monitoring only under the first job (removal of shingles) and fourth job (removal of lead-painted windows). The other three jobs all included work that requires air monitoring as part of the initial assessment in every case.[3]

Sections 2 through 6 of this report present results from the five site visits. The only lead exposures measured during this study that exceeded the AL or the PEL were during the third site visit (manual demolition of lead-painted plaster), where air lead concentrations of 548 $\mu g/m^3$, 55 $\mu g/m^3$ and 63 $\mu g/m^3$ were measured during working periods of 23, 24 and 51 minutes respectively. None of the exposures measured during any of the other four site visits exceeded either the AL or the PEL during the work periods. Most measured exposures were around 10 $\mu g/m^3$ or less during work periods, and would generally be lower than that when combined with other activities and expressed as an 8-hour TWA. Several of the air lead results were reported as below the method detection limit for NIOSH 7082 (the standard laboratory analytical method for air lead measurement), prompting use of the more sensitive NIOSH 7105 procedure for air samples collected during other visits. The first, fourth and fifth site visits each involved work that was performed largely or

[3] OSHA Instruction CPL 2-2.58 (December 13, 1993) states that "Construction work covered by 29 CFR 1926.62 includes any repair or renovation activities or other activities that disturb in place lead-containing materials ... but does not include routine cleaning and repainting (e.g., minor surface preparation and repainting of rental apartments between tenants or at scheduled intervals) where there is insignificant damage, wear or corrosion of existing lead-containing paint and coatings or substrates." It goes on to say that "Employees performing maintenance activities not associated with construction work are covered by the general industry standard for lead, 29 CFR 1910.1025. Maintenance activities covered by the general industry standard are those which involve making or keeping a structure, fixture, or foundation in proper condition in a routine, scheduled, or anticipated fashion" (p.A-1). Based on this it is possible that the work performed at sites #2 and #5 would fall under the general industry lead standard rather than the construction industry lead standard.

entirely outdoors, and the apartment windows were left open during the second visit. Only one person was at work during the first and fifth site visits. These factors may have contributed to the low air lead concentrations measured at those sites.

The results provide support for the OSHA requirement that half-mask respirators be worn during manual demolition of lead-painted walls and ceilings, but not for the presumption that respirators are needed to keep exposures below 30 $\mu g/m^3$ during all manual scraping and sanding of paint containing lead, particularly when the work is performed outdoors. They also indicate that removal and replacement of windows with high levels of lead in the paint, as well as removal of lead-painted wall shingles with hand tools, produce exposures well below the AL. They suggest that for the activities studied, with the exception of manual demolition, the requirements of the current rule may be overly conservative when applied to small-scale residential remodeling type work that is undertaken in a repair and remodeling context, as opposed to intentional lead abatement. In this respect, the results provide useful objective data for the remodeling industry on potential exposures during selected tasks, as well as new information for consideration by OSHA on the relevance of the regulatory framework adopted under sections 1926.62(d)(2) and (d)(3) of the Interim Final Rule on Lead Exposure in Construction.

## 2. SITE VISIT #1: REMOVAL OF WOODEN SHINGLES COATED WITH LEAD-CONTAINING PAINT

This section describes the results of air monitoring performed at a single family home where wood shingle siding painted with lead-containing paint was being removed. Results of laboratory analysis of the paint on the shingles is also included.

### 2.1 DESCRIPTION OF WORK PERFORMED

The shingle removal and clean-up took place in August 1993, over a period of just under 3 hours. The home was built in approximately 1960, and is located in a neighborhood of homes of similar construction near the Atlantic Coast of New Jersey. The shingles were being removed from the outside end wall of a garage as the first step in construction of an addition to the home. The shingles were made of red cedar, measuring approximately 3.5" to 4.5" in width, 17" in length, and tapered from 1/16" to 3/8" in thickness. Two layers of shingles were applied along each course, with the vertical lap approximately 2" to 3", and 14" to 15" exposed to the weather. The shingles were nailed to plywood sheathing on 2 x 4 wood studs. The top layer of shingles on each course were painted white, while the lower layer was unpainted. The shingled area of the wall measured 26 feet wide at the base, and ranged in height from about 8 feet at the corners to 12 feet in the center (at the gable peak). The total area from which shingles were removed was about 260 square feet. The paint on the shingles was deteriorating in many locations and showed hairline cracks, but no substantial areas of peeling were observed.

All removal of shingles was performed by the owner-occupant, using a flat pry bar; the underlying nails were then removed with the claw end of a hammer. Some of the shingles (estimated as about one third) broke during removal, generally by splitting lengthwise. The person who removed the shingles and performed about half of the clean-up, while not a professional remodeling contractor or subcontractor, was serving as general contractor for the addition to his house and has previously worked in various capacities in the construction field. His skill level was probably closer to that of the professional than to that of the typical "do-it-yourselfer." He wore a half-mask respirator with HEPA filters throughout the work period. Weather during the work period was cloudy, with the temperature in the mid 70s. Wind speed at the site was estimated at approximately 5 mph. There was no rain during the work period, but rain began to fall less than an hour after the testing was concluded.

Two air samples were collected with personal sampling pumps. One air sample was collected in the "personal breathing zone" of the worker, and the second sample was an "area sample" positioned about 16 inches above the grass and 12 feet from the wall from which the shingles were being removed.

A qualitative paint test ("LeadCheck" swab) performed on the paint on a shingle prior to the site visit had been positive for lead. Specimen painted shingles were retrieved for preparation of paint samples following completion of the monitoring, and three paint samples were subsequently prepared. The first sample was the top layer(s) of paint, removed as a single sheet by use of a heat gun. The second sample was the lower layer(s) of paint, scraped off the shingle down to the bare wood with a wood chisel after softening with a heat gun. A third sample was paint flakes

containing all layers of paint on the shingle, removed without application of heat. Prior to sending the samples to the laboratory, the total paint density ($mg/cm^2$) was measured for each sample to allow conversion of laboratory results (reported in percent lead by weight) to units of milligrams of lead per square centimeter of painted surface ($mg/cm^2$). All laboratory analysis was performed by Environmental Reference Laboratory Services, a division of Maryland Medical Laboratory, Inc., located in Baltimore, Maryland.

A photograph of the work site appears below.

## 2.2 TEST RESULTS

### 2.2.1 Air Sample Results

A summary of the reported air lead concentrations is in Table 2-1.

**TABLE 2-1**
**AIR LEAD CONCENTRATIONS**

| Sample Number | Sampling Duration | Type | Description | Air Lead Concentration During Monitoring Period |
|---|---|---|---|---|
| 1. | 137 minutes | PBZ | Worker #1: shingle removal, clean-up | Below MDL (less than 2.5 $\mu g/m^3$) |
| 2. | 170 minutes | Area | Side yard, near garage wall | Below MDL (less than 2.5 $\mu g/m^3$) |

Note that Type "PBZ" indicates a Personal Breathing Zone sample and Type "Area" is an sample from the work area. "MDL" refers to the NIOSH 7082 "Method Detection Limit", which was reported by the laboratory as 2.5 µg/$m^3$. For quality control purposes, an air cassette that was taken to the site but not attached to a sampling pump was also submitted to the laboratory for analysis. Results for this field blank were reported as below the MDL. Finally, note that the worker's 8-hour TWA exposure would equal the air lead concentration in the table if the worker had remained in a similar atmosphere for a full 8 hours.

### 2.2.2 Paint Testing Results

The quantitative paint test results are summarized in Table 2-2.

**TABLE 2-2 PAINT TEST RESULTS**

| Sample Number | Description | Location | Total Weight of Paint | Percent Lead by Weight | Lead Concentration per Unit Area |
|---|---|---|---|---|---|
| 1. | white sheet, top layers only | wood shingle on garage wall | 48.8 mg/$cm^2$ | 0.982% | 0.48 mg/$cm^2$ |
| 2. | off-white chips, bottom layer only | wood shingle on garage wall | 52.3 mg/$cm^2$ | 5.187% | 2.71 mg/$cm^2$ |
| 3. | white flakes, all paint layers | wood shingle on garage wall | 101 mg/$cm^2$ | 4.517% | 4.55 mg/$cm^2$ |

All three samples were taken from one of the shingles that was removed. Samples 1 and 2 were prepared with use of a heat gun, and represent the top and bottom layers of the paint respectively. Sample 3 includes all paint layers, was removed without heat, and reflects the overall lead content in the paint on the shingles. Based on samples 1 and 2 the paint was 3.2% lead or 3.19 mg/$cm^2$; based on sample 3 the paint was 4.5% lead or 4.55 mg/$cm^2$.

## 2.3 SAMPLING AND ANALYTICAL PROCEDURES

### 2.3.1 Air Sampling and Analysis

Personal breathing zone (PBZ) and area air samples were collected during this survey. Cellulose ester membrane filters (0.8 µm pore size) mounted in 37 mm plastic cassette holders were attached with Tygon tubing to SKC universal flow sampling pumps (Model 224-PCXR8). Prior to the visit each pump was calibrated with an SKC Accuflow digital calibrator to a flow rate of 2.0 liters per minute. Calibration was re-checked at the site with the rotameter style flowmeter built into each sampling pump.

For the PBZ sample, the pump was mounted on the worker's belt and the filter assembly suspended from his collar within about eight inches of his mouth. The pump was placed temporarily in "hold" mode (run time and sampling suspended) during several short interruptions, while the worker left the work area to perform unrelated activities. Total run time for this pump was 137 minutes.

For the area sample, the pump was placed on a concrete block in the yard, about 12 feet from the base of the wall being worked on and approximately 16 inches above the grass. It was left in place from start to finish of the shingle removal. Total run time for this pump was 170 minutes.

The air cassettes were analyzed for lead using NIOSH method 7082, Atomic Absorption Spectroscopy by flame.

### 2.3.2 Paint Sampling and Analysis

Paint samples for quantitative analysis were removed from wood shingles that were retrieved during the site visit. The weight of each paint sample per unit area was measured prior to submitting the samples for laboratory analysis. In addition, one sample consisted solely of the top layer of paint on a wood shingle (which was separated by use of a heat gun), and another sample consisted solely of the lower layer or layers from that same area (softened with a heat gun then scraped off with a chisel).

The laboratory analysis of paint samples was by EPA method 7420, Atomic Absorption Spectroscopy by flame. Lab results were reported in percent lead by weight, and were converted to area mass based on the area of paint included in each sample.

## 2.4 CONCLUSIONS

The air lead exposure of a worker involved in outdoor removal of shingles painted with a lead-containing paint was below the detection limit of 2.5 $\mu g/m^3$. Had this level of exposure been maintained for a full 8-hour day, it would have been below the action level of 30 $\mu g/m^3$ and below the permissible exposure limit of 50 $\mu g/m^3$ in the OSHA Interim final rule on lead exposure in construction. Air lead measured in an area sample was also below the detection limit. Based on these test results, respiratory protection was not necessary to keep exposures during this work below the action level or the permissible exposure limit.

The overall lead content on the painted shingle was between 3.2% and 4.5% by weight, or between 3.19 and 4.55 $mg/cm^2$. Lead concentration was lower in the top layers of paint than in the bottom layers. If the paint on the shingles had contained more lead, or the work had been performed in an enclosed area rather than outdoors, higher airborne lead levels and higher worker exposures might have resulted.

## 3. SITE VISIT #2: DRY SCRAPING OF PLASTER COATED WITH LEAD-CONTAINING PAINT

This section describes the results of air lead monitoring performed in an apartment building where deteriorated areas of lead-containing paint on plaster walls and ceilings were being scraped prior to routine repainting. Results of laboratory testing of paint samples for lead content is also included. The work was selected as characteristic of ordinary periodic maintenance rather than lead paint "abatement."

### 3.1. DESCRIPTION OF WORK

The scraping of defective painted surfaces and associated cleanup in two rooms of this apartment unit took place in August 1993 over a working period of about 3 hours. The job site was a one-bedroom apartment in a large apartment building constructed around 1928, and located in metropolitan New York City. A floor plan for this apartment unit appears further below. The paint scraping was the first step in routine repainting of this unit between occupancies.

The bedroom and the kitchen of this apartment unit were scraped, in that order, during this monitoring project. Paint condition in these two rooms was highly variable. Most of the defective paint in the bedroom was located on one wall, while the kitchen had large areas of paint literally falling off the walls and the ceiling, apparently due to water damage from above. The paint in the kitchen was in the worst condition of any paint in the apartment.

All paint scraping was performed by two workers that regularly did paint maintenance in the apartment building. Both workers wore half-mask respirators with HEPA filters during the work periods. Polyethylene sheeting was taped in place on the floor during the scraping process. In addition, the windows were kept open for ventilation, which was necessary for worker comfort due to the hot summer weather.

The general working procedure involved testing the paint for adhesion by tapping the wall or ceiling surface with a 5-inch metal scraper similar to a putty knife. Areas where the paint was not "tight" then had the paint removed by dry scraping down to the plaster or other substrate. Areas with sound paint were left alone. A large area of painted wallpaper on one bedroom wall was pulled off at an early stage, exposing lower layers of paint that were scraped extensively, and some areas of paint in the kitchen had fallen off before work began. After the scraping was completed, debris was collected in the polyethylene sheeting as it was removed; the poly-wrapped debris was then placed in heavy-duty plastic bags for disposal. Following the work performed on this visit, standard procedures call for the walls and ceilings to be replastered to a level condition, and then repainted without further sanding or scraping.

According to the workers and the building manager, the amount of scraping and paint removal involved in the bedroom and kitchen of this particular apartment unit was greater than average for that building. Approximately 20 percent of the wall area in the bedroom and 40 - 50 percent of the wall and ceiling area in the kitchen was scraped or had paint removed; the majority of this area had plaster exposed when the work was concluded. Work time was about equally split between the

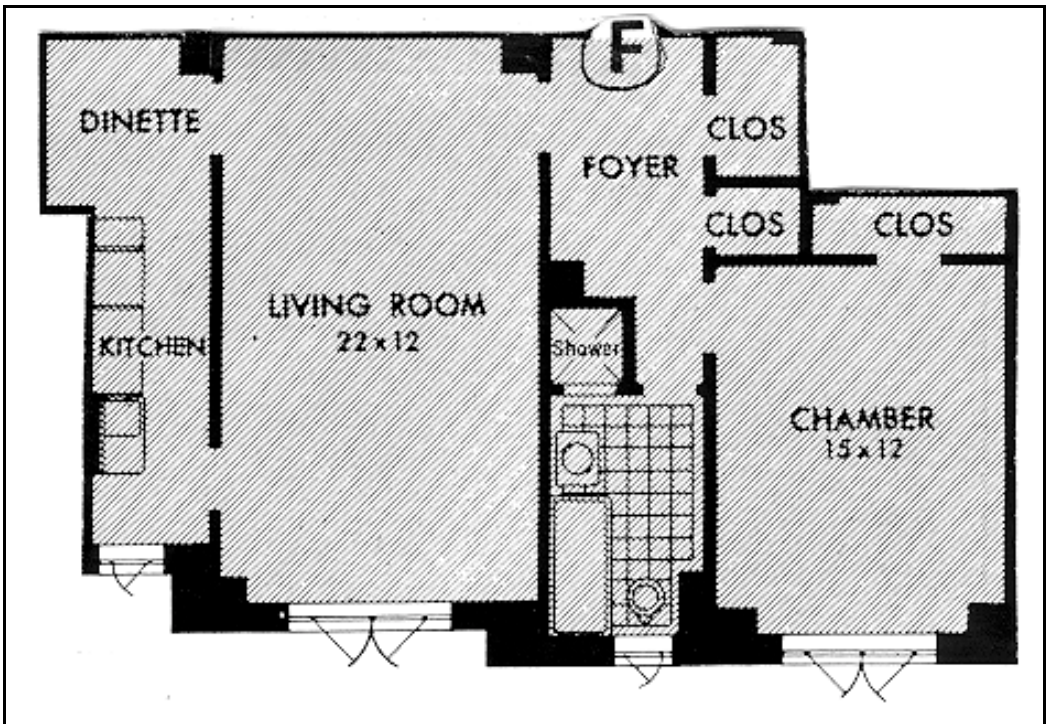
bedroom and the kitchen, with both workers performing essentially the same tasks in the same room at the same time.

Three air samples were collected with personal sampling pumps during this site visit. One air sample was collected in the "personal breathing zone" (PBZ) of each worker, and the third sample was an "area sample" taken with a pump that was moved during testing so as to remain in or immediately adjacent to the rooms being worked on. Air sampling began when the workers started laying polyethylene on the floor, and continued during the paint scraping and through clean-up. The PBZ samplers were turned off during the lunch break (about 1 hour), but the area sampler remained on from start to finish.

Several paint samples were retrieved during the site visit for subsequent laboratory analysis. Paint samples were removed from plaster in the bedroom and the kitchen, where most of the scraping took place. The bedroom sample was taken from beneath a large area of painted wallpaper (after the wallpaper was peeled off, the area underneath was scraped extensively). Other paint samples were taken from the wood trim in the bedroom and the metal radiator cover in the living room (similar in appearance to paint scraped from radiators in the bedroom and kitchen during the monitoring period). All paint samples except the one from the radiator were quite thick, and showed evidence of multiple coats of paint. All laboratory analysis was performed by Environmental Reference Laboratory Services, in Baltimore, Maryland.

A floor plan for the unit where the work was performed is below. Note that the room marked "CHAMBER" is referred to in this report as the "bedroom."

**APARTMENT UNIT FLOOR PLAN**



## 3.2 TEST RESULTS

### 3.2.1 Air Sample Results

A summary of the reported air lead concentrations is in Table 3-1.

**TABLE 3-1**
**AIR LEAD CONCENTRATIONS**

| Sample Number | Sampling Duration | Type | Description | Air Lead Concentration During Monitoring Period |
|---|---|---|---|---|
| 1. | 125 minutes | PBZ | Worker #1: set-up, paint scraping, clean-up | 10.8 µg/$m^3$ |
| 2. | 130 minutes | PBZ | Worker #2: set-up, paint scraping, clean-up | Below MDL (less than 2.5 µg/$m^3$) |
| 3. | 185 minutes | Area | Kitchen and Bedroom | Below MDL (less than 2.5 µg/$m^3$) |

Under the "Type" column the entry "PBZ" indicates a Personal Breathing Zone sample, and "Area" indicates a sample taken in the general area where the work was being performed. "MDL" refers to the NIOSH 7082 "Method Detection Limit", reported as 2.5 µg/$m^3$. For quality control purposes, an air cassette that was taken to the site but not attached to a sampling pump was also submitted to the laboratory for analysis. Results for this field blank were reported as below the MDL. Finally, note that the workers' 8-hour TWA exposures would equal the air lead concentrations in the table if the workers had remained in a similar atmosphere for a full 8 hours.

### 3.2.2 Paint Testing Results

A summary of the quantitative paint test results is in Table 3-2.

**TABLE 3-2**
**PAINT TEST RESULTS**

| Sample Number | Description | Location | Total Weight of Paint | Percent Lead by Weight | Lead Concentration per Unit Area |
|---|---|---|---|---|---|
| 1. | chips, green surface | bedroom wall, under wallpaper | 176 mg/$cm^2$ | 0.457% | 0.81 mg/$cm^2$ |
| 2. | chips, white surface | wood trim in bedroom | 250 mg/$cm^2$ | 0.257% | 0.64 mg/$cm^2$ |
| 3. | chips, black | radiator cover in living room | 118 mg/$cm^2$ | 4.851% | 5.72 mg/$cm^2$ |
| 4. | chips, brown surface | kitchen ceiling | 251 mg/$cm^2$ | 0.275% | 0.69 mg/$cm^2$ |

Samples 1 and 4 are characteristic of most of the paint that was scraped. Lesser amounts of paint on wood trim (sample 3) and on metal radiators (similar in appearance to sample 4) were also scraped.

## 3.3 SAMPLING AND ANALYTICAL PROCEDURES

### 3.3.1 Air Sampling and Analysis

Personal breathing zone (PBZ) and area air samples were collected during this survey. Cellulose ester membrane filters (0.8 µm pore size) mounted in 37 mm plastic cassette holders were attached with Tygon tubing to SKC universal flow sampling pumps (Model 224-PCXR8). Prior to the visit each pump was calibrated with an SKC Accuflow digital calibrator to a flow rate of 2.0 liters per minute. Calibration was re-checked at the site with the rotameter style flowmeter built into each sampling pump.

For the PBZ samples, one pump was mounted on each worker's belt and the filter assembly suspended from their collars within about eight inches of the mouth. The pump was placed temporarily in "hold" mode (run time and sampling suspended) during the regular lunch break, but was left running when the workers performed set-up, clean-up and retrieval of tools or equipment. Total run times for the PBZ samples were 125 minutes for worker #1 and 130 minutes for worker #2.

For the area sample, the pump was placed in or immediately adjacent to the room being worked on, and was moved when the work shifted from the bedroom to the kitchen. It was located about 2 feet above the floor, but not underneath any open window. Total run time for the area sample was 185 minutes.

The air cassettes were analyzed for lead using NIOSH method 7082, Atomic Absorption Spectroscopy by flame. Analysis was performed by Environmental Reference Laboratory Services (ERLS), a division of Maryland Medical Laboratory, Inc., located in Baltimore, Maryland.

### 3.3.2 Paint Sampling and Analysis

Paint samples for quantitative analysis were collected in the form of large flakes removed entirely from the plaster walls (2 samples), plaster ceiling (1 sample), metal radiator (1 sample) or wood trim (1 sample) of the apartment being worked on. The sample removed from the bedroom wall was taken from below a layer of painted wallpaper that remained largely intact as it was peeled off. The weight of each paint sample per unit area was measured prior to submitting the samples for laboratory analysis, generally by cutting a piece of known area from the large irregular pieces retrieved, and weighing the cut piece. This allowed conversion of lead content in percent by weight to area mass.

The laboratory analysis of paint samples was performed by ERLS, using EPA method 7420, Atomic Absorption Spectroscopy by flame. Lab results were reported in percent lead by weight, and were converted to area mass based on the previously determined overall density of the paint film per unit area.

## 3.4 CONCLUSIONS

One of two workers involved in dry scraping of painted surfaces in this 60-plus year old apartment building had a detectable exposure to airborne lead, based on a personal breathing zone sample. That worker was exposed to an air lead concentration of 10.8 $\mu g/m^3$ during a work period of just over 2 hours. The impact of shift length cannot be determined from this data, but had this level of exposure been maintained for a full 8-hour day, it would have been below the action level of 30 $\mu g/m^3$ and below the permissible exposure limit of 50 $\mu g/m^3$ in the OSHA Interim final rule on lead exposure in construction. Air lead exposure for the second worker was reported as below the NIOSH 7082 Method Detection Limit of 2.5 $\mu g/m^3$, and lead concentration in the area sample was also below the MDL. Based on these test results, respirators were not required to keep worker exposures below the PEL or the AL.

The lead content in the paint being scraped was generally moderate. A paint sample from the bedroom wall was 0.457% lead by weight, with an area lead concentration equal to 0.81 $mg/cm^2$. A paint sample from the kitchen ceiling was 0.275% lead by weight, with an area lead concentration equal to 0.69 $mg/cm^2$. A few square feet of paint containing significantly higher lead concentrations (about 4.9% by weight) were also scraped from metal radiator covers in the bedroom and kitchen. If the paint being scraped from the walls and ceiling had contained more lead, or if the windows had not been kept open due to the hot weather, higher airborne lead levels and higher worker exposures might have been observed.

## 4. SITE VISIT #3: DEMOLITION OF PLASTER WALL AND CEILING SURFACES COATED WITH LEAD-CONTAINING PAINT

This section describes the results of an air monitoring study performed at a single family home in September 1993, during demolition of plaster walls and a plaster ceiling coated with lead-containing paint. Results of laboratory testing for lead in the paint are also presented.

### 4.1 DESCRIPTION OF WORK PERFORMED

The work monitored during this study involved demolition of two walls and a ceiling and associated cleanup in this 100-year old single family home located in a northeastern U.S. town. Homes throughout the entire community are undergoing slow and systematic renovation. Varying amounts of lead had previously been detected in paint in this home through XRF testing.

The following tasks were performed during the monitoring period:

1. Demolition of a plaster wall (about 64 square feet) separating the dining room from a porch that had been converted to an entry alcove. Formerly this had been an exterior wall. The principal tools used for this task were a sawzall, a crowbar and hammers. The entry door to the alcove from outside remained open during most of this work.

2. Demolition and removal of the plaster ceiling in the kitchen (about 95 square feet), primarily by knocking holes in the plaster with a long heavy digging bar, then hooking the knob on the end of the bar through the holes and pulling down plaster in irregular sections. The kitchen windows remained closed throughout demolition of the ceiling, but the door from the kitchen to the dining room remained open, as did the windows at the far side of the dining room. The kitchen and dining room were both sealed off from the rest of the house interior with plastic sheeting prior to this work.

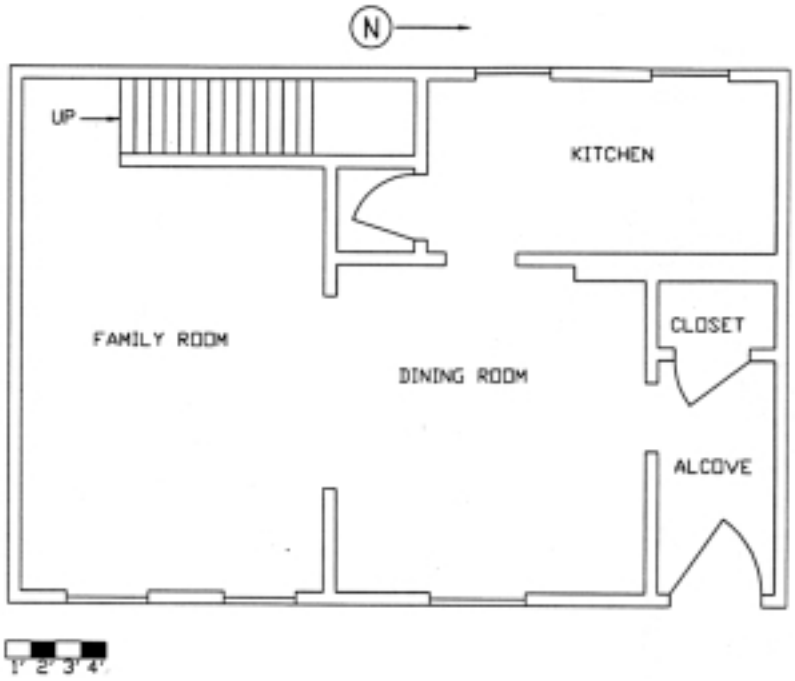
3. Demolition of the plaster wall on the west side of the kitchen (about 90 square feet), again with a crowbar and digging bar, to allow construction of a small alcove with a bay window. The kitchen windows remained closed during this work, while the windows at the far side of the dining room were open.

Most of the debris generated from the first two tasks was also removed from the house during the monitoring period.

Two workers performed all the work at this site. Worker #1 did the bulk of the demolition, spending essentially all his working time physically removing plaster from lath and lath from wood framing. Worker #2 assisted at some points in the demolition, but spent most of his time collecting the debris from the work area and carrying it to a dumpster outside. Both workers wore full-face respirators and full-body Tyvek suits throughout the work periods.

Representatives from EPA and OSHA were invited to observe the monitoring, and both were present for most of the work described in this section.

The approximate layout of the job site appears below.



## 4.2 TEST RESULTS

### 4.2.1 Air Sample Results

A summary of the reported air lead concentrations is in Table 4-1.

**TABLE 4-1**
**AIR LEAD CONCENTRATIONS**

| Sample Number | Sampling Duration | Type | Description | Air Lead Concentration During Monitoring Period |
|---|---|---|---|---|
| 1. | 21 minutes 8:31 - 8:52 | PBZ Worker #1 | Demolish wall between dining room and alcove | 4.64 µg/m$^3$ |
| 2. | 20 minutes 8:32 - 8:52 | PBZ Worker #2 | Remove debris; assist in demolition | 3.18 µg/m$^3$ |
| 3. | 22 minutes 8:34 - 8:56 | Area | Placed in dining room, beside kitchen door | 2.55 µg/m$^3$ |
| 4. | 23 minutes 8:53 - 9:16 | PBZ Worker #1 | Demolish kitchen ceiling | 547.83 µg/m$^3$ |
| 5. | 24 minutes 8:55 - 9:19 | PBZ Worker #2 | Remove debris; assist in demolition | 55.21 µg/m$^3$ |
| 6. | 57 minutes 8:57 - 9:54 | Area | Placed in dining room, beside kitchen door (includes break) | 30.70 µg/m$^3$ |
| 7. | 51 minutes 9:54 - 10:45 | PBZ Worker #1 | Demolish kitchen west wall | 63.24 µg/m$^3$ |
| 8. | 54 minutes 9:51 - 10:46 | PBZ Worker #2 | Remove debris; assist in demolition | 2.30 µg/m$^3$ |
| 9. | 53 minutes 9:55 - 10:49 | Area | Placed in dining room, beside kitchen door | 4.81 µg/m$^3$ |
| 10. | 146 minutes 10:50 - 1:16 | Area | Placed in dining room, beside kitchen door (this period includes breaks, cleanup, and limited demolition) | 1.27 µg/m$^3$ |

Type "PBZ" indicates a Personal Breathing Zone sample and Type "Area" is a sample taken from a stationary pump in the general vicinity of the work. For quality control purposes, an air cassette that was taken to the site but not attached to a pump was also submitted to the laboratory for analysis (reported sampling time 150 minutes). Results for this field blank were reported as 0.18 µg/m$^3$.

The air samples appearing in Table 4-1 can be logically grouped into four phases (indicated by double horizontal lines in the Table):

- During the first phase (samples 1-3), the plaster wall separating the dining room from the entry alcove was largely demolished, and some debris was removed.

- During the second phase (samples 4-6), the kitchen ceiling was demolished

and some debris was removed. Note that the area sampler (sample 6) was left running during the worker break that immediately followed demolition of the kitchen ceiling.

- During the third phase (samples 7-9), the west wall of the kitchen was demolished and some debris was removed.

- During the fourth phase (sample 10), only an area sample was taken. This period included the worker break that followed the third phase, about 30 minutes of alcove wall demolition and cleanup, and the lunch period.

The 8-hour TWA exposure for worker #1, based on PBZ samples 1, 4 and 7 and assuming no other exposure during the day, was 33.17 $\mu g/m^3$, above the OSHA action level of 30 $\mu g/m^3$ and below the permissible exposure limit of 50 $\mu g/m^3$. The 8-hour TWA exposure for worker #2, based on PBZ samples 2, 5 and 8 and assuming no other exposure during the day, was 3.15 $\mu g/m^3$, below the action level and the permissible exposure limit.

### 4.2.2 Paint Testing Results

Representative pieces of plaster from several surfaces were retrieved from the work site with all paint layers intact, and subsequently used to prepare paint samples for laboratory analysis. The paint was separated from the plaster samples by scraping with a chisel. Some upper layers of paint were easily removed, while other upper layers and most lower layers could not be separated without small amounts of plaster or wallpaper adhering. Layers of paint that could be readily separated from one another were submitted as separate samples. For each paint sample, the total area mass of paint was measured prior to laboratory analysis.

The home had previously been tested for lead paint by X-ray fluorescence analyzer (XRF), and a copy of that test report was provided by the property manager. Overall results for both the XRF and the laboratory testing of the various painted surfaces demolished during this work are summarized in Table 4-2. There was good agreement between the XRF and lab results for the two surfaces where both measurements were available.

## TABLE 4-2
## TOTAL PAINT LEAD CONTENT BY SURFACE

| Surface | XRF Results | Lab Results (by area) | Lab Results (by weight) |
|---|---|---|---|
| Dining room side of wall between alcove and dining room | n/a | < 0.01 mg/cm$^2$ | 0.01% |
| Alcove side of wall between alcove and dining room | 8.20 mg/cm$^2$ | 7.83 mg/cm$^2$ | 3.73% |
| Kitchen west wall - lower portion | n/a | 2.21 mg/cm$^2$ | 2.02% |
| Kitchen west wall - upper portion | 1.51 mg/cm$^2$ | n/a | n/a |
| Kitchen ceiling | 1.45 mg/cm$^2$ | 1.45 mg/cm$^2$ | 1.77% |

Although not included in Table 2, samples of the top layers of paint from the upper part of the kitchen wall (down to a layer of wallpaper) showed lead concentrations below 0.02 mg/cm$^2$ (0.04% by weight). Paint layers below the wallpaper were not retrieved or analyzed. However, the XRF result for this surface, as well as complete samples from the upper part of the kitchen wall (see Table 4-3), indicate that lead paint was present below the wallpaper.

Results of the laboratory analysis of paint samples appear in Table 4-3. Qualitative testing on individual layers with a "LeadCheck" (sodium rhodizonate) spot test kit was also performed prior to submitting samples to the lab. The paint layers that gave clear positive results for lead are indicated with a "(+)" in the column labeled "Paint Description". Results in Table 4-3 show that of the four samples containing significant amounts of lead (numbered 5, 6, 9 and 11), three consisted of a layer of dark green paint that had been applied directly on the plaster.

**TABLE 4-3**
**PAINT LEAD CONCENTRATIONS - ALL SAMPLES**

| Number | Location | Paint Description | Total Weight of Paint | Percent Lead by Weight | Lead Concentration per Unit Area |
|---|---|---|---|---|---|
| 1. | Kitchen west wall, upper left side | Upper layers: white | 53.0 mg/cm$^2$ | 0.037% | 0.02 mg/cm$^2$ |
| 2. | Kitchen west wall, upper center | Upper layers: white | 44.5 mg/cm$^2$ | 0.045% | 0.02 mg/cm$^2$ |
| 3. | Dining room side of wall between dining room and alcove | Upper layers: white | 26.7 mg/cm$^2$ | 0.006% | < 0.01 mg/cm$^2$ |
| 4. | | All layers: white, blue | 43.1 mg/cm$^2$ | 0.008% | < 0.01 mg/cm$^2$ |
| 5. | Alcove side of wall between dining room and alcove | Upper layers: off-white, light green (+) | 159.2 mg/cm$^2$ | 3.633% | 5.78 mg/cm$^2$ |
| 6. | | Lower layer(s): dark green (+) | 50.8 mg/cm$^2$ | 4.032% | 2.05 mg/cm$^2$ |
| 7. | Kitchen west wall, lower section | Top layers: white, light green | 17.3 mg/cm$^2$ | 0.052% | 0.01 mg/cm$^2$ |
| 8. | | Middle layer(s): light green | 29.1 mg/cm$^2$ | 0.083% | 0.02 mg/cm$^2$ |
| 9. | | Lower layer(s): dark green (+) | 63.0 mg/cm$^2$ | 3.459% | 2.18 mg/cm$^2$ |
| 10. | Kitchen ceiling | Upper layer(s): white | 44.3 mg/cm$^2$ | 0.067% | 0.03 mg/cm$^2$ |
| 11. | | Lower layer(s): dark green (+) | 37.6 mg/cm$^2$ | 3.785% | 1.42 mg/cm$^2$ |

### 4.2.3 Dust Testing Results

Although the principal purpose of the site visit was to measure airborne lead concentrations, three sets of side-by-side dust wipes were also taken on the surface of paneling that had been laid down on the kitchen floor prior to the start of work. One wipe from each pair was provided to an EPA observer, and one was submitted by NAHB Research Center to the laboratory that performed the remainder of the lead analysis in this study.

The objective of the dust testing was to compare dust lead levels on the floor before and after demolition and initial cleanup, and after further cleanup with a HEPA vacuum. Therefore, the first pair of samples was taken before any demolition began, the second pair was taken after demolition and dry-sweeping of debris had been completed, and the third pair was taken (by the property manager) several days later, after the floor had been HEPA vacuumed. Each sample was taken from an area measuring 10 cm by 10 cm, marked by masking tape.

Laboratory results from all three dust wipes submitted for analysis by NAHB Research Center were reported as less than the method detection limit of 10 µg/ft$^2$. These results do not indicate significant contamination of the work area by lead dust after broom cleaning.

### 4.2.4 Plaster Testing Results

Laboratory results from the air lead sampling showed high air lead levels during demolition of the kitchen ceiling, even though the paint lead concentration on the ceiling was only 1.45 mg/cm$^2$. In order to investigate this further, additional samples were prepared from the sections of plaster that had been retrieved, and submitted for lab analysis. The purpose was to determine whether the plaster itself contained significant amounts of lead that may have contributed to the air lead readings. This was considered appropriate because during the demolition process, not only was some of the plaster intentionally smashed to remove it, but pieces of plaster that fell to the floor had a clear tendency to crumble into powder or dust that became airborne.

Each piece of plaster actually consisted of two layers. The bottom (grey) layer, a cementitious material, ranged from 1.0 to 1.5 cm thick. The top (white) layer was just over 1 mm thick. All layers of paint had previously been removed from the plaster.

Four of the plaster samples included the grey bottom (cementitious) layer only. A fifth was the white (lime) layer that was located between the grey bottom layer and the applied paint films. Lead concentrations in the first four samples ranged from 0.003% to 0.007% by weight (30 ppm to 70 ppm), and lead concentration in the white top layer was 0.007% by weight (70 ppm). These results indicate that lead in the plaster probably contributed to the airborne lead readings, though accurate measurements of total airborne dust would be required to evaluate this further.

## 4.3 SAMPLING AND ANALYTICAL PROCEDURES

### 4.3.1 Air Sampling and Analysis

Both personal breathing zone (PBZ) and area air samples were collected during the site visit. Cellulose ester membrane filters (0.8 µm pore size) mounted in 37 mm plastic cassette holders were attached with Tygon tubing to SKC universal flow sampling pumps (Model 224-PCXR8). Prior to the visit each pump was calibrated with an SKC Accuflow digital calibrator to a flow rate of 2.0 liters per minute. Calibration was re-checked at the site with the rotameter style flowmeter in each sampling pump.

For the PBZ samples, a pump was mounted on the belt of each worker, then the air cassette was inserted into a plastic carrier and clipped near the worker's collar, within about eight inches of the mouth. For the area samples, the pump was clipped to an exposed piece of wood lath, about five feet off the ground, on a section of dining room wall adjacent to the kitchen door.

All air cassettes were analyzed for lead by Environmental Reference Laboratory Services (ERLS), a division of Maryland Medical Laboratory, Inc., using NIOSH method 7105, Atomic Absorption Spectroscopy by graphite furnace.

### 4.3.2 Paint Sampling and Analysis

Paint samples for quantitative analysis were prepared from samples of plaster with the paint intact, retrieved from various locations during the site visit. Paint was generally removed from plaster substrate by scraping with a wood chisel. Upper and lower layers were separated where possible. The weight of each paint sample per unit area was measured prior to submitting the samples for laboratory analysis, either by weighing the entire sample where the total area was known, or, for irregular paint chips, by trimming one or more large pieces to a rectangular shape, then measuring the area and weight of the trimmed pieces.

The laboratory analysis of paint samples was performed by ERLS using EPA method 7420, Atomic Absorption Spectroscopy by flame. Lab results were reported in percent lead by weight, and were converted to area mass based on the measured area included in the sample or the previously determined overall density of the paint film per unit area.

### 4.3.3 Dust Sampling and Analysis

Dust samples were all taken from the kitchen floor, on areas measuring 10 cm x 10 cm (15.5 square inches), using a commercial pre-packaged "wet-nap" and sample container provided for this purpose by ERLS. The wet-nap was wiped across the floor in an "S" pattern over the sample area, then folded once and wiped back across the same area in an "S" pattern perpendicular to the first pass, then folded again and placed in the container for shipment to the lab. Samples were analyzed for lead by ERLS, using EPA method 7420, Atomic Absorption Spectroscopy by flame.

### 4.3.4 Plaster Sampling and Analysis

Plaster samples were prepared with all surface paint removed. Samples 1-4 included only the grey cementitious layer, while sample 5 included only the white lime layer. The layers were separated manually by scraping with a chisel. All samples were thoroughly powdered before submitting to the laboratory. Samples were analyzed for lead by ERLS, using EPA method 7420, Atomic Absorption Spectroscopy by flame.

## 4.4 CONCLUSIONS

Air monitoring results indicate that high concentrations of airborne lead were present during demolition of a plaster ceiling covered with lead-based paint (paint lead concentration 1.45 $mg/cm^2$, or about 1.8% by weight), when performed with the windows closed in a room with a floor area of about 100 square feet. Peak airborne lead exposure for one worker during this activity was 548 $\mu g/m^3$ over a 23-minute period. Peak exposure for a second worker was 55 $\mu g/m^3$ over a 24-minute period.

Demolition of plaster walls in the same room under similar conditions produced lower but still significant peak airborne lead exposure of 63 $\mu g/m^3$ over a 51-minute period, while demolition of plaster walls containing even greater amounts of lead in the paint (but located next to an open exterior door) produced much lower airborne lead exposures of about 2.3 - 4.8 $\mu g/m^3$.

Airborne lead levels dropped rapidly after completion of the demolition work. For the 2.5 hour period following completion of the kitchen demolition, airborne lead in the work area averaged about only 1.3 $\mu g/m^3$.

The 8-hour TWA exposure to airborne lead for worker #1 (whose measured exposure was the highest) was over 30 $\mu g/m^3$, while the 8-hour TWA for worker #2 was about one-tenth as high. These TWAs assume no lead exposure outside the work periods monitored. Respiratory protection and protective clothing was used here, and should be used in similar situations. Positive ventilation of the work area (which was not used here) could also help to reduce worker exposure.

Dust wipes indicated low dust lead on the floor both before work commenced and after dry sweeping. Laboratory testing indicated that lead was present in small amounts in the plaster itself, which may have contributed to the airborne lead levels during demolition.

## 5. SITE VISIT #4: REMOVAL AND REPLACEMENT OF WINDOWS COATED WITH LEAD-CONTAINING PAINT

This section describes the results of an air monitoring study performed at a single family home during removal and replacement of wood windows coated with lead-containing paint, and the results of laboratory analysis of the paint for lead content.

### 5.1 DESCRIPTION OF WORK PERFORMED

The work monitored during this study involved removal and replacement of a total of ten wood windows in an early-19th century home located in a northeastern U.S. town. The windows were single-hung, single pane site-built units; approximately half of the windows had what appeared to be original sash mounted in the frame, while the other half had a newer style of sash. Based on the window construction details, type of nails used and estimated age of the structure, the contractor estimated the windows to be at least 175 years old. There was no evidence to suggest that any of the window frames (as opposed to the sash) had been replaced since the home was originally built.

Air samples were taken for the three workers who performed all the work of removing the windows during the monitoring period, which extended for virtually the entire working day. Most of their working time was spent outside the building; slightly more than half of their time was spent removing the old windows and trim boards, and the remainder installing the new windows (and a small amount of insulated sheathing). The work generally alternated between removing old windows and installing the new ones. At least 75% of removal and installation work was performed from outside the house, although some work from inside was necessary to remove the window casings. A fourth worker (whose breathing air was not sampled) spent most of the day outside cutting new framing for mounting the new window units in the old openings. There was a light wind at the site for most of the day, and no precipitation.

A photograph showing the house, including most of the ten windows that were replaced, is below.

## 5.2 TEST RESULTS

### 5.2.1 Air Sample Results

A summary of the reported air lead concentrations is in Table 1. The approximate times when the sampling began and the cassette was finally removed are given, but actual run times (in minutes) were taken from the timer in each pump, and are typically somewhat lower because the pump was placed on "hold" while the workers took breaks or (in one case) left the job site temporarily. The first set of samples were taken in the morning, then sampling was stopped and the filters were changed during the lunch break, and new filters were used for sampling in the afternoon. Sample #5 was terminated after 32 minutes when worker #2 left the job early in the afternoon.

**TABLE 5-1**
**AIR LEAD CONCENTRATIONS**

| Sample Number | Sampling Duration | Worker # | Description | Air Lead Concentration During Monitoring Period |
|---|---|---|---|---|
| 1. | 240 minutes 8:03 - 12:30 | Worker #1 | Remove old windows; install new windows Inside and outside work | 12 µg/m$^3$ |
| 2. | 260 minutes 8:08 - 12:30 | Worker #2 | Remove old windows; install new windows Inside and outside work | 15 µg/m$^3$ |
| 3. | 241 minutes 8:30 - 12:30 | Worker #3 | Remove old windows; install new windows Primarily inside work | 15 µg/m$^3$ |
| 4. | 216 minutes 1:02 - 4:45 | Worker #1 | Remove old windows; install new windows Inside and outside work | 12 µg/m$^3$ |
| 5. | 32 minutes 1:02 - 2:02 | Worker #2 | Remove old windows; install new windows Inside and outside work | 20 µg/m$^3$ |
| 6. | 210 minutes 1:02 - 4:35 | Worker #3 | Remove old windows; install new windows Inside and outside work | 11 µg/m$^3$ |
| 7. | 150 minutes 2:38 - 5:10 | n/a | Area monitor; placed near street, upwind from work site | 6 µg/m$^3$ |

Note that samples #1 to #6 were taken from the personal breathing zones of the workers, while sample #7, was taken at a location about ten feet from the street (30 feet from the front of the house), generally upwind of the job site, to learn about the "background" lead level in the outdoor atmosphere. For quality control purposes, an air cassette that was taken to the site but not attached to a pump was also submitted to the laboratory for analysis (reported sampling time 150 minutes). Results for this field blank were reported as below the NIOSH 7082 method detection limit of 2.5 µg/m$^3$.

The 8-hour TWA exposure for worker #1, based on samples 1 and 4 and assuming no other exposure during the day, was 11.4 µg/m$^3$. The 8-hour TWA exposure for worker #2, based on samples 2 and 5 and assuming no other exposure during the day, was 9.5 µg/m$^3$. The 8-hour TWA exposure for worker #3, based on samples 3 and 6 and assuming no other exposure during

the day, was 12.3 µg/$m^3$. These levels indicate that respirators were not required to keep exposures below the OSHA action level.

### 5.2.2 Paint Testing Results

Representative pieces of painted woodwork from various window surfaces were retrieved from the work site with all paint layers intact, and subsequently used to prepare paint samples for laboratory analysis. The paint was separated from the wood by scraping with a chisel; in some cases the paint was softened first with a heat gun to facilitate removal. A few layers of paint were cleanly removed, but others had small amounts of wood substrate that could not be completely separated. Layers of paint that could be readily separated from one another were submitted as separate samples. For each paint sample, the total area mass of paint was determined prior to laboratory analysis and subsequently used to convert laboratory results (percent lead by weight) to mass of lead per unit area (mg/$cm^2$), as presented in Table 5-2.

**TABLE 5-2**
**PAINT LEAD CONCENTRATIONS - ALL SAMPLES**

| Number | Location | Paint Description | Total Weight of Paint | Percent Lead by Weight | Lead Concentration per Unit Area |
|---|---|---|---|---|---|
| 1. | Exterior trim board - vertical | white | 156.2 mg/$cm^2$ | 36.288% | 56.7 mg/$cm^2$ |
| 2. | Top layer interior trim | off-white | 5.1 mg/$cm^2$ | 15.250% | 0.8 mg/$cm^2$ |
| 3. | Lower layer interior trim | light green | 37.5 mg/$cm^2$ | 47.029% | 17.6 mg/$cm^2$ |
| 2 + 3 | INTERIOR TRIM ALL LAYERS | n/a | 42.6 mg/$cm^2$ | 43.2% | 18.4 mg/$cm^2$ |
| 4. | Interior window bottom ledge | light green | 9.0 mg/$cm^2$ | 0.520% | 0.05 mg/$cm^2$ |
| 5. | Horizontal piece of window frame | white | 281.2 mg/$cm^2$ | 34.027% | 95.7 mg/$cm^2$ |
| 6. | Outside front edge of window frame | white | 197.5 mg/$cm^2$ | 37.788% | 74.6 mg/$cm^2$ |
| 7. | Exterior trim board - horizontal | white | 188.6 mg/$cm^2$ | 31.771% | 59.9 mg/$cm^2$ |
| 8. | Top of window frame, interior | blue-green | 29.0 mg/$cm^2$ | 33.804% | 9.8 mg/$cm^2$ |
| 9. | New-style sash outside surface | white | 19.4 mg/$cm^2$ | 0.161% | 0.03 mg/$cm^2$ |
| 10. | New-style sash inside surface | white | 14.9 mg/$cm^2$ | 0.114% | 0.02 mg/$cm^2$ |
| 11. | Old-style sash inside surface | blue-grey | 23.9 mg/$cm^2$ | 46.291% | 11.1 mg/$cm^2$ |
| 12. | Old-style sash outside surface | white | 115.1 mg/$cm^2$ | 16.489% | 19.0 mg/$cm^2$ |

The entry numbered "2 + 3" gives the overall results for both paint layers on the interior trim board, based on lab results for samples 2 and 3. Samples 5 and 6 were taken from the same piece of wood, with sample 5 removed from the horizontal portion of the sill (where the sash rests), and sample 6 from the vertical front edge of the sill. The paint appeared the same in both cases.

Paint lead content was very high for most surfaces, with the white paint on the window frames and exterior trim (samples 1, 5, 6 and 7) having lead levels from about 32% to 38% by weight, and corresponding area concentrations of 56 mg/cm$^2$ to 96 mg/cm$^2$. Concentrations by weight on the interior surfaces were as high as 47%, but area concentrations were lower due to thinner films. Area concentrations on the old-style sash were 11 mg/cm$^2$ (interior) and 19 mg/cm$^2$ (exterior). The lowest readings (less than 0.2% by weight) were for paint on the inside and outside of the newer style sash, indicating that they were of much more recent origin than the original window frames and sash.

## 5.3 SAMPLING AND ANALYTICAL PROCEDURES

### 5.3.1 Air Sampling and Analysis

All air samples were collected on cellulose ester membrane filters (0.8 µm pore size) mounted in 37 mm plastic cassette holders, attached with Tygon tubing to SKC universal flow sampling pumps (Model 224-PCXR8). Prior to the visit each pump was calibrated with an SKC Accuflow digital calibrator to a flow rate of 2.0 liters per minute. Calibration was re-checked at the site with the rotameter style flowmeter built into each sampling pump.

For the PBZ samples (1 through 6), a pump was mounted on the belt of each worker, then the air cassette was inserted into a plastic carrier and clipped near the worker's collar, within about eight to ten inches of the mouth. For the area sample (#7), the cassette holder was mounted from a steel guy wire about five feet above the ground and ten feet from the edge of the road.

All air cassettes were analyzed for lead by Environmental Reference Laboratory Services (ERLS), a division of Maryland Medical Laboratory, Inc., using NIOSH method 7082, Atomic Absorption Spectroscopy by flame.

### 5.3.2 Paint Sampling and Analysis

Paint samples for quantitative analysis were prepared from painted wood samples retrieved during the site visit. Paint was generally removed from plaster substrate by scraping with a wood chisel; upper and lower layers were separated where possible. The weight of each paint sample per unit area was measured prior to submitting the samples for laboratory analysis, either by weighing the entire sample where the total area was known, or, for irregular paint chips, by trimming one or more large pieces to a rectangular shape, then measuring the area and weight of the trimmed pieces.

The laboratory analysis of paint samples was performed by ERLS, using EPA method 7420, Atomic Absorption Spectroscopy by flame. Lab results were reported in percent lead by weight, and were converted to area mass based on the measured area included in the sample or the previously measured overall density of the paint film per unit area.

## 5.4 CONCLUSIONS

Three workers working outside and inside an early 19th century house to remove a total of ten

windows and window trim containing very high levels of lead, and install new windows, were exposed to 8-hour TWA airborne lead concentrations ranging from 9.5 µg/$m^3$ to 12.3 µg/$m^3$, well below the OSHA "action level" of 30 µg/$m^3$ under the OSHA interim final rule for lead exposure in construction.

# 6. SITE VISIT #5: OUTDOOR SCRAPING AND SANDING OF WINDOWS COATED WITH LEAD-CONTAINING PAINT

This section describes the results of an air monitoring study performed at a single family home in December 1994, during outdoor manual scraping and sanding of wood window sash and frames coated with lead-containing paint. The work was intended to be typical of the kind of surface preparation that would be performed prior to repainting wood windows.

## 6.1 DESCRIPTION OF WORK PERFORMED

The work monitored during this site visit involved hand scraping and hand sanding of a total of five wood windows in a 1954 home located in an eastern U.S. metropolitan area. The windows were all double-hung, single pane units that appeared to date back to the original construction. Four of the windows were 2'8" x 4'8" in size; the fifth was 2'8" x 3'6". Paint was very similar on all windows, with only minor signs of spot repainting. The window sills, sash and exterior trim boards all were scraped and sanded as required to remove unsound paint and prepare a suitable surface for repainting.

Personal breathing zone air samples were collected for the worker who performed all the sanding and scraping; two background readings were also collected approximately 60 feet east and 100 feet west of the work site. All work was performed outdoors. Total working time was slightly less than 4-1/2 hours, with the time approximately evenly divided between scraping and sanding. Scraping was performed using two hand scrapers, one with a 2" blade and another with a 1/2" blade, as required to remove loose and peeling paint. Sanding was done to smooth the entire surface and to remove defective areas of paint down to the bare wood, using coarse (60 grit) and medium (100 grit) sandpaper. Condition of the paint on the windows ranged from fair to very poor. Sections of paint on each window were cracked or flaking, particularly on the sills and lower part of the sash. All scraping and sanding was performed dry. Polyethylene sheeting was placed on the ground to facilitate cleanup. The weather was unseasonably warm, sunny and dry with only a light breeze throughout the work period.

Before and after photographs of two of the windows used in this study are reproduced below.

**BEFORE** **AFTER**

**BEFORE** **AFTER**

## 6.2 TEST RESULTS

### 6.2.1 Air Sample Results

A summary of the reported air lead concentrations is in Table 6-1. The approximate times when the sampling began and the filter cassette was finally removed are given, but actual run times (in minutes) were taken from the timer in each pump. Sampling duration is less than elap[sed time for the personal samples because the pump was placed on "hold" whenever work was interrupted. One personal air sample was taken primarily in the morning and the second was taken in the afternoon. Both area samplers were turned on at the start of work and left running continuously through the day.

**TABLE 6-1**
**AIR LEAD CONCENTRATIONS**

| Sample Number | Sampling Duration | Sample Type | Description | Air Lead Concentration During Monitoring Period |
|---|---|---|---|---|
| 1. | 105 minutes 10:40a - 1:00p | Personal Breathing Zone | Hand scrape and hand sand frame and sash of first two windows | 6.78 µg/m$^3$ |
| 2. | 156 minutes 2:00p - 5:08p | Personal Breathing Zone | Hand scrape and hand sand frame and sash of last three windows | 8.75 µg/m$^3$ |
| 3. | 394 minutes 10:35a - 5:10p | Area | Located approximately 100 feet west of the work site | 0.11 µg/m$^3$ |
| 4. | 394 minutes 10:37a - 5:11p | Area | Located approximately 60 feet east of the work site | 0.04 µg/m$^3$ |

For quality control purposes, just prior to starting sample #2 the worker also uncapped and recapped a new air cassette without attaching it to a pump. This "field blank" was submitted to the laboratory for analysis along with the other four filter cassettes. The reported result of about 0.9 µg lead was unexpectedly high compared to both the area samples and previous tests of unused air cassettes. It is possible that lead dust on the worker's hands was accidentally introduced into the field blank during the process of removing and replacing the caps. If so, this may have artificially raised the second personal breathing zone sample (sample #2 above) as well.

Based on the reported air lead concentrations, no respiratory protection or special clothing was required to keep exposures for this work below the 30 µg/m$^3$ action level under the OSHA standard, and none would be required for similar exposure throughout an 8-hour working day. Any possible contamination in the field as noted above would not affect this conclusion.

### 6.2.2 Paint Testing Results

Three paint samples were taken. Sample 1 was collected prior to the day work was performed, while samples 2 and 3 were taken on the day of the work. The procedure for each sample was the

same. Paint flakes were manually removed from window surfaces (generally the window sill). The flakes included all paint layers down to the bare wood. The weight per unit area was estimated for each sample by cutting larger flakes to approximately rectangular shape, then measuring the area and weight. The following table gives lead content as percent by weight and mass per unit area.

**TABLE 6-2**
**PAINT LEAD CONCENTRATIONS - ALL SAMPLES**

| Number | Location | Paint Sample Description | Total Weight of Paint | Percent Lead by Weight | Lead Concentration per Unit Area |
|---|---|---|---|---|---|
| 1. | Outdoor sill of kitchen window | white flakes | 46.0 mg/cm$^2$ | 3.5% | 1.61 mg/cm$^2$ |
| 2. | Outdoor sill of living room east window | white flakes | 55.7 mg/cm$^2$ | 4.3% | 2.39 mg/cm$^2$ |
| 3. | Outdoor sill of living room southeast window | white flakes | 43.0 mg/cm$^2$ | 4.3% | 1.85 mg/cm$^2$ |

Based on these three samples the lead content of the paint on these windows averaged about 4.0% by weight, and 1.95 mg/cm$^2$.

## 6.3 SAMPLING AND ANALYTICAL PROCEDURES

### 6.3.1 Air Sampling and Analysis

All air samples were collected on cellulose ester membrane filters (0.8 µm pore size) mounted in 37 mm plastic cassette holders, attached with Tygon tubing to SKC universal flow sampling pumps (Model 224-PCXR8). Prior to the visit each pump was calibrated with an SKC Accuflow digital calibrator to a flow rate of 2.0 liters per minute. Calibration was verified at the site with the rotameter style flowmeter in each sampling pump. Calibration was checked once again with the Accuflow calibrator after the sampling was completed, and the averages of the before and after readings (which ranged from 1.96 to 2.04 liters per minute) were reported to the laboratory with the appropriate air samples.

For the PBZ samples (#1 and #2), the pump was mounted on the worker's belt, then the air cassette was inserted into a plastic carrier and clipped near the worker's collar, within about eight to ten inches of the mouth. For the area samples (#3 and #4), one pump was placed in each side yard about 3 to 4 feet above the ground, so as to allow good air flow to the filter.

All air cassettes were analyzed for lead by DeYor MetPath Laboratories, Youngstown Ohio, using NIOSH method 7105, Atomic Absorption Spectroscopy by graphite furnace.

### 6.3.2 Paint Sampling and Analysis

Paint samples for quantitative analysis were retrieved as flakes from painted surfaces during the site visit. The flakes included all paint layers down to the wood substrate, so there were no problems

with substrate removal. Weight per unit area was estimated by cutting larger flakes to rectangular shape, then measuring linear dimensions and total weight.

The laboratory analysis of paint sample #1 was performed by Environmental Reference Laboratory Services, a division of Maryland Medical Laboratory. Paint samples #2 and #3 were analyzed by DeYor MetPath Laboratories. All 3 samples were analyzed using atomic absorption spectroscopy by flame. Lab results were reported in percent lead by weight, and were converted to area mass based on the previously determined overall density of the paint film per unit area.

## 6.4 CONCLUSIONS

A worker performing outdoor dry scraping and dry sanding of windows coated with lead-based paint in preparation for repainting was exposed to airborne lead concentrations of about 6.8 to 8.8 $\mu g/m^3$, well below the 30 $\mu g/m^3$ "action level" under the OSHA Interim Final Rule for Lead in Construction. Lead content of the paint averaged 4.0% by weight, or 1.95 $mg/cm^2$.