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QUALITY ASSURANCE PROJECT PLAN FOR CHARACTERIZATION OF DUST LEAD LEVELS AFTER RENOVATION, REPAIR, AND PAINTING ACTIVITIES

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Version #1

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Glossary of Terms
for the
Field Study to Characterize Dust Lead Levels After Renovation, Repair, and Painting

Baseline Cleaning – This is representative of standard cleaning practices currently used by RRP contractors. This includes sweeping and vacuuming with a non-HEPA vacuum.

Child-Occupied Facility (COF) – a building, or portion of a building, constructed before 1978 that could be used by children under six years old, such as a daycare center or early year kindergarten at a school, and could conceivably meet the formal definition of 40 CFR part 745.223.

Experiment – full implementation of a single phase of one job, including all work, cleaning, and environmental sampling.

Housing Unit – a structure or portion of a structure that is typically occupied by one or more persons as living quarters.

Job – a specific renovation, repair, or painting activity that is of interest for the risk assessment and economic cost-benefit analysis, such as installing a new window.

Lead-based paint – paint or other coating with lead content at or above 1.0 mg/cm^2 or at or above 0.5% by weight (5,000 $\mu g/g$).

Level or Intensity-level – one of three categories of jobs (low, medium, or high), determined by the amount of dust expected to be generated by the activity.

Phase – one of four iterations of a job specified by the use or non-use of containment and a particular cleaning method (plastic sheeting with specialized cleaning, plastic sheeting with baseline cleaning, no plastic sheeting with specialized cleaning, and no plastic sheeting with baseline cleaning), each implemented under comparable conditions so the effect of each of these iterations (or scenarios or routines) can be assessed.

Replicate – a repetition of a specific job, including all 4 phases or iterations associated with the job (e.g., a 2nd set of gutting a kitchen).

RRP – an acronym that stands for Renovation, Repair, and Painting.

Sites - housing units or COFs participating in the study by undergoing one or more experiments.

Specialized Cleaning – Cleaning required by the EPA Proposed Rule for Renovation, Repair, and Painting.

Stage (of Sampling) – the four different points of time within an experiment at which environmental samples are collected (after completion of the RRP job, after completion of cleaning, after completion of the last wet cloth in the cleaning verification, and after completion of the last dry cloth in the cleaning verification).

Study Location – a city or other geographic area participating in the study through identification and participation of housing units and COFs.

Work Area – the location within the work room or on the exterior perimeter where the actual RRP work will be performed. Note that the interior work area can cross the boundaries of the work room, i.e. if a window is being replaced from the inside, the work area may include portions of the exterior.

Work Room – the room in the housing unit or COF where the RRP work is to be performed.

1.0 PROJECT MANAGEMENT

1.1 DISTRIBUTION LIST

Individuals who will receive copies of the approved Quality Assurance Project Plan (QAPP) and any subsequent revisions are listed in Table 1-1. Each individual's role on the project and the organization to which he/she belongs are also provided.

Table 1-1. Distribution List for QAPP

Individual	Organization	Project Responsibility/Role
Sineta Wooten	U.S. EPA / OPPT	EPA Project Officer
Barbara Leczynski	U.S. EPA / OPPT	EPA/OPPT QA Manager
John Schwemberger	U.S. EPA / OPPT	Work Assignment Manager (WAM)
Samuel Brown	U.S. EPA / OPPT	Deputy WAM
Bruce Buxton	Battelle	Project Manager
Zachary Willenberg	Battelle	QA Manager
Tim Pivetz	Battelle	Principal Investigator
Warren Strauss	Battelle	Technical Advisor
Ian MacGregor	Battelle	Field Operations Coordinator
Jack Anderson	Healthy Housing Solutions	Site Supervisor - VA/MD
Brad Goodwin	Battelle	Site Supervisor - Columbus
Darrell Joseph	Battelle	Site Supervisor - Pittsburgh

1.2 PROJECT/TASK ORGANIZATION

Tim Pivetz will have overall responsibility for this study. Mr. Pivetz will be assisted on this project by Mr. Warren Strauss, who will provide overall technical guidance and specific guidance on study design and data analysis; Mr. Zachary Willenberg, who will serve as the Battelle Quality Assurance (QA) Manager; and Dr. Bruce Buxton, who will provide technical guidance and management oversight. Mr. Ian MacGregor will serve as the overall Field Operations Coordinator for all field work. Multiple organizations will implement field operations including qualified renovation and remodeling contractors, who will perform renovation and clean-up activities; certified lead inspectors and XRF technicians, who will test housing for presence of lead based paint and lead hazards; specialized cleaning contractors, who will clean participating housing units prior to, between, and after jobs to remove lead hazards;

and local officials or Battelle, who will conduct environmental sampling activities. These firms will either report directly to Battelle or to the appropriate organization coordinating field operations in that location. Field Supervisors for the individual cities involved include Mr. Jack Anderson of Healthy Housing Solutions for potential sites in Virginia; Mr. Brad Goodwin of Battelle for Columbus, Ohio; and Mr. Darrell Joseph of Battelle for Pittsburgh, Pennsylvania. Matthew D. Asbury of Schneider Laboratories, Inc. will serve as the Laboratory Manager. John Schwemberger of EPA is the Work Assignment Manager (WAM), and Samuel Brown of EPA is the Deputy WAM. Sineta Wooten of EPA is the Project Officer. Barbara Leczynski is the EPA QA Manager. Figure 1-1 displays the organizational relationship between these individuals.

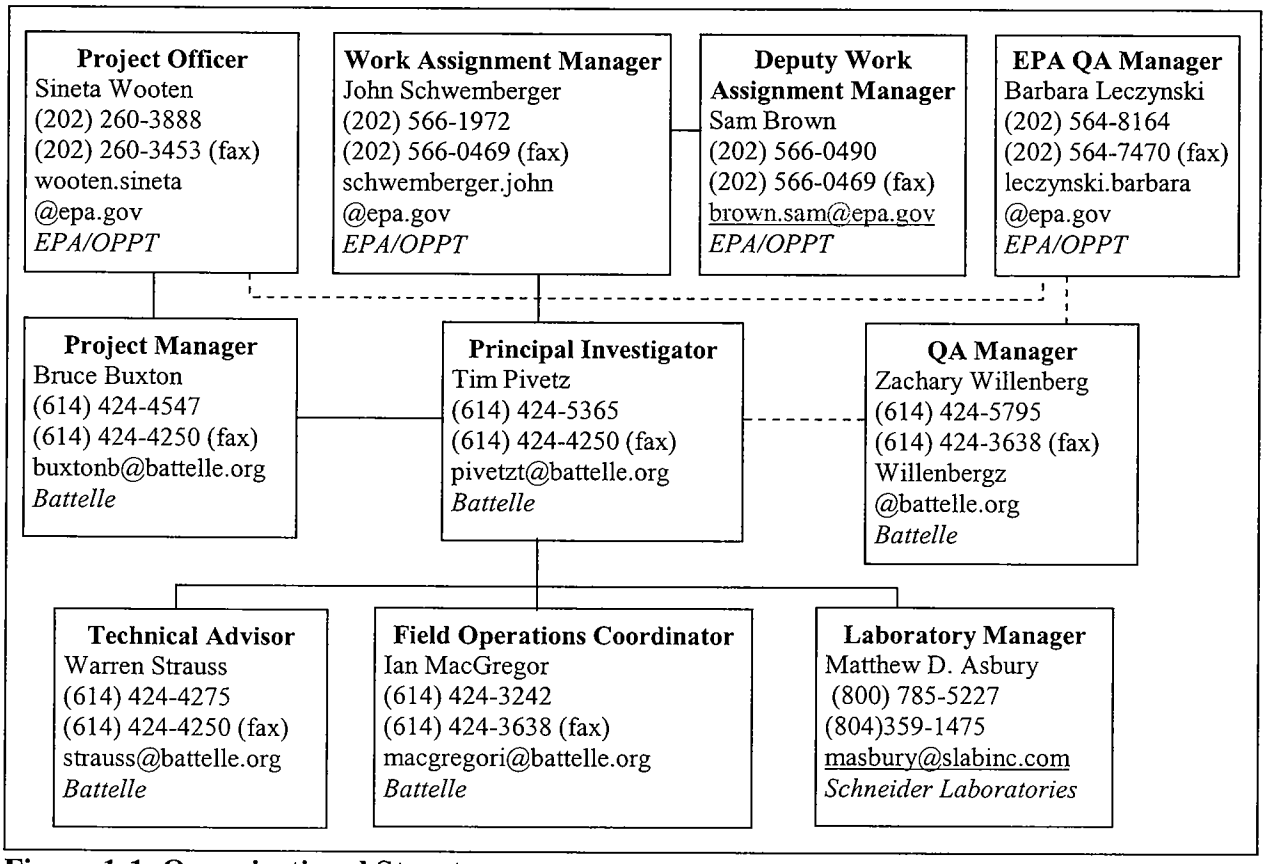


Figure 1-1. Organizational Structure

1.3 PROBLEM DEFINITION/BACKGROUND

EPA's proposed rule for Renovation, Repair, and Painting (RRP) of pre-1978 housing units with lead based paint was published in the Federal Register on January 10, 2006 (see Appendix B). The summary of the proposed rule included in the Federal Register stated, "EPA is proposing

new requirements to reduce exposure to lead hazards created by renovation, repair, and painting activities that disturb lead-based paint. This action supports the attainment of the Federal government's goal of eliminating childhood lead poisoning by 2010. The proposal would establish requirements for training renovators and dust sampling technicians; certifying renovators, dust sampling technicians, and renovation firms; accrediting providers of renovation and dust sampling technician training; and for renovation work practices. These requirements would apply in ''target housing,'' defined in section 401 of the Toxic Substances Control Act (TSCA) as any housing constructed before 1978, except housing for the elderly or persons with disabilities (unless any child under age 6 resides or is expected to reside in such housing) or any 0-bedroom dwelling. Initially the rule would apply to all renovations for compensation performed in target housing where a child with an increased blood lead level resides, rental target housing built before 1960 and owner-occupied target housing built before 1960, unless, with respect to owner-occupied target housing, the person performing the renovation obtains a statement signed by the owner-occupant that the renovation will occur in the owner's residence and that no child under age 6 resides there. EPA is proposing to phase in the applicability of this proposal to all rental target housing and owner-occupied target housing built in the years 1960 through 1977 where a child under age 6 resides. This proposal is issued under the authority of TSCA section 402(c) (3). EPA is also proposing to allow interested States, Territories, and Indian Tribes the opportunity to apply for and receive authorization to administer and enforce all of the elements of the new renovation provisions."

In order to adequately complete a risk assessment and a cost-benefit analysis of the proposed rule, a characterization of dust lead levels during appropriate stages of RRP activities via a small scale field study will be conducted. The first stage of the project entails identifying and screening possible sites – vacant housing at which children could reside and vacant child-occupied facilities (COFs) – where the study can be conducted. This stage is discussed separately in the QAPP titled "QAPP for Selecting Sites for Characterization of Dust Lead Levels After Renovation, Repair, and Painting Activities." The completion of the field data collection, laboratory analysis, and data analysis and reporting is covered by this QAPP. The study will investigate the comparative impact on dust lead levels from (1) using plastic coverings during RRP work, (2) using a more extensive clean-up routine than what is typically conducted, and (3) conducting cleaning verification as specified in the rule. After an interior RRP job is completed by actual renovation and remodeling contractors, field technicians will collect dust-wipe samples from floor and window sill surfaces. The samples will be collected before and after cleaning activities, which also will be conducted by the renovation contractors. Technicians will also collect air samples throughout the study and analyze them for lead content. Interior jobs will also include post-experiment hallway dust-wipe samples, pre- and post-experiment exterior soil samples, and an exterior dust-wipe sample following any window replacement jobs. For exterior jobs, dust-wipe samples will be collected above, underneath, and outside of plastic sheeting. Pre- and post-experiment soil samples will also be collected.

Analysis of sample results will assess the impact of the proposed techniques for reducing lead levels of the dust left behind from RRP activities.

1.4 PROJECT/TASK DESCRIPTION

This project will be conducted to characterize the dust lead levels after Low, Medium, and High RRP jobs in housing units and COFs with lead-based paint. Both interior and exterior jobs will be considered. Interior jobs will be defined as taking place in a primary "work" room in the unit or building. The targeted room layout is three sequentially adjacent rooms on a single level so that the room adjacent to the work room may be used for observation and a third, unused room may be used to help characterize the spread of lead dust to the rest of the unit or COF. In COFs with a very large room, distances may be used in place of rooms to designate the observation "rooms." Exterior jobs will involve work taking place on a single side of the building, and will require sufficient space in the yard to lay down plastic in accordance with the rule and beyond to protect areas from the spread of leaded dust.

Although an exact number of units to be enrolled is not decided, for design purposes we assume that the targeted amount of work of 60 total interior experiments and 15 total exterior experiments can be completed within a pool of 39 units (36 housing units and 3 COFs). The study will assign each unit or building a high, medium, or low RRP activity in such a way that there are four sets of high, medium, and low activities among the 12 housing units and one set of high, medium, and low for the three COFs. It is possible that a housing unit or building may be able to serve as both an interior and exterior site, as long as the areas to undergo work will not lead to cross-contamination. Current plans require field work to begin in August 2006 and be completed by October 2006 so that a draft full study report can be completed by December 2006.

The study is being designed to compare environmental lead levels at appropriate stages after low, medium, and high RRP activities on the interior and exterior of residential housing units and COFs. Of specific interest is the impact of the use of plastic coverings and the proposed rule cleaning method on lead levels. (Excerpts from the proposed rule regarding the containment and cleaning procedures are included in Appendix B.) The study design will collect data to evaluate the following six study objectives.

1. What is the effect of low, medium, and high level RRP work on post-work, post-cleaning, and post-verification dust lead levels (interior and exterior)?
2. Are there significant differences in lead levels at the post-cleaning and/or post-verification phases from the use of heavy-duty polyethylene plastic sheeting during the work activity? Is there an interaction between level of RRP work and the use of plastic?
3. Are there significant differences in post-cleaning and/or post-verification lead levels between surfaces cleaned with the proposed rule cleaning method and surfaces cleaned

with baseline cleaning methods? Is there an interaction between level of RRP work and cleaning method used?

4. Are there differences in the amount of lead dust migration from the work room to adjacent rooms between different levels of RRP work, use and non-use of plastic, and use and non-use of proposed rule cleaning methods?
5. Does the use of plastic ground coverings during exterior work reduce the amount of dust lead falling onto the ground?
6. Are there significant differences in the lead levels remaining after the two steps of the cleaning verification, i.e., the wet cloth step and the dry cloth step?

For each interior work level, the study will evaluate four work area protection/clean-up routines or phases –combinations of (1) use of plastic coverings/no use of plastic coverings and (2) baseline cleaning after work completion/cleaning per the proposed rule after work completion. Thus, the four protection/clean-up (P/CU) phases are:

1) Use of plastic coverings and cleaning per the proposed rule after work completion
2) Use of plastic coverings and baseline cleaning after work completion
3) No plastic coverings and cleaning per the proposed rule after work completion
4) No plastic coverings and baseline cleaning after work completion

In order to adequately evaluate these four interior routines across the three work levels, the study will collect dust wipe samples from floors and window sills at four points in time during an RRP activity – following completion of the work, following completion of the cleanup routine, and at two points in the cleaning verification step. Data collection will occur in the work room, in the adjacent room, and in a third observation room next to the adjacent room. Air samples will be collected to add additional information regarding lead levels in the three rooms, and personal air monitors will be used to evaluate worker exposure. Hallway dust wipe samples will be collected at the end of the study protocol to assess the amount of lead potentially tracked through a property. Exterior soil samples will also be collected before and after interior RRP work from three locations – near the entryway to the building, between the entryway and the street, and near a window closest to the work area. Data collectors also will gather detailed notes on the type and location of work conducted.

For exterior work, the study is interested in evaluating the impact of the use of plastic coverings. To investigate this, plastic coverings will be set up around an exterior job site with dust collection trays set up on the plastic covering, under the plastic covering, and outside the plastic covering. Dust wipes of these dust collection trays will be obtained following completion of the work. Investigators will gather meteorological data during the exterior work activity and also obtain detailed notes on the exterior work conducted. Soil samples will be obtained prior to the

job commencing to allow consideration of the baseline lead levels in the soil around the work area and after the work is completed to identify any property contamination. The background exterior dust levels will be evaluated by placing dust collection trays near the work area and collecting samples before the work commences.

Following collection of dust wipe and air samples at a site, technicians will label, record, and package all samples appropriately before shipping or delivering the samples to the selected laboratory for chemical analysis. Technicians will utilize data collection forms to record unique sample identification numbers (Sample IDs) and other appropriate supporting information for each sample such as sample location, sample surface, room type, and work/sampling phase. Technicians will complete appropriate chain-of-custody forms to track samples during the collection and shipment process.

The study will utilize various quality assurance (QA) and quality control (QC) measures to ensure that high quality data are collected. Field technicians will receive instructions on the proper protocol for collecting, labeling, storing, and transporting samples. The QA Manager will conduct field and laboratory audits to ensure that data collection and chemical analysis protocols are followed correctly. RRP contractors will receive training on the protocol for setting up containment, post-work cleaning, and cleaning verification. Field technicians will enter blank samples into the set of samples collected to ensure that there is not contamination from sampling procedures, transportation, or laboratory preparation. Spiked samples and laboratory duplicates and replicates will be utilized to monitor the accuracy of the laboratory analysis methods. Once all field data collection and laboratory analyses are completed and the data are entered into an electronic database, the study team will ensure their validity by conducting a data audit, which will involve comparing a subset of electronic data values to data collection forms, reviewing scatter plots, and checking for outliers.

Following data validation, Battelle will analyze the various information collected using appropriate methods to address the six study objectives. Battelle will prepare a report summarizing the design, methodology, and results of the data analysis. This report will include sections discussing the field data collection work and results of QA/QC activities.

1.5 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

1.5.1 STUDY QUESTION #1: What is the effect of low, medium, and high level RRP work on dust lead levels (interior and exterior)? Is there an interaction between level of RRP work and the use of plastic? Is there an interaction between level of RRP work and cleaning method used?

The effect of the RRP activity level is determined by comparing environmental lead levels (via floor dust, window sill dust, and air samples) within the work room obtained from the three

levels of RRP work activities. Data analysts will run linear regression models for each endpoint of interest (post-work, post-cleaning, post-verification dust lead loadings, percent reductions of dust lead loadings, etc.) to investigate significant differences in lead levels based on work activity level. Dust lead levels from dust wipes will be analyzed for interactions between activity level and use of plastic and activity level and cleaning method. Relationships will be evaluated based on model fits and regression coefficients.

Data required for this objective includes paint lead loadings, dust lead levels, air lead measurements, and work activity levels. The data should meet the following criteria:

- 95 percent or more of the paint chips associated with surfaces worked on should be successfully collected with no obvious problems,
- 95 percent or more of the dust wipe samples should be successfully collected with no obvious problems,
- 95 percent or more of the air samples should be successfully collected with no obvious problems,
- 95 percent or more of the soil samples should be successfully collected with no obvious problems,
- 95 percent or higher of all sample types should be successfully analyzed by the laboratory with QC samples within limits and having no reported problems, and
- 100 percent of work activities should be accurately assigned to a work activity level (low, medium, or high).

Jobs will be pre-assigned to an activity level based on anticipated dust lead levels to be given off by that job. After post-work dust lead levels are analyzed, however, an activity can be assigned to a different activity level if average dust lead levels across all phases conducted for that activity were found to be significantly lower or higher than expected. Variability and spread of the dust levels on each job will be considered in evaluating whether the job was assigned to the proper intensity level. This would impact analyses comparing differences between work activity levels or specific jobs.

Using the linear regression models presented in Appendix A, if there are significant differences in lead levels based upon work activity level, Model 2 should obtain the best fit of the three models presented. On the other hand, Model 3 assumes that not only are there differences between work activity levels (low, medium, and high), but that there are differences based upon the individual jobs conducted within each level as well. For power study purposes, the assumption that there are work activity level differences but not individual job differences is used. Thus, Model 2 will have the best fit and there will be significant differences between work activity level with regression coefficients $\beta_{11} \neq \beta_{12} \neq \beta_{13}$, or $\beta_{21} \neq \beta_{22} \neq \beta_{23}$, etc. The power study reports that under Model 2, assuming 2 replicates of 6 jobs spread evenly across the work

levels, there will be sufficient power to see efficiency differences of approximately 78 percent for containment and clean-up.

1.5.2 STUDY QUESTION #2 – Are there significant differences in lead levels at the post-cleaning and/or post-verification phases from the use of heavy-duty polyethylene plastic sheeting during the work activity?

The proposed rule includes the use of plastic sheeting or another impermeable material as a covering and an airlock to reduce lead hazards when remodeling target housing containing lead paint. For the purpose of this study, heavy-duty polyethylene plastic sheeting at least 6 mils thick will be required for containment. The plastic sheeting is to be placed on the floor, used to cover openings such as gaps around pipes, and cover furniture and other objects in a room. Also, an airlock is constructed at the entry to the work area. The airlock consists of two pieces of plastic sheeting. The first is taped along all four edges (top, two sides, and floor) and slit down the middle. The second sheet is only secured to the top and acts as a flap covering the slit in the first piece of heavy-duty plastic. In this study, each job will be conducted both with and without the use of the plastic sheeting. To evaluate the effectiveness of the interior containment protocol, the mean level of lead remaining after the post-work cleaning process and after the cleaning verification process will be compared between experiments using plastic coverings and those not using plastic covering for each clean-up method and work level, as well as overall.

The following criteria on data quality indicators should be met in order to allow the determination of differences in the lead levels obtained by the use of heavy-duty polyethylene plastic sheeting:

- 95 percent or more of the paint chips associated with interior surfaces worked on should be successfully collected and analyzed with no obvious problems,
- 95 percent of interior dust wipe and air samples should be successfully collected with no obvious problems, and
- 95 percent or higher of interior dust wipe and air samples should be successfully analyzed by the laboratory with QC samples within limits and having no reported problems.

The power study results in Appendix A indicate that, under Model 2 (differences across work levels), the minimum difference in efficiency able to be detected between use and non-use of containment with 80 percent power is 78%, considering 12 full experiments.

1.5.3 STUDY QUESTION #3 – Are there significant differences in post-cleaning and/or post-verification lead levels between surfaces cleaned with the proposed rule cleaning method and surfaces cleaned with standard cleaning methods?

The proposed rule includes use of a post-work cleaning process involving HEPA vacuuming and a two bucket mopping process, among other things. In this study, contractors will perform each job multiple times with half followed by a baseline cleaning process and the other half followed by the proposed rule cleaning process. The baseline cleaning process used for comparison purposes in this study will involve broom sweeping and vacuuming with a standard Shop-Vac vacuum cleaner. Differences in post-cleaning and post-cleaning verification lead levels will be evaluated using both the dust wipe samples and the ambient air samples. Note that the collection of samples following both the initial cleaning step and the cleaning verification step will allow the proposed rule clean-up to be evaluated both with and without the verification step. To enable this analysis, the environmental samples collected should achieve the following criteria:

- 95 percent or more of the paint chips associated with interior surfaces worked on should be successfully collected and analyzed with no obvious problems,
- 95 percent or more of the planned pre-cleaning, post-cleaning, and post-cleaning verification dust wipe and air samples should be successfully collected with no obvious problems, and
- 95 percent or higher of all dust wipe and air samples should be successfully analyzed by the laboratory with QC samples within limits and having no reported problems.

The power study results in Appendix A indicate that, under Model 2 (differences across work levels), the minimum difference in efficiency able to be detected between use and non-use of containment with 80 percent power is 78%, considering 12 full experiments. Alternatively, assuming that the rule cleaning is 70 percent more efficient than the baseline cleaning and applying Model 1, the power study estimated a power of 0.815 under this design scenario.

1.5.4 STUDY QUESTION #4 – Are there differences in the amount of lead dust migration from the work room to adjacent rooms between different levels of RRP work, use and non-use of plastic, and use and non-use of proposed rule cleaning methods?

EPA is also interested in the migration of dust lead throughout the RRP process, which includes differences in migration across levels of RRP activity and possible interaction with plastic use and cleanup methods. When performing interior work, during each phase, dust wipe and air samples will be taken in the adjacent tool storage room and an observation room (2 rooms away from the work room). Other physical conditions may impact the level of lead dust spread to other rooms in the house. The distance between door openings, the width of door openings, and air flow from opened windows could all be important indicators in the likelihood of other rooms

of the house being contaminated with lead dust. To control air flow and dust migration within the interior of a housing unit, all vents will be covered, windows will be closed, and the central air conditioning system or ceiling fans will be turned off. If necessary for safety purposes, a window air conditioning unit will be installed and run from a window in a nearby room.

Thus, for interior sites the following items will be documented in addition to the dust wipe and air samples discussed in the previous study objectives:

- 95 percent or more of the paint chip, dust wipe, and air samples in each of the three study rooms should be successfully collected and analyzed with no obvious problems,
- All doorways will be measured and area of opening calculated for the work, tool, and observation rooms,
- The distance between doors and turns in the hallway will be recorded,
- The open/shut status of all windows in the three study rooms will be recorded (although the protocol calls for all windows to be closed), and
- If windows have to be open during the work activity for safety reasons, qualitative data on wind speed and direction in the work room will be gathered for at least 95 percent of work activity days.

Another aspect of dust migration that will be evaluated is the spread of dust to hallways connecting the work area with entrances to the unit. Technicians will collect hallway floor dust wipe samples after the renovator has finished and left the site to measure the amount of dust lead tracked out of the work area. For this study, plastic coverings will not be used in hallways outside of the work room and decontamination area.

1.5.5 STUDY QUESTION #5 – Does the use of plastic ground coverings during exterior work reduce dust lead falling onto the ground?

Exterior jobs will be conducted with plastic sheeting placed on the ground around the impact area of the job. Dust collection trays will be placed above, under and near the plastic to collect dust during the work and clean up processes. To evaluate the effectiveness of the plastic coverings, mean levels of lead will be compared between the dust wipe samples collected on top of the plastic and those collected under the plastic, and between the samples collected near the plastic coverings and those under the coverings. For the exterior containment analyses, additional information is required including the direction and strength of wind speed and the size and height of the work area. Data requirements include:

- 95 percent or more of the paint chips associated with exterior surfaces worked on and planned dust wipes should be successfully collected with no obvious problems,

- 95 percent or higher of all sample types should be successfully analyzed by the laboratory with QC samples within limits and having no reported problems.
- 90 percent or higher of planned soil samples should be successfully collected and analyzed by the laboratory,
- 95 percent of work area characteristics data will be successfully recorded, such as the dimensions of the plastic,
- 95 percent of dust collection sampling locations will be successfully recorded, and
- For 95 percent or more of the days that exterior work is occurring, data on average wind speed and wind direction at the job site during the work period will be successfully recorded.

1.5.6 STUDY QUESTION #6 – Are there significant differences in the lead levels remaining after the two steps of the cleaning verification step, i.e., the wet cloth step and the dry cloth step?

The cleaning verification procedure proposed for inclusion in the study will involve two primary steps – wiping with a wet disposable cleaning cloth and wiping with a dry disposable cleaning cloth. If, after two full cleanings and verification checks, the wet cloth does not pass verification based on a comparison to a photo of a clean cloth, the contractor will need to re-clean the surface, let it dry and use a dry cloth for verification. The contractor will repeat the verification with a dry disposable cleaning cloth up to four times for the floor surface and all windowsills. To evaluate the benefit of conducting both steps, environmental dust wipe samples will be collected following the wet verification step and the dry verification step, if needed. Dust lead levels between the two sets of samples will be compared to assess differences. In addition to the requirements list for the other objectives on sampling locations, paint lead data, and work area characteristics, data requirements for this objective include

- 95 percent or higher of the dust wipes gathered during or after the cleaning verification step should be successfully analyzed by the laboratory with QC samples within limits and having no reported problems.

1.6 SPECIAL TRAINING/CERTIFICATION

All contractors performing the renovation work on units or buildings containing lead-based paint will have to follow the appropriate local and state regulations related to conducting renovations of areas with lead based paint. The OSHA standard covering the type of work performed on this study is 29 CFR 1926.62 Lead. Appendix C contains detailed guidance on worker protection from the HUD Guidelines that will be adhered to for this study, as applicable. Both renovation contractors and field data collectors will need to follow the guidelines below.

- All study personnel must have their blood lead level tested before the study begins and after they have completed all required study activities.
- The workers must have a respiratory protection program that addresses medical evaluation/spirometry, fit testing, training, maintenance and emergency procedures, which are maintained annually.
- The workers must have adequate personal protective equipment. Respiratory protection must be chosen in conformance with the OSHA requirements (based on airborne lead level and type of activity, e.g. greater level of protection needed for abrasive blasting than for scraping). They must not leave the worksite wearing the same clothes that are required to be worn for job tasks.
- The workers must have undergone training in accordance with the OSHA HAZCOM standard in regards to lead (methods and observations to detect presence or release, physical and health hazards, measures to protect from hazards including work practices and personal protective equipment (PPE), details of the employers HAZCOM program including labeling and MSDSs) and also with the OSHA Lead-in-Construction standard.
- In addition, at least one member of the contract work crew must have attended the 8 hour HUD/EPA lead-safe program to ensure containment and cleaning processes are executed correctly.
- Use portable washbasins or showers to remove leaded dust, as appropriate.

Site visits will be made by a competent person who holds the appropriate training and certifications to meet OSHA requirements. The competent person will ensure that the workers are properly protected and that no OSHA violations are taking place. All environmental safety and health requirements and protocols are detailed in the study's Health and Safety Plan (drafted August 3, 2006). Site-specific health and safety plans will be developed for each site at which work will occur.

The initial cleaning, the cleaning between experiments, and the cleaning at the end of the study for each unit will be performed by abatement firms and/or workers with training, certification and experience in abatement cleaning. The final clearance samples will be collected by certified inspectors or risk assessors independent of the cleaning firms.

The laboratory analyzing samples collected in this study is recognized by EPA's National Lead Laboratory Accreditation Program (NLLAP) and by the American Industrial Hygiene Association's (AIHA) Environmental Lead Laboratory Accreditation Program (ELLAP), which is recognized by the NLLAP program as an approved laboratory accrediting organization. The ELLAP program accredits laboratories performing analysis of lead in environmental samples including paint, soil, dust wipes, and air. The analysis protocols that the laboratories must follow will be clearly specified. Any choices that must be made in implementing those protocols will have to be specified by the laboratory. Laboratory QA/QC manuals will be requested to ensure that quality procedures are followed.

Copies of all relevant qualifications and certifications will be obtained from appropriate participants and maintained in files by the PI.

1.7 DOCUMENTATION AND RECORDS

Detailed records will be kept of all field data collection activities. Information to be recorded includes:

- Site wind speed and direction data for each data of external work activity and each day of internal work activity, if windows are open;
- Precipitation activity during outdoor work;
- Work level, specific type, and duration of specific RRP activities, including setting up plastic coverings, conducting cleaning, and conducting cleaning verification;
- Unit ID, room or side of building, and specific location of samples obtained;
- Sample design parameters related to use of plastic covering and cleaning method for each interior dust wipe and air sample;
- Surface type and size of dust wipe samples;
- Air sampling locations and air flow rates for each sampler;
- Distance of sample locations from work activity;
- Location of the decontamination area where booties and other protective gear are removed when exiting the work area;
- Size and location of doorways between interior study rooms;
- Paint lead levels on components undergoing work activity;
- Regular sample and QC sample identification information;
- Chain-of-custody records; and
- Signature and initials of sample collectors.

If data collectors make or discover errors on their data collection forms, they should cross out the incorrect information with a single line, insert the correct information, and add their initials and the date next to the change. Appendix D contains sample data collection forms.

Records describing sample receipt, handling, and storage will be prepared and maintained by the designated sample custodian or designee. The documentation will record sample receipt, problems, or anomalies in the samples or shipment conditions, and will provide a record that custody records were received for each sample. The documentation will also identify missing documents or incomplete data.

The laboratory staff will enter all data for sample preparation and analysis into a project record book designated for that purpose. Entries will be made promptly and legibly in ink and will be dated, signed, and initiated by the responsible staff member(s). Any deviations from the QAPP covering the paint chip, soil, dust wipe, or air sampler analysis procedures will be documented by providing copies of the changes/deviations and reason(s) for the deviation to all individuals identified on the distribution list. All error corrections will be made by drawing a single line through the error, initialing and dating the error, and adding a short explanation for non-obvious error corrections.

Laboratory staff members will identify and report sample and data collection problems to the Principal Investigator (PI). Corrective action reports that describe the problem and record how the problem was resolved will be prepared. Samples or data that are unusable will be identified and all associated results will be flagged accordingly. Corrective action reports will be maintained by the Principal Investigator and included as part of the prospective site report. In cases where samples or data are lost or compromised, the Principal Investigator will immediately send a copy of the report to the Project Manager who, in turn, will forward it to EPA.

Laboratory results will be returned from the laboratory on paper forms and/or in electronic spreadsheet files. If necessary, the results including sample identification number and measurement will be entered into a database at Battelle. The paper forms will be archived and used in verifying the results entered in the database or in checking the electronic files received from the laboratory.

QA records from (1) the field audit, laboratory audit, and data audit; (2) any necessary stop work orders, and (3) laboratory QC samples will be stored with the QA Manager in a secure location for a period of seven years after the close of Battelle's contract with EPA. The study PI will maintain the final version of the QAPP and have responsibility for implementing any necessary revisions or amendments to the QAPP. Data collection forms will not be included in the final report made available to the public in order to maintain the privacy of individual property owners.

2.0 MEASUREMENT/DATA ACQUISITION

2.1 SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

Following the protocols established in the QAPP focused on site selection, Battelle and EPA will identify, evaluate, and select sites that meet the requirements of the study. The study will seek to enroll properties in two or three cities and divide work approximately equally between the cities. The cities most likely to house sites for this study are Columbus, Ohio; Pittsburgh, Pennsylvania; and Arlington, Virginia. The housing units and COFs selected for interior work will contain lead-based paint, be vacant, and have three adjacent rooms with one serving as the work room. Buildings selected for exterior work must also contain lead-based paint and have enough yard space to allow for data collection around the work area. If possible, the study will utilize buildings that are scheduled for demolition to eliminate any risk to potential future inhabitants of these dwellings.

2.1.1 RRP Work Levels, Specific Jobs, and Contractors

The study will find a sufficient number of units so that environmental lead levels associated with low, medium, and high levels of interior and exterior RRP activity can be characterized. Internal EPA discussions have identified various activities for low, medium, and high levels of RRP work. In addition, high dust-generating work practices prohibited for lead abatement work as per 40 CFR 745.227(e) (6) (refer to http://www.epa.gov/docs/fedrgstr/EPA-TOX/1996/August/Day-29/pr24181DIR/pr-24181.pdf for more information) will be included in the study as they are not restricted by the proposed rule. The four prohibited jobs listed in 40 CFR 745.227(e) (6) are as follows:

(i) Open-flame burning or torching of lead-based paint is prohibited;

(ii) Machine sanding or grinding or abrasive blasting or sandblasting of lead-based paint is prohibited unless used with High Efficiency Particulate Air (HEPA) exhaust control which removes particles of 0.3 microns or larger from the air at 99.97 percent or greater efficiency;

(iii) Dry scraping of lead-based paint is permitted only in conjunction with heat guns or around electrical outlets or when treating defective paint spots totaling no more than 2 square feet in any one room, hallway or stairwell or totaling no more than 20 square feet on exterior surfaces;

(iv) Operating a heat gun on lead-based paint is permitted only at temperatures below 1100 degrees Fahrenheit

Interior work is summarized in Table 2-1. Table 2-2 identifies the various external job types for each of the three work activities levels. Each enrolled housing unit will receive at least one of the three levels of RRP work. All jobs must disrupt at least one component having at least 2 square feet of lead-based paint on the surface area. Jobs identified as prohibited by 40 CFR 745.227(e) (6) will be identified by the number (i)-(iv) of the specific restricted work practice.

Table 2-1. Possible Interior RRP Jobs at Three Levels of RRP Work

Low Level Work	Medium Level Work	High Level Work
Make three cut-outs, each of a 2 foot or more section of wall with LBP, to perform plumbing or electrical or HVAC work, perform the work inside the wall, and repair and repaint wall, disturbing approximately 6 ft^2 of lead-based paint. Replace window from inside unit, disturbing at least 2 ft^2 of LBP.	Scrape deteriorating LBP from a flat interior component, scraping 50-75 ft^2 of painted surfaces, and repaint the surfaces which were scraped. (iii) Scrape or plane 20-40 ft^2 of LBP from an interior door, and repaint the surface from which paint was removed. (iii)	Remove paint from 75-100 ft^2 of lead-based painted components by using a heat gun over 1100° Fahrenheit held at one inch or the distance specified from paint, and repaint all components from which paint was removed (iv) Gut out a kitchen, disturbing 100 ft^2 or more of lead-based paint.

Table 2-2. Possible Exterior RRP Jobs at Three Levels of RRP Work

Low Level Work	Medium Level Work	High Level Work
Replace an exterior door and doorway, disturbing 25-50 ft^2 of lead-based paint. Replace fascia boards, soffits, and other exterior trim on one side of the structure, disturbing approximately 50 ft^2 of lead-based paint.	Replace siding with lead-based paint on one exterior side of the structure with vinyl (complete replacement of the existing siding, not just nailing over the existing siding), disturbing at least 100 ft^2 of lead-based paint. Remove lead-based paint from exterior components by dry scraping, disturbing approximately 100 ft^2 of lead-based paint, and repainting areas from which paint was removed. (iii)	Remove paint by power sanding or grinding on at least 100 ft^2 of lead-based paint on exterior wood components on one side of the structure, and repaint components from which paint was removed. (ii) Remove lead-based paint by torching or open-flame burning on least 100 ft^2 of lead-based paint from brick, concrete, stone, metal, or wood on one side of the structure, and repaint areas from which paint was removed. (i)

If possible, work activities and levels will be assigned randomly to enrolled housing units; however, because it is likely that private properties will be enrolled and those properties will be in need of certain types of work and not others, random assignment of jobs is not a reasonable expectation. The types of jobs pursued will be contingent upon what property owners allow the study to conduct within their units. If housing scheduled to be demolished is identified during site selection and all enrolled units and buildings are going to be demolished, the study should be able to randomly assign work levels and specific jobs to all units. If only a subset of enrolled units and buildings are going to be demolished, the study will assign the high and medium level

RRP jobs to those units and buildings, so that the low level RRP jobs which generate less dust are done in units and buildings that will be utilized again in the future.

For each job to be conducted, the order in which the four study phases are implemented for that job will be randomly determined. The order will be determined once a job is identified for study. As housing units are enrolled to receive a particular job, the next phase in the predetermined order will be assigned to that unit.

In order to capture variation between contractors, if specific jobs are replicated (i.e., a full experiment is run two or more times for a job), the study will hire different contractors to conduct each replicate, if possible. Also, if contractors are able to work on more than one job, the study will seek to have them conduct jobs across different activity levels.

2.1.2 Protection/Clean-up Routines Evaluated

Interior Jobs

For each interior work level, the study will evaluate four work area protection/clean-up routines or phases– all combinations of (1) use of plastic coverings/no use of plastic coverings and (2) baseline cleaning after work completion/cleaning per the proposed rule after work completion. Thus, the four protection/clean-up (P/CU) phases are:

1) Use of plastic coverings and cleaning per the proposed rule after work completion
2) Use of plastic coverings and baseline cleaning after work completion
3) No plastic coverings and cleaning per the proposed rule after work completion
4) No plastic coverings and baseline cleaning after work completion

Within each enrolled housing unit, the study will seek to measure the specified work activity under each of the four P/CU phases. The preferred method for achieving this will be to split the work activity planned for a room into four phases of equal activity – the 4-Phase/1-room Approach – and conduct the experiment independently four times so that each experiment corresponds to one of the four P/CU phases. If the job is unable to be replicated four times in the same room, the next alternative is to conduct the work across two rooms – applying two of the four P/CU phases in one room and the other two phases in another room. These two rooms could be in the same housing unit or in separate units, however, they will have to contain similar characteristics in terms of paint lead levels in the components undergoing work and room layouts. The preference for the 4-Phase/2-room approach is to use two rooms in the same unit, if possible. As a last resort, for jobs with phases that cannot be replicated in one or two rooms, the study will use a 4-Phase/4-room approach where each P/CU phase is conducted in a different room. As with the 4-Phase/2-room approach, these rooms could be in the same unit or different

units but they must present a similar set of components with similar paint-lead levels. The 4- Phase/4-room approach is not optimal due to the increased number of units needing to be enrolled in the study. The approaches requiring multiple rooms or units to complete a full job will produce data for which comparability depends on the degree to which similar room layouts with lead-based paint on the same components can be found. Table 2-3 lists all the possible jobs with the potential approach for completing that job.

If multiple phases are conducted in the same room as will be the case in the 4-Phase/1-room or 4-Phase/2-room approaches, the three study rooms will undergo a thorough cleaning between phases and clearance samples will be taken to show that all areas are free of lead hazards. The 4-Phase/1-room approach will require unit cleaning and testing five separate times – prior to work beginning, between the 1st and 2nd, 2nd and 3rd, and 3rd and 4th phases, and again once all study activities are completed. This approach will lead to considerable "down-time" and extend the amount of time required to conduct the full protocol at each housing unit or facility.

Exterior Jobs

For exterior jobs, the primary protection technique under evaluation is the use of a plastic ground covering. To investigate this, plastic coverings will be set up under an exterior job as required by the proposed rule with dust collection trays both under and on top of the plastic coverings. After completion of a job, dust wipe samples will be obtained from the trays on top of and under the plastic, as well as areas outside the plastic. Thus, the exterior work and associated sampling will be performed in one phase.

Table 2-3. Possible Interior Jobs and Associated Possible Approaches for Conducting Experiment

Activity Level	Job	Possible Approach
Low	Cut out 2 foot+ section of wall, complete plumbing work, and repair and repaint wall section cut open. Repeat for electrical and HVAC work, for a total of three separate cut-outs and repair/repaints.	4-Phase/4-room
	Replace window from inside house	4-Phase/2 room
Medium	Scrape deteriorating lead-based paint from a flat interior component, scraping 50-75 ft^2 of painted surfaces, and repaint the surfaces which were scraped.	4-Phase/1-room
	Scrape or plane 20-40 ft^2 of LBP from an interior door, and repaint the surface from which paint was removed.	4-Phase/2-room

Activity Level	Job	Possible Approach
High	Remove paint from 75-100 ft^2 of lead-based painted components in a room by using a heat gun at or over 1100 degrees Fahrenheit held at one inch or the distance specified in the instructions from paint, and repaint all components from which paint was removed	4-Phase/4 rooms
	Gut out a kitchen, disturbing 100 ft^2 or more of lead-based paint.	4-Phase/4 rooms

Table 2-4 contains a possible distribution of jobs by the various approaches for conducting the study. The table also provides an estimate of the number of sites that will need to be enrolled. Under this sample distribution of jobs to approaches, we estimate a need for 30 housing units to obtain a complete set of experiments for 12 interior jobs. We also estimate the need for 3 COFs and 6 housing units for exterior work. If we assume that no overlap between the properties used for exterior and interior work and that the 3 COFs provide sufficient surfaces for both the interior and exterior work, our estimate for total number of properties needed to complete the protocol is 39 (36 housing units and 3 COFs).

Table 2-4. Estimated Distribution of Work Assignment Approaches and the Associated Number of Sites Required for the Study

Work Level	Approach	# of Jobs	# of Sites
Low (Interior)	4 Phase/4 rooms (2 per unit)	2	4
	4 Phase/2 rooms (same unit)	2	2
Medium (Interior)	4 Phase/2 rooms (diff. units)	2	4
	4 Phase/4 rooms (1 per unit)	2	8
High (Interior)	4 Phase/4 rooms (2 per unit)	2	4
	4 Phase/4 rooms (1 per unit)	2	8
Exterior Work – Housing Units (no overlap w/ interior)		12	6
Sub-Total for Housing Units		24	36
COFs – Interior and Exterior (assume we find 3 sites w/ enough rooms to conduct all work)		6	3
Grand Total – Estimated Properties		30	39

2.1.3 Sampling Locations

The study-impacted areas of participating housing units or COFs is defined as a set of three rooms – one undergoing the RRP activities, an adjacent room for tool storage, and an observation room adjacent to the tool storage room. Figure 2-1 depicts a potential layout for an interior study area.

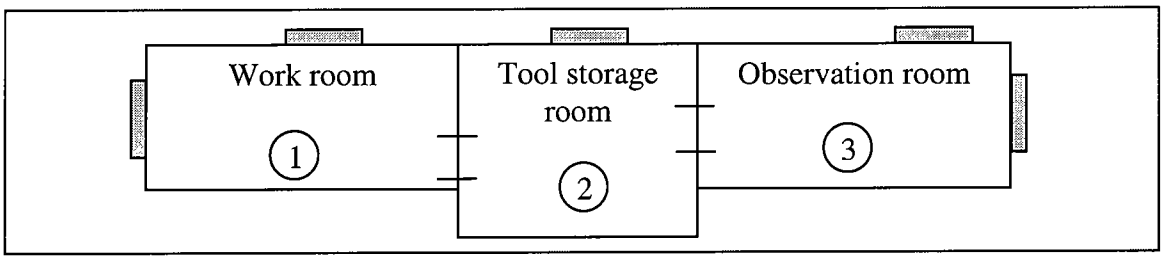


Figure 2-1. Proposed layout of study rooms within a prospective housing unit or COF. The horizontal lines represent doorways or openings connecting the rooms and the shaded boxes represent windows.

Paint samples will be collected from prospective rooms and exterior sides of prospective units for laboratory analysis. When paint lead levels are required for the interior of a prospective housing unit, the protocol will involve collecting one paint chip sample on each of the possible lead-based paint components in the room, with a duplicate sample on large components such as walls, ceilings, baseboards, and any other large component that spans the room. For example, one sample will be taken at 1/3 distance from the start of the component, while the second sample will be taken at 2/3 distance from the start of the component. Determining exterior paint lead levels will involve collecting one paint sample on each lead-based paint component on each side of the house that is a candidate for exterior work, with a second sample collected from large components. These samples are required to get an accurate measurement of the lead content of the paint for the data analysis and modeling. To avoid contamination from paint chip sampling, plastic will be laid down below the area to be sampled, such that it would catch all resulting dust and debris.

Soil samples will be collected before both interior and exterior work commences to measure the potential track-in contamination during work (interior) and background lead contamination of the property (exterior), as well as after the exterior work has been completed. For exterior work, dust collection trays will also be set up and samples collected prior to commencing work to determine the background dust lead levels in the ambient air.

specified by site- and job-specific sampling plans which will specify the numbers and locations of samples for each job and site. Within the adjacent rooms, the sampling locations will also be given in the site- and job-specific sampling plan. The window sill samples from within the work room should be taken from the window closest to the work area, as long as the window sill is available for sampling throughout the course of the work, i.e. it is not undergoing work itself. If two windows are available for sampling, they can both be used for sampling purposes, if necessary, to accommodate the number of samples required with the size of the window sill, considering that the same location may not be sampled more than once during a specific job. If window sills are badly damaged or missing, a dust collection tray may be placed near the window for an alternate sample.

Air samples will also be collected as part of this study. For interior work, indoor air samples will be taken. Air samplers will be placed on a tripod approximately five feet off the ground so as to approximate levels of dust lead available to be inhaled. For both interior and exterior work, personal air monitoring will be used in order to assure compliance with OSHA requirements; the results will not be analyzed as part of the study, however.

For exterior work, there are nine dust wipe sampling locations – three on top of the rule plastic coverings, three in corresponding positions underneath the rule plastic coverings, and three near but off of the rule plastic on top of the protection plastic. Data collectors will set up dust collection trays at the nine locations prior to the work commencing as contractors are setting up the plastic containment. Dust wipe samples will be taken from each tray following completion of the work.

2.1.4 Sample Size

Current plans call for the study to conduct 12 interior jobs at housing units and 3 interior jobs at COFs and, similarly, and 12 exterior jobs at housing units and 3 exterior jobs at COFs. For interior work, the protocol requires collection of at least four floor dust wipe samples and one window sill dust wipe sample from the work room and two floor dust wipe samples and one window sill dust wipe sample from the other two study rooms at each stage of clean-up. The work room will have four stages of clean-up – post-work, post-cleaning, post-wet cloth cleaning verification, and post-dry cloth cleaning verification. The two other study rooms will only have three sampling stages - post-work, post-cleaning, and post-verification. This set of samples will be gathered for each P/CU phase within each clean-up stage. Table 2-5 provides a detailed accounting of the number of interior dust wipe samples that will be collected from the work room for the 12 housing units. For each work activity level (low, medium, and high), the study will obtain 64 floor samples and 16 sill samples at each stage of clean-up resulting in 256 floor samples and 64 sill samples for each work activity level and a total of 768 floor samples and 192 sill samples within the work room. This same dust wipe collection protocol (except for the post-

samples and 64 sill samples for each work activity level and a total of 768 floor samples and 192 sill samples within the work room. This same dust wipe collection protocol (except for the post-wet cloth sampling stage) will be followed in each of the three study rooms. In the observation room and tool room, however, only two floor wipe samples will be taken after each stage.

Table 2-5. Number of Interior Dust Wipe Samples Planned for Collection in Work Room for Housing Units

Sampling Stage	Use of Plastic	Cleaning Method	Low (4)		Medium (4)		High (4)		Total (12)
			Job1 (2)	Job2 (2)	Job1 (2)	Job2 (2)	Job1 (2)	Job2 (2)	
Post-work	Yes	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
	No	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
Post-work Sub-total			64 Floor, 16 Sill		64 Floor, 16 Sill		64 Floor, 16 Sill		192 Floor,48 Sill
Post-cleaning	Yes	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
	No	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
Post-cleaning Sub-total			64 Floor, 16 Sill		64 Floor, 16 Sill		64 Floor, 16 Sill		192 Floor,48 Sill
Post-wet cloth verif.	Yes	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
	No	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
Post-wet cloth verif. Sub-total			64 Floor, 16 Sill		64 Floor, 16 Sill		64 Floor, 16 Sill		192 Floor,48 Sill
Post-dry cloth verif.	Yes	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
	No	Baseline	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
		Rule	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	8 F, 2 S	24 Floor, 12 Sill
Post-dry cloth verif. Sub-total			64 Floor, 16 Sill		64 Floor, 16 Sill		64 Floor, 16 Sill		192 Floor, 48 Sill
Total			256 Floor 64 Sill		256 Floor 64 Sill		256 Floor 64 Sill		768 Floor 192 Sill

For purposes of calculating the number of interior air samples to be collected, an assumption is made that one sample is collected during each of the first two sampling stages and another one

covering both cleaning verification stages. This protocol will occur in each of the three study rooms, so that each experiment results in nine air samples (3 rooms x 3 stages) or 36 across the four phases for a single job. For the purposes of calculating the number of personal exposure samples for interior jobs, an assumption is made that one sample is collected during each sampling stage. For exterior work, one personal air sample is collected while work is taking place. Table 2-6 summarizes the total number of environmental samples that will be collected, excluding those collected for clearance purposes.

Table 2-6. Total Number of Environmental Samples – Other Than Clearance Samples

Building Type	Sample Type	Work Area	Tool Room	Obs. Room	Hallway or Adj. Rooms/Exterior	Exterior	In Relation to Plastic			Total
							On top	Under	Near	
Housing Units (12)	Floor dust wipe	768	288	288	144	-	36	36	36	1,596
	Sill dust wipe	192	144	144	-	-	-	-	-	480
	Indoor Air	144	144	144	-	-	-	-	-	432
	Personal Air	144	-	-	-	12	-	-	-	156
	Background Dust	-	-	-	-	36	-	-	-	36
	Soil Samples	-	-	-	288	72	-	-	-	360
	Paint Chips	240	-	-	-	60	-	-	-	300
COFs (3)	Floor dust wipe	192	72	72	36	-	9	9	9	399
	Sill dust wipe	48	36	36	-	-	-	-	-	120
	Indoor Air	36	36	36	-	-	-	-	-	108
	Personal Air	36	-	-	-	3	-	-	-	39
	Background Dust	-	-	-	-	9	-	-	-	9
	Soil Samples	-	-	-	72	18	-	-	-	90
	Paint Chips	60	-	-	-	15	-	-	-	75
Total		**1,860**	**720**	**720**	**540**	**225**	**45**	**45**	**45**	**4,200**

During site preparation and site clean-up activities, additional dust wipe samples will be gathered following the pre-experiment (initial clearance) and post-experiment (final clearance) cleanings for interior jobs to ensure (1) that each phase of work is beginning in a clean environment and (2) that housing units and buildings do not contain any lead hazards when work is completed.

clearance sampling. For purposes of estimating the number of samples obtained from this process, we estimate that the sampling protocol following a full cleaning of study impacted areas will involve collection of five dust wipes (4 floor, 1 sill) in the work room and three dust wipes (2 floor and 1 sill) in the tool and observation rooms plus three additional samples in hallways or other areas impacted by the study, for a total of 14 samples. Because more than one experiment may take place in the same unit, there may be some overlap between (1) and (2). For example, in the 4-phase/1-room approach, pre-experiment cleaning and sampling is required four times and post-experiment cleaning and sampling is required only once at the end. Thus, at a minimum, this may require an additional 70 dust wipe samples per job (14 samples times 5 cleanings) or 840 across a full study with 12 total housing units. Since additional samples will be required to re-test if any areas fail clearance, it is assumed that 25 re-tests will be required. For planning purposes, the estimated distribution of approaches in Table 2-4 is used to estimate the number of cleanings and associated cleaning samples required, which results in an estimate of 86 pre- and post- experiment cleanings over a total of 30 housing units and a total of 1,204 samples. Considering the assumed number of wipes for re-tests, the total estimated number of dust wipe samples related to pre- and post-experiment clearance is 1,229.

2.1.5 Detailed Sampling Protocol

All samples will be labeled following a standard sample identification protocol. The SampleID is composed of a series of codes representing UnitID-Experiment-Sample room/wall-Stage and Type-Sample number and will be in the format UUU-EE-RRR-SST-##. UnitID is the combination of one letter and two digits uniquely assigned to each unit involved in the study. The letter is either H for housing unit or C for COF. The experiment number is a unique indicator of the room that the work is being performed in and the phase of containment/cleaning being used. Sample room/wall is the room/wall from which the sample is obtained. Stage is a three letter code with the first two letters representing the stage (post-work, post-cleaning, post-wet cloth cleaning verification, or post-cleaning verification), and the final letter representing the type of sample (floor dust wipe, sill dust wipe, paint chip, ambient air sample, personal air sample, soil sample, or one of the three exterior dust wipe locations). Sample number is a 2-digit number identifying the sample.

2.1.5.1 <u>Interior Jobs</u>

2.1.5.1.1 Pre-Experiment Sampling

Prior to the start of an experiment, paint chip samples will be collected to evaluate the lead concentrations of each of the components in a unit. The paint chip samples should measure approximately 2" by 2", and will be collected from prospective rooms and exterior sides for

laboratory analysis. The protocol will involve collecting one paint chip sample on each of the possible lead-based paint components in the room, with a duplicate sample on large components such as walls, ceilings, baseboards, and any other large component that spans the room. For example, one sample will be taken at 1/3 distance from the start of the component, while the second sample will be taken at 2/3 distance from the start of the component. To avoid contamination from paint chip sampling, plastic will be laid down below the area to be sampled, such that it would catch all resulting dust and debris.

In addition, three composite soil samples will be collected (see 2.2.5) to estimate potential track-in of lead from exterior sources and spread of dust to the exterior. The three samples will be taken from bare soil nearest to (1) the entryway to the building used by the workers, (2) the walkway from the entryway to the street, and (3) a window closest to the work area.

2.1.5.1.2 Prepare a Housing Unit or COF

When work is able to begin in the interior of a property, study personnel will identify the three or more rooms that will serve as one of the three study rooms (work and two observation rooms), any hallways or adjacent rooms that will be passed through in traveling from entrances to the study rooms, and any other rooms needed for ventilation or other reasons, such as a bathroom. Technicians will block off all other areas of the unit using plastic coverings. Technicians will look to cover access points such as doorways and stairways, which can be more easily sealed off. The plastic will be attached to these access points using duct and masking tape so that a tight seal is obtained.

Technicians will also seal all air vents in floors, walls, or ceilings in any of the areas impacted by the study, including any rooms in which work is to be performed. The air vents will be sealed with plastic tightly attached to the surface with masking tape. Note that hallways connecting the entrance and the work rooms will not be covered with plastic coverings. The protocols for exiting the work room call for cleaning off debris and removing booties or protective suits prior to leaving the work room.

Because the windows in the work room will be closed and air vents will be sealed off, the interior temperature may become a problem for workers. If the temperature in the house is above 80 degrees Fahrenheit, study personnel may install a window air conditioning unit in one of the non-work rooms which will serve as a cool-down room to prevent contractors or study personnel from overheating. Most likely, worker safety will be insured by instituting a 2-hour work, 15-minute water-break plan that may be adjusted by the site supervisor based on the working conditions. The buddy system will also be in place to minimize the risk of heat exhaustion. All study personnel will receive training on recognizing the signs of heat exhaustion. If the site supervisor determines that 2-hour work times are insufficient to protect

worker safety, breaks will be required more frequently. Other types of mobile air cooling devices will be investigated to determine if there are other feasible options for keeping the unit cool on high temperature days.

2.1.5.1.3 Clean a Unit to Acceptable Clearance Levels

Prior to beginning work in a property, a thorough cleaning will be conducted by a lead abatement firm with experience cleaning after lead abatement activities in accordance with Chapter 14 of the HUD Guidelines, Clearance, included as Appendix G. The study will clean areas impacted by the study, but not those sealed off from the impacted areas. All surfaces will be cleaned – floors, walls, window sills, etc. The initial cleaning will include vacuuming all areas with a HEPA vacuum, followed by wet washing, and a final cleaning with the HEPA vacuum. Chapter 14, Section III details the cleaning methods and procedures. The wet washing step will use detergent with a high phosphate content [at least 5 percent trisodium phosphate (TSP)]. If local and state rules do not permit the use of TSP, an all-purpose cleaner or a cleaner specific for lead will be used.

The licensed clearance technicians hired by the study will follow an approved sampling plan for conducting clearance testing. If the clearance testing protocol is flexible, the study will request that five dust wipes (4 floor, 1 sill) be obtained by the person or organization performing the cleaning from the work room and three dust wipes (2 floor and 1 sill) obtained from the tool and observation rooms plus three additional samples in hallways or other areas impacted by the study. Samples collected for clearance purposes will be sent to the laboratory for analysis with 24-hour turnaround time or less. If lead is no more than the reporting limit of the lab, or 25% of the levels of 40 $\mu g/ft^2$ on floors and 250 $\mu g/ft^2$ on window sills, whichever is higher, declare the room clean.

2.1.5.1.4 Set up the Experiment (including Work Area Containment)

Once the unit is cleaned, the work area will be set up. In order to protect the public, under proposed § 745.85(a)(1), work areas will be clearly defined with signs warning occupants – and other persons not involved in renovation activities – to remain outside of the work area. These signs will be posted by the site supervisor before beginning the renovation and will remain in place until the renovation has been completed and the work area has been verified to have been adequately cleaned. Depending on the predominant languages of the area residents, these signs may be posted in multiple languages. Neighbors will be provided notices informing them of the study.

If the interior P/CU phase to be implemented involves containment, plastic coverings will be set up in the work room according to the proposed rule included in Appendix B so that no visible

dust or debris leaves the work room while the renovation is being performed. The main parts of the interior containment protocol are:

- Remove or cover all objects in the work area.
- If windows are being replaced from the inside, tape plastic to the outside of the window frame so that no debris can fall to the ground outside the window. If necessary, use a ladder from the outside of the house to tape up the plastic. Lay out plastic on the ground under the window and set a dust collection tray in the middle.
- Close and seal all doors into the work room. Cover all doors within the work area that must be used while the job is being performed with plastic sheeting in a manner that allows workers to pass through, while confining dust and debris to the work area.
- Cover the entire floor surface with taped-down plastic sheeting in the work room; if more than one sheet is required, tape sheets together to prevent dust and debris from falling underneath plastic.
- No plastic sheeting is required to be laid down in the hallways or adjacent rooms outside the work room.

For the interior phases or routines that call for no use of containment, any furniture and objects in the work room that might be impacted by dust or are not cleanable will be removed from the room prior to the work.

Once the interior work room is ready for work to begin, study technicians should set up the air samplers in the three study rooms. The sampler in the work room should be set up away from the immediate work area so that it does not get in the way. The air samplers in the two adjacent rooms should be set up approximately in the middle of the room to represent air quality throughout each room. Field technicians should start the air samplers when the contractors are ready to begin work. The technicians should also have a personal exposure monitor fitted and ready for use by one of the contractors.

2.1.5.1.5 Set up Decontamination Area

Mark off an area of the work room by the exit with masking tape, if possible, to serve as the decontamination area where workers remove and dispose of booties, protective suits, and brush off debris. If the location or extent of the work in the room makes it difficult to perform these activities in the work room, the decontamination area should be set up immediately outside the work room. In that case, the area in that adjacent room (the hallway or tool storage room) would also be covered with plastic sheeting.

A second decontamination area will be set up just outside the main entrance to the unit. This area will be equipped with tack paper to clean off the bottom of all study personnel's shoes to

prevent lead being taken with them. Personnel will also brush off any debris left over on tools, clothing, or the exterior of waste containers.

2.1.5.1.6 Conduct the RRP Work Activity

The hired RRP contractor(s) will enter the property, set up their equipment and work space, and conduct their job as they normally would, within the specifications of the study. A technician will turn the personal exposure monitor on for the designated contractor. Contractors and study personnel will follow the appropriate OSHA and other guidelines regarding safety precautions specified in the study and site-specific health and safety plans. For example, all contractors and study personnel will wear protective clothing and footwear and half- or full-mask respirators. The study training manuals will contain directions on proper use of personal exposure monitors, respirators, and protective clothing as well as further details on environmental health and safety procedures.

The following steps must be followed EACH time study personnel leave the work room:

- While standing in the decontamination area, slowly roll down Tyvec suit, careful to trap all dust and debris in the suit. Place suit in heavy duty garbage bag.
- Remove disposable booties and place in heavy duty garbage bag.
- Vacuum the exterior of the respirator using a HEPA Vac. Place respirator in designated storage area.
- Immediately wash hands and face with soap and water.
- If the contractor is equipped with the personal exposure monitor, the monitor will be removed and placed on designated shelf or hook within the work room before removing Tyvec suit.

2.1.5.1.7 Obtain Post-Work Environmental Samples

Following job completion, the field technician will turn the personal exposure monitor off for the designated contractor, collect the sample, store and label appropriately. All study personnel will wait one hour to allow dust to settle from the activity. Subsequently, the list of sampling activities below will commence.

- The air samplers in each of the three study rooms will be turned off and the filter removed, stored in the appropriate container, and labeled.
- Obtain four 1 ft^2 floor dust wipe samples. The location of the samples to be collected will be specified in the job-specific sample plans.

- Obtain one 3" by 6" window sill dust wipe sample from a window within five feet of the work area, if possible, or from the nearest available window to the work area.
- Obtain two 1 ft^2 floor dust wipe samples and one 3" by 6" window sill sample from each of the two adjacent rooms. Again, the location of the samples to be collected will be specified in the job-specific sample plans. Label these appropriately so that they are identifiable as post-work samples.
- Insert new filters in all air samplers and restart when contractors are ready to begin the cleaning stage.

2.1.5.1.8 Take Down Containment

Once post-work environmental samples are collected, the contractors will take down, wrap up, and place the plastic sheeting serving as containment in a garbage bag. They will not take off the plastic covering vents and blocking off non-study areas at this point. Also, the sheeting isolating the work room from the other areas of the unit must remain in place until all cleaning activities have been completed. First, contractors should wrap up the plastic covering surfaces in the work room in a manner that traps debris within the plastic by misting the plastic and folding it inward. The folded up plastic should be inserted in heavy-duty plastic bags before being removed from the work room. The contractors will close the bags tightly to ensure that no dust or debris escapes and the technician will dispose of these according to state and local regulations.

2.1.5.1.9 Perform Post-work Cleaning (Baseline and Proposed Rule Methods)

During the post-work cleaning, a designated contractor will wear a personal exposure monitor. The field technician will turn the personal exposure monitor on before cleaning activities begin.

Contractors will be instructed to follow one of two cleaning methods – a baseline cleaning or the proposed rule cleaning. For a baseline cleaning effort at the completion of a job, the contractor will sweep the entire work room with a broom and dustpan to collect all large pieces of debris. Subsequently, the contractor will vacuum the work area with a Shop Vac-type vacuum supplied by the study. The standard vacuum used will be a Shop-Vac brand 10-gallon, 4 HP wet/dry vacuum, which will be made available to all contractors.

For the rule cleaning, the contractor will follow the guidelines detailed in the proposed rule to clean the entire work room. The HEPA-vacuum that will be used for the rule cleaning is an Electrolux Aptitude vacuum (true HEPA and beater bar-equipped), or comparable equipment. Initially pick up all paint chips and debris with a damp cloth, and then:

i) Clean all walls starting from the ceiling and working down to the floor. The walls will be vacuumed with a vacuum equipped with a HEPA filter. As noted, painting will not

occur until after cleaning activities are completed; thus, there will be no need to wait for the paint to dry before cleaning the walls.

ii) Thoroughly vacuum all remaining surfaces and objects in the work area, including floors, and any fixtures, with a HEPA-vacuum.

iii) After vacuuming, wipe all surfaces and objects in the work area, except for walls and upholstered surfaces, with a damp cloth.

iv) Thoroughly mop floors using a 2-bucket mopping method that keeps the wash water separate from the rinse water.

If containment was used in the experiment, after completion of all appropriate cleaning activities, the plastic covering the door separating the work room from the other areas of the unit may be taken down by misting, carefully folding the plastic and placing it in a heavy duty garbage bag.

2.1.5.1.10 Obtain Post-Cleaning Environmental Samples

Following completion of the cleaning routine, the field technician will turn the personal exposure monitor off for the designated contractor, collect the sample, and store and label it appropriately. All study personnel will wait one hour to allow any dust to settle from the activity. Subsequently, the list of sampling activities below will commence.

- The air samplers in each of the three study rooms will be turned off and the filter removed, stored in the appropriate container, and labeled.
- Obtain four 1 ft^2 floor dust wipe samples. The location of the samples to be collected will be specified in the job-specific sample plans.
- Obtain one 3" by 6" window sill dust wipe sample from a window within five feet of the work area, if possible, or from the nearest available window to the work area.
- Obtain two 1 ft^2 floor dust wipe samples and one 3" by 6" window sill sample from each of the two adjacent rooms. Again, the location of the samples to be collected will be specified in the job-specific sample plans. Label these appropriately so that they are identifiable as post-work samples.
- Insert new filters in all air samplers and restart when contractors are ready to begin the cleaning stage.

2.1.5.1.11 Perform Cleaning Verification

During the cleaning verification stage, a designated contractor will wear a personal exposure monitor. The field technician will turn the personal exposure monitor on before verification activities begin.

Once all post-cleaning samples are collected, the contractor will start the cleaning verification process. Following are the main steps involved in the cleaning verification process, as detailed

in the rule. Refer to Figures 2-2 and 2-3 for windowsill and floor verification processes, respectively. The field technician will record the time that all cleaning verification processes start and end. Field technicians will video record a sample of approximately six cleaning verification processes, one for each job.

Interior Windowsills:

Wipe each interior windowsill in the work room with a wet disposable cleaning cloth (all wet cloths used in the post-renovation cleaning verification process must be at least damp to the touch, and must remain so during the process). Compare the cloth to the WET cleaning verification card (Figure 2-4), after wiping each windowsill with a wet cloth.

(a) If the cloth matches the card, that windowsill has passed the post-renovation cleaning verification.
(b) If the cloth does not match the card, that windowsill must be re-cleaned in accordance with proposed § 745.85(a) (4) (ii).

Wipe the windowsill with a new wet cloth, or the same one folded so that an unused surface is exposed, and compare it to the cleaning verification card after the windowsill has been re-cleaned. If the cloth matches the card, that windowsill has passed. If the cloth does not match the card, the windowsill must be re-cleaned again and left to dry. The study technicians will take one 3" by 6" post-wet verification windowsill dust wipe sample according to the job- and site-specific test plan before the contractors proceed with the re-cleaning and dry verification process.

Wait for one hour after the surface has been re-cleaned or until the surface has dried, whichever is longer. Wipe the windowsill with a dry disposable cleaning cloth and compare it to the DRY cleaning verification card (Figure 2-5). These steps must be repeated until a dry cloth, or a folded section of a dry cloth that has wiped the windowsill matches the cleaning verification card, or up to four dry cloth wipings, whichever comes first. At that point, that windowsill has passed the post-renovation cleaning verification process. Each windowsill in the work room must pass the post-renovation cleaning verification process before proceeding to the floor verification step.

Floors:

The technicians will have the floor taped off into zones that are less than 40 ft^2 in area, representing sampling and verification zones (see Section 2.2.2 for more information). Wipe each zone of the floor in the work area with a wet disposable cleaning cloth after the windowsills in the work area have passed the post-renovation cleaning verification. Wiping of floors must be done with an application device consisting of a long handle and a head to which the wet cloth is attached. The wet cloth must remain at least damp to the touch throughout this process, thus the zones are limited to an area of less than 40 ft^2.

Wipe a particular zone of floor. If the wet cloth matches the WET cleaning verification card (Figure 2-4), that zone has passed the post-renovation cleaning verification. If the wet cloth does not match the cleaning verification card after the first wiping of a zone, the surface of that zone of the floor must be re-cleaned in accordance with proposed § 745.85(a)(4)(ii). After re-cleaning, wipe that zone of the floor again using a new wet cloth. If the wet cloth matches the cleaning verification card, that zone of the floor has passed. If the wet cloth does not match the verification card, that zone of the floor must be re-cleaned as directed in proposed § 745.85(a) (4) (ii) and left to dry. The study technicians will take one 1 ft^2 post-wet verification floor dust wipe samples from the zone of the floor that has failed according to the job- and site-specific test plan before the contractors proceed with the re-cleaning and dry verification process.

For those zones of the floor that did not achieve post-renovation cleaning verification using the wet cloths, the contractor must wait for 1 hour after the floor has been re-cleaned or until the floor has dried, whichever is longer. Wipe those zones of the floor with a dry disposable cleaning cloth and compare it to the DRY cleaning verification card (Figure 2-5). This wiping must also be performed using an application device with a long handle and a head to which the dry cloth is attached. This process must be repeated until a dry cloth that has wiped all of the zones of the floor that have not yet passed verification matches the cleaning verification card or up to four dry cloth wipings, whichever comes first After all windowsills and floors have passed cleaning verification, the field technicians will proceed to post-verification sampling.

Figure 2-2. Cleaning verification process for windowsills.

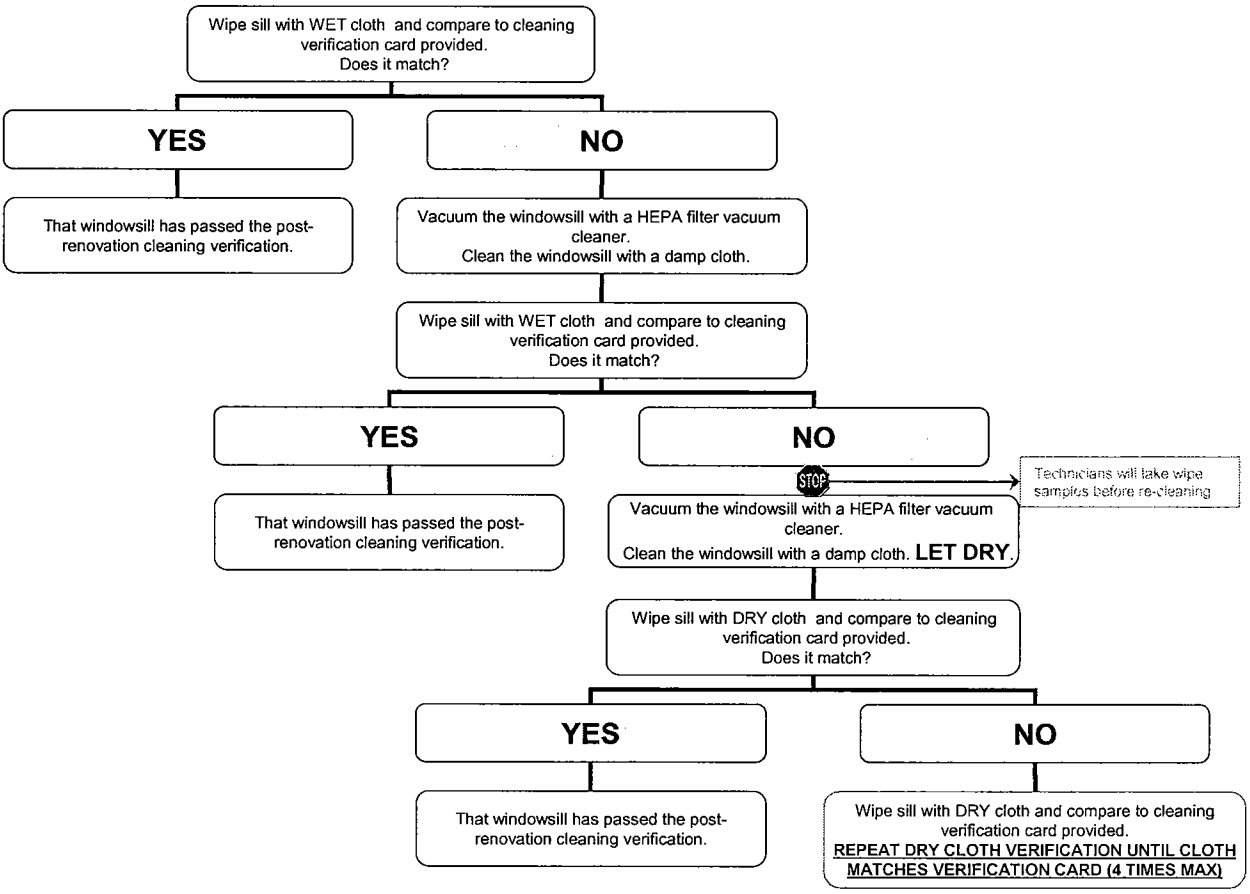


Figure 2-3. Cleaning verification process for floor zones.

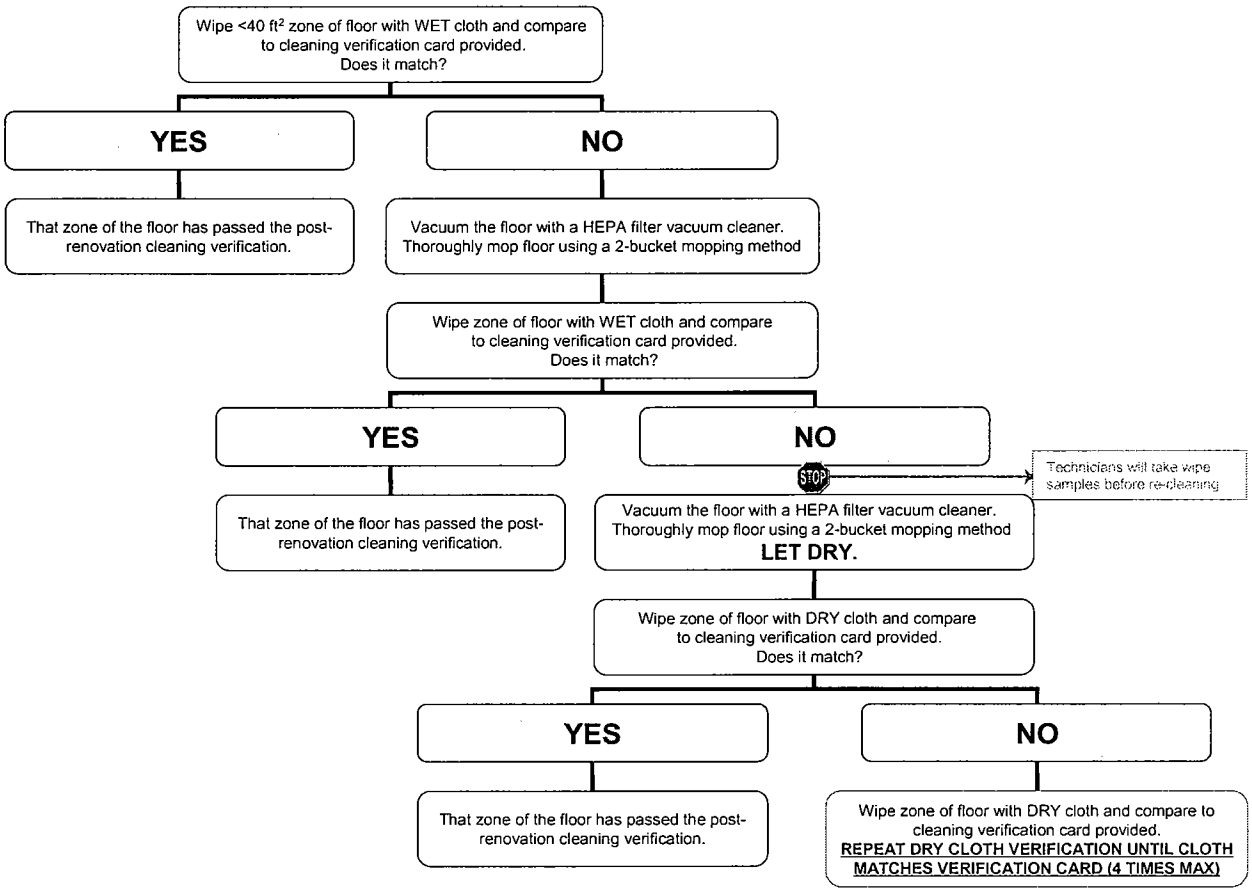


Figure 2-4. Verification card used for matching with WET verification cloths.

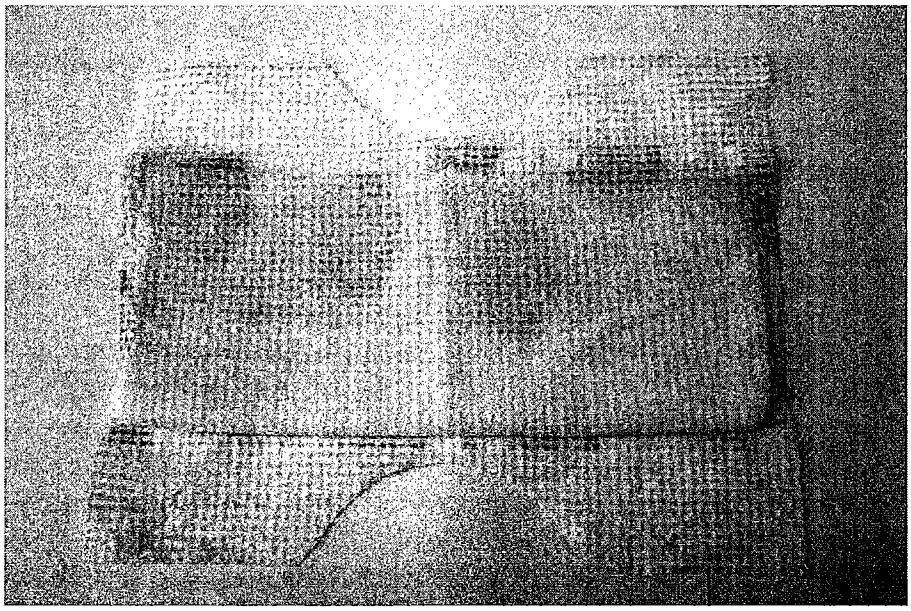
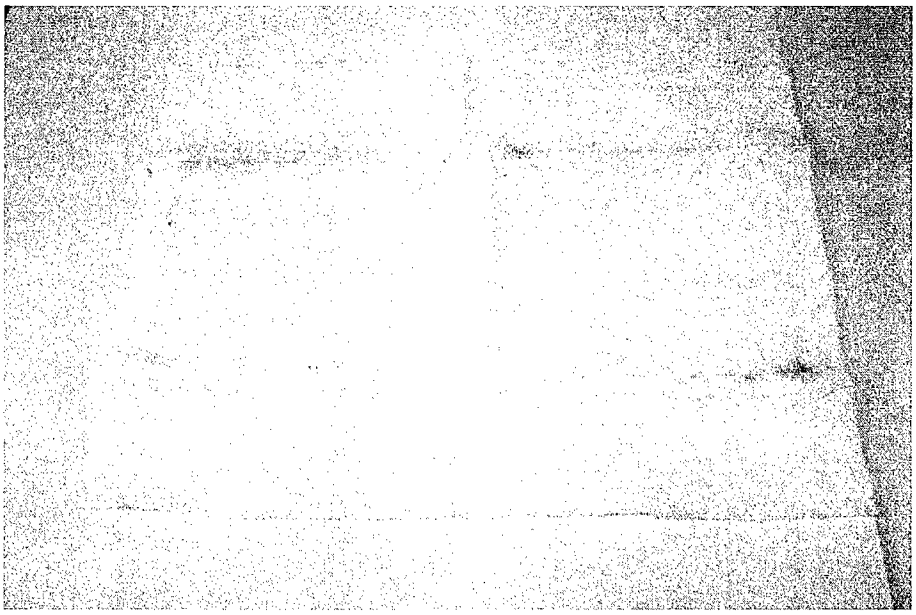


Figure 2-5. Verification card used for matching with DRY verification cloths.



2.1.5.1.12 Obtain Post-Cleaning Verification Environmental Samples

Study personnel will collect the post-cleaning verification environmental samples.

- The air samplers in each of the three study rooms will be turned off and the filter removed, stored in the appropriate container, and labeled.
- Obtain four 1 ft^2 floor dust wipe samples. The location of the samples to be collected will be specified in the job-specific sample plans.
- Obtain one 3" by 6" window sill dust wipe sample from a window within five feet of the work area, if possible, or from the nearest available window to the work area.
- Obtain two 1 ft^2 floor dust wipe samples and one 3" by 6" window sill sample from each of the two adjacent rooms. Again, the location of the samples to be collected will be specified in the job-specific sample plans. Label these appropriately so that they are identifiable as post-work samples.
- Take down all of the air samplers, pack them appropriately, and remove them from the unit.

After collection of the cleaning verification samples from the three study rooms and after the renovator leaves the site, the technicians will collect three additional 1 ft^2 floor dust wipe samples from a hallway connecting the study rooms to an entrance. This should be a hallway or path used by the contractors to transit between the entrance and the work room. These samples will be used to investigate differences in transported dust among various protection and cleaning routines.

In addition, three composite soil samples will be collected (see section 2.2.5). The three samples will be taken from bare soil nearest to (1) the entryway to the building used by the workers, (2) the walkway from the entryway to the street, and (3) a window closest to the work area without overlapping the samples taken during pre-experiment sampling.

2.1.5.1.13 Perform Post-Experiment Full Study Area Cleaning and Sampling

Following completion of all sampling activities for a single experiment in a housing unit that will undergo a subsequent job, a cleaning crew will re-clean all areas of the unit impacted by the study following the procedures detailed in Section 2.1.5.2. The plastic sheeting protecting the parts of a housing unit not impacted by the study will be left in place. At the completion of the cleaning activities, one dust wipe sample will be obtained by a certified inspector/risk assessor or clearance technician from all impacted rooms to determine if dust lead levels are below clearance levels. Technicians will store and label these samples and ship them immediately to the laboratory for analysis. If all samples are below the reporting limit of the lab, or 25% of the clearance levels, whichever is higher, the property is ready to be re-used for the study. If one or more samples achieve dust lead levels over the reporting limit of the lab, or 25% of the

associated clearance level, whichever is higher, the area that the sample was taken from will undergo re-cleaning. Following re-cleaning, another clearance sample will be obtained and re-analyzed.

2.1.5.1.14 Conduct Full House Post-Study Cleaning and Sampling

Following completion of all study activities in a housing unit, a cleaning crew will re-clean all areas of the unit impacted by the study following the procedures detailed in section 2.1.5.2. Subsequently, the plastic sheeting protecting the parts of a housing unit not impacted by the study should be taken down. The cleaning crew then will clean the remaining parts of the house following the same protocol. At the completion of these activities, one floor dust wipe and one window sill sample will be obtained by a certified inspector/risk assessor or clearance technician from all rooms in a housing unit to determine if dust lead levels are below clearance levels in all rooms. Technicians will store and label these samples and ship them immediately to the laboratory for analysis. For the final clearance, if all samples are below clearance, the property is ready to be vacated of all study activities. If one or more samples achieve dust lead levels over the clearance level, the area that the sample was take from will undergo re-cleaning. Following re-cleaning, another clearance sample will be obtained and re-analyzed.

2.1.5.2 Exterior Jobs

2.1.5.2.1 Pre-Experiment Sampling

Prior to setting up the plastic, technicians will obtain three composite soil samples (see section 2.2.5). If the surface is grass covered, the samples will be soil cores. If the surface is dirt covered, the scoop method of soil sampling will be used. If the surface is man-made, dust wipe samples will replace these pre-work soil samples. The three locations of the soil samples are as follows:

- Near the foundation of the housing unit/COF within the area to be covered by the rule plastic.
- At the back edge (furthest from the housing unit/COF) of the rule plastic.
- At the back edge (furthest from the housing unit/COF) of the containment plastic.

Three dust trays will also be set out prior to work commencing, to evaluate the background level of dust in the air. This will help determine if there is any cross-contamination from other sources in the work area. Technicians will take one 1 ft^2 dust sample from each of the three trays.

2.1.5.2.2 Prepare a Housing Unit or COF

In order to protect the public, under proposed § 745.85(a)(1), work areas will be clearly defined with signs warning occupants – and other persons not involved in renovation activities – to remain outside of the work area. These signs will be posted by the site supervisor before beginning the renovation and will remain in place until the renovation activity has been completed. Depending on the predominant languages of the area residents, these signs may be posted in multiple languages.

Either study technicians or a sub-contracted organization will set up containment for the purposes of protecting the property and surrounding properties from contamination. This "protection containment" will include a large area of plastic covering the ground, and may contain vertical containment up to the height of the work.

Study technicians will set up a weather station as close to the work area as possible without being in the way of the workers. The devices will be set up on the same side of the building as the work. In cases where work occurs on the corner of a building, the wind measurement devices should be installed so as to measure the wind at that corner, which might differ from the wind along the side of the building.

The technicians should also have a personal exposure monitor fitted and ready for use by one of the contractors.

2.1.5.2.3 Set up the Experiment (Including Work Area Containment)

For exterior jobs, all jobs will have a rule containment area set up by the contractors, which involves laying down plastic sheeting on the ground under the work on the exterior of the building. For the purpose of this study, the ground is considered to be the protection containment set up by field technicians. Three dust collection trays will be set up in the area that will be covered by the plastic prior to it being laid down. Subsequently, the plastic sheeting will be laid down on the ground covering the trays. The containment protocol includes:

- The plastic will extend out from the edge of the building a sufficient distance to collect falling paint debris.
- The plastic will be secured to the house using duct tape and weighted down on all sides with heavy objects such that a gust of wind will not disturb the dust and debris on the plastic due to movement of the plastic.
- Close all doors and windows within 20 feet of the outside of the work area on the same floor as the renovation.
- Close all doors and windows on the floors below that area.

- Cover doors within the work area (that must be used while the job is being performed) with plastic sheeting in a manner that allows workers to pass through while confining dust and debris to the work area.
- Where other buildings are in close proximity to the work area, or where the work area abuts a property line, take extra precautions in containing the work area to ensure that dust and debris from the renovation does not contaminate other buildings or migrate to adjacent property.

Dust collection pans will then be placed by study technicians on top of and near the rule plastic covering.

2.1.5.2.4 Set up Decontamination Area

The field technician will set up a decontamination area, where all study personnel will remove and dispose of their protective suits and booties, and remove all dust and debris from tools and supplies. For exterior experiments, this decontamination area will be located on the protection (extended) plastic, far enough off of the rule plastic as to not contaminate the data, and far enough from the edge of the extended plastic so that the grass or surrounding ground is not contaminated, either. Privacy will be taken into consideration if study personnel must change their clothing; in that case a tent or partial enclosure will be erected with plastic sheeting used as a floor and a pathway from the work area to the changing area.

2.1.5.2.5 Conduct the RRP Work Activity

The hired RRP contractor(s) will enter the property, set up their equipment and work space, and conduct their job as they normally would, within the specifications of the study. A technician will turn the personal exposure monitor on for the designated contractor. Contractors and study personnel will follow the appropriate OSHA and other guidelines regarding safety precautions, as specified in the study and site-specific health and safety plans. For example, all contractors and study personnel will wear protective clothing and footwear and half- or full-mask respirators. The study training manuals will contain directions on proper use of personal exposure monitors, respirators, and protective clothing as well as further details on environmental health and safety procedures

The following steps must be followed EACH time study personnel leave the work area:

- While standing in the decontamination area, slowly roll down Tyvec suit, careful to trap all dust and debris in the suit. Place suit in heavy duty garbage bag.
- Remove disposable booties and place in heavy duty garbage bag.

- Vacuum the exterior of the respirator using a HEPA Vac. Place respirator in designated storage area.
- Immediately wash hands and face with soap and water.
- If the contractor is equipped with the personal exposure monitor, the monitor will be removed and placed on designated shelf or hook within the work area before removing Tyvec suit.

2.1.5.2.6 Obtain Post-Work Environmental Samples

For the exterior work, following the one-hour wait after job completion, the field technicians will first obtain the dust-wipe samples from the dust collection pans that are on top of the rule plastic sheeting. Subsequently, the technician will have the contractor mist and fold the plastic sheeting inward to trap dust and debris inside. The contractor will then insert the plastic in a heavy duty garbage bag and the technician will dispose of it according to state and local regulations. Next they will obtain the dust wipe samples from the pans under the rule plastic. Lastly, the technicians will obtain the dust-wipe samples from the trays that were placed near the rule plastic.

After work is completed, technicians will obtain three composite soil samples (see 2.2.5). If the surface is grass covered, the samples will be soil cores. If the surface is dirt covered, the scoop method of soil sampling will be used. If the surface is man-made, dust wipe samples will replace these pre-work soil samples. The three locations of the soil samples are as follows:

- Near the foundation of the housing unit/COF within the area to be covered by the rule plastic.
- At the back edge (furthest from the housing unit/COF) of the rule plastic.
- At the back edge (furthest from the housing unit/COF) of the containment plastic.

The samples must not overlap with those taken during pre-experiment sampling.

2.1.5.2.7 Tear Down Containment

The field technician or sub-contracted organization that erected the vertical containment will remove the structure from the property. The field technician will then mist and fold inward the protection plastic and place it in a heavy duty garbage bag for disposal.

2.1.5.3 Follow Appropriate Safety and Health Guidelines

Appropriate safety and health guidelines will be followed by the contractors and field technicians while implementing the study protocol. While conducting RRP work, follow-up sampling, and post-work cleaning, respirators, disposable protective suits, and disposable protective footwear will be worn. These will be removed when exiting the work room. All personnel involved with the study should follow the separate environmental health and safety compliance plan.

2.2 SAMPLING METHODS

The study will utilize various methods of field data collection – paint chip sampling, dust wipe sampling, air sampling, soil sampling, work description information, wind information, and digital photographs. These data collection methods are described separately below.

2.2.1 Paint Chip Sampling

The study will conduct analyses of paint-chip samples to obtain laboratory measurements of the lead in the paint that is disturbed by the study jobs for data analysis and modeling. The results will also confirm the presence of lead based paint measured by the portable XRF device or verify inconclusive XRF results. In some cases, due to the condition of paint an XRF measurement may not be feasible, and a paint chip sample for laboratory analysis will have to be collected. Laboratory analysis is more accurate and precise than XRF but only if great care is used to collect and analyze the paint-chip sample. The method used to collect paint samples will be the cold-scraping method described in ASTM E1729, "Standard Practice for Field Collection of Dried Paint Samples for Subsequent Lead Determination". The size of the samples obtained will be approximately two square inches and will include all paint down to the substrate, minimizing the amount of substrate material in the sample. After collecting a sample and placing it in the appropriate sample container, the field technician will label it accordingly and record the sample locations and sample number on the Paint Chip Data Collection Form. Technicians will take appropriate safety precautions when collecting the paint samples, although it is not anticipated that respirators will be necessary.

2.2.2 Dust Wipe Sampling

Dust wipe sampling will occur according to ASTM 1728 Standard Practice for Collection of Settled Dust Samples Using Wipe Sampling Methods for Subsequent Lead Determination the Field technicians will collect wipe samples from interior floors and window sills (both from the surfaces and from plastic covering those surfaces) and from dust collection trays set up around exterior work using a dust wipe that meets the specifications of ASTM 1792.

For interior wipe sampling, samples taken across the four sampling stages (post-work, post-cleaning, post wet and dry cleaning-verification) for a single experiment will not be permitted to overlap. The location of each floor dust wipe sample will be specified by a job- and site-specific sampling plan. An example of such a plan is shown in Figure 2-6. The job in this example consists of a window replacement in a large room represented by the thick red line on the left wall of the room. The room is first divided into three zones (Zone 1, Zone 2, and Zone 3) that are less than 40 ft^2 in area so that they also may serve as the sections of the floor isolated for cleaning verification. Zone 1 represents the floor space closest to the work area. The sampling plan indicates randomly assigned sampling areas at each of the sampling stages. Zone 1 is randomly assigned two samples per stage. To permit more dense observations close to the work area, one of those samples will be required to be inside the direct area of influence (represented by the triple red line in Figure 2-6), while the other can be located anywhere inside of Zone 1. The area of influence will be flexibly determined prior to each job based on the unique configuration of each work room and the job to be conducted. Zones 2 and 3 will each be assigned one sample at each sampling stage, for a total of four samples per experiment. If the work room is smaller than 20 ft^2, adjustments to the site-specific sampling plan will be made accordingly. For example, if it is determined that the entire room represents the direct area of influence, all samples will be randomly selected from within the full room. If the technician determines that the designated sample area of the floor is not suitable for sampling with a dust wipe, the adjacent square - **within the same zone** - that is closest to the work area (and is not planned to be sampled) will serve as an alternate location. The new location of the sample will be recorded on the data collection sheets to ensure data accuracy and that there will be no overlapping samples.

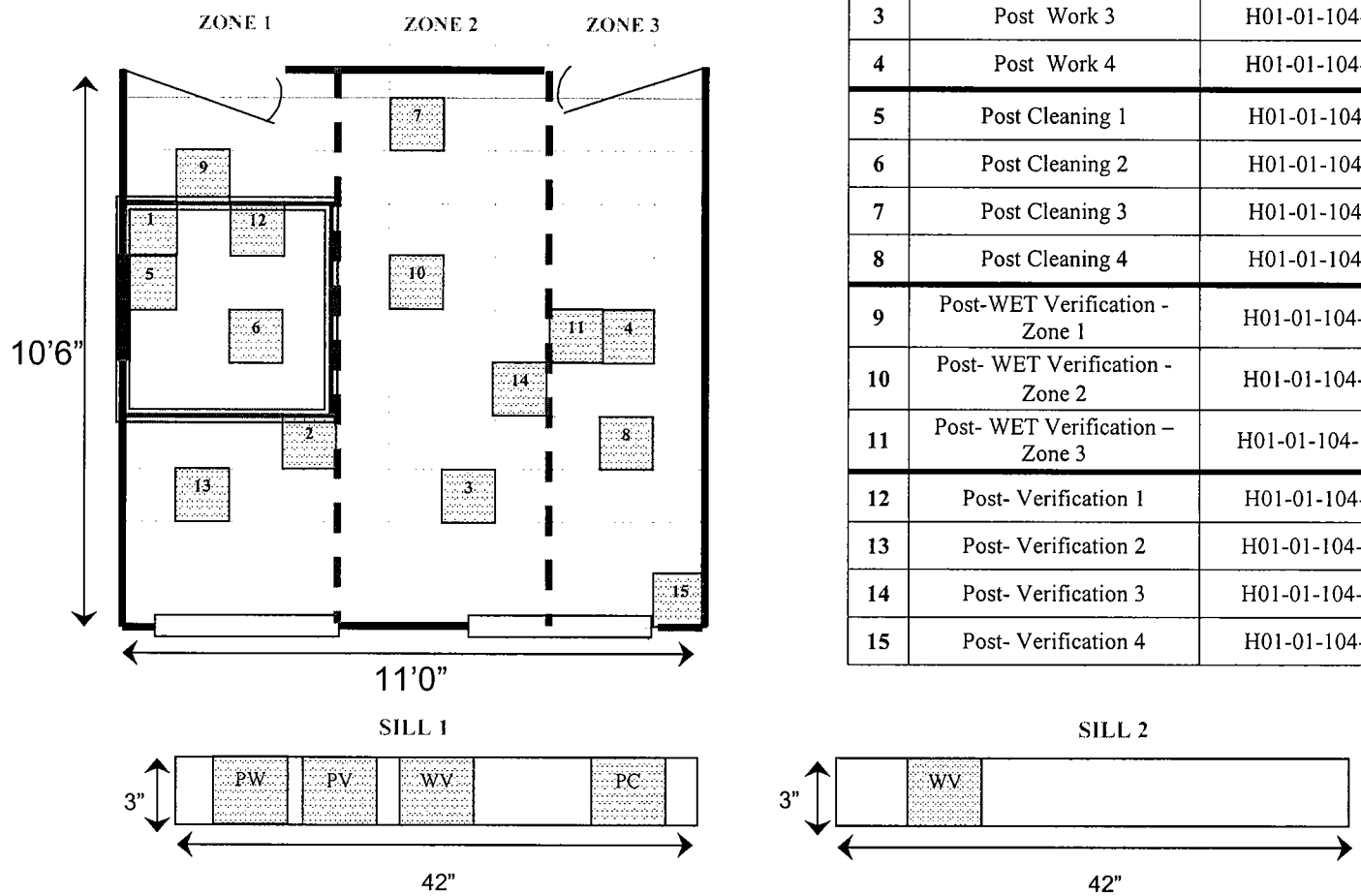
A similar sampling plan, as seen in Figure 2-6 for the work room, will be developed for the tool and observation rooms, as well. The rooms will be split in half according to the location of the door or walkway for workers. One floor dust wipe sample will be taken in each half during each sampling stage. The window sill to be tested in each room will be the one closest to the opening in the room nearest the work room, or to the path traveled by the workers.

The field technician will mark each floor sample location using a 1 ft^2 template. Immediately before laying down the template, the technician will wipe the template down with a moist towelette and dispose of the towelette in a heavy duty garbage bag. For window sills, technicians will mark sampling locations with 3" x 6" templates that present a wipe area exceeding the 0.1 ft^2 minimum required area for dust wipe samples. Technicians will record interior sampling information on the Interior Dust Wipe Collection Form included in Appendix D.

After preparing the sample container and donning a new disposable glove on the hand that will handle the sample, the technician will wipe the surface and package the wipe following the guidelines in Appendix E. Details of the protocol include:

- With a fully opened wipe laying flat on the surface, wipe side-to-side with an S-like motion pressing down with the palm and fingers until the entire area is covered. Debris should be included in the samples to the degree possible.
- Fold the wipe in half with the contaminated side facing inwards and wipe the area again from top-to-bottom with an S-like motion. For window sills, use two side-to-side passes. Debris should be included in the samples to the degree possible.
- Fold the wipe in half again with the contaminate side facing inwards and insert into the sampling container. Debris should be included in the samples to the degree possible.
- Label the sampling container with the Sample ID and record the appropriate information on the data collection form.

Figure 2-6. Site-specific sampling plan. Each square represents 1 ft^2. The triple line indicates the direct area of influence and the rectangular boxes represent windows. The bold red line is the location of the work.



#	DESCRIPTION	SAMPLE ID
1	Post Work 1	H01-01-104-PWF-01
2	Post Work 2	H01-01-104-PWF-02
3	Post Work 3	H01-01-104-PWF-03
4	Post Work 4	H01-01-104-PWF-04
5	Post Cleaning 1	H01-01-104-PCF-01
6	Post Cleaning 2	H01-01-104-PCF-02
7	Post Cleaning 3	H01-01-104-PCF-03
8	Post Cleaning 4	H01-01-104-PCF-04
9	Post-WET Verification - Zone 1	H01-01-104-VWF-01
10	Post- WET Verification - Zone 2	H01-01-104-VWF-02
11	Post- WET Verification – Zone 3	H01-01-104- VWF -03
12	Post- Verification 1	H01-01-104- PVF-01
13	Post- Verification 2	H01-01-104- PVF -02
14	Post- Verification 3	H01-01-104- PVF -03
15	Post- Verification 4	H01-01-104- PVF-04

Once the sampling for the stage has been completed, the used template will be wiped down with a moist towelette and stored for later use. Towelettes will be placed in a heavy duty garbage bag for later disposal.

For exterior experiments, the field technicians will follow the same protocol for collecting the samples from the dust collection trays as for the floor samples collected during interior experiments.

2.2.3 Ambient Air Sampling

Airborne dust samples will be collected at the specified locations following NIOSH Method 7082 using high volume sampling pumps. The pumps will be placed at approximately five feet off the ground. The following procedures will be used to set up the airborne dust sampling equipment and to collect the air samples for the study.

1) Set up a tripod to hold the air filter cassette or identify a shelf or other horizontal surface to hold the cassette. Set pump on the floor under the tripod or surface.
2) Put on clean disposable gloves and mount the filter cassette on the tripod or on the horizontal surface.
3) Connect the pump vacuum line to the filter cassette outlet and remove top inlet plug.
4) Store cassette plug and top cap in Ziploc bag.
5) Set the flow rate to 3L/min.
6) Turn on pump and enter start time on data collection form.
7) At stop time put on clean disposable gloves, tilt filter cassette inlet up so that sample particulate cannot fall out, then turn pump off.
8) Replace cassette top inlet plug and bottom plug. Put cassette into Ziploc bags. Discard gloves.
9) Enter end time on data collection form.

2.2.4 Personal Exposure Monitoring

During each sampling stage, at least one contractor will be equipped with a personal exposure monitor. The monitor will consist of a pre-loaded filter cassette connected to a low volume sampling pump (0.005 – 3 L/min). The filter cassette has no cut point, resulting in the sampling of all particles. The filters will be analyzed using NIOSH Method 7082. Each personal air monitor will be calibrated before and after each experiment. The following procedure will be used to set up and collect the samples from the personal air monitors:

1) Put on clean, disposable gloves and attach a pre-loaded filter cassette to the air pump.
2) Set the flow rate to 3 L/min.

3) Attach the filter cassette and pump to the contractor. The filter cassette should be attached to the outermost layer of protective clothing in a location most representative of what the contractor would be inhaling in the absence of a respirator.
4) Start the air sampler and record the start time on the data collection form.
5) Discard gloves.
6) At stop time, put on clean, disposable gloves, turn off air pump, and enter stop time on data collection form.
7) Remove the filter cassette from the contractor.
8) Remove the filter from the filter cassette so that no particulates can fall out and carefully place into a Ziploc bag with the appropriate identification label affixed.
9) Attach a new pre-loaded filter cassette to the air pump
10) Place the new cassette on the contractor in the same location as the first sample, restart air pump, and record start time on the data collection sheets.
11) Discard gloves.

Because the personal air monitor will be worn by an individual contractor, it is important that the contractor not leave the work room/area with the monitor. If the contractor does need to leave the area, the personal air monitor should be removed and remain in the work room/area for continued sampling.

2.2.5 Soil Sampling

Technicians will collect three composite soil samples at each exterior work location prior to the work commencing and the containment area being set up. The soil sampling protocol will follow ASTM E1727-05 Standard Practice for Field Collection of Soil Samples for Subsequent Lead Determination (included in Appendix E), which covers both scooping and coring methods. The scoop method will be used if bare soil is present. The coring method will be used if grass is present. The compositing procedure will involve obtaining five sub-samples from within a 1 ft radius circle of the first sub-sample. Each sub-sample will consist of the top ½" section of the soil core. The five sub-samples will be deposited into a single sampling container or baggie and labelled appropriately. The sampling locations should not overlap between each sub-sample and pre- and post-experiment sampling.

2.2.6 Work Description and Contractor Information

Form 11, the Experiment Information sheet, will be used to capture information on the type of RRP work conducted, the P/CU routine(s) used, and the contractor that conducted the work for each experiment.

2.2.7 Wind Information

In higher-wind environments, dust from the exterior work will spread over a larger area and be more difficult to measure with the fixed location dust collection trays. Thus, information on wind direction and speed is important for considering exterior sampling results. Prior to work beginning, technicians will set up a weather station that can indicate wind direction at the work location. If measured wind-speed is in excess of 30 miles per hour, no exterior work will be performed. Under these conditions, however, it is still appropriate to set-up exterior containment and sampling trays so that work can commence when the wind decreases. Technicians will record wind speed on the appropriate data collection form.

2.2.8 Precipitation

Exterior work cannot be performed during precipitation. If the predicted probability of precipitation for a given workday exceeds 20 percent, no exterior work will be performed on that day. If precipitation does occur once work has begun, work will cease immediately. Tools and sampling materials will be brought in to a dry location, and the work site will be covered as much as possible. Based on the site supervisor's judgment, the experiment may be determined invalid and the work may have to be repeated. All precipitation events during outdoor work will be recorded.

2.2.9 Digital Photographs and Recordings

Technicians will obtain digital photographs of various locations and activities during the study including:

- The initial inspection of the properties,
- The contractors conducting the work,
- The plastic coverings set up as containment,
- The observation rooms with doorways visible into the adjacent study room,
- The air sampler in the work room,
- The post-work cleaning process, and
- The final wet and dry cleaning verification cloth.

Additionally, a sample of cleaning verifications will be video-recorded by study field technicians. The study will use a device that allows digital versions of the recordings to be created and stored electronically.

2.3 SAMPLE HANDLING AND CUSTODY

To ensure sample integrity throughout the collection and analysis process, every dust wipe and air sample storage container will be labeled with a permanent marker or adhesive label. Identifying information will include the Sample ID, date, and time, which will also be recorded on the appropriate data collection form. The data collector will store the samples in a cooler or other rigid-walled container until they can be shipped or transported to the laboratory. Prior to shipping, the data collector will record all samples on the Chain of Custody Record. When the laboratory receives the samples, they will ensure that all samples have been received by reviewing, annotating, and signing the Chain of Custody Record forms.

After analysis of the samples is completed, any remaining samples or digestate will be stored for at least six months. The Battelle laboratory (or other participating laboratory) will store the samples at their facility. Once the six month storage period has passed, Battelle will dispose of any remaining samples according to state and Federal guidelines, using Battelle's waste disposal program.

2.4 ANALYTICAL METHODS

Paint Chip Samples - Sample preparation will be performed according to EPA Method 3050B and the subsequent analysis of the determination of lead will follow EPA Method 7420 (Atomic Absorption). The analysis will provide measurements of lead concentrations in $\mu g/g$ and $\mu g/cm^2$. The performance of the method will be assessed by evaluation of the QC sample results. If the method does not perform acceptably, according to the QC criteria specified in Section 2.5, the procedures will be reviewed and altered as necessary.

Dust Wipe Samples – The dust wipe samples will be prepared according to EPA Method 3050B and analyzed for lead content using EPA Method 7420. The detailed protocols are included in Appendix F. The analysis will provide measurements of lead concentrations in $\mu g/ft^2$. The performance of the method will be assessed by evaluation of the QC sample results. If the method does not perform acceptably, according to the QC criteria specified in Section 2.5, the procedures will be reviewed and altered as necessary.

Ambient Air Samples – Air filter samples will be analyzed using NIOSH Method 7082 (included in Appendix F). The analysis will provide measurements of lead concentrations in $\mu g/m^3$.

Personal Air Samples - Air filter samples from the personal air monitors will be prepared and analyzed using NIOSH Method 7082. The analysis will provide measurements of lead concentrations in $\mu g/m^3$.

Soil Samples – EPA Method 3050B will be used to prepare the soil samples for analysis. EPA Method 7420 will be used to analyze the samples for lead. Both of these methods are included in Appendix F. The analysis will provide measurements of lead concentrations in µg/g. The performance of the method will be assessed by evaluation of the QC sample results. If the method does not perform acceptably, according to the QC criteria specified in Section 2.5, the procedures will be reviewed and altered as necessary.

2.5 QUALITY CONTROL

Quality control (QC) samples will be used to ensure accuracy and consistency in sample handling and laboratory analysis. Table 2.7 depicts the QC sample type, frequency and acceptance limits for all QC measures in accordance with the Laboratory Quality System Requirements (LQSR) developed by EPA. Note that the matrix spike and duplicate samples can only be performed for those sample types that can be split (i.e. paint chip and soil samples). The listing of QC requirements in Table 2.7 should not replace or remove any requirements of the LQSR, rather they may serve as a supplement to those requirements. If any of the laboratory QC samples are out of the range of acceptance limits, the laboratory will record the exception and report it to the Principal Investigator, who will take appropriate action. The items in **bold** represent QC samples to be provided by Battelle, without identification as such, to the laboratory for analysis. Upon receipt of the results, the control spike and field blank results will be reviewed by Battelle to ensure they are within the acceptance limits. If not, the Principal Investigator will be notified immediately and will take appropriate action.

Table 2.7 Quality Control Performance Requirements

QC SAMPLE	FREQUENCY	ACCEPTANCE LIMITS
Independent Calibration Verification (ICV)	Once per day after calibration.	Within ±10% of known value.
Initial Calibration Blank (ICB)	Once per run at the beginning of the run.	Absolute value not more than 10% of the regulatory limit or minimum level of concern.
Continuing Calibration Verification (CCV)	Beginning and at the end of a sample run as well as every 10 samples.	Within ± 15% of known value.
Interference Check Sample (ICS)	Beginning and end of each run or twice every eight hours	Within ±20% of known value
Continuing Calibration Blank (CCB)	After each ICS and CCV	Absolute value not more than 10% of the regulatory limit or minimum level of concern.

QC SAMPLE	FREQUENCY	ACCEPTANCE LIMITS
Laboratory Control Sample	One per 20 samples or batch (min. frequency 5%).	Within ±20% of known value
Matrix Spike Sample	One per 20 samples or batch (min. frequency 5%).	Within ±25% of calculated value.
Duplicate Field Sample	One per 20 samples or batch (min. frequency 5%).	Within ±25% Relative Percent Difference (RPD)
Laboratory Blank Sample	One per 20 samples or batch (min. frequency 5%).	Absolute value not more than 10% of the regulatory limit or minimum level of concern.
Replicate Analysis	One per 20 samples or batch (min. frequency 5%).	Within ±10% Relative Percent Difference (RPD)
Field Blank Sample	**Two per interior experiment, one per exterior experiment**	**Absolute value not more than 10% of the regulatory limit or minimum level of concern.**
Control Spike Sample	**One per 20 samples or batch (min. frequency 5%).**	**Within ±20% of calculated value.**

Since the sampling media for personal air and indoor air samples are the same, they are combined for the purposes of calculating the total number of field blanks and control spikes required. The control spike samples will be prepared by the Department of Environmental Services (DES) at the University of Cincinnati using National Institute of Standards and Technology (NIST) Standard Reference Materials. Internal QC procedures at DES require that spike samples be prepared to within a 5% tolerance for low spike amounts and a 3% tolerance for larger spike amounts. DES will prepare approximately 5 additional internal QC spike samples for every batch of 20 control spike samples ordered for analysis. If any of these internal QC spike samples have lead concentrations higher than the specified 3% or 5% tolerance, the entire batch of QC samples will be discarded and a new batch of samples will be generated.

2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Laboratories used to analyze samples collected in the study will be asked to provide or verify appropriate credentials, e.g., their NLLAP recognition if they are an NLLAP-recognized lab. They will also be asked to provide:

- records of their experience using the protocols that they are being asked to implement,
- the written procedures or manuals they follow in conducting all QA/QC work,
- the QC sample results for review by the study team, and

- procedures for implementing corrective action when QC sample limits are exceeded.

They will be asked to ensure that all instruments and equipment are maintained in sound operating condition and are capable of operating at acceptable performance levels. Records will be maintained for each major instrument, including records of in-house preventive maintenance and service. The frequency of calibration/verification for each instrument will be documented. Description of the problem or service, dates and types of repair, organization and person performing repair, and contact phone number will be recorded. The record will identify the instrument by make and model number.

2.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The laboratory used for chemical analysis will be asked to provide calibration measurements for the instruments used in analyzing the dust wipe, air samples, soil samples and paint chip samples as specified in the analytical method. The instruments will be calibrated with a minimum of three standards daily prior to use. Calibration coefficients of .0995 or better should be achieved or the instrument will be recalibrated. All calibration curves will be dated and labeled with applicable method, instrument identification, analysis date, analyte concentrations, and instrument response. Measurements used to calculate detection limits will also be requested.

2.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All supplies and consumables to be used in the field and laboratory activities will be inspected by qualified staff (under the supervision of the Field Activities Coordinator and Laboratory Manager) and determined to be acceptable for use on the project prior to use. The Field Activities Coordinator and the Laboratory Manager(s) will determine appropriate acceptance criteria (e.g. expiration dates, certificates of cleanliness or testing) for critical field and laboratory supplies. Results of the inspection will be documented in the study files.

2.9 NON-DIRECT MEASUREMENTS

The study will utilize publicly available meteorological data to account for wind speed and direction on sampling and work activity days if the study weather station cannot provide data for any reason. All non-directly collected data will be evaluated to ensure that they meet the standards and requirements for data that are collected directly (see section 1.5) and if used will be noted accordingly.

2.10 DATA MANAGEMENT

The Battelle Principal Investigator and the Laboratory Manager(s) are responsible for the detection and correction of errors and for the prevention of data loss during data entry, reduction, reporting, and other manipulation. Error detection and correction will be properly documented. Battelle will manage the data on computers using MS Excel 2003 and SAS v9.1.

Consistent back-up and data archiving techniques will be used to ensure that data management work products are not subject to computer failure. Daily backups of individual PCs and computers are conducted. Final datasets containing all study measurements - XRF readings (in mg/cm^2), paint chip lead levels (in $\mu g/g$ and mg/cm^2), dust lead levels (in $\mu g/ft^2$), air lead levels (in $\mu g/m^3$), work descriptions, and other descriptive information for each completed site will be provided to EPA in an agreed upon format that can be made available to the public. A data dictionary describing each data field will also be written and delivered to EPA with the final data.

Information gathered on hard copy data collection forms will be data entered into custom data entry screens with the appropriate identifying information and stored in a study database. Data entry results will be spot-checked by the PI to ensure accurate transfer of data from the hand-written forms to the electronic files. Data managers will transfer all the data from the study database to SAS datasets for statistical analysis purposes.

Laboratory measurements of lead levels in paint, wipe, and air samples will be obtained from the laboratory in an Excel spreadsheet. Following review, a data manager will transfer these data to the study database. Additionally, supporting information for the various samples will be transcribed from the data collection forms into study database, reviewed for accuracy, and transferred to SAS datasets.

3.0 ASSESSMENT AND OVERSIGHT

3.1 ASSESSMENTS AND RESPONSE ACTIONS

Three field audits will be performed in order to ensure that all elements of the QAPP have been implemented correctly and that data of sufficient quality are generated. One audit will take place during interior sample collection. A second audit will occur during exterior sample collection. A third audit will occur during sample collection at a child occupied facility. The Battelle QA Manager will have the responsibility of reviewing the field data collection process to ensure that sample collection procedures specified in Section 2.2 or referenced methods are being followed. In addition, the sample design and all other specifications related to the field activity specified in this QAPP will be examined for compliance. These audits will occur at multiple units or buildings, if possible, and overlap with actual work activities. If problems are identified with sample collection protocols, the Battelle QA Manager will immediately report these to the Field Activity Coordinator who will ensure that the problems are corrected. Because the field implementation process needs to happen over a short period of time, it is critical that any problems be identified and corrected quickly.

Findings of the field audit will be recorded and submitted to the Principal Investigator for immediate corrective action (if needed) in an audit report. The Principal Investigator will then return the field audit report, documenting any corrective actions taken, to the Battelle QA Manager who will confirm that the corrective actions were adequate and completed. Finally, the field audit report will be routed through the Project Manager for review. The Battelle QA Manager will retain the report in permanent files. Copies of the audit report will also be provided to the EPA WAM.

All data will be entered into the study database, with the QA Manager responsible for conducting audits of data quality for the various QC samples including blank samples, spiked samples, and laboratory duplicate samples. The QA Manager will also perform a data audit soon after all data are received from the participating laboratories to ensure that sample information received from the labs matches with the sample information collected in the field and that the data have been correctly entered into the study database. The QA Manager will lead a software audit of all SAS and Excel programs used for data analysis and modeling with assistance from experienced statisticians.

3.2 REPORTS TO MANAGEMENT

Written reports covering the progress made and the results of this study will be delivered to EPA on a regular basis. The schedule for these reports is provided in Table 3-1. In addition, we will keep the EPA WAM informed on weekly progress, problems, etc. via e-mail and/or conference calls. A written progress report will be included in the contract's monthly progress report.

Table 3-1. Schedule of Reports

Report	Due Date
Final Full Study QAPP	After peer review of study design
Field Audit Reports	2 weeks after each audit
Laboratory TSA report	2 weeks after each audit
Data audit report	2 weeks following audit
Field data collection report	October 2, 2006
Draft Final Study report	November 2, 2006
Revised Final Study report with data and data dictionary	December 29, 2006
Monthly progress reports	20th day of subsequent month

Descriptions of these reports listed in Table 3-1 are as follows.

QAPP – a document detailing all aspects of the study protocol, DQOs, and analysis plan.

Field Audit Reports – Reports containing observations and results from field audits. This report will discuss any issues identified during the audits and steps taken to address those issues.

Laboratory TSA Reports – Reports containing observations and results from lab audits. This report will discuss any issues identified during the audits and steps taken to address those issues.

Data audit report – Report containing observations and results from data audit. This report will discuss any issues identified during the audit and steps taken to address those issues.

Field data collection report – This report will summarize the field work conducted including number of units/buildings enrolled and the type of work conducted at each.

Draft final study report – This report will summarize the design, implementation, and data analysis results for the entire study.

Revised final study report with data and data dictionary – This revised report will reflect changes to the draft report based on feedback received from EPA and additional analyses completed since the draft report was submitted. The data in electronic format will be included, along with a data dictionary that defines and explains each data element.

Monthly Progress Reports – Each month Battelle will provide a written summary of activities completed that month and any issues encountered,

4.0 DATA VALIDATION AND USABILITY

4.1 DATA REVIEW, VERIFICATION, AND VALIDATION

In order to determine if data collected during the project achieve the criteria on data quality specified in Section 1.5, the Principal Investigator will subject all data to a verification and validation process. Data will be reviewed using the criteria specified below, and any data that fail to meet any of the criteria will be investigated as described in Section 4.2. If data errors cannot be corrected (i.e., errors other than calculation errors, data entry errors, transcription errors, etc.), those data will be flagged and excluded from final analyses.

4.2 VERIFICATION AND VALIDATION METHODS

Data verification and validation will be performed to ensure that the criteria specified below have been met. Methods for verifying the compliance, correctness, consistency, and completeness of the data are described below.

Compliance and Correctness – The characteristics of selected sites will be documented to show that they meet the required criteria for inclusion. Data collector and laboratory log books will be reviewed to determine if data collection and analysis protocols were followed and basic operations and calculations were performed correctly.

Consistency - The range of the dust lead and ambient air lead measurements will be evaluated to determine whether they appear to be reasonable and consistent.

Completeness – Completeness of the data is determined by successful sample collection and analysis of at least 95 percent of all planned dust wipe and ambient air samples. In addition, work activities need to be accurately captured for 100 percent of all units and buildings undergoing work.

Once it is determined that the data have successfully passed the data verification elements above, data validation will take place. This process will ensure that the data can be used as intended to make decisions and address project objectives. The PI will review that all targeted housing units or other enrolled facilities contain the required characteristics for use in this study.

When data problems are found, the Principal Investigator will notify the responsible person for the data (e.g., Field Operations Coordinator, Laboratory Manager, etc.). This individual will attempt to resolve the data problem. Possible solutions include correcting a mistake in a spreadsheet formula, correcting a calibration curve, and correcting data entry errors. Corrected data will be re-submitted to the Principal Investigator for validation and verification again.

Data that are confirmed to be in error but cannot be corrected (e.g., sample was contaminated in laboratory) will be removed from the study database and replaced with a flag indicating the specific problem. Data that appear suspicious but have no reason for which to invalidate them will be reported in the database accompanied by a flag that indicates their possible outlier status. Analysts and users of the data will need to consider how to include these data points in their analyses.

4.3 RECONCILIATION WITH USER OBJECTIVES

Data results will be compiled, and the Battelle Principal Investigator will determine if the results fall within the acceptable limits defined in this QAPP. Reconciliation with the data quality objectives specified in Section 1.5 will be performed once all data problems have been resolved. If criteria on data quality (e.g. DQOs) are not achieved, reanalysis will be required until these criteria are met or until Battelle and EPA determine that the data cannot be improved. If a sufficient number of housing units or other facilities with the required characteristics are not identified at the completion of the data collection process, additional prospective units will have to be identified and screened according to the procedures in this plan.

APPENDIX A

STATISTICAL ANALYSIS PLAN AND POWER STUDY

Appendix A
General Statistical Methods and Power Study for the EPA RRP Spread of Dust Study

For the purposes of generating data quality objectives for the RRP Spread of Dust Field Study, we introduce the following series of three general regression models:

$$Y_{ijklm} = \mu_{ij} + \beta_1 \cdot I_{k=2} + \beta_2 \cdot I_{l=2} + \beta_3 \cdot I_{k=2} \cdot I_{l=2} + \beta_4 \cdot C_{ijklm} + W_{ijm} + \varepsilon_{ijklm} \quad (1)$$

$$Y_{ijklm} = \mu_{ij} + \beta_{1i} \cdot I_{k=2} + \beta_{2i} \cdot I_{l=2} + \beta_{3i} \cdot I_{k=2} \cdot I_{l=2} + \beta_4 \cdot C_{ijklm} + W_{ijm} + \varepsilon_{ijklm} \quad (2)$$

$$Y_{ijklm} = \mu_{ij} + \beta_{1ij} \cdot I_{k=2} + \beta_{2ij} \cdot I_{l=2} + \beta_{3ij} \cdot I_{k=2} \cdot I_{l=2} + \beta_4 \cdot C_{ijklm} + W_{ijm} + \varepsilon_{ijklm} \quad (3)$$

where an activity represents a unique combination of i,j,k,l and m; and

i = 1,…,3 (representing low, medium, and high intensity RRP activities)
j = 1,…,n_i (representing specific activity-types within the above categories)
k = 1 (no containment) or 2 (containment)
l = 1 (normal cleanup) or 2 (RRP proposed cleanup)
m = 1,….,r – where r represents the number of replicate experiments[1]

Y_{ijklm} represents the response variable in the experiment, and for interior jobs may represent dust-lead loadings on a variety of surfaces (bare floors, window sills, stainless steel dust collectors) at various points in time during the experiment (prior to cleanup, following cleanup, following verification), and in different locations relative to the RRP activity (in the same room, an adjacent room). For interior RRP jobs, the response variable could also represent air monitoring samples at various points in time or locations. The response variable in the model could also represent percent reductions in dust-lead levels from post-activity to post-cleaning (or from post-cleanup to post-verification) on different surface types. While the above three models were introduced with interior RRP experiments in mind, they could easily be generalized to exterior RRP jobs, where the response variable could represent soil-lead concentrations at various points in time or locations relative to the RRP activity.

It is anticipated that the above series of models would be fit to each candidate response variable separately. Within Model (1), μ_{ij} represents the mean response (dust-lead loading or air-lead concentration) for treatment intensity (i) and activity type (j) assuming no containment and normal cleanup. β_1 is a parameter that captures the differential effect of containment on the response variable (compared to no containment), β_2 is a parameter that captures the differential effect of the proposed RRP cleanup on the response variable (compared to normal cleanup), and β_3 is a parameter that captures any interaction between containment and RRP cleanup on the response variable.

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[1] *Note – r could be replaced by r_{ij} (to allow for different numbers of replicates for different types of activities) or even by r_{ijkl}*

In some cases, multiple measurements will be taken of response variables. For example, four dust-wipe samples will be taken from the work-room during each sampling opportunity in order to better characterize spatial distribution of leaded dust (sampling opportunity is defined as a unique combination of RRP job, replicate, phase, stage, and work area). For the purpose of fitting Models (1), (2) or (3), however, our proposed statistical approach is based on an average lead-loading or lead-concentration response variable among the multiple samples obtained within each sampling opportunity. In later modeling stages, if individual sample information is employed in a model that accounts for spatial variability among these samples, the power to detect the effects of cleaning and containment will only increase.

C_{ijklm} represents a vector of covariates that must be factored into the model (e.g. paint-lead loadings on the surfaces that are disturbed, pre-activity dust-lead loading, etc.). The specific form of these covariates should be considered to allow for appropriate interpretation of the other parameters in the model (e.g. we may wish to adjust the results for activities that disturb lead-painted surfaces containing 2 mg Pb/cm^2, requiring us to center that particular variable, as appropriate, prior to fitting the model). β_4 is a vector of parameters that capture the effect of C_{ijklm} on the response variable.

While the μ_{ij} and β parameters discussed above are fixed-effects parameters, we also introduce a random effect (W_{ijm}) that is meant to capture variability attributable to which RRP worker is conducting the activity. By design, we intend to have a single RRP contractor perform an activity under all possible permutations of containment and clean-up. We assume that W_{ijm} follows a normal distribution with mean zero and variance σ^2_{Worker}.

ϵ_{ijklm} represents error left unexplained by the model, and is assumed to follow a normal distribution with mean zero and variance σ^2_{Error}.

> *Note: There also may need to be a series of additional random effects that are entered into the model to account for (1) activities that are conducted within the same room, (2) activities conducted within the same residential unit, and (3) activities conducted within the same city. These random effects would essentially partition the above error term into different variance components – and may affect the standard errors associated with any of the parameter estimates (μ or β) in the above general models.*

In Model (2), we assume that the effects of containment and cleanup method (and any interaction) are captured in the β_{1i}, β_{2i}, and β_{3i} parameters – and that the effects of containment and cleanup are different across the intensity-levels, but similar among different activity types within the same intensity level. Finally, in Model (3), we assume that the effects of containment and cleanup method (and any interaction) are captured in the β_{1ij}, β_{2ij}, and β_{3ij} parameters – and that the effects of containment and cleanup are different across both intensity-levels and activity types.

Note that the effects of containment and cleanup might not be included for every response variable. For example, it is questionable whether the effects of containment would be detectable when assessing the amount of dust-lead hazard generated by an activity in the work room (the containment system might keep dust-lead hazards from escaping the work area – but it is

questionable whether this would be detectable within the limited number of samples being collected in this field study). For looking at hazards attributable to RRP activities in an adjacent room, the model would likely adjust for the effects of containment (but not cleanup). Similar reductions of the model would likely occur for use with the exterior RRP experiments.

Study Objectives

Study Objective 1

As described in Section 1.5, the first study question will attempt to establish the effect of low medium and high level RRP work on dust lead levels both for interior and exterior projects.

In addressing this objective, for each dust-lead response variable, a test for normality and log-normality will be performed using a Shapiro-Wilk test. Histograms and normal probability plots will be constructed to graphically explore the distribution of the dust-lead loading type. If the dust-lead loading type is found to follow a lognormal distribution then the analysis would be performed on the natural logarithm of the results (which is presumed in this document). Scatter plots and tables of descriptive statistics will be used to characterize the dust lead levels post-work, post-cleaning, and post-verification both across intensity levels and within intensity levels.

Models (1) through (3) as described in the beginning of this section will then be applied to each response variable of interest (post-work, post-cleaning, post-verification dust lead loadings, percent reductions of dust lead loadings, etc) with careful attention paid to model fit. If dust lead levels are in fact dependent on intensity level of the RRP work, one would expect Model (2) to show the best fit and $\beta_{11} \neq \beta_{12} \neq \beta_{13}$, etc. However, if the dust lead levels are activity specific, then Model (3) will show a better fit of data. The findings from Study Objective 1 will play a significant role in determining which of the 3 Models will be used for subsequent objectives. Please note that additional testing of the individual β's is covered in the study objectives below.

Study Objective 2

Study Question 2 will investigate the role of heavy duty polyethylene plastic sheeting during the work activity on lead dust levels at post cleaning and post verification phases. This second question also will investigate whether the role of plastic sheeting has an interaction with level of intensity of RRP work.

The specific questions that will be posed to address this research objective are:

- Do the dust-lead loading results reasonably follow a normal or lognormal distribution?
- Is the effect of using plastic sheeting constant across intensity of RRP activities (low, medium, and high) and specific activity-type?
- Does the effect of cleanup (normal cleanup or RRP proposed cleanup) interact with the effect of plastic sheeting?
- What covariates could be added to the model that might explain some of the variability in effectiveness of plastic sheeting?

Similar methods as those proposed for Objective 1 will be used to assess the distributional assumptions for each response variable considered for Objective 2, and
Models 1, 2, and 3 will be fit to the dust-lead loading results. Using model fitting parameters such as individual F-statistics, we will decide which of the three models best fits the data. If Model 3 fits the data best, then the effects of containment (plastic sheeting) are different across both intensity-levels and activity types. If Model 2 fits the data best, then the effects of containment are different across the intensity-levels, but similar among different activity types within the same intensity level. If Model 1 fits the data best, then the effects of containment are similar across intensity-levels and activity types.

In the Models (1, 2 and 3), the β_1 coefficient corresponds to the main effect of using plastic sheeting on the mean response for each activity type and intensity level. The hypothesis $H_0 : \beta_1 = 0$ (or $H_0 : \beta_{1i} = 0$, $H_0 : \beta_{1ij} = 0$ as appropriate) will be tested to see if there is a statistically significant effect of plastic containment on lead dust levels.
Also, 95% confidence intervals for the main effect of plastic sheeting can be found using these models.

The β_3 coefficient in Models 1, 2 and 3 corresponds to the interaction between using plastic sheeting and RRP proposed cleanup. If this coefficient is significantly different than zero, then the effect of plastic sheeting is different depending upon the type of cleanup.

There are a number of possible covariates that should be factored into the model. These include the baseline level of paint lead loading on the disturbed surfaces, pre-activity dust lead level, and distance of the collection tray/wipe from the disturbed surface. Other possible covariates could be added to control for other environmental factors, such as the floor surface type and condition. Also, random effects could be added to help explain variability among room, house, contractor, and city.

Study Objective 3

Study objective 3 will investigate whether there are significant differences in post-cleaning and/or post-verification lead levels between surfaces cleaned with the proposed rule cleaning method and surfaces cleaned with standard cleaning methods. The specific questions that will be posed to address this research objective are:

- Do the dust-lead loading results reasonably follow a normal or lognormal distribution?
- Is the effect of clean-up (normal cleanup or proposed RRP rule cleanup) constant across intensity of RRP activities (low, medium, and high) and specific activity-type?
- Does the effect of cleanup (normal cleanup or proposed RRP rule cleanup) interact with the effect of plastic sheeting?
- What covariates could be added to the model that might explain some of the variability in effectiveness of cleaning method?

Similar methods as those proposed for Objective 1 will be used to assess the distributional assumptions for each response variable considered for Objective 3, and Models 1, 2, and 3 will be fit to the dust-lead loading results. Using model fitting parameters such as individual F-statistics, we will decide which of the three models best fits the data. If Model 3 fits the data best, then the effects of cleanup (normal cleanup or RRP proposed cleanup) are different across both intensity-levels and activity types. If Model 2 fits the data best, then the effects of cleanup are different across the intensity-levels, but similar among different activity types within the same intensity level. If Model 1 fits the data best, then the effects of cleanup are similar across intensity-levels and activity types.

In the Models (1, 2, and 3), the β_2 coefficient corresponds to the main effect of using the proposed RRP rule cleanup method on the mean response for each activity type and intensity level. The hypothesis $H_0 : \beta_2 = 0$ (or $H_0 : \beta_{2i} = 0$, $H_0 : \beta_{2ij} = 0$ as appropriate) will be tested to see if there is a statistically significant effect of cleanup method on lead dust levels. Also, 95% confidence intervals for the main effect of cleanup can be found using these models.

Again, the β_3 coefficient in Models 1, 2, and 3 corresponds to the interaction between use of plastic sheeting and cleanup method. If this coefficient is significantly different than zero, then the effect of plastic sheeting is different depending upon the type of cleanup. Possible covariates including the baseline level of lead loading on the disturbed surfaces, pre-activity dust load level, distance of the collection tray/wipe from the disturbed surface and environmental factors will be input into the model as appropriate. Also, random effects could be added to help explain variability among room, house, contractor, and city.

Study Objective 4

Study Question #4 investigates the dust migration from the work room to adjacent rooms during different levels of interior RRP work. Statistical analysis, including distribution assumptions, graphical presentation, tabular presentation, and hypothesis testing will follow the general outline of study objectives #2 and #3. This time, however, the endpoints will be those collected in the tool and observation rooms. Study Question #4 also encompasses the analysis of air monitoring throughout the interior work. Analysis of the lead in the air filters will be checked for normality and analyzed much like the dust endpoints. Special care will be given when analyzing the dust and air endpoints to carefully control for the covariates that describe distance from the work room.

Study Objective 5

Exterior work and the use of plastic ground coverings as advised by the proposed RRP rule is covered under Study Question #5. Specifically, Study Question #5 asks if the plastic ground coverings are sufficient in reducing dust lead from falling onto the surrounding ground. Statistical analysis, including distribution assumptions, graphical presentation, tabular presentation, and hypothesis testing will follow the general outline of study objectives #2 and #3. Similar to Study Question #4, special care will be given when analyzing the dust endpoints to carefully control for the covariates that describe distance from the work area as well as the meteorological data which may have influenced the fall of lead to the ground.

Limitations of the Study

It should be noted that the study is not designed to address issues related to lead hazards that were present in the housing unit prior to when RRP activities occur. It is also not designed to directly address cases of difficult to clean floor and sill surfaces, and is also not designed to address RRP-related dust-lead hazards on carpeted floor surfaces.

Power Study

To assess the potential for the RRP Spread of Dust study to address the above study objectives, a series of power studies were conducted utilizing the general statistical model introduced earlier in this appendix. The power studies investigated all combinations of the following:

- ***Response Variable:*** The power studies considered natural-log transformed interior floor dust-lead loadings as the primary response variable. Three specific responses were investigated:
    - Amount of dust-lead hazard generated by the RRP activity in the work area (e.g. the natural-log transformed dust-lead loading from a stainless steel dust collector located in proximity to the lead-painted surface(s) being disturbed).
    - Natural-log transformed dust-lead loading found on smooth floor surfaces in the work area following cleanup (and containment, as applicable)
    - Natural-log transformed dust-lead loading found in an adjacent room
- ***Number of Replicates:*** The number of replicates correspond to the number of times each unique combination of activity-type, containment (yes/no), and cleanup type (normal/RRP) is pursued in the study. The power study considered values of 2, 3, 4 and 5 replicates to determine how this impacts the ability to assess the various different objectives of the study.
- ***Variability Left Unexplained (σ_{Error}):*** The power studies considered three values (0.75, 1.00, and 1.25) as low, medium and high anticipated levels of variability in dust-lead loadings left unexplained by the model.

Many of the specific parameters that were included in the power studies (for the effects of μ and β) were based on EPA's draft Economic Analysis for the proposed RRP rule[1] and other studies that were referenced in that document. Table A1 provides input for the six different activities that we selected for this power study, based on information contained in Tables 5C-4 and 5C-5 of EPA's RRP Economic Analysis Report. EPA assumed that the dust-lead hazards found in adjacent rooms would be approximately 16% of the hazard generated by each activity, based on an analysis of air samples collected in work areas and adjacent areas during the EPA Renovation and Remodeling Environmental Field Sampling Study.

Table A1 Target RRP Activities and Assumed Geometric Mean Dust-Lead Hazards Generated in the Work Area and Found in an Adjacent Room

RRP Treatment Intensity	Model Parameter	Description of Activity*	Dust-Lead Loading ($\mu g/ft^2$)	
			Work Area	Adjacent Room
Low	μ_{11}	Add/Replace Internal Water Pipes	1,800	288
	μ_{12}	Add/Replace Electrical Wiring	4,663	746
Medium	μ_{21}	Add/Replace Built in Heating Equipment	7,750	1240
	μ_{22}	Add/Replace Doors or Windows	12,444	1991
High	μ_{31}	Renovation of Bathroom	35,631	5701
	μ_{32}	Renovation of Kitchen	67,963	10874

*Note that the RRP activities listed in Table A1 above represent a subset of the RRP activities that EPA was initially considering for this field study, and do not exactly match the set of six targeted interior jobs listed in the main body of the QAPP. They can be considered representative, however, of the expected dust lead loadings that may be encountered at the three levels of work activity,

Additional assumptions for the power study are as follows:

1. Normal cleanup on smooth floors reduces the dust-lead loading by between 96.3 and 98.5 percent. The proposed RRP cleanup will be 70 percent more effective at reducing dust-lead loadings on smooth floors.
2. Containment will reduce dust-lead hazards on floors in the work area and the adjacent room by between 95 and 99 percent.
3. The fraction of dust-lead hazards that is transported to an adjacent room ranges from 12 to 20 percent (with an average of 16 percent).
4. A random effect for RRP worker was included in the power study, with σ_{Worker}=0.4.
5. Random uniform numbers were used to select the specific value for the above parameters (within the specified range) in the power study.
6. The power studies do not include any additional covariates or random effects (other than the RRP worker cited above). The inclusion of covariates or random effects for the analysis of data from the field study (once conducted) would likely reduce the error left unexplained by the model, and have the effect of increasing the power of the study to detect the key parameters.

The power studies were conducted using Model (1) as the basis. If Model (2) is more appropriate (which assumes that the effects of clean-up or containment are different for each level of treatment intensity), then the effective sample size for the study is approximately ⅓ of what is presented under Model (1) in terms of the power to detect the β parameters. If Model (3) is more appropriate (which assumes that the effects of clean-up or containment are different for each type of activity), then the effective sample size for the study is approximately ⅙ of what is presented under Model (1) in terms of the power to detect the β parameters.

The power studies were conducted by simulating and analyzing 200 datasets for each combination of response variable, number of replicates, and σ_{Error}. Each dataset was analyzed in SAS using an appropriate Mixed Model Analysis of Variance (ANOVA) model, and the power to detect the effects of containment and/or cleanup were assessed (for each response variable)

using a two-sided test of statistical significance at the 0.05 level, as shown in Table A2a. The average difference in hazard-reducing efficiency of cleanup and containment were also assessed for each of the three response variables considered, with the value shown in Table A2a representing the average hazard-reducing efficiency differences attributable to containment (approximately 97%) or the more substantive RRP cleanup (approximately 70%). The power study results presented in Table A2a demonstrate that the study is adequately powered to detect the effects of containment under Model (1) with as few as 2 replicates.

Table A2b provides power study results across Models (1), (2) and (3). Here, the average parameter estimate and standard error from the analysis results the 200 simulated Model (1) datasets are used as a basis. The standard errors are multiplied by the appropriate multiplicative factor ($\sqrt{3}$ and $\sqrt{6}$ for Models (2) and (3), respectively) and then the relative difference in hazard reduction efficiency detectable with 80 percent power was computed formulaically, using the standard normal distribution. As expected, the results in Table A2b suggest that the study is well powered to detect the estimated differential effects of containment (97%) and cleanup (70%) assuming Model (1) with as few as 2 replicates. Under the assumptions of Model (2) [that the effects of containment and/or cleanup vary with treatment intensity], the study is still well powered to detect the estimated effects of containment with 2 replicates, but would require 3 replicates to detect a 70% (treatment intensity – specific) difference in the efficiency of cleanup methods. Under Model (3), the study would require more than 5 replicates to detect 70% differences in cleaning efficiency (which would be activity-specific) – which is likely not feasible given time and resource constraints.

Geometric means and associated 95% confidence intervals were also constructed for the dust-lead loading associated with each activity type from the Model (1) simulations, which are presented for each response variable in Tables A3-A5. These confidence intervals are based on the average parameter estimate and standard error observed among the 200 simulated datasets. They are also based on the assumptions of dust-lead levels generated by each RRP activity, based on the specific activities listed in Table A1. As expected, the geometric means are relatively stable for each activity type, with the 95% confidence intervals becoming narrower as a function of increasing replicates and decreasing σ_{Error}. Since we assumed the response variable(s) follow a lognormal distribution, the 95% confidence intervals have multiplicative interpretation, as shown in Table A6. The multiplicative half-width of the 95% confidence interval is the same across all activity types due to the balanced design (equal number of replicates for each combination of activity type, containment (yes/no) and method of cleanup (normal/RRP)) and the pooled error term (σ_{Error}) across the field study. *Note that the multiplicative half-widths of the 95% confidence interval are wider for the post-cleaning samples than the post-activity samples, because the power study assumes additional variability being introduced by each worker's cleaning habits.* The interpretation of these multiplicative factors is as follows: GM=LB*MF and UB=GM*MF – where GM represents the geometric mean, LB and UB represent the lower and upper bounds of the 95% confidence intervals, and MF represents the multiplicative factor listed in Table A6. The results in Table A6 suggest that although 2 replicates may be sufficient for detecting the effects of containment and cleanup-method on smooth floors, it may not be adequate for estimating the hazards and post-cleanup levels associated with different types of activities (depending on the level of precision required for these estimates).

Recommendations for Design

The above power study corresponds to RRP activities conducted on the interior of residential units, and does not provide direct insight for proposed experimentation within child occupied facilities (COFs) or residential exterior RRP activities. *The question of whether data from the COFs will be modeled separately from the residential data (or combined with the residential data in a single global model) has not yet been determined – and will likely depend on the degree of overlap of specific RRP activities that are conducted in the two types of buildings, as well as any important similarities or differences in the results revealed within the exploratory statistical analyses.*

When EPA initiated power studies for the COFs – it was determined that the assumptions that were going into the power studies for COFs were identical to those that were being used for the residential units – which led to a presumption that the data could be combined in subsequent data analyses.

Ultimately, it would be desirable to combine the data across the two building types – which would provide additional statistical power for the study – however, EPA was conservative in providing power study results only for the subset of data that would be collected in residential housing. Obviously, power analyses for data analysis objectives that consider COFs on their own would yield less power than those provided in this appendix (as less data is being collected in COFs than residential units). Based on a simple statistical calculation, any estimated differences that are detectable with power greater than 0.975 in Table A2a within residential units would be detectable within COFs (based on the notion that the number of experimental units within the COFs is approximately ¼ of the number of experimental units being pursued within residential units).

The study design that was explored in the above power analysis has the following features:

- Three treatment intensity levels (low, medium and high), and two specific RRP activities per treatment intensity level (for a total of six specific RRP activities explored).
- Within each RRP activity explored, a different RRP worker will conduct the activity four times, allowing us to gather data for a 2x2 experiment that looks at all combinations of containment (yes/no) and cleanup (normal/RRP).
- A replicate corresponds to the number of different times the above 2x2 experiment is conducted with a different RRP worker within the study (assuming that this number ranges from 2-5).

Thus, the above design with 3 replicates would represent a total of 18 different RRP workers, each repeatedly conducting a single activity four times, allowing EPA to collect post-activity, post-cleanup, and post-verification dust and air samples corresponding (as appropriate) to both types of clean-up and containment.

In terms of estimating the fixed-effects β parameters in the model associated with the effects of cleanup and containment under Model (1) – there is no difference between the above design with 6 RRP activities and 3 replicates, and one that includes (3 RRP activities and 6 replicates per

activity) or (9 RRP activities and 2 replicates per activity) – as these provide equivalent data with respect to estimating the effects of cleanup and containment. The same can be said for Model (2), as long as there are equal numbers of activities selected for each treatment intensity level. For Model (3), the power to detect the fixed-effects β parameters in the model will be inversely proportional to the number of activities represented in the design (as the assumption in Model (3) is that the effects of containment and cleanup are activity-specific).

In terms of estimating the fixed-effects μ parameters in the model associated with the mean dust-lead or air-lead levels associated with different activities (or treatment intensity levels), the width of the confidence intervals are directly influenced by the number of replicates included in the design.

EPA's choice of a study design should consider the following:

- Under Model (1), a design with 6 RRP activities (evenly distributed among the 3 treatment intensity levels), and 2 replicates would be sufficient to detect the hypothesized differences in hazard reduction efficiency attributable to containment and cleanup. This type of design would require 48 separate interior experiments: (6 RRP activities) x (2 Replicates) x (2 levels of Containment) x (2 levels of Cleanup).
- Under Model (2), the same design would be sufficient to detect the hypothesized effects of containment, however the effects of cleanup would require 3 replicates. This would increase the number of interior experiments from 48 to 72 – which may not be feasible given current resource and time limitations.
- Similarly, under Model (3) the same design would be sufficient to detect the hypothesized effects of containment, but the effects of cleanup would require more than 5 replicates (which is almost certainly infeasible).

Table A2a **Power to Detect the Estimated Difference in Containment or Cleanup Efficiency on Various Surfaces as a Function of the Number of Replicates and σ_{Error} Assuming Model (1)**

Number of Replicates	σ_{Error}	Effects of Containment vs. No Containment				Effects of RRP vs. Normal Cleanup	
		Work Area Bare Floors		Adjacent Room		Work Area Bare Floors	
		Estimated Difference	Power	Estimated Difference	Power	Estimated Difference	Power
2	0.75	0.973	1.000	0.973	1.000	0.708	0.970
	1.00	0.973	1.000	0.973	1.000	0.702	0.815
	1.25	0.972	1.000	0.972	1.000	0.702	0.635
3	0.75	0.973	1.000	0.973	1.000	0.700	1.000
	1.00	0.973	1.000	0.973	1.000	0.698	0.960
	1.25	0.972	1.000	0.972	1.000	0.703	0.840
4	0.75	0.972	1.000	0.972	1.000	0.702	1.000
	1.00	0.973	1.000	0.973	1.000	0.691	0.980
	1.25	0.971	1.000	0.971	1.000	0.701	0.970
5	0.75	0.973	1.000	0.973	1.000	0.701	1.000
	1.00	0.972	1.000	0.972	1.000	0.701	1.000
	1.25	0.973	1.000	0.973	1.000	0.694	0.975

*Note – These results are based on a 2-sided test with size α=0.05

Table A2b **Minimal Efficiency of Containment or Cleanup Detectable with 80 Percent Power as a Function of the Assumed Model, the Number of Replicates and σ_{Error}**

Number of Replicates	σ_{Error}	Effects of Containment						Effects of Cleanup		
		Work Area Bare Floors			Adjacent Room			Work Area Bare Floors		
		M1	M2	M3	M1	M2	M3	M1	M2	M3
2	0.75	0.505	0.704	0.821	0.481	0.679	0.799	0.505	0.704	0.821
	1.00	0.586	0.783	0.885	0.569	0.767	0.873	0.586	0.783	0.885
	1.25	0.652	0.840	0.925	0.644	0.833	0.921	0.652	0.840	0.925
3	0.75	0.438	0.631	0.756	0.417	0.607	0.733	0.438	0.631	0.756
	1.00	0.514	0.714	0.829	0.499	0.698	0.816	0.514	0.714	0.829
	1.25	0.579	0.776	0.880	0.569	0.768	0.873	0.579	0.776	0.88
4	0.75	0.396	0.582	0.709	0.377	0.559	0.686	0.396	0.582	0.709
	1.00	0.465	0.661	0.784	0.450	0.645	0.769	0.465	0.661	0.784
	1.25	0.531	0.731	0.844	0.522	0.721	0.836	0.531	0.731	0.844
5	0.75	0.366	0.546	0.672	0.347	0.521	0.647	0.366	0.546	0.672
	1.00	0.430	0.622	0.748	0.418	0.608	0.734	0.430	0.622	0.748
	1.25	0.493	0.691	0.810	0.484	0.683	0.803	0.493	0.691	0.810

*Note – These results are based on a 2-sided test with size α=0.05

Table A3 Geometric Mean and Associated 95% Confidence Interval for the Amount of Lead Hazard Found in the Work Area Prior to Cleanup as a Function of RRP Activity Type

Number of Replicates	σ_{Error}	Geometric Means and Associated 95% Confidence Intervals					
		Low Intensity Treatment		Medium Intensity Treatment		High Intensity Treatment	
		Plumbing μ_{11}	Wiring μ_{12}	Heating μ_{21}	Window/Door μ_{22}	Gut Bathroom μ_{31}	Gut Kitchen μ_{32}
2	0.75	1797 (833,3875)	4661 (2161,10053)	7610 (3528,16414)	13085 (6067,28222)	34376 (15938,74145)	69335 (32146,149547)
	1	1790 (730,4393)	4894 (1995,12010)	7798 (3178,19136)	12562 (5119,30824)	35175 (14335,86313)	66013 (26902,161983)
	1.25	1832 (643,5222)	4416 (1550,12587)	7837 (2750,22336)	12250 (4298,34913)	35780 (12554,101974)	68283 (23959,194607)
3	0.75	1792 (975,3293)	4641 (2525,8528)	7832 (4262,14393)	12530 (6818,23026)	36603 (19919,67264)	66592 (36237,122373)
	1	1836 (887,3798)	4822 (2331,9976)	7926 (3831,16400)	12980 (6273,26854)	36303 (17546,75110)	67719 (32731,140108)
	1.25	1865 (814,4273)	4750 (2073,10885)	7820 (3413,17921)	12490 (5451,28622)	35276 (15394,80837)	66240 (28906,151790)
4	0.75	1801 (1068,3036)	4784 (2837,8067)	7959 (4720,13420)	12583 (7462,21217)	35347 (20963,59601)	67980 (40316,114627)
	1	1773 (962,3268)	4439 (2409,8180)	7727 (4193,14240)	12468 (6766,22976)	37419 (20306,68957)	67958 (36877,125233)
	1.25	1869 (906,3858)	4849 (2349,10010)	7852 (3804,16208)	12853 (6227,26530)	35995 (17438,74298)	69622 (33729,143711)
5	0.75	1819 (1132,2925)	4771 (2968,7670)	7812 (4860,12558)	12146 (7556,19525)	36189 (22513,58172)	66241 (41208,106479)
	1	1810 (1029,3185)	4653 (2645,8188)	7437 (4227,13085)	12176 (6920,21424)	36231 (20591,63749)	67115 (38144,118090)
	1.25	1780 (924,3427)	4972 (2582,9576)	7799 (4049,15019)	12272 (6372,23635)	36186 (18790,69690)	66371 (34463,127821)

Table A4 Geometric Mean and Associated 95% Confidence Interval for the Amount of Lead Hazard Found in Adjacent Rooms (Assuming No Containment) as a Function of RRP Activity Type

Number of Replicates	σ_{Error}	Geometric Means and Associated 95% Confidence Intervals					
		Low Intensity Treatment		Medium Intensity Treatment		High Intensity Treatment	
		Plumbing μ_{11}	Wiring μ_{12}	Heating μ_{21}	Window/Door μ_{22}	Gut Bathroom μ_{31}	Gut Kitchen μ_{32}
2	0.75	288 (124,667)	740 (319,1716)	1194 (515,2768)	2097 (905,4860)	5455 (2353,12644)	11149 (4810,25841)
	1	285 (106,764)	775 (289,2078)	1255 (468,3365)	2002 (747,5367)	5559 (2074,14900)	10585 (3949,28372)
	1.25	283 (90,891)	690 (219,2172)	1236 (393,3889)	1912 (608,6017)	5610 (1783,17655)	10864 (3452,34188)
3	0.75	285 (146,556)	734 (377,1429)	1245 (639,2425)	1996 (1025,3889)	5835 (2996,11367)	10587 (5435,20623)
	1	293 (132,647)	772 (349,1707)	1256 (568,2777)	2050 (927,4534)	5781 (2614,12786)	10670 (4824,23599)
	1.25	294 (119,730)	744 (300,1845)	1228 (495,3046)	1962 (791,4864)	5537 (2233,13729)	10359 (4178,25685)
4	0.75	284 (160,505)	759 (427,1349)	1253 (705,2229)	1995 (1122,3548)	5600 (3149,9958)	10868 (6111,19327)
	1	284 (145,556)	712 (364,1393)	1237 (632,2420)	2006 (1025,3926)	5942 (3036,11627)	10847 (5543,21226)
	1.25	286 (130,628)	757 (344,1665)	1207 (549,2655)	1977 (899,4349)	5574 (2534,12258)	10757 (4891,23659)
5	0.75	287 (170,484)	756 (448,1274)	1237 (733,2085)	1941 (1151,3273)	5752 (3411,9699)	10428 (6184,17583)
	1	286 (155,528)	739 (400,1364)	1180 (639,2178)	1908 (1034,3523)	5758 (3119,10631)	10578 (5730,19528)
	1.25	284 (139,578)	798 (392,1624)	1248 (613,2541)	1963 (964,3997)	5803 (2850,11817)	10669 (5239,21727)

Table A5 Geometric Mean and Associated 95% Confidence Interval for the Amount of Lead Hazard Found in the Work Area on Smooth Floors Following Normal Cleanup (No Containment) as a Function of RRP Activity Type

Number of Replicates	σ_{Error}	Geometric Means and Associated 95% Confidence Intervals					
		Low Intensity Treatment		Medium Intensity Treatment		High Intensity Treatment	
		Plumbing μ_{11}	Wiring μ_{12}	Heating μ_{21}	Window/Door μ_{22}	Gut Bathroom μ_{31}	Gut Kitchen μ_{32}
2	0.75	60 (24,149)	150 (60,375)	245 (98,611)	426 (171,1062)	1101 (442,2745)	2243 (900,5591)
	1	57 (20,168)	155 (53,454)	253 (87,737)	401 (137,1168)	1109 (380,3235)	2104 (721,6137)
	1.25	58 (17,198)	139 (41,475)	245 (72,840)	393 (115,1348)	1134 (331,3885)	2201 (643,7540)
4	0.75	57 (28,116)	146 (71,299)	246 (120,506)	392 (191,805)	1157 (563,2376)	2088 (1016,4291)
	1	59 (25,140)	155 (65,366)	250 (106,591)	410 (173,969)	1156 (489,2732)	2125 (899,5024)
	1.25	59 (22,156)	150 (57,397)	244 (92,644)	397 (150,1051)	1107 (418,2927)	2088 (790,5523)
8	0.75	57 (31,107)	152 (81,283)	249 (133,464)	404 (217,755)	1121 (601,2091)	2164 (1160,4038)
	1	56 (27,116)	139 (68,287)	243 (118,502)	397 (193,818)	1172 (568,2415)	2133 (1035,4397)
	1.25	58 (25,135)	150 (64,352)	242 (103,565)	398 (170,930)	1114 (476,2607)	2185 (934,5113)
16	0.75	58 (33,102)	153 (87,269)	246 (140,434)	389 (221,684)	1152 (654,2028)	2087 (1186,3675)
	1	56 (29,110)	149 (76,289)	235 (121,456)	384 (197,746)	1146 (589,2228)	2118 (1089,4119)
	1.25	56 (26,121)	157 (73,337)	246 (115,527)	390 (182,834)	1158 (541,2479)	2114 (987,4528)

Table A6 **Multiplicative Half-Width of 95% Confidence Intervals for the Geometric Mean Dust-Lead Loading Associated with Each Activity.**

Number of Replicates	σ_{Error}	Multiplicative ½ Width of 95% Confidence Interval		
		Work Area Hazard	Adjacent Room Hazard	Post Clean Smooth Floors
2	0.75	2.157	2.318	2.493
	1.00	2.454	2.680	2.917
	1.25	2.850	3.147	3.425
3	0.75	1.838	1.948	2.055
	1.00	2.069	2.212	2.364
	1.25	2.292	2.479	2.645
4	0.75	1.686	1.778	1.866
	1.00	1.843	1.957	2.062
	1.25	2.064	2.199	2.339
5	0.75	1.607	1.686	1.760
	1.00	1.760	1.846	1.944
	1.25	1.926	2.036	2.142

Descriptive Statistics

Prior to running the statistical models, data analysts will summarize the various types of study data and generate descriptive statistics on the data collected, e.g. means, medians, standard deviations, as appropriate. Tables A7-A9 are examples of the descriptive summaries of the data that will be produced and evaluated prior to running statistical models.

Table A7. Comparing Mean Dust Lead Levels Across Interior Study Rooms and Work Levels

Work Phase	Study Room	Low Level		Medium Level		High Level	
		Floors	Sills	Floors	Sills	Floors	Sills
Post-Work	Work Room	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
	Tool Storage	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
	Observation	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
Post-Cleaning	Work Room	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
	Tool Storage	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
	Observation	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
Post-Cleaning Verification	Work Room	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
	Tool Storage	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)
	Observation	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)	μ (σ)

Table A8. Comparing Mean Air Lead Levels Across Interior Study Rooms and Work Levels

Work Phase	Study Room	Low Level	Medium Level	High Level
Post-Work	Work Room	μ (σ)	μ (σ)	μ (σ)
	Tool Storage	μ (σ)	μ (σ)	μ (σ)
	Observation	μ (σ)	μ (σ)	μ (σ)
Post-Cleaning	Work Room	μ (σ)	μ (σ)	μ (σ)
	Tool Storage	μ (σ)	μ (σ)	μ (σ)
	Observation	μ (σ)	μ (σ)	μ (σ)
Post-Cleaning Verification	Work Room	μ (σ)	μ (σ)	μ (σ)
	Tool Storage	μ (σ)	μ (σ)	μ (σ)
	Observation	μ (σ)	μ (σ)	μ (σ)

Table A9. Mean Lead Levels Across Individual Interior Jobs

Work Level	Specific Job	Post-Work			Post-Cleaning			Post-Cleaning Verif.		
		Floors	Sills	Air	Floors	Sills	Air	Floors	Sills	Air
L	Job1									
	Job2									
M	Job3									
	Job4									
H	Job5									
	Job6									

[1] U.S. Environmental Protection Agency (2005) Economic Analysis for the Renovation, Repair, and Painting Program Proposed Rule. Draft Report submitted by Abt & Associates to US EPA Office of Pollution Prevention and Toxics under contract 68-W2-077

APPENDIX B

EXCERPTS FROM PROPOSED RRP RULE

Work Area Containment, Cleaning, and Cleaning Verification

Excerpts from Federal Register/Vol. 71, No. 6, January 10, 2006

Work Area Containment

b. *Containing the work area.* Under proposed § 745.85(a)(2), a firm must contain the work area so that no visible dust or debris leaves the work area while the renovation is being performed. Containment refers to methods of preventing leaded dust from contaminating objects in the work area and from migrating beyond the work area. It includes everything from the simple use of disposable plastic drop cloths to the sealing of openings with plastic sheeting. When planning a renovation project, special consideration should be given to determining the type of work site preparation necessary to prevent dust and debris from leaving the work area.

Renovation projects generate varying amounts of leaded dust, paint chips, and other lead-contaminated materials depending on the type of work, area affected, and work methods used. Repairing a small area of damaged drywall is likely to generate less lead-contaminated dust and debris than sanding a large area in preparation for painting. Because of this variability, the size of the area that must be isolated and the containment methods used will vary from project to project. Large renovation projects could involve one or more rooms and potentially encompass an entire home or building, while small projects may require only a minimal amount of containment. The necessary work area preparations will depend on the size of the surface(s) being disturbed, the method used in disturbing the surface, and the building layout. The certified renovator assigned to a renovation would weigh all of these factors in determining the appropriate work area size and preparation level for that particular situation. For example, repairing a small area of damaged drywall would probably require a smaller work area and minimal preparation while demolition work would probably require a larger work area and extensive preparation in order to prevent the migration of dust and debris from the work area. The certified renovator is responsible for weighing all of these factors and designing a system of containment that ensures that no dust and debris leaves the work area. EPA is proposing to define the term ''work area'' as the area that the certified renovator establishes to contain all of the dust and debris generated by a renovation, based on the certified renovator's evaluation of the extent and nature of the activity and the specific work practices that will be used.

i. *Interior renovations.* At a minimum, interior work area preparations must include removing or covering all objects in the work area, closing and covering all forced air HVAC ducts in the work area, closing all windows in the work area, closing and sealing all doors in the work area, and covering the floor surface, including installed carpet, with taped-down plastic sheeting in the work area. Doors within the work area that must be used while the job is being performed must be covered with plastic sheeting or other impermeable material in a manner that allows workers to pass through, while confining dust and debris to the work area. In addition, all personnel, tools, and other items, including the exterior of containers of waste, must be free of dust and debris when leaving the work area. Alternatively, the paths used to reach the exterior of the home must be covered with plastic sheeting or other impermeable material to prevent the debris outside the work area.

ii. *Exterior renovations.* For exterior projects, work area preparations must include, at a minimum, covering the ground with plastic sheeting or other disposable impermeable material extending out from the edge of the structure a sufficient distance to collect falling paint debris, closing all doors and windows within 20 feet of the outside of the work area on the same floor as the renovation, and closing all doors and windows on the floors below that area. For example, if the renovation involves sanding a 5-foot by 5-foot area of paint on the third floor of a building, and that side of the building is only 40 feet long, all doors and windows on that side of the third floor must be closed, as well as all of the doors and windows on that side of the second and first floors. In situations where other buildings are in close proximity to the work area, or where the work area abuts a property line, the firm performing the renovation may have to take extra precautions in containing the work area to ensure that dust and debris from the renovation does not contaminate other buildings or migrate to adjacent property. In addition, doors within the work area that must be used while the job is being performed must be covered with plastic sheeting or other impermeable material in a manner that allows workers to pass through while confining dust and debris to the work area.

Cleaning the Work Area

d. *Cleaning the work area.* Under proposed § 745.85(a)(4), a firm would be required to clean the work area to remove visible dust, debris or residue, as well as dust particles too small to be seen by the naked eye. All renovation activities that disturb painted surfaces can produce dangerous quantities of leaded dust. Because very small particles of leaded dust are easily absorbed by the body when ingested or inhaled, a small amount can create a health hazard for young children. Unless this dust is properly removed, renovation and remodeling activities are likely to introduce new lead-based paint hazards. Therefore, careful cleaning is required. Improper cleaning can increase the cost of a project considerably because additional cleaning may be necessary during post-renovation cleaning verification. Although it may not be possible to remove all leaded dust generated by the renovation, it is possible to reduce it below levels that EPA has determined to be hazardous.

The proposal specifies that, upon completion of renovation activities, all paint chips and debris must be picked up. Protective sheeting must be misted and folded dirty side inward, using care to trap any remaining dust. Sheeting used to isolate contaminated rooms from non-contaminated rooms must remain in place until after the cleaning and removal of other sheeting; this sheeting must then be misted and removed last. Removed sheeting must be either folded and taped shut to seal or sealed in heavy-duty bags and disposed of as waste.

After the sheeting has been removed from the work area, the entire area must be cleaned. The walls, starting from the ceiling and working down to the floor, would have to be vacuumed with a vacuum equipped with a HEPA filter or wiped with a damp cloth. The proposal would require that all remaining surfaces and objects in the work area, including floors, furniture and fixtures, be thoroughly vacuumed with a vacuum equipped with a HEPA filter. When cleaning carpets, the HEPA-equipped vacuum must be equipped with a beater bar to aid in dislodging and collecting deep dust and lead from carpets. The beater bar must be used on all passes on the carpet face during dry vacuuming. Where feasible, floor surfaces underneath a rug or carpeting must also be thoroughly vacuumed with a HEPA-equipped vacuum. This cleaning step is intended to remove as much dust and remaining debris as possible.

EPA requests comment on whether the rule should allow the use of vacuums other than vacuums equipped with HEPA filters. HEPA filters were first developed by the U.S. Atomic Energy Commission during World War II to capture microscopic radioactive particles that existing filters could not remove. HEPA filters have the ability to capture particles of 0.3 microns with 99.97% efficiency. Particles both larger and smaller than 0.3 microns are easier to catch. Thus, HEPA filters capture these particles with 100% efficiency. Available information indicates that lead particles generated by renovation activities range in size from over 20 microns to 0.3 microns or less (Ref. 58). It has been suggested that vacuums not equipped with HEPA filters fail to capture smaller lead particles, and that these vacuums are more likely to recirculate these particles to the air instead. EPA is concerned that the unintended release of lead particles into the air during cleaning activities may not only cause unintended dust lead hazards in the work area, but that it could impact other areas of the dwelling unit. EPA requests comment on whether there are other vacuums that have the same efficiency at capturing the smaller lead particles as HEPA-equipped vacuums, along with any data that would support this performance equivalency and whether this performance specification is appropriate for leaded dust cleanup. EPA also requests comment on whether the rule should allow other types of vacuums in addition to HEPA-equipped vacuums, given that the OSHA Lead in Construction standard, at 29 CFR 1926.62(h)(4), requires that vacuums be equipped with HEPA filters where vacuums are used.

After vacuuming, all surfaces and objects in the work area, except for walls and carpeted or upholstered surfaces, must be wiped with a damp cloth. Uncarpeted floors must be thoroughly mopped using a 2-bucket mopping method that keeps the wash water separate from the rinse water, or using a wet mopping system with disposable absorbent cleaning pads and a built-in mechanism for distributing or spraying cleaning solution from a reservoir onto a floor.

These special cleaning methods and procedures are typically not standard operating procedure for general home improvement contractors. Therefore, this proposal seeks to train renovators and establish work practice standards that renovators must follow to ensure no lead-based paint hazards are introduced as a result of a renovation.

When cleaning following an exterior renovation, under the proposal all paint chips and debris must be picked up. Protective sheeting used for containment must be misted with water. All sheeting must be folded carefully from the corners or ends to the middle to trap any remaining dust. The sheeting must be disposed of as waste.

EPA invites comment on all aspects of its proposed work practice standards. EPA is especially interested in studies showing the effectiveness of each component of its proposed work practices, as well as the effectiveness of these components in combination. As noted in the Draft Economic Analysis for this proposed rule, discussed in greater detail in Unit VIII.A., the Agency assumes that the specified combination of warning signs, containment barriers, cleaning measures, and the post-renovation cleaning verification process discussed in the next section, taken together, will result in lead dust levels at or below the dust-lead hazard standards established at 40 CFR 745.65(b). The available data, however, does not support a quantitative assessment of the independent efficiency of each of these measures.

Cleaning Verification

E. Cleaning Verification

1. *Background.* The goal of this proposed rule is to ensure that lead-based paint hazards are not created and left behind after residential renovations.

To achieve this goal, EPA has outlined training requirements to provide renovators with information and techniques on how to minimize the lead dust they produce during renovation activities and the appropriate methods for cleaning the work area after a renovation has been completed. The Agency has also proposed a series of work practice standards that must be followed during renovations. In addition, to achieve the goal of ensuring that residential renovations do not increase exposure to lead-based paint hazards, EPA has determined that additional cleaning verification procedures are necessary.

However, requiring dust clearance sampling after each renovation project, as is done for abatements, would be problematic for several reasons. Dust clearance sampling, which is required after abatements, may be very expensive. The costs can be attributed to two major factors: the cost of trained personnel to collect the samples and the cost of the laboratory analysis. EPA estimates the cost of three dust samples to be approximately $160 to collect and analyze. If EPA were to require dust clearance sampling after every renovation project, it would make up a significant portion of the cost of smaller projects. More information on the costs of dust clearance sampling can be found in Unit VIII.A. and in EPA's draft economic analysis of the impacts of this proposal (Ref. 59). In addition, dust clearance sampling takes a great deal of time. Laboratory results may not be available for several days, during which time the work area cannot be re-occupied.

On the other hand, a visual inspection, while less expensive and less time-consuming than dust clearance sampling, does not provide sufficient assurance that the renovation activities have not increased the potential for exposure to lead-based paint hazards. Recent studies indicate that visual inspection alone is not a reliable and effective method for identifying the presence of a lead-based paint hazard after cleaning (Ref. 60).

In addition, one of the significant difficulties associated with requiring clearance after renovation projects is the difference in focus and scope between abatement projects and renovations. The purpose of an abatement project is to permanently eliminate lead-based paint and lead-based paint hazards. It is therefore perfectly appropriate to require an assurance that the abatement firm has, in fact, eliminated these hazards. However, renovations may be performed for many reasons, most of which have nothing to do with eliminating lead-based paint hazards. Moreover, if clearance using dust wipes were required after every renovation job, it could have the effect of holding the renovation firm responsible for abating all dust-lead hazards, including such hazards that may have existed in the area before the renovation commenced. During the public meetings in 1998 and 1999, as well as during the SBREFA panel process, discussed in Unit VIII.C., contractors pointed out that, if post-renovation clearance sampling were required, the contractors would have to protect themselves by collecting pre-renovation dust samples, to ensure that they would not be held liable for pre-existing hazards. EPA understands this concern and has attempted to address it by finding an alternative to dust clearance sampling. The goal of this proposal is to ensure

any potential lead-based paint hazards created during the actual renovation project are cleaned up by the renovation firm. EPA requests comment on all of the available methods for achieving this goal, including visual inspections, dust clearance testing, and the proposed post-renovation cleaning verification process described below. EPA also requests comment on whether any cleanup verification is necessary, given the proposed cleaning requirements described above.

2. *Disposable Cleaning Cloth/White Glove Study.* EPA began looking for an alternative to dust clearance sampling that would be quick, inexpensive, reliable, and easy to perform. EPA conducted a series of studies using commercially available disposable cleaning cloths to determine whether variations of a ''white glove'' test could serve as an effective alternative to dust clearance sampling. White disposable cleaning cloths were used to wipe windowsills and wipe floors, then examined to determine whether dust was visible on the cloth. This determination was made by visually comparing the cloth to a photographic standard that EPA developed to correlate to a level of contamination that is below the dust lead hazard standard in 40 CFR 745.65(b). Cloths that matched the standard were considered to have achieved ''white glove.''

Initial studies focused on dry, or electrostatic, disposable cleaning cloths (dry cloths). These cloths were used to wipe a windowsill or a section of floor until a cloth had achieved ''white glove.'' Then, dust samples were collected to determine whether the windowsill or floor had also achieved clearance. These studies were conducted both in vacant buildings, where the amount of leaded dust on the surfaces was uncontrolled and no pre-cleaning was done, and in a controlled laboratory setting. The results of these studies indicate that dry cloths are most effective in predicting clearance through the ''white glove'' test when the initial lead levels are between 40 $\mu g/ft^2$ and 200 $\mu g/ft^2$.

EPA then began looking at wet disposable cleaning cloths (wet cloths) as a means to improve the effectiveness of dry cloths. In a controlled setting, the effectiveness of various combinations of dry cloths and wet cloths were tested, using a leaded dust loading of 1,600 $\mu g/ft^2$. The first protocol tested used only dry cloths--after ''white glove'' was achieved, the surface was wiped with two more dry cloths. This protocol led to a false negative error rate of 30%, meaning that in 30% of the cases, ''white glove'' was achieved, but dust sampling indicated that the surface lead levels exceeded 40 $\mu g/ft^2$. This procedure was performed again, and followed by one wiping with a wet cloth. With this protocol, all 12 of the tests performed resulted in levels below the clearance standard, or a false negative error rate of 0%. Finally, the original dry cloth protocol was used, until ''white glove'' was achieved, and then followed by one mopping with a wet cloth. This simplified protocol achieved a false negative error rate of 10%.

The promising results of this controlled study led to a field test of three potential protocols: Dry cloths to ''white glove,'' dry cloths to ''white glove'' followed by one wet cloth, and wet cloths to ''white glove.'' This field test was performed in vacant housing units. Lead levels were determined before testing began, but no cleaning was performed. The results of this field test were as follows: On floors, 91.5% of the surfaces that achieved ''white glove'' using only dry cloths also achieved clearance, while 97.3% of the floors that achieved ''white glove'' using only wet cloths also achieved clearance. In addition, 10 of the 11 floors where ''white glove'' was not achieved using dry cloths, and 20 of the 21 floors where ''white glove'' was not achieved using wet cloths, achieved clearance anyway. Unexpectedly, the protocol using dry cloths to ''white glove'' followed by one wet cloth was the least successful protocol--the false negative error rate for this protocol was nearly 20%. Windowsills were also tested during this part of the study, but only the all-dry-cloth protocol and the all-wet-cloth protocol were used. For the dry cloth protocol, 96.4% of the sills that achieved ''white glove'' also achieved clearance, and the one sill that did not achieve ''white glove'' still passed clearance. For the wet cloth protocol, all of the sills that achieved ''white glove'' also achieved clearance, as did the four sills that did not reach ''white glove.''

The floors in the housing units tested in this portion of the study were in vacant buildings that had high levels of accumulated lead that was often encrusted on the surface as part of a hard, gummy layer. In the case where false negative results were seen, it was primarily due to the moisture from the wet cloth loosening lead after the ''white glove'' was achieved with the wet cloth.

The final report for these studies and the earlier studies, entitled *Electrostatic Cloth and Wet Cloth Field Study in Residential Housing*, underwent an external peer review process. The final report, including the Quality Assurance Project Plan, the photographic comparison standards, the comments from the peer reviewers, and EPA's response to

the comments from the peer reviewers, has been placed into this docket (Ref. 61). EPA also requests comments on the conclusions drawn from this study, as well as on the study itself. EPA is particularly interested in information or data on the Agency's conclusions that this approach is practical and provides reliable information on removal of lead hazards and that renovators will be able to use a reference card to properly assess when "white glove" is achieved.

3. *Steps for cleaning verification.* Based on these study results, EPA is not proposing to require dust clearance sampling after any renovations. Instead, for interior renovations, EPA is proposing to require an additional post-cleaning verification step following the visual inspection. This step involves wiping the interior windowsills and floors with a wet disposable cleaning cloth and, if necessary, a dry disposable cleaning cloth, and comparing it to a cleaning verification card that EPA will develop and distribute. A prototype of this card has been placed in the docket (Ref. 62). The purpose of this step is to verify that horizontal surfaces where dust will settle have been adequately cleaned. The specific post-renovation cleaning verification requirements are proposed as follows.

a. *Visual inspection.* A certified renovator must perform a visual inspection to determine whether visible dust, debris, or residue is still present in the work area. If such dust, debris, or residue is present, these conditions must be eliminated. If the renovation involved is an interior renovation, these conditions must be eliminated by re-cleaning the work area as directed in proposed § 745.85(a)(4). After an exterior work area passes the visual inspection, the project has been properly completed and the warning signs may be removed. After an interior work area passes the visual inspection, the cleaning of each windowsill and uncarpeted floor within the work area must be verified as discussed in this Unit.

b. *Interior windowsills.* For interior renovations, after the work area has been cleaned and has passed the visual inspection, a certified renovator must wipe each interior windowsill (also known as a stool) in the work area with a wet disposable cleaning cloth. All wet cloths used in the post-renovation cleaning verification process must be at least damp to the touch, and must remain so during the process. After wiping each windowsill with a wet cloth, the certified renovator must compare the cloth to the cleaning verification card. If the cloth matches the card, that windowsill has passed the post-renovation cleaning verification. If the cloth does not match the card, that windowsill must be re-cleaned in accordance with proposed § 745.85(a)(4)(ii). After the windowsill has been re-cleaned, the certified renovator must wipe that windowsill with a new wet cloth, or the same one folded so that an unused surface is exposed, and compare it to the cleaning verification card. If the cloth matches the card, that windowsill has passed. If not, the windowsill must be re-cleaned again and left to dry.

To perform this verification on a windowsill, the certified renovator must wait for one hour after the surface has been re-cleaned or until the surface has dried, whichever is longer. Then, the certified renovator must wipe the windowsill with a dry disposable cleaning cloth and compare it to the cleaning verification card. This process must be repeated until a dry cloth, or a folded section of a dry cloth, that has wiped the windowsill matches the cleaning verification card. At that point, that windowsill has passed the post-renovation cleaning verification process. Each windowsill in the work area must pass the post-renovation cleaning verification process.

EPA considered requiring that certified renovators repeat the process of cleaning and then wiping with a wet disposable cleaning cloth until each windowsill and each section of uncarpeted floor within the work area achieved post-renovation cleaning verification with a wet cloth. The disposable cleaning cloth studies suggest that it is possible that some floors may never achieve verification with a wet cloth. Verification on floors that are in poor condition or floors with built-up layers of grime may be particularly difficult. In the second field study of disposable cleaning cloths, there were 21 floors that did not achieve "white glove," even after 15 separate wipings with a fresh wet cloth. However, 20 of these floors passed clearance through dust sampling.

Therefore, for each windowsill and for those sections of the floor that did not achieve post-renovation cleaning verification using the wet cloths, EPA is proposing to require that after the second re-cleaning, the surface be allowed to dry, and then a dry disposable cleaning cloth verification process be performed. The dry cloth may be less likely to dissolve additional layers of built-up grime, which may have contributed to the phenomenon of floors passing clearance, but not achieving "white glove" with the wet cloths. In addition, lead dust trapped in built-up layers of grime is not likely to be the result of a current renovation activity.

c. *Floors.* After the windowsills in the work area have passed the post-renovation cleaning verification, a certified renovator must wipe the floor surfaces in the work area with a wet disposable cleaning cloth. Wiping of floors must be done with an application device consisting of a long handle and a head to which the wet cloth is attached. This will help the certified renovator apply fairly constant pressure over the floor surface. Again, the wet cloth must remain at least damp to the touch throughout this process. During the field studies, the cloths tended to dry out as they were used over large areas, or on more porous floor surfaces. As the cloths dry out, they pick up less dust. To ensure that the cloths remained damp during the field studies, the persons performing the wiping were directed to use each wet cloth on no more than 40 ft^2 of floor area (Ref. 63). EPA is proposing to require the same for the purposes of post-renovation cleaning verification, but requests comment on whether this is an appropriate size cut-off. If the floor surface in the work area exceeds 40 ft^2, the certified renovator would divide the floor surface into sections, each section being less than 40 ft^2, and perform the post-renovation cleaning verification on each section separately.

If the wet cloth used to wipe a particular section of floor matches the cleaning verification card, that section has passed the post-renovation cleaning verification. If, however, on the first wiping of a section of the floor surface, the wet cloth does not match the cleaning verification card, the surface of that section of the floor must be re-cleaned in accordance with proposed § 745.85(a)(4)(ii). After re-cleaning, the renovator must wipe that section of the floor again using a new wet cloth. If the wet cloth matches the cleaning verification card, that section of the floor has passed. If the wet cloth does not match the verification card, that section of the floor must be re-cleaned as directed in proposed § 745.85(a)(4)(ii) and left to dry.

For those sections of the floor that did not achieve post-renovation cleaning verification using the wet cloths, the certified renovator must wait for 1 hour after the floor has been re-cleaned or until the floor has dried, whichever is longer. Then, the certified renovator must wipe those sections of the floor with a dry disposable cleaning cloth and compare it to the cleaning verification card. This wiping must also be performed using an application device with a long handle and a head to which the dry cloth is attached. This process must be repeated until a dry cloth that has wiped all of the sections of the floor that have not yet passed verification matches the cleaning verification card. At that point, the entire floor has passed the post-renovation cleaning verification process and the warning signs may be removed.

EPA believes that adherence to this post-renovation cleaning verification protocol, in combination with the proposed training, containment, and cleaning requirements is a safe, reliable and effective system of ensuring that renovation activities do not result in an increased risk of exposure to lead-based paint hazards. In the great majority of cases, windowsills and floors that achieve post-renovation cleaning verification will also pass dust clearance sampling. EPA specifically requests comment on the elements of the proposed protocol, especially with regard to their efficacy and utility. EPA also requests comments on whether the reliability of the cleaning verification would be improved if it were performed by an individual who had not previously participated in the renovation activity, for example, another certified renovator in the renovation firm.

d. *Carpets.* As a final step in the renovation process, EPA is proposing that after containment is removed, the work area be thoroughly cleaned. For floors, the proposal would require vacuuming with a HEPA-equipped vacuum. When cleaning carpets, the vacuum would have to be equipped with a beater bar to aid in dislodging and collecting leaded dust. EPA believes that use of the HEPA-equipped vacuum equipped with a beater bar to dislodge dust and debris is the most effective cleaning practice for carpets, and that an effective cleaning verification method for carpets is not available. EPA is not proposing that the ''white glove'' cleaning verification protocol be used on carpets after they have been cleaned using a HEPA-equipped vacuum equipped with a beater bar. EPA did not verify use of the ''white glove'' protocol on carpets. In addition, there are questions about the validity of dust clearance sampling on carpeted floors, even though such sampling is required by EPA after abatements and by HUD after interim controls. In its final rule for hazard and clearance standards for the Title X program (Ref. 24), the Agency included standards for carpeted floors, even though the proposed floor standards would have applied only to bare floors (Ref. 64). The Agency initially was concerned that there was a lack of data on the relative performance of sampling methods for carpets, given that various studies had used different sampling techniques (e.g., the Baltimore

Repair and Maintenance Study's ''BRM'' vacuum (Ref. 65), the Comprehensive Abatement Performance Pilot Study's ''Blue Nozzle'' vacuum (Ref. 66), and standard dust wipes). Additionally, the Agency did not have adequate data on the effectiveness of carpet cleaning techniques that would be needed to establish a dust clearance level for carpeted floors. Consequently, there were problems establishing a dust lead level on a wipe that would independently indicate that the carpet had been sufficiently cleaned. This problem was exacerbated by the wide variety of carpet types and conditions that would likely be encountered in residential units.

The Agency changed its position in the final lead hazard standards rule as a result of commenters' concerns that many housing units contained carpeting and that, without a standard, such units could not be assessed for the presence of lead hazards from floor dust. Based upon data available to the Agency at that time (Ref. 67), EPA estimated that approximately 54 million housing units built prior to 1978 contained some wall-to-wall carpeting and, of these, 47 million had such carpeting in living rooms and 46 million in bedrooms (i.e., rooms in which children reside and play frequently). Agreeing with these concerns, the Agency determined that the floor standards (using dust wipes) should apply to both bare and carpeted floors in order that all floors would be addressed in lead hazard screens, risk assessments, and abatements.

In making this determination, EPA did not specifically consider the question of whether both the hazard and the clearance floor standards should apply to carpeted floors. Because the hazard and clearance standards were numerically equal, even though they served different purposes and uses, EPA chose to apply both standards to carpeted and uncarpeted floors.

The decision to apply the clearance standard to carpeted floors ultimately had little consequence, given the context in which clearance standards are used--namely, to ensure that sufficient cleanup has been performed after an abatement. Typically, in abatement situations, carpets that are in poor condition or are known to be highly contaminated are removed and disposed of. Where carpets are not replaced, they are cleaned according to specified criteria (Ref. 27). In general, carpets are acknowledged to be potential traps of leaded dust and great care is taken to replace or thoroughly clean them in order to ensure that, once the abatement is concluded, the housing unit is cleanable so that the benefits of the abatement will continue as long as routine cleaning is performed. Consequently, EPA believes that it is this special attention to carpets that ensures that they are sufficiently clean, rather than reliance upon only a post-abatement wipe clearance sample.

e. *Optional use of clearance testing.* Some renovators or homeowners may choose to perform clearance at the completion of renovation activities instead of the post-renovation cleaning verification described in proposed § 745.85(b). If so, dust sampling for clearance would have to be performed by a certified inspector, risk assessor, or dust sampling technician, who would be responsible for collecting dust samples, sending them to an EPA-recognized laboratory, and comparing the results to the clearance levels in accordance with 40 CFR 745.227(e)(8). EPA recommends that the renovation work area be re-cleaned if the home fails the clearance test. It is a good idea to specify in the renovation contract who is responsible for this re-cleaning if the home fails the clearance test. EPA welcomes comment on this part of the proposal.

Exact Proposed Rule Text, 40 CFR Part 745:

§ 745.82 Applicability.

(a) This subpart applies to all renovations of target housing performed for compensation, except for the following:

(1) Minor repair and maintenance activities (including minor electrical work and plumbing) that disrupt 2 square feet or less of painted surface per component.

(2) Renovations in target housing in which a written determination has been made by an inspector (certified pursuant to either Federal regulations at § 745.226 or a State or Tribal certification program authorized pursuant to § 745.324) that the components affected by the renovation are free of paint or other surface coatings that contain lead equal to or in excess of 1.0 milligrams/per square centimeter (mg/cm^2) or 0.5% by weight, where the firm performing the renovation has obtained a copy of the determination.

(3) Renovations in target housing in which a certified renovator, using an acceptable test kit and following the kit manufacturer's instructions, has determined that the components affected by the renovation are free of paint or other surface coatings that contain lead equal to or in excess of 1.0 mg/cm^2 or 0.5% by weight.

(b) The information distribution requirements in § 745.84 do not apply to emergency renovation operations, which are renovation activities that were not planned but result from a sudden, unexpected event (such as non-routine failures of equipment) that, if not immediately attended to, presents a safety or public health hazard, or threatens equipment and/or property with significant damage. Interim controls performed in response to an elevated blood lead level in a resident child are also emergency renovation operations. The work practice, training, and certification requirements in §§ 745.85, 745.89, 745.90 and the recordkeeping requirements in § 745.86(b)(6) and (b)(7) apply to emergency renovation operations to the extent practicable.

(c) The work practice standards for renovation activities in § 745.85 apply to all renovations covered by this subpart, except for renovations in target housing for which the firm performing the renovation has obtained a statement signed by the owner that the renovation will occur in the owner's residence and no child under age 6 resides there. For the purposes of this section, a child resides in the primary residence of his or her custodial parents, legal guardians, and foster parents. A child also resides in the primary residence of an informal caretaker if the child lives and sleeps most of the time at the caretaker's residence.

5. Section 745.83 is amended as follows:

a. Remove the definition of "Emergency renovation operations."

b. Revise the definition of "Pamphlet" and the definition of "Renovator."

c. Add 11 definitions in alphabetic order.

§ 745.83 Definitions.

* * * * *

Acceptable test kit means a commercially available kit recognized by EPA pursuant to section 405 of TSCA as being capable of allowing a user to accurately determine the presence of lead at levels equal to or in excess of 1.0 milligrams per square centimeter, or more than 0.5% lead by weight, in a paint chip, paint powder, or painted surface.

* * * * *

Cleaning verification card means a card developed and distributed, or otherwise approved, by EPA for the purpose of determining, through comparison of disposable cleaning cloths with the card, whether post-renovation cleaning has been properly completed.

Component or building component means specific design or structural elements or fixtures of a building or residential dwelling that are distinguished from each other by form, function, and location. These include, but are not limited to, interior components such as: Ceilings, crown molding, walls, chair rails, doors, door trim, floors, fireplaces, radiators and other heating units, shelves, shelf supports, stair treads, stair risers, stair stringers, newel posts, railing caps, balustrades, windows and trim (including sashes, window heads, jambs, sills or stools and troughs), built in cabinets, columns, beams, bathroom vanities, counter tops, and air conditioners; and exterior components such as: Painted roofing, chimneys, flashing, gutters and downspouts, ceilings, soffits, fascias, rake boards, cornerboards, bulkheads, doors and door trim, fences, floors, joists, lattice work, railings and railing caps, siding, handrails, stair risers and treads, stair stringers, columns, balustrades, window sills or stools and troughs, casings, sashes and wells, and air conditioners.

Dry disposable cleaning cloth means a commercially available dry, electrostatically charged, white disposable cloth designed to be used for cleaning hard surfaces such as uncarpeted floors or counter tops.

* * * * *

Firm means a company, partnership, corporation, sole proprietorship or individual doing business, association, or other business entity; a Federal, State, Tribal, or local government agency; or a nonprofit organization.

HEPA-equipped vacuum means a vacuum equipped with a high efficiency particulate air filter.

Interim controls means a set of measures designed to temporarily reduce human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards, and the establishment and operation of management and resident education programs.

* * * * *

Pamphlet means the EPA pamphlet titled *Protect Your Family from Lead During Renovation, Repair & Painting* developed under section 406(a) of TSCA for use in complying with section 406(b) of TSCA, or any State or Tribal pamphlet approved by EPA pursuant to 40 CFR 745.326 that is developed for the same purpose. This includes reproductions of the pamphlet when copied in full and without revision or deletion of material from the pamphlet (except for the addition or revision of State or local sources of information). Before [insert date 8 months after date of publication of the final rule in the **Federal Register**], the term

''pamphlet'' also means any pamphlet developed by EPA under section 406(a) of TSCA or any State or Tribal pamphlet approved by EPA pursuant to § 745.326.

* * * * *

Renovator means a person who either performs or directs uncertified workers who perform renovations. A certified renovator is a renovator who has successfully completed a renovator course accredited by EPA or an EPA-authorized State or Tribal program.

Training hour means at least 50 minutes of actual learning, including, but not limited to, time devoted to lecture, learning activities, small group activities, demonstrations, evaluations, and hands-on experience.

Wet disposable cleaning cloth means a commercially available, pre-moistened white disposable cloth designed to be used for cleaning hard surfaces such as uncarpeted floors or counter tops.

Wet mopping system means a device with the following characteristics: A long handle, a mop head designed to be used with disposable absorbent cleaning pads, a reservoir for cleaning solution, and a built-in mechanism for distributing or spraying the cleaning solution onto a floor.

Work area means the area that the certified renovator establishes to contain all of the dust and debris generated by a renovation, based on the certified renovator's evaluation of the extent and nature of the activity and the specific work practices that will be used.

§ 745.84 [Removed]

6. Section 745.84 is removed.

§ 745.85 [Redesignated]

1 Section 745.85 is redesignated as §745.84.
2 Newly designated § 745.84 is amended as follows:

□ a. Revise the introductory text of paragraph (a) and revise paragraph (a)(2)(i).
□ b. Revise the introductory text of paragraph (b) and revise paragraphs (b)(2) and (b)(4).
□ c. Revise the introductory text of paragraph (c).

§ 745.84 Information distribution requirements.

□ (a) *Renovations in dwelling units.* No more than 60 days before beginning renovation activities in any residential dwelling unit of target housing, the firm performing the renovation must:

□ (1)***(2)***

□ (i) Obtain, from the adult occupant, a written acknowledgment that the occupant has received the pamphlet; or certify in writing that a pamphlet has been delivered to the dwelling and that the firm performing the renovation has been unsuccessful in obtaining a written acknowledgment from an adult occupant. Such certification must include the address of the unit undergoing renovation, the date and method of delivery of the pamphlet, names of the persons delivering the pamphlet, reason for lack of acknowledgment (e.g., occupant refuses to sign, no adult occupant available), the signature of a representative of the firm performing the renovation, and the date of signature.

□ * * * * *

□ (b) *Renovations in common areas.* No more than 60 days before beginning renovation activities in common areas of multi-unit target housing, the firm performing the renovation must:

□ (1)***

□ (2) Notify in writing, or ensure written notification of, each affected unit and make the pamphlet available upon request prior to the start of renovation. Such notification shall be accomplished by distributing written notice to each affected unit. The notice shall describe the general nature and locations of the planned renovation activities; the expected starting and ending dates; and a statement of how the occupant can obtain the pamphlet, at no charge, from the firm performing the renovation.

□ (3)***

(4) If the scope, locations, or expected starting and ending dates of the planned renovation activities change after the initial notification, the firm performing the renovation must provide further written notification to the owners and occupants providing revised information on the ongoing or planned activities. This subsequent notification must be provided before the firm performing the renovation initiates work beyond that which was described in the original notice.

(c) *Written acknowledgment.* The written acknowledgments required by paragraphs (a)(1)(i), (a)(2)(i), and (b)(1)(i) of this section must:

* * * * *

9. Section 745.85 is added to subpart E to read as follows:

§ 745.85 Work practice standards.

(a) *Standards for renovation activities.* Renovations must be performed by certified firms using certified renovators as directed in § 745.89.

(1) *Occupant protection.* Firms must post signs clearly defining the work area and warning occupants and other persons not involved in renovation activities to remain outside of the work area. These signs must be posted before beginning the renovation and must remain in place and readable until the renovation and the post-renovation cleaning verification have been completed. If warning signs have been posted in accordance with 24 CFR 35.1345(b)(2) or 29 CFR 1926.62(m), additional signs are not required by this section.

(2) *Containing the work area.* Before beginning the renovation, the firm must isolate the work area so that no visible dust or debris leaves the work area while the renovation is being performed.

(i) *Interior renovations.* The firm must:

(A) Remove all objects from the work area, including furniture, rugs, and window coverings, or cover them with plastic sheeting or other impermeable material with all seams and edges taped or otherwise sealed.

(B) Close and cover all ducts opening in the work area with taped-down plastic sheeting or other impermeable material.

(C) Close windows and doors in the work area. Doors must be covered with plastic sheeting or other impermeable material. Doors used as an entrance to the work area must be covered with plastic sheeting or other impermeable material in a manner that allows workers to pass through while confining dust and debris to the work area.

(D) Cover the floor surface of the work area with plastic sheeting or other impermeable material with all seams taped and all edges secured at the perimeter of the work area

(E) Ensure that all personnel, tools, and other items including waste are free of dust and debris when leaving the work area. Alternatively, the paths used to reach the exterior of the home must be covered with plastic sheeting or other impermeable material to prevent the spread of lead contaminated dust and debris outside the work area.

(ii) *Exterior renovations.* The firm must:

(A) Close all doors and windows within 20 feet of the renovation. On multi-story buildings, close all doors and windows within 20 feet of the renovation on the same floor as the renovation, and close all doors and windows on all floors below that are the same horizontal distance from the renovation.

(B) Ensure that doors within the work area that must be used while the job is being performed are covered with plastic sheeting or other impermeable material in a manner that allows workers to pass through while confining dust and debris to the work area.

(C) Cover the ground with plastic sheeting or other disposable impermeable material extending out from the edge of the structure a sufficient distance to collect falling paint debris.

(3) *Waste from renovations.* (i) Waste from renovation activities must be contained to prevent releases of dust and debris before the waste is removed from the work area for storage or disposal. If a chute is used to remove waste from the work area, it must be covered.

(ii) At the conclusion of each work day and at the conclusion of the renovation, waste that has been collected from renovation activities must be stored under containment, in an enclosure, or behind a barrier that prevents release of dust and debris out of the work area and prevents access to dust and debris.

(iii) When the firm transports waste from renovation activities, the firm must contain the waste to prevent identifiable releases of dust and debris.

(4) *Cleaning the work area.* After the renovation has been completed, the firm must clean the work area until no visible dust, debris or residue remains.

(i) *Interior and exterior renovations.* The firm must:

(A) Pick up all paint chips and debris.

(B) Remove the protective sheeting. Mist the sheeting before folding it, fold the dirty side inward, and either tape shut to seal or seal in heavy-duty bags. Sheeting used to isolate contaminated rooms from non-contaminated rooms must remain in place until after the cleaning and removal of other sheeting. Dispose of the sheeting as waste.

(ii) *Additional cleaning for interior renovations.* The firm must clean all objects and surfaces in and around the work area in the following manner, cleaning from higher to lower:

(A) *Walls.* Clean walls starting at the ceiling and working down to the floor by either vacuuming with a HEPA-equipped vacuum or wiping with a damp cloth.

(B) *Remaining surfaces.* Thoroughly vacuum all remaining surfaces and objects in the work area, including furniture and fixtures, with a HEPA-equipped vacuum. The HEPA-equipped vacuum must be equipped with a beater bar when vacuuming carpets and rugs. Where feasible, floor surfaces underneath a rug or carpeting must also be thoroughly vacuumed with a HEPA-equipped vacuum.

(C) Wipe all remaining surfaces and objects in the work area, except for carpeted or upholstered surfaces, with a damp cloth. Mop uncarpeted floors thoroughly, using a 2-bucket mopping method that keeps the wash water separate from the rinse water, or using a wet mopping system.

(b) *Standards for post-renovation cleaning verification.* (1) *Interiors.* (i) A certified renovator must perform a visual inspection to determine whether visible amounts of dust, debris or residue are still present. If visible amounts of dust, debris or residue are present, these conditions must be eliminated by re-cleaning and another visual inspection must be performed.

(ii) After a successful visual inspection, a certified renovator must:

(A) Verify that each windowsill in the work area has been adequately cleaned, using the following procedure.

(*1*) Wipe the windowsill with a wet disposable cleaning cloth that is damp to the touch. If the cloth matches the cleaning verification card, the windowsill has been adequately cleaned.

(*2*) If the cloth does not match the cleaning verification card, re-clean the windowsill as directed in paragraphs (a)(4)(ii)(B) and (C) of this section, then either use a new cloth or fold the used cloth in such a way that an unused surface is exposed, and wipe the windowsill again. If the cloth matches the cleaning verification card, that windowsill has been adequately cleaned.

(*3*) If the cloth does not match the cleaning verification card, clean that windowsill again as directed in paragraphs (a)(4)(ii)(B) and (C) of this section and wait for one hour or until the windowsill has dried completely, whichever is longer.

(*4*) After waiting for the windowsill to dry, wipe the windowsill with dry disposable cleaning cloths until a cloth, or section of cloth, used to wipe the windowsill matches the cleaning verification card.

(B) Wipe uncarpeted floors within the work area with a wet disposable cleaning cloth, using an application device with a long handle and a head to which the cloth is attached. The cloth must remain damp at all times while it is being used to wipe the floor for post-renovation cleaning verification. If the floor surface within the work area is greater than 40 square feet, the floor within the work area must be divided into roughly equal sections that are each less than 40 square feet. Wipe each such section separately with a new wet disposable cleaning cloth. If the cloth used to wipe each section of the floor within the work area matches the cleaning verification card, the floor has been adequately cleaned.

(*1*) If the cloth used to wipe a particular floor section does not match the cleaning verification card, re-clean that section of the floor as directed in paragraphs (a)(4)(ii)(B) and (a)(4)(ii)(C) of this section, then use a new wet disposable cleaning cloth to wipe that section again. If the cloth matches the cleaning verification card, that section of the floor has been adequately cleaned.

(*2*) If the cloth used to wipe a particular floor section does not match the cleaning verification card after the floor has been re-cleaned, clean that section of the floor again as directed in paragraphs (a)(4)(ii)(B) and (a)(4)(ii)(C) of this section and wait for 1 hour or until the entire floor within the work area has dried completely, whichever is longer.

(*3*) After waiting for the entire floor within the work area to dry, wipe those sections of the floor that have not yet achieved post-renovation cleaning verification with dry disposable cleaning cloths until a cloth that has wiped those sections of the floor matches the cleaning verification card. This wiping must also be performed using an application device with a long handle and a head to which the cloths are attached.

(iii) Dust clearance sampling may be performed instead of, or in addition to, the procedures identified in paragraph (b)(1)(ii) of this section. If dust clearance sampling is performed, it must be performed in accordance with § 745.227(e)(8) through (e)(9), except that a dust sampling technician certified in accordance with this subpart may collect and report the results of the required samples.

(iv) When the work area passes the post-renovation cleaning verification or dust clearance sampling, remove the warning signs.

(2) *Exteriors.* A certified renovator must perform a visual inspection to determine whether visible amounts of dust, debris or residue are still present. If visible amounts of dust, debris or residue are present, these conditions must be eliminated and another visual inspection must be performed. When the area passes the visual inspection, remove the warning signs.

(c) *Activities conducted after post-renovation cleaning verification.* Activities that do not disturb paint, such as applying paint to walls that have already been prepared, are not regulated by this subpart if they are conducted after post-renovation cleaning verification has been performed.

□

APPENDIX C

HUD Guidelines for the Evaluation and Control of Lead-based Paint Hazards in Housing

Chapter 9: Worker Protection

CHAPTER 9: WORKER PROTECTION

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Worker Protection: How To Do It

1. Since worker exposure to lead during residential lead abatement work may be greater than the permissible exposure limit (PEL) set by the Occupational Safety and Health Administration (OSHA), develop a written compliance plan and designate a competent person to oversee worker protection efforts (usually an industrial hygienist or a certified lead abatement supervisor). [See the OSHA Lead in Construction Standard for complete details (29 CFR 1926.62). Call your local OSHA office for a copy (see Appendix 4 for a listing).] A model written compliance plan is provided at the end of this chapter.

2. Conduct an exposure assessment for each job classification in each work area. Monitoring current work is the best means of conducting exposure assessments. Perform air sampling in 1 dwelling unit out of every 20 being treated, with an emphasis on sampling "worst-case" dwellings. Alternatively, if working conditions are similar to previous jobs by the same employer, previously collected exposure data can be used to estimate worker exposures. Finally, objective data (as defined by OSHA) may be used to determine worker lead exposures in some cases. Exposures to airborne leaded dust greater than 30 $\mu g/m^3$ (8-hour, time-weighted average) trigger protective requirements that are enforced by OSHA.

3. If lead hazard control will include manual demolition, manual scraping, manual sanding, heat gun use, or use of power tools such as needle guns, then specific worker protection measures (outlined in this chapter) are required until an initial exposure assessment is completed. If the initial exposure assessment indicates exposures are less than 30 $\mu g/m^3$, the requirements do not legally apply, although exposure to lead should be kept as low as possible at all times.

4. Implement engineering, work practice, and administrative controls to bring worker exposure levels below the PEL. Examples of such controls include the use of wet abatement methods and the selection of other work methods that generate little dust.

5. Where needed, supplement the use of engineering and work practice controls with appropriate respirators (at a minimum, use a half-mask, air-purifying respirator approved by the National Institute for Occupational Safety and Health (NIOSH)) and implement a respiratory protection program. Provide a respirator to any employee who requests one, regardless of the degree of exposure. Most residential lead hazard control projects will involve the use of a half-mask, air-purifying respirator with high-efficiency particulate air (HEPA) cartridges.

6. Arrange for a medical exam before work begins for each worker who will be required to wear a respirator. The exam will indicate whether the worker is physically capable of wearing a respirator safely. Conduct fit testing for all workers who will be required to wear respirators. Workers with beards, scars, or unusual facial shapes may not be able to wear certain kinds of fitted respirators.

7. Provide protective clothing and arrange for proper disposal or laundering of work clothing.

8. Provide handwashing facilities, preferably with showers.

9. Implement a medical surveillance program that includes blood lead monitoring under the supervision of a qualified physician pursuant to OSHA regulations. Initial blood testing for lead exposure is required by OSHA for workers performing certain tasks, such as manual scraping, and for any worker who may be exposed to greater than 30 $\mu g/m^3$ of lead on any day.

10. Ensure that workers are properly trained in the hazards of lead exposure, the location of lead-containing materials, the use of job-specific exposure control methods (such as respirators), the use of hygiene facilities, and the signs and symptoms of lead poisoning. See Appendix 15 for a Worker Fact Sheet on the OSHA Standard that can be used for training purposes. OSHA and the U.S. Environmental Protection Agency require all lead hazard control workers to be trained, even if exposures are very low.

11. Post lead hazard warning signs around work areas. Also, post an emergency telephone number in case an on-the-job injury occurs.

12. Conduct work as specified.

13. Conduct worker decontamination before all breaks, before lunch, and at the end of the shift. Decontamination usually consists of:

    - Cleaning all tools (end of the shift only).
    - HEPA vacuuming all protective clothing if visibly contaminated with paint chips or dust before entering the decontamination area.
    - Entering the decontamination area (dirty side).
    - Removing protective clothing by rolling inward (do not remove respirator yet); removing work shoes and putting in plastic bag.
    - Entering shower or washing facility.
    - Washing hands and then removing respirator.
    - Taking a shower using plenty of soap and water; washing hair, hands, underneath fingernails, and face especially well (hand and face washing only is permitted for lunch and breaks).
    - Entering the clean area and putting on street clothing and shoes.

14. Maintain exposure assessment and medical surveillance records for 30 years. Notify workers within 5 days after receiving air sampling and blood lead level results.

Chapter 9: Worker Protection

I. Introduction

The potential for worker exposure to lead (as well as to other hazardous substances, safety hazards, and physical agents) exists during all lead hazard control projects. This chapter provides recommendations to:

- Assist contractors and facility owners in establishing programs to control employee lead exposures.
- Help employers and facility owners understand and meet the requirements of the Occupational Safety and Health Administration (OSHA) interim final rule for lead exposure in construction as it applies to residential work (29 CFR 1926.62) (OSHA, 1993).

A model written compliance plan is provided at the end of this chapter to help employers comply with the standard. A summary of the standard for workers prepared by the Alice Hamilton Occupational Health Center is found in Appendix 15.

Due to the recognized adverse health effects of lead, employers should minimize worker lead exposures as much as possible. The OSHA construction lead standard is the minimum level of protection that employers must legally provide to workers during all lead hazard control projects. Employers should refer directly to the OSHA construction lead standard for complete requirements.

Where To Get the OSHA Standard

The OSHA standard can be obtained by writing or calling OSHA, Office of Publications, Room N-3101, United States Department of Labor, Washington, DC 20210; (202) 219-4667, or by contacting any local OSHA office (see Appendix 4).

II. Adult Occupational Exposure to Lead

Inhalation of dust and fumes, and ingestion resulting from contact with lead-contaminated food, cigarettes, clothing, or other objects, are the major routes of worker exposure to lead. Once absorbed, lead accumulates in the blood, soft tissues, and bones, with the highest accumulation initially in the liver and kidneys (NIOSH, 1992a). Lead is stored in the bones for decades, and may cause toxic effects in adults as it is slowly released over time (Silbergeld, 1992). Chronic overexposure to lead results in damage to the kidneys, the gastrointestinal tract, the peripheral and central nervous systems, the reproductive system, and the blood-forming organs. Adverse effects in adults include:

- Abdominal discomfort.
- Anemia.
- Colic.
- Constipation.
- Excessive tiredness.
- Fine tremors.
- Headache.
- High blood pressure.
- Irritability or anxiety.
- Loss of appetite.
- Muscle and joint pain.
- Pallor.
- Pigmentation on the gums ("lead line").
- Sexual impotence.

- Weakness.
- Inability to keep the hand and arm fully extended ("wrist drop").

The frequency and severity of symptoms associated with lead exposure increase as blood lead levels increase. The signs and symptoms of chronic lead poisoning are well recognized (Hernberg, 1988; Landrigan, 1985; Proctor, 1988).

Overt symptoms of lead poisoning in adults generally become apparent when blood lead levels are between 60 and 120 micrograms per deciliter (µg/dL) (Figure 9.1). Neurologic, hematologic, and reproductive effects, however, may be detectable at much lower levels. OSHA recommends a blood lead level no greater than 30 µg/dL to prevent reproductive problems, although the medical removal provisions do not take effect until the level reaches 50µg/dL. In 1990, the U.S. Public Health Service established the national goal of eliminating, by the year 2000, all occupational exposures that result in worker blood lead levels greater than 25 µg/dL (DHHS, 1990). The mean blood lead level for men in the United States during the period from 1976 to 1980 was 16 µg/dL (Mahaffey, 1982; Annest, 1983). In addition, the American Conference of Governmental Industrial Hygienists (ACGIH) has proposed that worker blood lead levels be controlled to 20 µg/dL (ACGIH, 1993).

Recent studies suggest that adverse health effects can be detected when blood lead levels are *below* the current OSHA standard for occupational exposure (50 µg/dL). Therefore, the OSHA standard may not sufficiently protect workers' health. OSHA is currently developing a final rule to address this issue (the current rule is an interim final standard).

In males, increased blood lead levels are associated with increased blood pressure, with no apparent blood lead threshold (less than 10 µg/dL). A number of studies have found neurological symptoms in workers with blood lead levels as low as 40 µg/dL. In addition, decreased fertility in men (low sperm count, low sperm motility, and abnormal sperm shape) has been identified at blood lead levels as low as 40 µg/dL.

In women, exposure to lead (as low as 10 to 15 µg/dL) before and during pregnancy is associated with preterm delivery, low birth weight, an increased frequency of miscarriage and stillbirth, and problems in early mental development of the fetus (ATSDR, 1990; National Academy of Sciences, 1993).

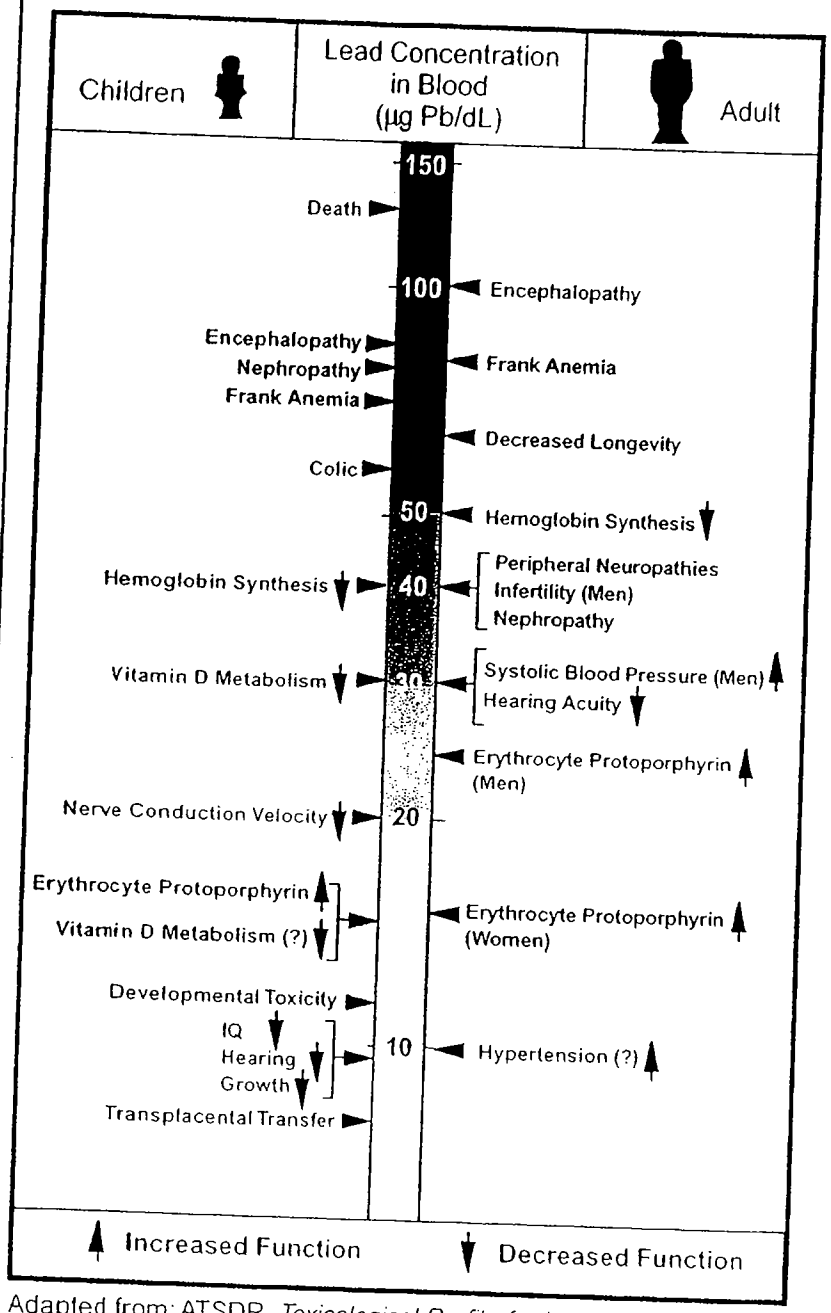
When a family member is occupationally exposed to lead, leaded dust may be carried home on clothing, on skin and hair, and in vehicles. High blood lead levels in resident children and elevated concentrations of lead in house dust have been found in the homes of workers employed in industries associated with high lead exposure (Grandjean, 1986). Children of workers with lead poisoning or children of any worker exposed to high lead levels should be tested for lead exposure by a qualified health-care provider.

III. Background on Federal Worker Protection Standards for Lead

For many years, there was a large disparity between OSHA's requirements for lead-exposed workers in general industry and those in construction. In 1978, OSHA promulgated a final lead standard for general industry (29 CFR 1910.1025). This comprehensive standard established a permissible exposure limit (PEL) of 50 micrograms of lead per cubic meter of air (µg/m^3) (8-hour, time-weighted average) and included requirements for engineering controls, personal protective equipment, air monitoring, medical surveillance, and employee training. Medical removal, with economic protection of wages and benefits, was specified for employees with an average blood lead level at or above 50 µg/dL.

The construction industry was exempted from the 1978 lead standard, primarily due to concerns regarding feasibility, the short duration of many exposures, and the relatively high number of temporary employees (OSHA, 1978). Prior to 1993, worker exposures to lead in the

Figure 9.1 Adverse Health Effects of Lead In Adults and Children.



- Effects in children generally occur at lower blood lead levels than in adults.
- The developing nervous system in children can be affected adversely at blood lead levels of less than 10 µg/dL.

Adapted from: ATSDR, *Toxicological Profile for Lead* (1989)

construction industry were regulated by several sections of the 1971 construction industry standards (29 CFR 1926), which included a PEL for lead of 200 μg/m³, and did not include requirements for medical monitoring, removal of exposed workers, or other specific protective measures regarding lead.

The *HUD Interim Guidelines for Lead-Based Paint Abatement in Public and Indian Housing* (Revised Chapter 8, 55 FR 39973, August 1991) recommended that the requirements of the OSHA general industry lead standard be established as a minimum level of protection for workers performing lead-based paint abatement, and that additional medical monitoring and respiratory protection be provided. Both OSHA and the National Institute for Occupational Safety and Health (NIOSH) have recently published recommendations that exposures to lead in construction be minimized through the use of engineering controls and work practices, and that comprehensive worker protection programs be provided for lead-exposed workers (OSHA/NIOSH, 1991; NIOSH, 1992a).

In 1990, OSHA began to develop a comprehensive standard regulating lead exposure in the construction industry. Since no proposed final rule was forthcoming by late 1992, Congress required in Title X of the Housing and Community Development Act of 1992 (October 28, 1992) that OSHA issue an interim final rule for the construction industry within 180 days. Congress required that the standard be as protective as the worker protection requirements contained in the 1991 *HUD Interim Guidelines for Lead-Based Paint Abatement in Public and Indian Housing* (i.e., PEL of 50 μg/m³). OSHA complied with this mandate, issuing an interim final rule for lead exposure in construction on May 4, 1993 (OSHA, 1993).

Workers engaged in routine maintenance work are covered by the general industry standard. Maintenance workers engaged in interim control or abatement work are covered by the construction standard.

Generally speaking, the new lead in construction standard requires employers to do the following:

- Evaluate workers' exposures.
- If exposures cannot be assessed before a job begins, determine if the job will involve manual demolition, manual scraping, or heat gun or power tool use.
- Implement engineering, work practice, and administrative controls.
- If these controls do not reduce exposures below the PEL, implement a respiratory protection program.
- Provide protective clothing.
- Provide handwashing or shower facilities.
- Provide a medical surveillance and blood lead monitoring program.
- Ensure that workers are trained adequately.
- Post warning signs.

IV. Previous Evaluations of Worker Exposures During Residential Lead Hazard Control Work

Prior to the initiation of lead hazard control work, employers should review the results of previous exposure assessments to help select proper methods, engineering controls, personal protective equipment, and work practices. In general, the data collected to date indicate that workers are occasionally exposed to lead levels greater than 50 μg/m³ in most types of lead hazard control work, and that exposures are highly variable. Practically speaking, this means that most lead hazard control workers will need protective measures, such as respirators and medical surveillance. Some forms of lead hazard control (such as wet cleaning) may require only minor worker protection measures while others may require more substantial measures.

OSHA has recently collected exposure data that are representative of employees' lead exposure levels (8-hour, time-weighted average) for various construction activities, and are summarized in a table in the *Federal Register* (58 FR, No. 84, May4, 1993, Table 4, p.26612).

While *average* exposures in housing are generally below the PEL, it is important to understand that worker exposures at a given site may vary widely from previous exposure assessments (even for the same activity) due to variations in environmental conditions, work practices, the lead concentration in paint, and the total quantity of lead-based paint abated. Results from two relevant NIOSH studies of abatement activities are summarized below to illustrate how variable exposures can be.

A. The HUD Lead-Based Paint Abatement Demonstration

NIOSH investigators evaluated exposures and analyzed the exposure data collected by HUD contractors during the 1990 HUD Lead-Based Paint Abatement Demonstration that took place in single-family Federal Housing Authority (FHA) homes (NIOSH, 1992). During the demonstration, HUD prohibited certain abatement methods with high exposure potential (such as torch burning) and required the use of competent persons (as defined in the OSHA Lead Exposure in Construction standard), engineering and work practice controls, worker training, protective clothing and equipment, medical surveillance, and exposure monitoring.

Table 9.1 Personal Breathing Zone Air Sampling for Lead by Method or Activity*

Abatement Method/Activity	Personal Breathing Zone Lead Concentrations				
	Number of Samples	Minimum (μg/m³)	Maximum (μg/m³)	Geometric Mean (μg/m³)	Geometric Standard Deviation
Abrasive	28	0.4	399	8.8	7.6
Chemical removal	291	0.4	476	3.3	4.1
Cleaning	138	0.4	588	1.9	3.6
Encapsulation	83	0.4	26	1.4	2.8
Enclosure	50	0.4	72	1.7	3.2
Final cleaning	56	0.9	36	2.1	2.8
Heat gun	360	0.4	916	6.4	4.7
Precleaning	31	0.9	11	1.5	2.2
Replacement	110	0.4	46	2.5	3.9
Setup	153	0.4	137	1.5	3.1
Other[1]	15	0.4	207	1.9	5.1
Missing[2]	87	—	—	—	—

NOTE: Underlined methods resulted in maximum exposures above the OSHA PEL

OSHA PEL (8-hour, time-weighted average) = 50 μg/m³

* Data collected by HUD Industrial Hygiene Contractors.

[1] Other abatement activities.

[2] Samples with no identified method/activity are not reported.

Laboratory-assigned Limit of Quantitation (LOQ): 0.4 μg/m³

Understanding Worker Exposure Variability: Why Every Contractor Needs to Monitor Worker Exposure

Worker lead exposures during lead hazard control activities have been found to be highly variable. Due to differences in individual work practices and environmental variations, personal airborne lead exposures even among workers in the same job category and work area can vary significantly. Therefore, it is recommended that employers sample each type of worker on the job, preferably over several shifts (days) that are representative of the entire job. This recommendation is based on the NIOSH determination that estimating the exposures of a group of workers with similar exposure risk (e.g., same job category) by sampling only a few workers in the group is reasonably accurate (within 20 percent) *only* if the geometric standard deviation (GSD) of the group's exposures is less than 1.15 (McDermott, 1985). In the vast majority of occupational groups, and particularly in the construction industry, this condition will *not* be met; therefore, employers should monitor every type of employee at the worksite. For example, NIOSH investigators found that GSDs for residential lead-based paint abatement during the HUD demonstration ranged from 2.2 to 7.6 by method (see Table 9.1). However, it is *not* necessary for employers to conduct monitoring on each and every residence where work is proceeding. If the work is similar, monitoring may be performed in 1 of every 20 dwellings.

The NIOSH summary of the personal monitoring results is presented in Table 9.1. This personal breathing zone sampling was conducted primarily to examine exposures during different methods and activities. Sampling periods were generally less than a full shift, making it impossible to compare these results to typical lead hazard control jobs. While the average personal exposures to lead were generally low, the variability of exposures was very high. The geometric mean exposures were 3.1 $\mu g/m^3$, but the geometric standard deviation was 4.4. NIOSH recommends that generalizing the results from a limited sample, such as the HUD demonstration, to an entire population of workers is reasonable only if the variability is low and if the geometric standard deviation is less than 1.15. According to the maximum exposure levels, workers were exposed to lead above the OSHA PEL in 7 of the 11 NIOSH-assigned method categories, which would indicate that most types of lead hazard control can produce exposures above the PEL.

Personal lead exposures were found to vary significantly for different abatement methods, contractors (with significant method-contractor interaction), and housing units. Paint lead concentration alone was found to be a poor predictor of personal breathing zone exposures during abatement.

The HUD data should be useful for initial planning purposes. However, when reviewing the exposures, it is important to recognize that exposures during the HUD demonstration will not be representative of other contractors, work locations, or types of buildings.

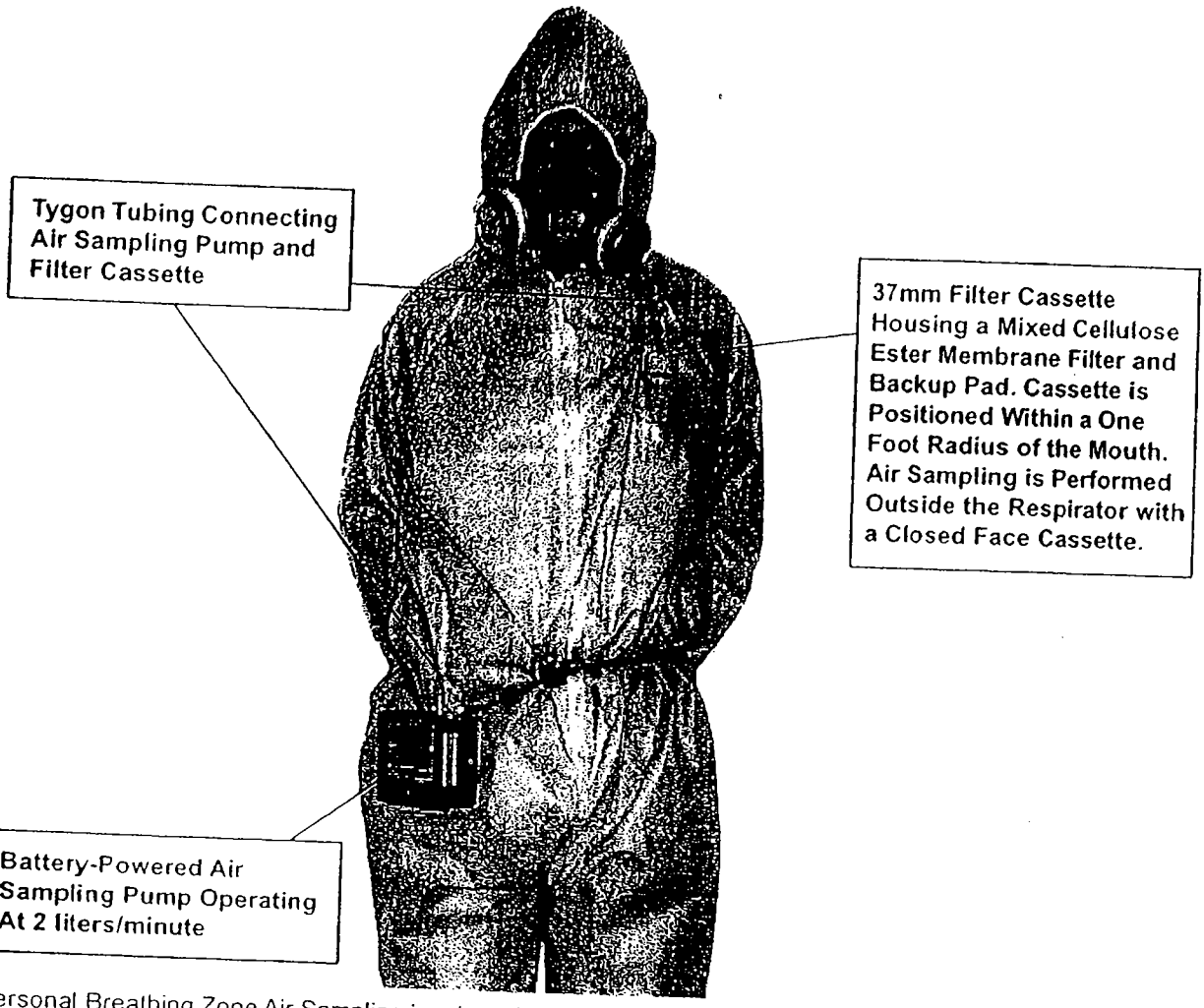
Limited air sampling for at least a few job sites for each contractor is therefore recommended, although it is not necessary to perform air sampling on every job.

B. Lead-Based Paint Removal

NIOSH investigators conducted an evaluation of worker exposures during a lead-based paint removal and cleaning pilot project (NIOSH, 1993). The project was designed to evaluate the following removal methods:

- Dry scraping followed by broom sweeping (dry sweeping)—this was selected to demonstrate exposures with no use of engineering or work practice controls.
- Wet scraping (painted surfaces were wetted with water mist) followed by high-efficiency particulate air (HEPA) vacuuming (wet HEPA).
- Wet scraping followed by HEPA vacuuming, with an air-filtration device (AFD) that is

Figure 9.2 Personal Breathing Zone Air Sampling.



Personal Breathing Zone Air Sampling involves drawing air through a 0.8μ Mixed Cellulose Ester Filter in a closed-face 37mm filter cassette using an air sampling pump running at 2 liters/minute.

equipped with a HEPA filter (wet HEPA/AFD) to pump air out of the work area (i.e., "negative air").

The final step for each of the methods was the wet mopping of floors.

In this study, workers were potentially overexposed to lead when using each of the removal methods. Short-term exposures ranged from 5 to 360 μg/m³, with a geometric standard deviation of 2.9 overall. Of the methods evaluated, the wet HEPA method appeared to offer the best control for worker exposures and area airborne lead concentrations. Extrapolated 8-hour exposures for workers who used all three methods during a shift (which should be considered minimum values) ranged from 6 to 73 μg/m³.

The method, mean paint lead concentration, precleaning surface lead concentration, and work crew practices were all found to be related to average worker exposures.

V. OSHA Requirements for Residential Lead Hazard Control Work

The preceding NIOSH data indicate that the OSHA standard will apply to most forms of residential lead hazard abatement work. The OSHA interim final rule for construction applies a level of protection (generally equivalent to the lead standard for general industry) to all occupational exposures to lead in construction, including lead abatement, repair or renovation of structures containing lead, cleaning and disposal of lead-contaminated materials, and maintenance operations.

The OSHA standard covers the following work:

- Demolition or salvage of structures containing lead.
- Removal, enclosure, or encapsulation.
- Renovation, alteration, repair, or construction of structures or substrates that are coated with lead-based paint.
- Lead cleanup.
- Transportation, storage, disposal, or containment of lead debris at the site of lead hazard control activities.
- Any maintenance work.

Various provisions of the standard are triggered by an action level of 30 μg/m³ (the same as the general industry standard) and a PEL of 50 μg/m³ (both measures are expressed as 8-hour, time-weighted averages). Employers may use a combination of engineering controls, work practices, and respiratory protection to comply with the PEL. However, engineering and work practice controls must be used first. As a practical matter, engineering and work practice controls in residential lead hazard control work are limited largely to the use of low dust-generating hazard control methods, such as enclosure and wet methods. This means that respirators will be needed for most types of lead hazard control work in housing, since the variability of exposures is quite high.

As in the general industry standard, OSHA requires adjustment of the PEL to ensure that employees who work longer than 8 hours are not exposed to a greater daily dose of airborne lead. For work shifts longer than 8 hours, the PEL is reduced according to the following formula:

$$\text{Adjusted PEL} = \frac{400}{\text{number of hours worked}}$$

For example, if the work shift is 10 hours, the PEL becomes 40 μg/m³.

$$\frac{400}{10 \text{ hours}} = 40\ \mu g/m^3$$

A trigger for worker protection requirements based on paint lead concentration was considered by OSHA, but rejected. Given the variability of work practices and methods, OSHA concluded that no useful correlation between surface concentrations and occupational exposures could be established.

In recognition of the difficulties of conducting exposure assessments during construction jobs, the interim final rule establishes task-related triggers. Certain protective measures are triggered by tasks (listed in Table 9.4) that commonly produce exposures greater than the PEL, even with prescribed protective measures. Performance of any task on one of the lists triggers specific interim protective requirements that will remain in effect until results of an exposure assessment demonstrate that such protection is not necessary.

The interim final rule requires that the following provisions be made:

- Written compliance plan and competent person(s).
- Initial exposure assessment and periodic exposure monitoring.
- Task-related triggers, with interim protection during assessment.
- Engineering, work practice, and administrative controls.
- Respiratory protection program.

Table 9.2 Worker Exposure Limits and Guidelines

Air lead	
OSHA Permissible Exposure Limit (PEL)	50 µg/m³
OSHA action level	30 µg/m³
Blood lead	
OSHA medical removal limit	50 µg/dL
OSHA recommended level to prevent reproductive problems	30 µg/dL
ACGIH proposed Threshold Limit Value	20 µg/dL

Table 9.3 Required Action Under the OSHA Standard by Exposure Level

CATEGORY I	CATEGORY II	CATEGORY III
30 µg/m³* and under (below the action level)	30–50 µg/m³ (above the action level, but below the PEL).	50 µg/m³ and over (above the PEL).
Train employees. Conduct exposure monitoring. Maintain records.	Same as category I, plus: Provide respirator at employee request. Conduct exposure monitoring every 3 months. Conduct blood lead monitoring.	Same as category II, plus: Enforce respirator use. Enforce use of protective clothing. Develop monitoring every 6 months. Enforce housekeeping. Provide hygiene facilities and enforce washing.

* All exposure levels are 8-hour, time-weighted averages.

- Protective clothing and equipment.
- Housekeeping.
- Hygiene facilities and practices
- Medical surveillance.
- Medical removal protection.
- Hazard communication programs and training on specific operations causing lead exposure.
- Signs.
- Recordkeeping.
- Observation of monitoring.

Individual States that have approved plans for OSHA enforcement may adopt their own lead standards for the construction industry, as long as their requirements are at least as stringent as the Federal OSHA standard. Employers will need to ensure that their programs for worker protection meet applicable State requirements.

The OSHA standard does not specify the methods for any given type of operation, such as lead-based paint removal. The method of

removal is left to the discretion of the employer, and constitutes an important potential engineering control. In some cases, however, the method of abatement or interim control will have already been selected by a risk assessor and/or the property owner based on other considerations.

A. Written Compliance Plan and Competent Person(s)

For every job, OSHA requires employers to prepare a written compliance plan that specifically describes how the standard will be implemented and includes regular and frequent inspections of the job site by a competent person. The written compliance plan, in conjunction with frequent work area inspections by a competent person, should ensure the prevention of dangerous, unhealthy, or unsafe conditions.

1. Written Compliance Plan

An example of a written compliance plan appears at the end of this chapter. Prior to the start of every job in which employee exposure will potentially exceed the OSHA PEL, employers must develop and implement a written compliance plan. (Providing respirators does not make a written plan unnecessary.) The written plan should be an organized strategy for protecting workers and should account for potential exposure problems, control alternatives, and a schedule for inspection of the job by the competent person(s). At a minimum, OSHA requires that written plans include:

- A description of equipment and materials, controls, crew size, job responsibilities, and operations and maintenance procedures for each activity in which lead is emitted.
- A description of specific control methods (e.g., abatement process selection, wet methods). For engineering controls, include supporting engineering plans and studies used to select methods.
- Technology considered in meeting the PEL.
- Air monitoring data documenting sources of lead emissions.
- A detailed implementation schedule for the compliance plan, including the schedule for inspections by a competent person.
- A description of the lead work practice program that will be used to control worker exposures. (This includes the use of protective work clothing and equipment, hygiene facilities and practices, and housekeeping practices.)
- A description of arrangements made among contractors on multicontractor worksites to inform affected employees (including bystanders) of potential lead exposures, and to clarify responsibilities with regard to control of those exposures.

For those hazard control jobs that proceed over an extended period in multifamily housing, OSHA requires that the written compliance plan be updated at least every 6 months. Single-family housing will require a separate plan for each dwelling. The plan must be available at the worksite for representatives of OSHA or NIOSH, and at the request of any affected employee or employee representative. (See the end of this chapter for copies of blank and completed written compliance plans.)

2. Competent Person(s)

As defined by OSHA, a "competent person" is one who is capable of identifying existing and predictable hazards at the worksite, and who has the authority to ensure prompt corrective measures are taken to eliminate them. The employer must utilize a competent person (or persons) to ensure that the worker protection program is effective. The definition of a competent person and the requirement for regular and frequent inspections of job sites, materials, and equipment by a competent person are identical to those already required by OSHA's general safety and health provisions for construction work (29 CFR 1926.32 and 29 CFR 1926.20). In the context of a lead-based paint abatement job, the competent person should have knowledge of the lead exposures for each abatement method in use; the potential hazards from lead and other substances or physical agents in the worksite; the appropriate engineering controls,

work practices, and personal protective equipment for the job; the requirements of OSHA construction standards (29 CFR, Part 1926); and the recommendations of these *Guidelines* and other general sources of information. The competent person's worksite inspection frequency should be based on the magnitude of potential lead exposures, the number of workers at each site, and the employer's past experience. Duties of the competent person include:

- Determining whether lead is present before work begins.
- Ensuring that employee exposure assessment is performed.
- Ensuring that workers use required protective clothing and respirators.
- Ensuring that up-to-date copies of respirator fit tests and medical examination results are available.
- Ensuring that proper hygiene facilities are available and in use.
- Ensuring that engineering controls are operating properly and are effective.
- Posting lead hazard work areas with warning signs.

B. Exposure Assessment

1. Initial Exposure Assessment

The OSHA standard requires all employers to conduct initial exposure assessments for all jobs involving the use or removal of lead or lead-containing materials. The purpose of the initial assessment is to determine if *any* workers are being exposed to lead equal to or greater than the action level of 30 $\mu g/m^3$. The exposure assessment can include current results from exposure monitoring of employees, previous monitoring results, or other objective data demonstrating that the specific product, process, operation, or activity involving lead cannot result in exposures above the action level under any circumstances. Each of these methods for exposure assessment is discussed in more detail below.

The initial exposure assessment may be limited to workers that are believed to have the greatest exposures to airborne lead. When planning which employees to include in the initial exposure assessment, the following should be considered: any information, observations, or calculations that would indicate potential airborne exposure to lead, including previous measurements of airborne lead; and any employee complaints of symptoms consistent with exposure to lead. Additional factors that should be considered include the worker's distance from airborne lead sources; employee movement, ventilation, and airflow patterns; and individual work practices. If no information is available for assessing maximum-risk employees, then all workers should be assumed to be at risk. NIOSH has published recommendations for selecting maximum-risk employees (NIOSH, 1977).

Positive initial determination

When the initial assessment shows the potential for any employee to be exposed to lead at or above the action level (for 1 day or more), the determination is *positive* and exposure monitoring (or assessment with existing data) for each individual on the job must be conducted during representative work shifts

Negative initial determination

When the determination shows that no employee is potentially exposed to lead at or above the action level (for 1 day or more), the determination is *negative* and further exposure assessment is not necessary until there is a change in the workplace (see Monitoring frequency below).

2. Exposure Monitoring

Personal monitoring

"Exposure monitoring" refers to the measurement of a worker's exposure to an airborne contaminant, regardless of any respiratory protection worn. An air sample is collected outside of any respirator worn, as close to the worker's mouth and nose as is practical (often the collection device is located on the shirt collar)

OSHA requires that exposure monitoring consist of full-shift samples (at a minimum, one sample for each job classification in each work area). In the case of multiple shifts, each shift or the shift with the highest expected exposure level should be monitored. Since the degree of worker protection provided may depend on the results of exposure monitoring, it is critical that the sampling be representative of the employees' regular, daily, and highest exposure to lead. It is not necessary to perform sampling in each dwelling where work is performed.

Number of samples

There is no formula for determining the total number of samples to be collected during each job. The sampling protocol should be developed on a case-by-case basis by an industrial hygienist or other qualified occupational safety and health professional.

Sampling methods

NIOSH and OSHA have published laboratory-based sampling methods for personal airborne lead, with guidelines for acceptable precision and accuracy (OSHA, 1985; NIOSH, 1984). The sampling method used for monitoring must have an accuracy rate not less than ±25 percent for the action level of 30 $\mu g/m^3$. Employers should use laboratories that are accredited for environmental lead analyses. Requirements for a National Lead Laboratory Accreditation Program (NLLAP) have been developed by the U.S. Environmental Protection Agency's (EPA's) Office of Pollution Prevention and Toxics for the recognition of private and/or State laboratory accreditation systems. A complete list of EPA NLLAP-recognized laboratories is available to the public from NIOSH (1-800-35-NIOSH) or the National Lead Information Center Clearinghouse (1-800-424-LEAD).

Monitoring frequency

Employers do not need to perform air sampling in each dwelling treated. A reasonable approach would be to conduct air sampling in 1 dwelling out of every 20 treated, with an emphasis on sampling worst-case dwellings. This approach can be used for both large, multifamily and small, single-family jobs.

If employee exposures to lead are at or above the action level, but not exceeding the PEL, then employers must perform monitoring at least every 6 months. If employee exposures are above the PEL, then monitoring must be performed at least every 3 months. The monitoring must be continued every 6 months (or every 3 months) until at least two consecutive measurements that are taken at least 1 week apart are below the action level (or PEL).

Employee notification

Employees must be provided with written results of their exposure within 5 (working) days of the completion of the exposure assessment. This concludes the exposure assessment requirement.

Other air sampling

Samples collected inside a worker's respirator may be used to determine the effectiveness of a respiratory protection program, although such sampling is often quite difficult for most types of respirators. "Area" samples (those collected in the general area of the work activity or at the perimeter of the lead hazard work area) may be used to assess potential bystander exposures. While inside-respirator and area samples are potentially useful, neither can be used to meet OSHA monitoring requirements and they should not be considered a substitute for personal sampling.

3. Previous Monitoring Results

To use previous monitoring results for exposure assessment of employees, the data must have been collected within the past 12 months, and the work operations and work conditions should closely resemble the processes and types of materials, control and containment methods, work practices, and environmental conditions in the current workplace, including the condition of the lead-based paint, the concentration of lead in paint, and the degree of employee training and supervision. Employers must have this data in their possession to present to an OSHA compliance officer.

4. Objective Data

Objective data may not be used for exposure assessment for any of the activities listed in OSHA's task-related triggers (see below). Examples of objective data that OSHA would allow are the results of laboratory product test results from manufacturers of lead-containing products or materials, or results of an industry-wide study. (The HUD demonstration project described earlier does not constitute an industrywide study since project conditions were different from ordinary conditions.) Since manufacturers' data are of varying quality, employers should determine whether the data have been collected in a sound and objective manner.

Additional requirements for the use of objective data are:

- The data must show that the product, process, or material cannot result in employee exposure to lead that is equal to or greater than 30 μg/m³ during any aspect of the job.
- The employer must establish and maintain accurate records of the objective data and its relevancy (see the information on recordkeeping below).

C. Task-Related Triggers

Until exposure assessments have been completed, employers must rely on OSHA's task-related triggers to determine appropriate controls and work practices. OSHA's task-related triggers are based on three categories of exposure (see Table 9.4). If lead is present when any of these tasks are performed, interim protective provisions are required prior to and during assessment of employee exposures.

Required interim protection during initial exposure assessment includes respiratory protection, protective work clothing and equipment, change areas, handwashing facilities, training, and initial blood sampling and analysis. Requirements for the three lists of tasks are identical except for the minimum respiratory protection, which depends on the assumed exposure range. For example, for airborne concentrations of lead less than 500 μg/m³, the required minimum respiratory protection is a half-mask, air-purifying respirator with HEPA filters (see Figure9.3).

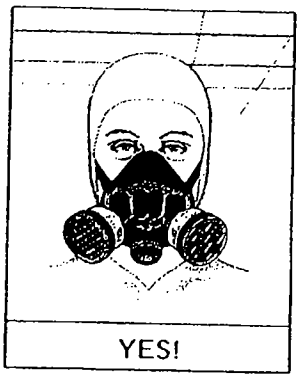
The employer can discontinue the interim protection for any employee performing one of these tasks only after it is documented that the employee's exposure is below the PEL. Respiratory protection can be reduced only after it is documented that the exposure is below the assumed range for the task. It is unlikely that risk assessors or inspector technicians, who scrape limited surface areas, will require respiratory protection. It is not necessary for such individuals to wear respirators, unless a large number of samples will be collected on a single day.

Table 9.4 Residential Lead Hazard Control Assumed Exposures for OSHA's Task-Related Triggers (adapted from 29 CFR 1926.62)

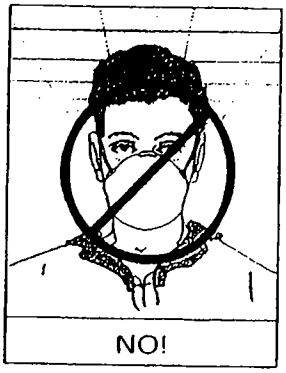
50 μg/m³ to 500 μg/m³	500 μg/m³ to 2,500 μg/m³	Greater than 2,500 μg/m³
Manual demolition Manual scraping Manual sanding Heat gun use Power tool paint removal in the HEPA vacuum-assist dust collection system	Cleanup on dry, abrasive blasting jobs Abrasive blasting enclosure movement/removal	Abrasive blasting

Note: Abrasive blasting without a HEPA local exhaust system is not permitted in residential dwellings.

Figure 9.3 How to Inspect Your Respirator.



A Half-Mask, Air-Purifying Respirator with HEPA Cartridges Is Appropriate for Many Residential Lead Hazard Control Jobs. Paper Dust Masks are NOT Adequate.



STRAPS—hold the respirator on your head. One goes over the crown of your head. Another headband has two plastic straps, which go straight up and straight back on your head.

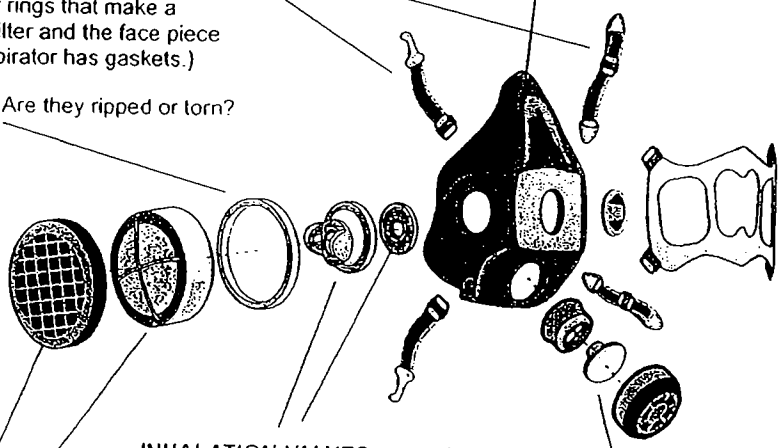
Check: Are they elastic? Are they torn? Do the buckles and snaps work?

GASKETS—are rubber rings that make a tight seal between the filter and the face piece present. (Not every respirator has gaskets.)

Check: Are they there? Are they ripped or torn?

FACE PIECE—is made of rubber, silicon, or other materials.

Check: Is it ripped or worn? Is the face piece bent? Is it clean?



INHALATION VALVES—are where you breathe in. There are two small rubber flaps behind the filters.

Check: Are both there? Are they ripped or bent? Are they dirty?

Filters—filter the air. They are also called "cartridges."

Check: Do you have the right one for the job? When you work with lead, you need HEPA filters. When you use solvents or caustic paste, you will need other filters, too. Change filters regularly, especially when it becomes harder to breathe.

EXHALATION VALVE—is where you breathe out. It is a small rubber flap about the size of a quarter. It is underneath a cover.

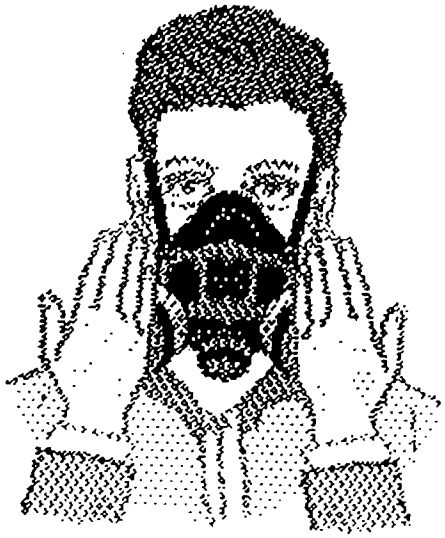
Check: Take off the cover. Is the valve there? Is it ripped or bent? Is it dirty?

Courtesy: Alice Hamilton Occupational Health Center

Figure 9.4 Qualitative Respirator Fit Checks.

Negative-pressure fit check

Cover the two filters or the air hose with your hands and inhale gently. Hold for a count of ten. You will feel the respirator pull against your face. You can feel the area of the seal tightening to your face. If there is a leak, air will rush in through the leak instead of pulling the mask against your face. You will feel air move against your cheeks. It may feel like a feather brushing across your face. The air will move toward your mouth. You may hear the air flow. If someone is watching you, they should see the respirator suck in a little at your nose.



Negative-pressure fit check

Positive-pressure fit check

Cover the rubber flap exhalation valve with one hand and puff out gently. You should feel the force of your breath balloon the respirator out a tiny bit. This is like the feeling you get when you first blow up a balloon. You have to blow harder to get over the resistance of the balloon. As the mask moves out, you will feel the seal of the respirator tighten on your face. If there is a leak in the mask, air will rush out of the leak instead of making the mask balloon out. If there is a leak, you will feel air rush out against your cheeks. You will not feel the seal tightening to your face. Don't blow too hard, or you can blow out your intake valves and break a good seal

Positive-pressure fit check

Courtesy: Alice Hamilton Occupational Health Center

D. Engineering and Work Practice Controls

OSHA requires employers to institute engineering and work practice controls to the extent feasible to reduce worker exposures so they are at or below the PEL. The Society for Occupational and Environmental Health (SOEH) has published recommendations on engineering and work practice controls (SOEH, 1993).

Some examples of good engineering controls are:

- Providing HEPA-filtered local exhaust ventilation for devices and abrasive power tools, including all blasting equipment, needle guns, sanders, and grinders.
- Using HEPA vacuums for cleanup instead of dry sweeping or compressed air.
- Providing adequate ventilation during indoor heat gun use to prevent buildup of lead and volatile organic compounds.
- Using wet methods to reduce airborne dust generation; for example, a water sprayer to hold down settled leaded dust on the plastic sheeting covering the floor or ground.

Some examples of good work practices are:

- Wetting of surfaces with water mist prior to scraping, sweeping, or sawing.
- Providing onsite washing facilities, and following good hygiene practices.
- Daily cleanup of work area and equipment to prevent leaded dust accumulations.
- Whenever feasible, avoiding methods with known high exposure potential, such as machine sanding without local exhaust ventilation.

E. Respiratory Protection Program

Even with implementation of engineering and work practice controls, respiratory protection will probably be necessary for most abatement methods, such as lead-based paint removal by chemicals, heat gun, or abrasive techniques, and some other operations, including setup, cleaning, many forms of interim control, and maintenance. Due to the variability of exposures in construction, contractors may need to use more than one type of respirator at a given job. Respirator selection for each job should be determined by an industrial hygienist or other trained health and safety professional.

OSHA requires the use of respirators:

- When an employee's exposure exceeds the PEL and as interim protection for tasks specified in the task-related triggers.
- In work situations where engineering and work practice controls are not sufficient to reduce employee exposures below the PEL.
- Whenever an employee requests a respirator.

Because there are recognized health effects at blood lead levels below what is allowed by OSHA, employees may wish to use respirators even when their exposures are below the PEL.

Whenever respirators are used, either on a voluntary or mandatory basis, employers must establish a respiratory protection program. Respirators are devices that must be used carefully (29 CFR 1910.134, OSHA respirator standard). A minimally acceptable respiratory protection program must include selection of respirators on the basis of worker exposures; written standard operating procedures; training of workers in the proper use of respirators; fitting, regular cleaning, maintenance, and inspection of equipment; and storage in a clean and sanitary location. Workers must not be assigned to tasks requiring the use of respirators unless it has been determined by a physician that they are physically able to perform the work and use the respirator. Under the OSHA Lead Exposure in Construction standard, employers are required to

- Provide respirators approved by NIOSH and the Mine Safety and Health Administration (MSHA) for protection against leaded dust, fume, and mist at no cost to the employee.

- Select required respirators for employees based on the maximum airborne concentrations of lead, expected or measured, according to Table 1, 29 CFR 1926.62.
- Upon employee request, provide a powered air-purifying respirator (PAPR) to any employee in lieu of the selected respirator if this will provide sufficient protection.
- Ensure that the respirator issued to each employee fits properly and exhibits minimum face piece leakage.
- Perform qualitative or quantitative fit tests at the time of the initial fitting and at least every 6 months thereafter for employees wearing negative-pressure respirators.
- If an employee exhibits difficulty during fit testing or subsequent use, provide an appropriate medical examination to determine whether the employee can wear a respirator while performing the job.
- If filter respirators are used, maintain an adequate supply of filters, and instruct each employee to change the filter elements whenever an increase in breathing resistance is detected

1. Respirator Selection

If a respirator is required, it is the employer's duty to enforce its use.

Employers should refer to the OSHA interim construction lead standard (Table 1, 29 CFR 1926.62) for the proper selection of respirators. In the absence of hazardous contaminants other than lead, the half-mask, air-purifying respirator with HEPA filters should be adequate for most lead hazard control jobs, since most exposures are usually less than 500 $\mu g/m^3$.

Respirators specified for higher concentrations can also be used at lower concentrations of lead For example, PAPRs may be preferred over half-mask, negative-pressure respirators because they are more protective, produce less cardiovascular stress, and are generally more comfortable to wear. PAPRs include a small, battery-powered blower that provides clean air to the worker, thus reducing breathing resistance.

If an initial determination or exposure monitoring indicates potential airborne exposure to contaminants other than lead, such as solvents used during chemical stripping or heat gun use, reevaluation of the respirator selection is warranted. It would be prudent to select a respirator (or filter) that protects against *both* lead particulate and organic vapors. If a worker has an increase in blood lead level, reevaluation of the respirator program, personal hygiene, and work practices is needed.

F. Protective Clothing and Equipment

OSHA requires that employers provide and enforce the use of protective clothing whenever employees are exposed to airborne lead above the PEL (irrespective of respirator use) and as interim protection for employees performing tasks listed in the task-related triggers. Hardhats, goggles, safety shoes, and other personal protective equipment may also be required by other OSHA standards, depending on the type of work performed. These materials must be supplied at no cost to employees.

Leaded dust is not absorbed directly through the skin; however, lead contamination of workers' clothing and person has resulted in lead exposure for workers and their families in the past. The use of protective equipment, in conjunction with good hygiene practices and washing facilities, should prevent contamination of workers' personal clothing and prevent the transfer of lead contamination from the work area to lunch and break areas, personal vehicles, and workers' homes. Workers should be equipped with disposable or reusable coveralls or similar full-body work clothing, gloves, hardhats, safety shoes, disposable shoe covers, chemical-resistant clothing (for skin-contact hazards), safety glasses, face shields, and goggles (in conjunction with portable eyewash equipment)

Since workers may spend most of their time on abatement jobs wearing protective clothing, it should be selected to prevent heat stress. For

Figure 9.5 Types of Respirators Used in Residential Lead Hazard Control Work.

Half-Mask, Air Purifying Respirator

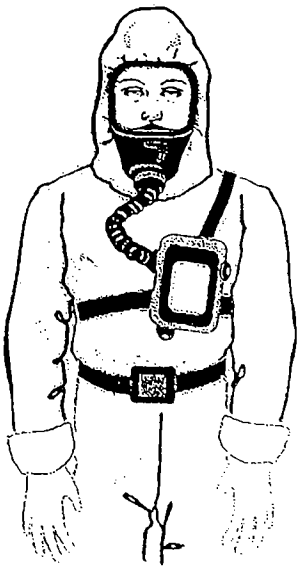
Adequate for Atmospheres Up To 500 μg/m³ Lead

Full-Face, Air Purifying Respirator

Adequate for Atmospheres Up To 2500 μg/m³ Lead

Powered Air Purifying Respirator

Adequate for Atmospheres Up To 2500 μg/m³ Lead
(Filter and Battery-Powered Blower are worn on Belt)



example, the use of breathable clothing (cotton or paper fabric) is appropriate during most abatement work to reduce the potential for employee heat stress. Shoes or disposable shoe covers should have nonskid soles, particularly for work on plastic-covered surfaces. Shoe covers should *not* be used when workers need to climb ladders and scaffolding because they may cause slips and falls; nonskid work boots should be used instead. Work boots or shoes should be removed from the work area only in a sealed plastic bag. Torn shoe coverings also present a serious hazard and should be replaced as often as necessary. Chemical-resistant protective clothing will be necessary for any work involving caustic or solvent-based strippers and other substances that are hazardous upon skin contact. For example, caustic paint strippers require special clothing and gloves (see the Manufacturer's Material Safety Data Sheet). Paper suits and shoe covers are not appropriate for chemical processes.

The possibility of heat stress and its signs and symptoms while wearing protective clothing should be included in worker training. Contractors should consult an industrial hygienist or other qualified health and safety professional for the proper selection of protective clothing.

OSHA requires that employers supply clean work clothing at least weekly to employees with personal exposures above the PEL, and daily to those with levels greater than 200 μg/m³ as an 8-hour, time-weighted average.

Employers are responsible for cleaning, laundering, and disposing of protective clothing and equipment; repairing or replacing protective clothing and equipment to maintain its effectiveness; ensuring that all protective clothing is removed at the end of a work shift only in designated change areas; ensuring that contaminated clothing is placed in a closed container in the change area to prevent the spread of lead contamination; and notifying in writing anyone who cleans or launders the protective clothing that the clothing is contaminated with lead.

Removal of lead from clothing by blowing, shaking, or any other means that disperses lead into the air is prohibited. HEPA vacuuming heavily contaminated protective work clothing as an initial cleaning method is recommended.

G. Housekeeping

Employers must keep all surfaces in the worksite as free as practicable from lead accumulations. This is important to prevent dispersal of leaded dust into the air during work activities, thus reducing employee exposure to lead. Cleanup of floors and other surfaces must be completed by vacuuming (using vacuums equipped with HEPA filters and/or wet washing methods) or other methods that minimize airborne lead during cleaning.

Shoveling, wet sweeping, and brushing may only be used for cleanup where vacuuming or other equally effective methods have been tried and proven ineffective. For example, shoveling and sweeping may be necessary to pick up large debris. In such cases, the debris should be misted with water prior to cleanup to minimize leaded dust generation.

OSHA prohibits the use of compressed air to clean leaded dust from any surface.

H. Hygiene Facilities and Practices

OSHA requires that employers provide hygiene facilities and ensure good hygiene practices for all employees performing work that is covered by the task-related triggers or for workers who are exposed to airborne lead above the PEL (irrespective of respirator use). Employers must ensure that no food, beverage, or tobacco product be present or consumed, and that cosmetic products not be applied in work areas. Employers must also provide change areas, showers (where feasible), eating areas, and handwashing areas. Good hygiene facilities and practices will minimize additional employee exposure to lead from ingestion or inhalation, and prevent contamination of workers' vehicles and homes. Wipe sampling of designated "clean" areas during abatement jobs longer than 2 weeks should be conducted. Even if exposures are less than 50 μg/m³, contamination of workers' automobiles, clothes, and homes with settled leaded dust can be a serious problem. Good personal

hygiene is essential even if airborne dust exposures appear to be low.

Specific hygiene requirements for employees exposed above the PEL (without regard to respirators) are listed below. Change areas and handwashing facilities are also required as interim protection during exposure assessment for the task-related triggers.

1. Decontamination Procedures

Conduct worker decontamination before all breaks, before lunch, and at the end of the shift. Decontamination consists of:

- Cleaning all tools (at the end of the shift).
- HEPA vacuuming all protective clothing before entering the decontamination area.
- Entering the decontamination area (dirty side).
- Removing protective clothing by rolling inward (do not remove respirator yet); removing work shoes and putting in plastic bag.
- Entering shower or washing facility.
- Removing respirator after washing hands.
- Taking a shower, if available, using plenty of soap and water; washing hair, hands, fingernails, and face thoroughly (before lunch and at the end of the shift only).
- Entering the clean area and putting on street clothing and street shoes.

2. Change Areas

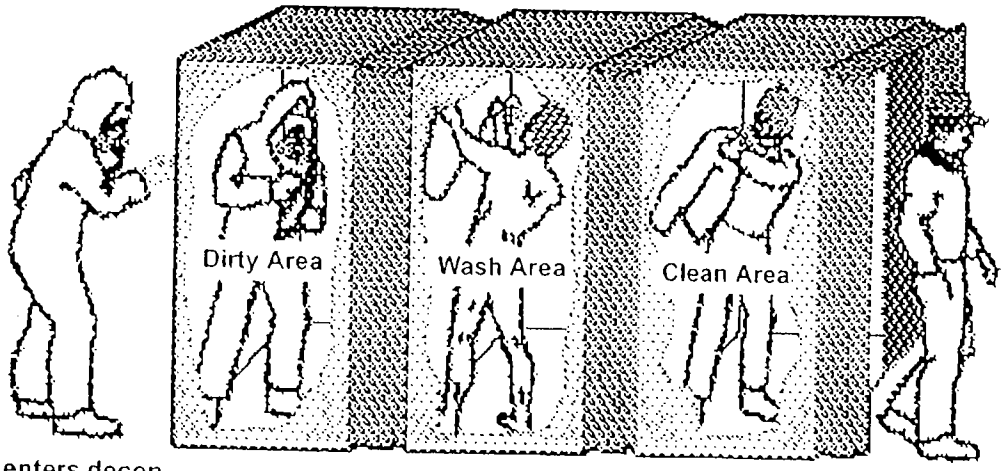
To prevent cross-contamination, change areas must have separate storage facilities for protective work clothing and equipment and workers' street clothes. The employer is responsible for ensuring that employees do not leave the worksite wearing protective work clothing. Change areas and clean areas should be cleaned on a regular basis.

In those worksites where a decontamination zone is not feasible, workers can wear two layers of protective clothing, if heat stress is not a problem. The first layer is removed at the work area exit; the second is removed in the clean area.

3. Showers

Wherever feasible, employers should provide shower facilities onsite. Employers must make soap and towels available, and make sure that

Figure 9.6a Worker Decontamination.



Worker enters decon from work area.

Worker exits decon after washing and changing.

employees shower before lunch and at the end of their shifts to remove lead from skin and hair.

4. Eating Facilities

Employers must provide clean, accessible eating areas for employees. The dwelling and work area should not be used as eating areas.

Employers must ensure that workers wash their hands and face prior to eating, drinking, smoking, or applying cosmetics. Also, workers may not enter eating areas with contaminated protective work clothing or equipment unless surface leaded dust has been removed by vacuuming or another cleaning method that controls leaded dust dispersion.

Although not specifically addressed by OSHA Lead Exposure in Construction standard, if workers voluntarily leave the worksite for lunch, they should be required to wash or shower, and change into street clothing to prevent contamination of their personal vehicles. Showering is not needed for other breaks, although workers should always wash their hands and face before eating, drinking, or smoking.

5. Handwashing Facilities

Employers must provide adequate handwashing facilities for employees exposed to lead. Handwashing facilities must be in accordance with general construction health and safety requirements (29 CFR 1926.51 (f)). The facilities should be located near the worksite and be sufficiently equipped so that workers can remove lead effectively. Where showers are not provided, employers must ensure that workers wash their hands and face at the end of their work shift.

1. Medical Surveillance

Workers must undergo both initial and routine medical surveillance, depending on the level and duration of their airborne exposures to lead. Employers and physicians should consult AppendixC in 29 CFR 1926.62 for detailed guidelines on medical surveillance of lead-exposed workers. All medical examination procedures must be under the supervision of

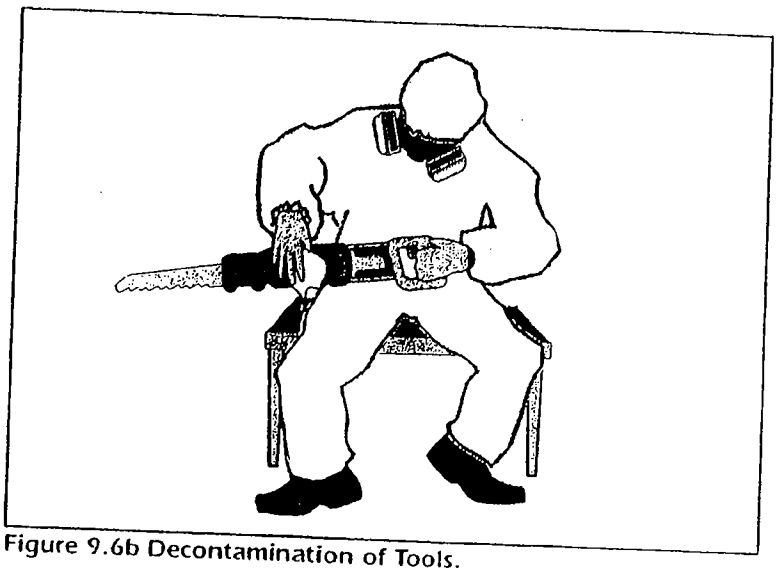
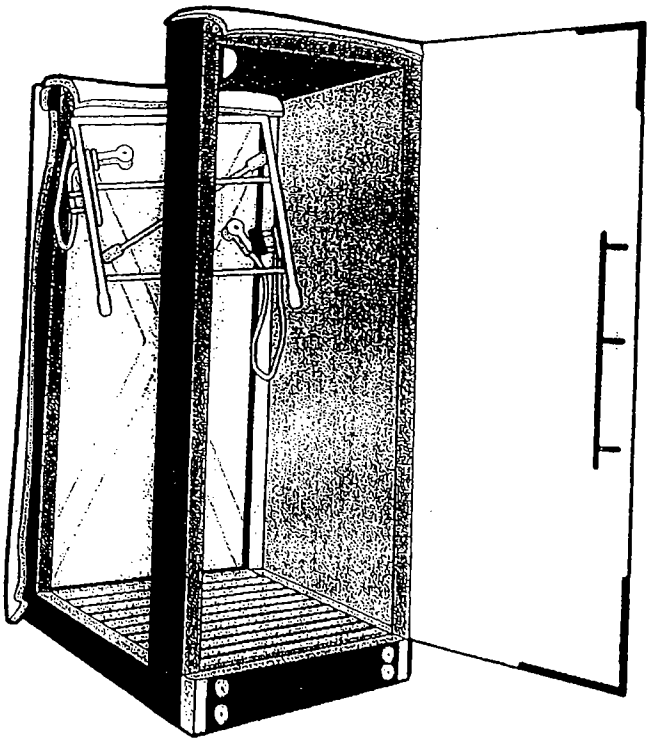


Figure 9.6b Decontamination of Tools.

Figure 9.7 Portable Showers Make Worker Decontamination More Effective and Feasible.



a licensed physician, preferably one who is board-certified in occupational health.

Lead abatement contractors should use medical surveillance to measure the effectiveness of their worker protection programs. For example, significant increases in blood lead levels of 10 µg/dL or greater or blood lead levels exceeding 20 µg/dL should trigger timely investigations of exposures, work practices, respirators, and personal hygiene practices.

1. Initial Surveillance

One purpose of initial medical (or biological) monitoring is to establish baseline blood lead levels and to allow early detection of increases in worker blood lead levels. Another purpose is to detect workers who have already been overexposed to lead on previous jobs. OSHA requires employers to:

- Make initial biological monitoring available to all employees who are exposed *on any single day* to lead levels equal to or greater than 30 µg/m³.
- Provide initial biological monitoring to all employees who will be performing task-related trigger activities (see Table9.4).
- Conduct biological monitoring of workers' blood lead levels *and* zinc protoporphyrin levels (zinc protoporphyrin levels are one way of measuring long-term exposures).
- When an employee's initial blood lead level is equal to or greater than 40 µg/dL, provide continued biological monitoring at least every 2 months, until two consecutive blood lead level results are less than 40 µg/dL.

2. Routine Surveillance

Generally, most lead hazard control workers in the residential setting should have their blood lead levels checked every month or two and a baseline level determined before beginning work. An ongoing medical surveillance program, including biological monitoring of blood lead and zinc protoporphyrin levels and medical examinations, must be provided for all employees who *are or may be* exposed to lead levels greater than 30 µg/m³ for more than 30 days in any consecutive 12-month period. OSHA requires employers to pay for biological monitoring and medical examinations.

Biological monitoring requirements

The employer must make available the following:

- Biological monitoring for blood lead and zinc protoporphyrin levels at least every 2 months for the first 6 months, and every 6 months thereafter.
- When an employee's blood lead level is equal to or greater than 40 µg/dL, biological monitoring at least every 2 months, until two consecutive blood lead level results are less than 40 µg/dL.
- When an employee's blood lead level meets the criterion for removal from the worksite (equal to or greater than 50 µg/dL), followup blood testing within 2 weeks.
- Monthly blood lead level testing during the removal period for any employee medically removed due to an elevated blood lead level (EBL).
- Blood lead sample analysis by an OSHA-approved laboratory (call 1-800-35-NIOSH for a list of OSHA-approved laboratories).

The employer must notify all employees of their individual blood lead level in writing within 5 working days after receipt of results. In addition, each employee with a blood lead level greater than 40 µg/dL must be informed that temporary medical removal from the worksite (with benefits) is required when periodic and followup blood testing indicate a blood lead level equal to or greater than 50 µg/dL. Medical removal means that a worker is not permitted to continue to work in a leaded environment. If no other equivalent work is available from the employer, wages and benefits must be maintained in full. A worker cannot be penalized for having an elevated blood lead level.

Medical examinations

The employer must:

- Provide medical examinations prior to assignment for workers whose exposures will be equal to or greater than 30 μg/m³ for more than 30 days per year.
- Make medical examinations available at least annually for any employee who had a blood lead level equal to or greater than 40 μg/dL any time during the past 12 months.
- Provide a medical examination as recommended by the treating physician for any employee who either has reported symptoms consistent with lead intoxication or upon employee request. Reasons that an employee may request a medical examination include medical advice related to conceiving a healthy baby, pregnancy, and difficulty in breathing during respirator fit test or use.
- Furnish employees with written medical opinions from examining physicians.
- Make available medical examinations for employees medically removed from the job due to exposure to lead.
- Provide a multiple-physician review mechanism as specified in the standard 29 CFR 1926.62(j)(3)(iii) to give workers the opportunity to obtain a second and possibly a third medical opinion.

At termination of employment, an employer would be well advised to have an exit medical examination performed for each worker, due to workers' compensation considerations.

Medical examinations provided to employees must include detailed work history; medical history; physical examination; pulmonary status to determine if respirator can be worn; blood pressure check; blood sampling and analysis for blood lead level, zinc protoporphyrin level, and other specified parameters (hematocrit, hemoglobin, peripheral smear morphology, and red cell indices); routine urinalysis with microscopic examination (checking levels of urea nitrogen and serum creatinine); pregnancy testing or laboratory evaluation of male fertility, if requested by the worker; and any other test relevant to lead exposure recommended by the examining physician. Prophylactic chelation (routine use of drugs to keep blood lead levels low) of any employee at any time is prohibited.

J. Medical Removal Protection

Medical removal protection is designed to give employees time away from lead exposure to reduce blood lead levels. The trigger for required medical removal protection is either a blood lead level equal to or greater than 50 μg/dL, or a "final medical determination," which is the examining physician's written opinion on the employee's health or the outcome of the multiple-physician review mechanism (see Medical examinations above).

Since medical removal protection includes retention of salary and benefits for employees removed from work, employers have a strong economic incentive to prevent excess lead exposure. With effective controls very few employees should reach the trigger levels requiring removal during lead hazard control work.

The following are OSHA's basic medical-removal protection requirements for construction employers:

- Remove employee on each occasion that a worker's periodic and followup blood lead levels are equal to or greater than 50 μg/dL; employee can return to work when two consecutive blood lead levels are less than 40 μg/dL.
- Remove employee on each occasion when a final medical determination indicates a medical condition that places the employee at "increased risk of material impairment to health" due to lead exposure.
- Implement protective recommendations for the employee that are included in the results of final medical determinations.
- Provide medical-removal protection benefits for up to 18 months, or as long as the job continues, each time an employee is removed

- Maintain employee's normal earnings, seniority, and other employment benefits during removal, including the right to return to the former job.
- Provide the same medical-removal protection benefits to any employee who is removed even if not required under the standard.

K. Hazard Communication Programs and Training on Specific Operations Causing Lead Exposure

The employer must establish a hazard communication program for all potentially exposed workers (29 CFR 1926.59). This program should at a minimum include warning signs and labels, material safety data sheets, and the required employee information and training, including discussion of the Hazard Communication Standard. Employers must also have a written hazard communication program for their workplaces.

OSHA requires that employers provide a lead training program for all employees who are exposed to lead at or above the action level (30 $\mu g/m^3$) *on any single day*. The training program must be provided prior to the time of job assignment and at least annually for employees.

The employer must ensure that employees are trained in:

- The content of the OSHA interim lead standard for construction (29 CFR 1926.62) and its appendixes, including supplying a copy of the standard and appendixes to the employee.
- The specific nature of the operations that would result in lead exposure above the action level.
- The purpose, proper selection, fitting, use, and limitations of respirators.
- The purpose of the medical surveillance program and the medical-removal protection program.
- The adverse health effects of excessive exposure to lead, with particular attention to the adverse reproductive effects on both males and females.
- The hazards to the fetus and precautions for pregnant employees.
- The specific engineering controls and work practices associated with the employee's job assignment.
- Relevant good work practices described in Appendix B of the OSHA standard.
- The content of any compliance plan.
- The risks associated with chelating agents. They should not routinely be used to remove lead from their bodies and should not be used at all except under the direction of a licensed physician.
- Their right of access to records under OSHA's Access to Exposure and Medical Records Standard (29 CFR 1910.20).

EPA Regional Lead Training Centers currently provide training courses for inspector technicians, project supervisors, and abatement workers. SOEH has also developed a training guide, which is referenced in the OSHA standards (SOEH, 1993). Other training providers also offer EPA training (see Chapter2). Appendix 15 contains a summary of the OSHA standard for workers. It is likely that EPA worker training will meet the OSHA training requirements as long as job-specific information is included.

L. Signs

Employers are required to post warning signs with the wording shown in Figure 9.8. This requirement does not preclude the employer from posting other appropriate hazard warnings, such as "Respirators required in this area." The signs must be posted in each work area where an employee's lead exposure is above the PEL, and illuminated and cleaned as necessary so that the legend is readily visible.

Figure 9.8 Example of Required Sign.

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

M. Recordkeeping

OSHA requires employers to maintain records of exposure assessments, medical surveillance, medical removals, and, if applicable, objective data used for exemption from the requirement for initial monitoring. Records must be made available upon request to affected employees, former employees, designated employee representatives, and OSHA and NIOSH. These records (except medical removals) must be kept for 30 years (29 CFR 1910.20). If an employer ceases to do business, the records must be transferred to a successive employer. If there is no successor, these records must be submitted to the Director of NIOSH. Employers should refer to 29 CFR 1926.62(n)(6) for additional requirements for transfer and disposal of records.

Employer records can provide a basis for assessment of regulatory compliance and the effectiveness of the employer's worker protection program. Additionally, records of exposures and health effects may be useful in epidemiologic studies.

1. Exposure Assessments

Exposure monitoring records must include the following information:

- Date(s), number, duration, location, and results of each of the samples taken.
- A description of the sampling procedure used to determine representative employee exposure, where applicable.
- A description of the sampling and analytical methods used and evidence of their accuracy.
- The type of respiratory protection worn by monitored employees.
- Name, social security number, and job classification of the monitored employee and all other representative employees.
- The environmental variables that could affect the measurement of exposure (for example, temperature and relative humidity).

It is also recommended that the name of the laboratory conducting the monitoring and a contact person be included in the records.

2. Medical Surveillance

The employer must establish and maintain an accurate record for each employee included in the medical surveillance program. Medical records must be kept for the duration of employment plus 30 years, in accordance with 29 CFR 1910.20. Some States may require blood lead levels to be reported to a central occupational health registry. The record for each employee must include:

- Name, social security number, and description of the duties of the employee.
- A copy of the examining physician's written opinions.

- Results of any airborne exposure monitoring done and provided to the physician.
- Any medical complaints related to lead exposure.
- Medical examination results, including medical and work history information.
- A description of laboratory procedures and standards or guidelines used to interpret test results (or references to that information).
- Results of biological monitoring.
- Name of physician and laboratory and date of examination.

3. Medical Removals

Records for each employee who is medically removed should be kept at least for the duration of employment and must include:

- An explanation of how removal was accomplished.
- A statement of whether or not the removal was due to an elevated blood lead level.

4. Objective Data

Limitations on the use of objective data for exemption from initial monitoring were discussed above (see Initial Determinations and Exposure Assessment). The employer must maintain a record of the objective data.

N. Observation of Monitoring

OSHA requires that employers provide affected employees or their designated representatives (e.g., union representatives) with an opportunity to observe any monitoring of employee lead exposures that is conducted as part of exposure assessments. The observers are entitled to receive an explanation of measurement procedures, observe all steps related to the monitoring of lead at the worksite, and either record the results or receive copies of the laboratory results of air sampling.

VI. Other Employer Requirements

In addition to the OSHA construction lead standard, there are many other applicable construction standards that employers must comply with during lead hazard control projects. OSHA standards for construction are found in 29 CFR, Part 1926. Some of these standards are:

- General safety and health provisions, 29 CFR 1926.20.
- Medical services and first aid, 29 CFR 1926.50.
- Sanitation, 29 CFR 1926.51.
- Occupational noise exposure, 29 CFR 1926.52.
- Gases, vapors, fumes, dusts, and mists, 29 CFR 1926.55.
- Hazard communication, 29CFR 1926.59.
- Ventilation: welding, cutting, or heating of toxic metals, 29 CFR 1926.353(c).
- Safety equipment, such as hardhats, safety shoes, eyewash stations, etc.

VII. Example of an OSHA Written Compliance Plan

Following is a model worker protection compliance plan that meets the requirements of the OSHA Lead Exposure in Construction standard as they apply to housing. The model plan should be completed by applying its general provisions to the specific lead hazard control job.

Form 9.1
Model OSHA Written Compliance Plan

Date: __/__/__

This plan has been developed to comply with the OSHA Construction Lead Standard, 29 CFR 1926.62.

1. Location of Project:

This job will take place at the residence located at _____ (full address).

A previous lead inspection of this residence by _____ (name and address of inspection or risk assessment firm) revealed that lead hazards or lead-based paint are present in the following locations:

_____ (location and name of all building components to be treated)

_____

_____

_____

These building components are coated with lead-based paint and represent a hazard to workers who may disturb it during lead hazard control, renovation, or maintenance activities.

2. Brief Description of Job:

This job will involve the following lead hazard reduction measures (complete all that apply):

Replacement of _____ (name all components)

Enclosure of _____ (name all components)

Paint removal of _____ (name all components)

Encapsulation of _____ (name all components)

Paint film stabilization of _____ (name all components)

Friction surface treatments of _____ (name all components)

Impact surface treatments of _____ (name all components)

Dust removal in the following areas: _____ (name all areas)

3. Schedule:

The job is expected to start on _____ (date) and end on _____.(date). This compliance plan will take effect immediately on _____(date). The competent person will conduct worksite visual inspections on a daily basis.

Work will proceed according to the following schedule:

Day 1: Initial setup, followed by:

_____ (name all tasks to be completed)

_____

_____

Daily cleanup: wet mopping, HEPA vacuuming

Day 2: Tasks

Day 3: Tasks

Day 4: Final cleanup and clearance examination

4. Equipment and Materials:

HEPA vacuums, cleaning detergents, protective clothing, cotton work gloves, electric power saws, hammers, wrecking bars, pry bars, screwdrivers, plastic sheeting, metal scrapers, compressed air-powered water pumps, rollers, brushes, butyl rubber gloves, respirators, cutting shears, mops, plastic sheeting, paintbrushes, paint rollers.

5. Crew:

The work will be completed by a crew of _____(insert number) workers. Crew assignments are as follows:

Crew 1 _____(name) _____ (task)

Crew 2 _____(name) _____ (task)

6. Competent Person:

_____(Name), a certified lead abatement supervisor, will be onsite at all times and will act as the competent person for occupational health and safety issues. The lead supervisor license (or certificate) number is:_____. The lead supervisor will conduct daily inspections of the work areas to ensure that control measures, work practices, personal protective equipment, and hygiene facilities are used as prescribed in this document.

7. Control Measures:

The primary control methods for this project are (check all that apply):

_____ method substitution (building component replacement, enclosure)

_____ wet methods

_____ wrapping materials to be discarded in plastic

_____ respiratory protection

_____ local exhaust ventilation (needle guns, vacuum blasting)

_____ general room ventilation

_____ on-the-job training

_____ HEPA vacuums

_____ containment (use of plastic barriers)

8. Technology Considered in Meeting the Permissible Exposure Limit:

The *HUD Guidelines for Evaluation and Control of Lead Hazards in Housing* and *Protecting Workers and Their Communities From Lead Hazards: A Guide for Protective Work Practices*, published by the Society of Occupational and Environmental Health, and other publications were reviewed to determine the appropriate engineering controls to be used in this project. The only specialized equipment that will be utilized for this project are HEPA-filtered vacuum cleaners and _____ (name all special equipment).

9. *Respirators:*

All individuals in the work area will be provided with a NIOSH/MSHA-approved half-mask, air-purifying respirator equipped with HEPA cartridges or a powered air-purifying respirator (if so requested).

Respirators will be provided in the context of a complete respiratory protection program; the written respirator program is attached.

Respirators will be required during (name phases of job for which respirators will be required):

_____

_____

_____

Respirator use during other activities, including initial setup (laying down plastic for containment), and enclosure and encapsulation after surface preparation is not necessary, *unless* other workers nearby (same interior room or outside wall) are performing activities for which respirators are required.

10. *Protective Clothing:*

Disposable protective clothing will be worn at all times inside the work area. Protective clothing will be made of breathable fabric to reduce the potential for worker heat stress. If visibly contaminated with dust or paint chips, protective clothing will be vacuumed before it is removed.

11. *Hygiene Facilities:*

Handwashing facilities will be used to decontaminate workers, since leaded dust levels are expected to be low. Showers are used on jobs that generate high leaded dust levels. The facilities will be located in a portable trailer, which will be parked in the driveway of the residence. The trailer will contain two sinks, a fresh water tank, hot water heater, wastewater collection tank, and easily cleanable floors and benches. Labeled plastic bins with covers will be used to separate disposable protective clothing from street clothing. Hot water, soap, and towels will be provided. Hands and face will be washed before all breaks and at the end of the day. Wastewater will be collected, pretreated onsite with filtration, and disposed of in accordance with prior arrangements made with _____(name of local water and sewage authority).

12. *Air Monitoring Data:*

Previous data for lead hazard control projects conducted with similar controls, environmental conditions, personnel, and methods were reviewed. Air sampling will not be performed on this job, since typical exposures have already been established for these work crews by:

_____(name of person or firm completing air sampling).

Based on these results, the major exposures to lead will occur during _____(name tasks during which substantial exposures are likely to occur).

In previous work conducted by the same contractor and work crew on similar houses in the same city, using the same methods, *maximum* personal exposures measured for various activities were:

Maximum Exposure ($\mu g/m^3$)	Task

The environmental conditions in the homes previously abated closely resemble the current location. These maximum exposures are expected to represent "worst-case" exposures because they did not include breaks or setup time; it is expected that 8-hour, time-weighted average exposures on this job will be lower than these figures. However, worker respiratory protection requirements will be based on the maximum exposures to allow for unexpected variations.

13. *Medical Surveillance Program:*

A medical surveillance program is already in place for this work crew. It is supervised by:

Dr. _____ (name, address, and phone number of physician and/or firm).

Worker blood lead levels are measured initially before the onset of work, each month for the first 6 months of employment, and every 6 months thereafter.

Blood lead levels for current employees who will be assigned to this job are between:

_____ µg/dL to _____ µg/dL (list range of blood lead levels) based on the report dated _____ (add date for latest medical monitoring report). Worker blood lead increases of 10 µg/dL or greater or any blood lead level greater than 25 µg/dL will trigger an investigation of protective equipment and work practices. All workers on this project are informed of their blood lead levels as soon as they are received.

14. *Training:*

The following workers have been trained using the EPA Worker Training Curriculum and SOEH's *Guide For Protective Work Practices and Effective Worker Training*. The training was conducted by _____(name, address,. and phone number of training provider) on _____(insert date).

Trainees	Social Security Number
_____	_____
_____	_____
_____	_____

Plan completed by:

_____ (name and signature)

_____ (date)

Example of a Completed Worker Protection OSHA Compliance Plan

OSHA Written Compliance Plan
Date: 5/19/99

This plan has been developed to comply with the OSHA Construction Lead Standard, 29 CFR 1926.62.

1. ***Location of Project:***

This job will take place at a private residence located at 2952 Channing Way, Anywhere, New York. A previous lead inspection of this residence by Carefree Consultants, Inc., revealed that windows, window frames, and all interior walls in both units are coated with lead-based paint (the range was 1.5 mg/cm^2 to 24 mg/cm^2). In some areas the existing lead-based paint is deteriorated, with loose and peeling paint chips. The existing lead-based paint represents a hazard to workers who may disturb it during lead hazard control or renovation activities.

2. ***Brief Description of Job:***

The abatement job will involve the removal and replacement of six windows in the residence and the encapsulation or enclosure of kitchen and bathroom walls.

The primary window replacement activities that are expected to generate leaded dust are manual removal of existing wood frame windows and cleaning.

3. ***Schedule:***

Work will proceed according to the following schedule:

Window Replacement

Day 1: Initial setup, including placement of plastic sheeting on interior floor and exterior ground surfaces for containment purposes.

Begin manual removal of windows. All window components will be wetted with water mist prior to removal to minimize dust generation.

Daily cleanup: wet sweeping, HEPA vacuuming

Day 2: Complete removal of all windows.

Preparation of window openings for replacement windows—sawing or planing may be required.

Install replacement windows; employ daily cleanup as above.

Apply new caulking around replacement windows; final cleanup.

Encapsulation and Enclosure

Day 1: Initial setup, including placement of plastic sheeting on floors, and nonmovable furnishings, appliances, and furniture items

Prepare surfaces for enclosure system by removing loose and peeling paint. All surfaces will be thoroughly wetted with water mist prior to scraping. Surfaces will be lightly scraped with 9-inch metal paint scrapers

Daily cleanup: wet sweeping followed by HEPA vacuuming and mopping with detergent solution

Day 2: Install all mineral glass wallcovering material.

Manually apply the initial and final coats of the liquid encapsulant, polymer surfacing system over the mineral glass substrate. Rollers and brushes should be used to apply liquid encapsulant. Allow 8 hours to dry between coats, or until surface is hard and dry to the touch. Install enclosure system (drywall) over encapsulated surface.

Daily cleanup

Day 3: Final cleaning

4. *Equipment and Materials:*

Window Replacement

"Olofson" metal frame, thermal-pane, replacement windows (Model 000-111), HEPA vacuums, trisodium phosphate detergent, protective clothing, cotton work gloves, electric power saws, hammers, wrecking bars, pry bars, screwdrivers, plastic sheeting, and other hand tools as needed.

The abatement job will also include encapsulation or enclosure of all interior walls in the kitchen and bathroom areas. The primary activities that are expected to generate leaded dust are manual scraping and cleaning involved with surface preparation.

Encapsulation and Enclosure

"Cover It Up" Encapsulant System (Item 333-55), drywall, metal scrapers, compressed air- powered water pumps, rollers, brushes, butyl rubber gloves, respirators, cutting shears, brooms, HEPA vacuums, detergent solution, mops, and plastic sheeting.

The job is expected to start on July 11, 1999, and end on July 13, 1999. This compliance plan will take effect immediately on July 8, 1999. The competent person will conduct worksite visual inspections on a daily basis.

5. *Crew:*

The replacement of windows and encapsulation enclosure will each be completed by a crew of two workers. Crew assignments are as follows:

R. Smith, T. Jones	Crew 1, Window Replacement
Z. Topp, J. Gonzales	Crew 2, Encapsulation/Enclosure

6. *Competent Person:*

Mr. Homer Simpson, a licensed lead abatement supervisor, will be onsite at all times and will act as the competent person for occupational health and safety issues. Mr. Simpson's lead supervisor license number is: XMZ 678. Mr. Simpson will conduct daily inspections of the work areas to ensure that control measures, work practices, personal protective equipment, and hygiene facilities are used as prescribed in this document.

7. *Control Measures:*

The primary control method for this project is method substitution; that is, building component replacement and encapsulation and enclosure will be used for lead-based paint hazard abatement, instead of onsite paint removal.

During replacement, existing window frames, sashes, and troughs will be wetted with water mist prior to removal to reduce airborne dust generation during removal activities. During both replacement and encapsulation, all scraping or sawing activity will be done on wet surfaces; all debris will be wetted down before handling. Building components coated with lead-based paint will be wrapped in plastic sheeting after removal to reduce contamination of workers' hands and clothing

during handling and disposal. After initial surface preparation for encapsulation and window removal, it is expected that there will be minimal disturbance of existing lead coatings during this job. Wet methods (mopping) and HEPA vacuums will be used during cleaning to minimize worker exposures to lead.

To reduce generation of leaded dust in the work areas, paint chips and dust will be vacuumed on at least a daily basis with HEPA-filtered vacuums. Final cleaning will be accomplished by three successive cleanings consisting of HEPA vacuuming alternated with wet mopping with trisodium phosphate solution. The use of HEPA vacuums and wet cleaning methods will minimize worker lead exposures.

8. *Technology Considered in Meeting the Permissible Exposure Limit:*

The *HUD Guidelines for Evaluation and Control of Lead Hazards in Housing* and other publications were reviewed to determine the appropriate engineering controls to be used in this project. The only specialized equipment that will be utilized for this project are HEPA-filtered vacuum cleaners and air-powered water pumps with high-pressure hoses attached to aerosol-generating nozzles (for water misting of surfaces). Natural ventilation will be utilized, as mechanical ventilation with HEPA-filtered exhaust fans has not been found to reduce worker lead exposures with the methods that will be used during this project.

9. *Respirators:*

All individuals in the work area will be provided with a half-mask, air-purifying respirator equipped with HEPA cartridges or a powered air-purifying respirator if so requested. Respirators will be provided in the context of a complete respiratory protection program; the written respirator program is attached.

Respirators will be required during window removal, surface preparation for encapsulation, any sawing or use of power tools, manual scraping, cleaning activities, and final cleanup. Respirator use during other activities, including initial setup (such as laying down plastic for containment), and enclosure and encapsulation after surface preparation is not necessary, *unless* other workers nearby (same interior room or outside wall) are performing activities for which respirators are required.

10. *Protective Clothing:*

Disposable protective clothing will be worn at all times inside the work area. Protective clothing will be made of breathable fabric to reduce the potential for worker heat stress. If visibly contaminated with paint dust or chips, protective clothing will be vacuumed before it is removed.

11. *Hygiene Facilities:*

Handwashing facilities will be used to decontaminate workers. The facilities will be located in a portable trailer that will be parked in the driveway or parking area of the residence. The trailer will contain two sinks, a fresh water tank, hot water heater, wastewater collection tank, and easily cleanable floors and benches. Labeled plastic bins with covers will be used to separate disposable protective clothing from street clothing. Hot water, soap, and towels will be provided. Hands and face will be washed before all breaks and at the end of the day. Wastewater will be collected, pretreated onsite with filtration, and disposed of in accordance with prior arrangements made with the Anywhere Municipal Wastewater Treatment Facility. The trailer will be cleaned with a HEPA vacuum and wet washed twice each week.

12. *Air Monitoring Data:*

Previous data for lead abatement projects conducted with similar controls, environmental conditions, personnel, and methods were reviewed. Air sampling will not be performed on this job, since typical exposures have already been established for these work crews (see attached report from previous jobs prepared by XYZ Industrial Hygiene, Inc.). Based on these results, the major exposures to lead will occur during window removal, although significant exposures may also occur during cleanup.

In previous work conducted by the same contractor and work crew on similar houses in the same city, using the same methods, *maximum* personal exposures measured for various activities were: window removal and replacement, 121 μg/m³; encapsulation, 24 μg/m³; cleaning, 110 μg/m³; final cleaning, 50 μg/m³; and initial setup, 6 μg/m³. The environmental conditions in the homes previously abated closely resemble the current location. These maximum exposures are expected to represent "worst-case" exposures because they did not include breaks or setup time; it is expected that 8-hour, time-weighted average exposures on this job will be lower than these figures. However, worker respiratory protection requirements will be based on the maximum exposures to allow for unexpected variations.

13. *Medical Surveillance Program:*

A medical surveillance program is already in place for this work crew. It is supervised by Dr. William Jones, a board-certified occupational health physician with Occupational Health Clinic, Inc. (phone: 800-555-1111). Worker blood lead levels are measured initially before the onset of work, each month for the first 6 months of employment, and every 6 months thereafter. Blood lead levels for current employees who will be assigned to this job are 5–12 μg/dL, based on the May report (see attached). Worker blood lead increases of 10 μg/dL or more will trigger an investigation of protective equipment and work practices. All workers on this project are informed of their blood lead levels as soon as they are received.

14. *Training:*

All workers have been trained using the EPA Worker Training Curriculum. The training was conducted by Joe Smith, a certified industrial hygienist with XYZ Industrial Hygiene, Inc., and Bill Smith, the competent person, on March 3–5, 1993.

Workers trained on March 3–5 include:

R. Smith

T. Jones

Z. Topp

J. Gonzales

The job proceeded as planned. However, in the next month, one worker's blood lead level increased from 12 to 25 μg/dL. This employee was one of the most productive members of the crew. The employer investigated the possible causes of the significant increase (10 μg/dL or more). After observing and interviewing the worker on a subsequent job, it was clear that the worker was not wearing the half-mask, air-purifying respirator all the time and was not using enough water to moisten surfaces before scraping. A powered air-purifying respirator was provided to increase the worker's understanding of the need for respiratory protection. Additional training and counseling by the physician was also provided to this individual. The following month's blood lead level declined to 16 μg/dL, but the supervisor continued to conduct special oversight of this individual.

Plan completed by:

_____ (name)

_____ (signature)

_____ (date)

APPENDIX D

FIELD DATA COLLECTION FORMS

Form 9: Interior Dust Wipe Collection Form

Form 10: Exterior Dust Wipe Collection Form

Form 11: Experiment Information

Form 12: Chain of Custody Record

Form 13: Pre-Experiment Clearance Samples

Form 14: Post-Experiment/Post-Study Clearance Samples

Form 15: Composite Soil Sample Data Collection Form for Interior Jobs

Form 16: Composite Soil Sample Data Collection form for Exterior Jobs

Form 17: Interior Air Sample Data Collection Form

Form 18: Exterior Air Sample Data Collection Form

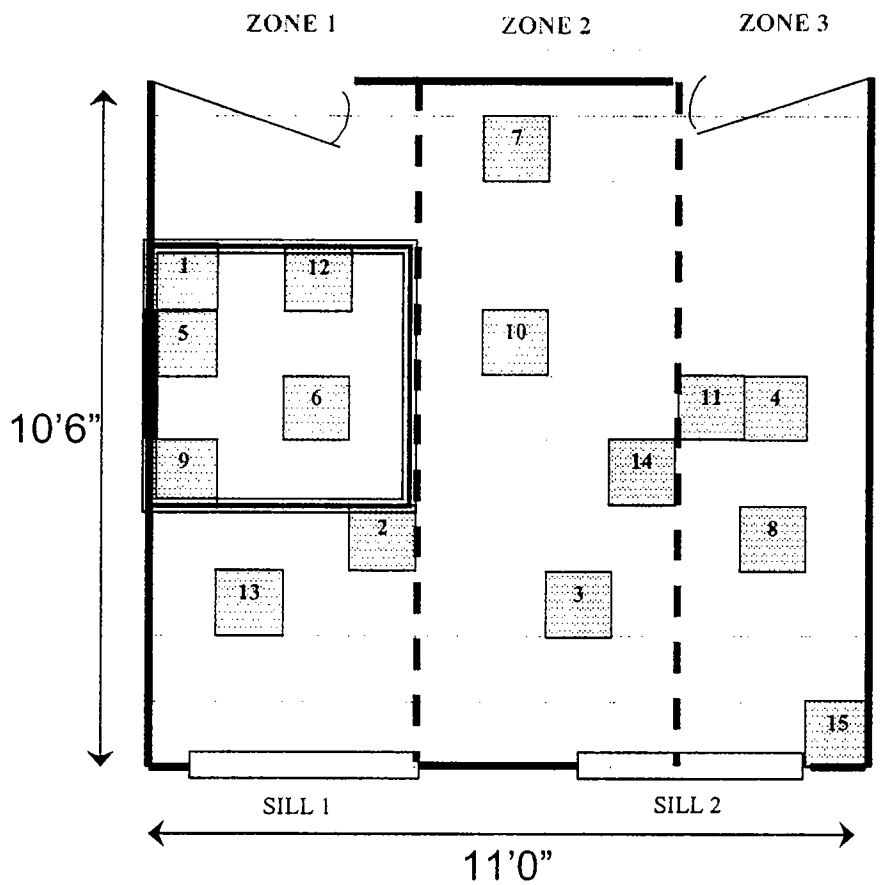
Form 19: Exterior Meteorological Data Collection Form

UNIT ID	EXPERIMENT #
H12	04

FORM 9: INTERIOR DUST WIPE COLLECTION FORM

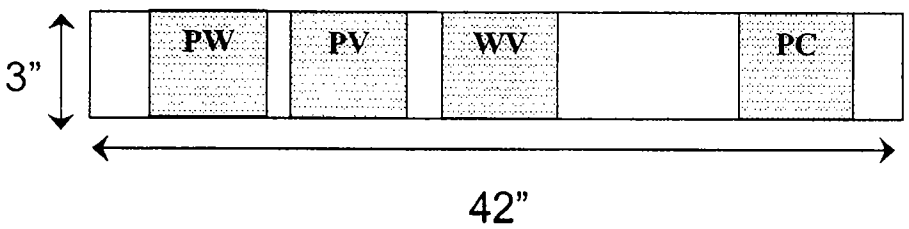
UNIT ID	Street Address			
H12				
EXPERIMENT #	Work Room	Total # of Samples	Date of Collection	Date Shipped to Lab
04	203			

WORK ROOM SAMPLING PLAN

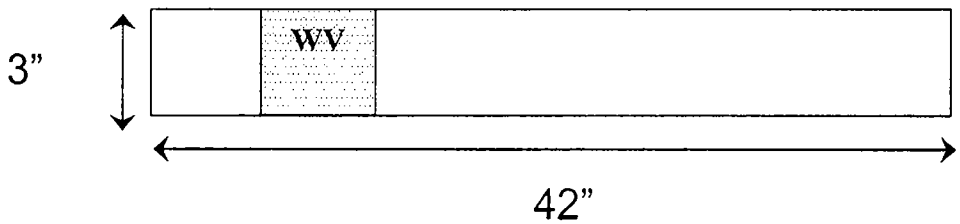


#	DESCRIPTION	SAMPLE ID
1	Post Work 1	H01-01-203-PWF-01
2	Post Work 2	H01-01-203-PWF-02
3	Post Work 3	H01-01-203-PWF-03
4	Post Work 4	H01-01-203-PWF-04
5	Post Cleaning 1	H01-01-203-PCF-01
6	Post Cleaning 2	H01-01-203-PCF-02
7	Post Cleaning 3	H01-01-203-PCF-03
8	Post Cleaning 4	H01-01-203-PCF-04
9	Post-WET Verification - Zone 1	H01-01-203-VWF-01
10	Post- WET Verification - Zone 2	H01-01-203-VWF-02
11	Post- WET Verification – Zone 3	H01-01-203- VWF-03
12	Post- Verification 1	H01-01-203- PVF-01
13	Post- Verification 2	H01-01-203- PVF-02
14	Post- Verification 3	H01-01-203- PVF -03
15	Post- Verification 4	H01-01-203- PVF -04

SILL 1



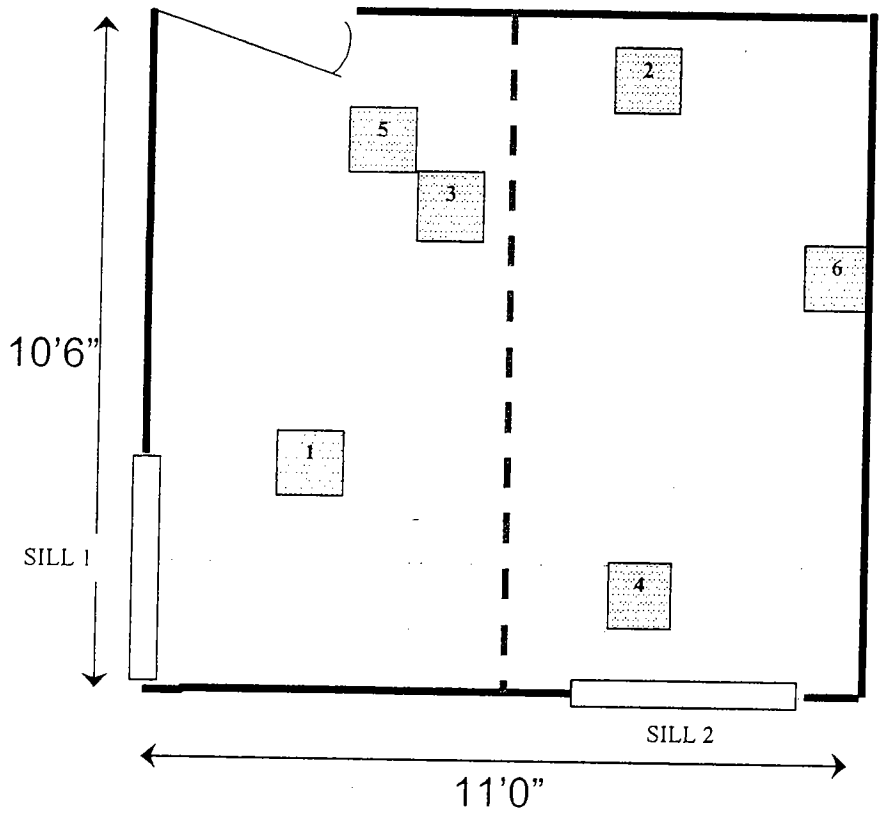
SILL 2



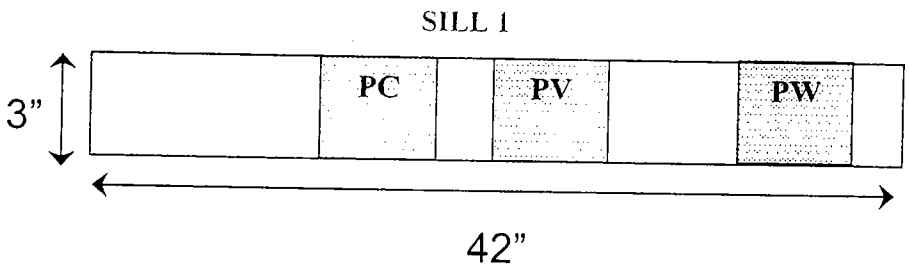
Note: windowsill sketches are not to scale

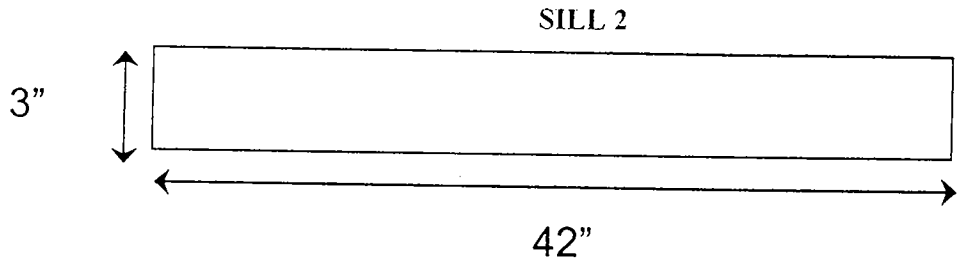
UNIT ID	EXPERIMENT #
H12	04

TOOL ROOM SAMPLING PLAN



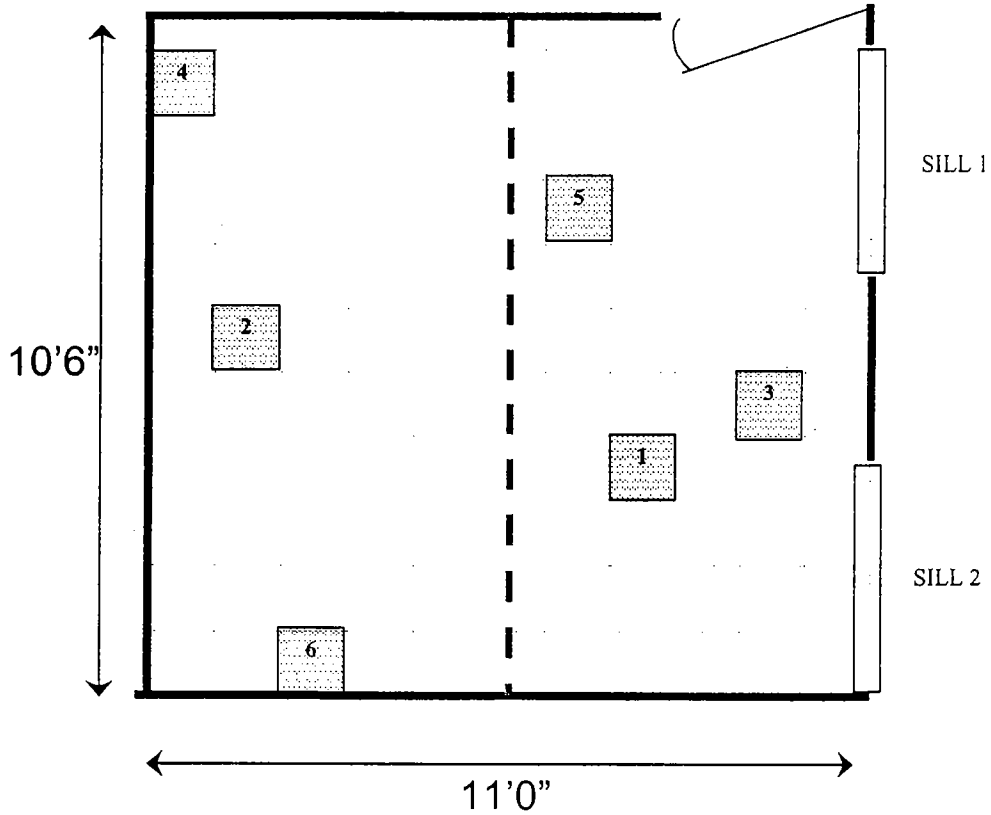
#	DESCRIPTION	SAMPLE ID
1	Post Work 1	H01-01-204-PWF-01
2	Post Work 2	H01-01-204-PWF-02
3	Post Cleaning 1	H01-01-204-PCF-01
4	Post Cleaning 2	H01-01-204-PCF-02
5	Post- Verification 1	H01-01-204- PV F-01
6	Post- Verification 2	H01-01-204- PVF -02





Note: windowsill sketches are not to scale

OBSERVATION ROOM SAMPLING PLAN



#	DESCRIPTION	SAMPLE ID
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2	Post Work 2	H01-01-202-PWF-02
3	Post Cleaning 1	H01-01-202-PCF-01
4	Post Cleaning 2	H01-01-202-PCF-02
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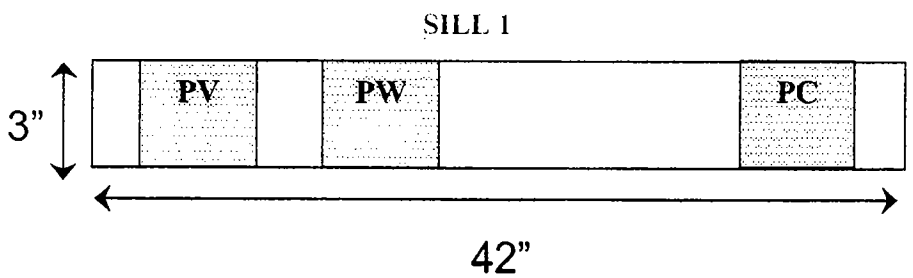
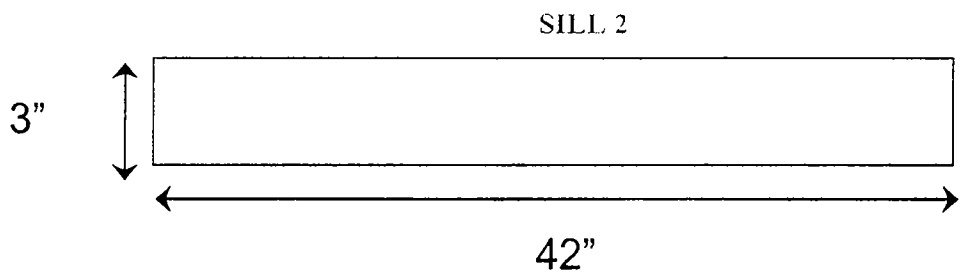
6	Post- Verification 2	H01-01-202- PVF -02





Note: windowsill sketches are not to scale

UNIT ID	EXPERIMENT #
H12	04

STAGE: POST-WORK (PW)

SAMPLE ID	DESCRIPTION	ROOM TYPE	LOCATION	COMMENTS
	Post Work – Floor 1	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 2	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 3	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 4	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Sill	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 1	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 2	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Sill	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 1	Obs.	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Floor 2	Obs.	___ft. from WALL 1 ___ft. from WALL 2	
	Post Work – Sill	Obs.	___ft. from WALL 1 ___ft. from WALL 2	

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

STAGE: POST-CLEANING (PC)

SAMPLE ID	DESCRIPTION	ROOM TYPE	LOCATION	COMMENTS
	Post Cleaning – Floor 1	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 2	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 3	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 4	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Sill	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 1	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 2	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Sill	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 1	Obs.	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Floor 2	Obs.	___ft. from WALL 1 ___ft. from WALL 2	
	Post Cleaning – Sill	Obs.	___ft. from WALL 1 ___ft. from WALL 2	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	EXPERIMENT #
H12	04

STAGE: POST-WET VERIFICATION (VW)

NOTE: These samples only collected if ZONE or SILL fails 2 WET verifications

SAMPLE ID	DESCRIPTION	ROOM TYPE	LOCATION	COMMENTS
	Post WET Verification – ZONE 1	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post WET Verification – ZONE 2	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post WET Verification – ZONE 3	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post WET Verification – Sill 1	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post WET Verification – Sill 2	Work	___ft. from WALL 1 ___ft. from WALL 2	

VERIFICATION INFORMATION

ZONE OR SILL	# OF WET CLOTHS	# OF DRY CLOTHS
Sill 1		
Sill 2		
Zone 1		
Zone 2		
Zone 3		

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

STAGE: POST-VERIFICATION (PV)

SAMPLE ID	DESCRIPTION	ROOM TYPE	LOCATION	COMMENTS
	Post DRY Verification – Floor 1	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 2	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 3	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 4	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Sill	Work	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 1	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 2	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Sill	Tool	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 1	Obs.	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Floor 2	Obs.	___ft. from WALL 1 ___ft. from WALL 2	
	Post DRY Verification – Sill	Obs.	___ft. from WALL 1 ___ft. from WALL 2	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

FORM 10: EXTERIOR DUST WIPE COLLECTION FORM

UNIT ID	Street Address			
H07				
EXPERIMENT #	Work Wall	Total # of Samples	Date of Collection	Date Shipped to Lab
11	4			

STAGE: BACKGROUND CONCENTRATIONS (BC)

SAMPLE ID	DESCRIPTION	DUST PAN EXPOSURE TIME		LOCATION	COMMENTS
		Start	End		
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #
H07	11

SAMPLE ID	DESCRIPTION	DUST PAN EXPOSURE TIME		LOCATION	COMMENTS
		Start	End		
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	
	Background Concentrations			___ft. AWAY ___ft. from WALL ___	

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	EXPERIMENT #
H07	11

STAGE: POST-WORK (PW)

SAMPLE ID	DESCRIPTION	DUST PAN	LOCATION	COMMENTS
	Dust Pan Wipe	On Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	On Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	On Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	Near Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	Near Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	Near Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	Under Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	Under Plastic	___ft. AWAY ___ft. from WALL ___	
	Dust Pan Wipe	Under Plastic	___ft. AWAY ___ft. from WALL ___	

Notes:

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

FORM 11: EXPERIMENT INFORMATION

UNIT ID	EXPERIMENT #	Street Address

Contractor Information:

Name _____

Street No. _____ Street Name _____ _____

City _____ State _____ Zip Code _____

Phone _____

01. Does the contractor have EPA-HUD Lead Safety for Remodeling, Repair and Painting Training?
☐ Yes ☐ No

Work Information:

01. Room Designations:

Work Room #	Tool Room #	Observation Room #

02. What components will be worked on for this experiment? (Check all that apply.)

☐ Floors
☐ Stairs
☐ Walls
☐ Trim
☐ Doors
☐ Door Casing
☐ Windows
☐ Cabinets
☐ Other (please specify):
☐ Other (please specify):

03. What interior job classification will be used for this experiment?

☐ High ☐ Medium ☐ Low

04. What exterior job classification will be used for this experiment?

☐ High ☐ Medium ☐ Low

05. Please check the phase of interior Protection/Clean-up (P/CU) for this experiment:

☐ I – Plastic coverings and rule cleaning
☐ II – Plastic coverings and baseline cleaning
☐ III – No plastic and rule cleaning
☐ IV – No plastic and baseline cleaning

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	EXPERIMENT #

06. Check below the type of Renovation, Repair, and Painting work to be performed:

	INTERIOR		EXTERIOR	
Low Level Work	☐	Make three cut-outs, each of a 2 foot+ section of wall with LBP, to perform plumbing or electrical or HVAC work, perform the work inside the wall, and repair and repaint wall, disturbing approximately 6 ft^2 of lead-based paint	☐	Replace an exterior door and doorway, disturbing 25-50 ft^2 of lead-based paint
	☐	Replace window from inside unit, disturbing at least 2 ft^2 of LBP.	☐	Replace fascia boards, soffits, and other exterior trim on one side of the structure, disturbing approximately 50 ft^2 of lead-based paint
Medium Level Work	☐	Scrape deteriorating LBP from a flat interior component, scraping 50-75 ft^2 of painted surfaces, and repaint the surfaces which were scraped. (iii)	☐	Replace siding with lead-based paint on one exterior side of the structure with vinyl disturbing at least 100 ft^2 of lead-based paint
	☐	Scrape or plane 20-40 ft^2 of LBP from an interior door , and repaint the surface from which paint was removed.	☐	Remove lead-based paint from exterior components by dry scraping, disturbing approximately 100 ft^2 of lead-based paint, and repaint
High Level Work	☐	Remove paint from 75-100 ft^2 of lead-based painted components by using a heat gun over 1100° Fahrenheit held at one inch or the distance specified from paint, and repaint all components from which paint was removed (iv)	☐	Remove paint by power sanding or grinding on at least 100 ft^2 of lead-based paint on exterior wood components on one side of the structure, and repaint
	☐	Gut out a kitchen, disturbing 100 ft^2 or more of lead-based paint.	☐	Remove lead-based paint by torching or open-flame burning on least 100 ft^2 of lead-based paint from brick, concrete, stone, metal, or wood on one side of the structure, and repaint
	☐	**OTHER (INTERIOR/EXTERIOR):**		

07. Describe in detail the Renovation, Repair, and Painting work performed for this experiment.

Notes:

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

FORM 12: CHAIN OF CUSTODY RECORD

UNIT ID	EXPERIMENT #	Street Address

Sampler(s)	Sampler(s)
Name (please print):	Name (please print):
Signature:	Signature:

Date Collected	Time Collected	Sample ID	Sample Type (Check Box)		Remarks
			Dust Wipe	Air Filter	

Relinquished by: (signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (signature)	Date	Time	Received by: (Signature)	Date	Time

UNIT ID	EXPERIMENT #

FORM 13: Pre-Experiment Clearance Samples

UNIT ID	Street Address			
EXPERIMENT #	Work Room	Total # of Samples	Date of Collection	Date Shipped to Lab

STAGE: INITIAL CLEARANCE (IC)

SAMPLE ID	DESCRIPTION	ROOM	LOCATION	COMMENTS

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

SAMPLE ID	DESCRIPTION	ROOM	LOCATION	COMMENTS

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

FORM 14: Post-Experiment/ Post-Study Clearance Samples

UNIT ID	Street Address			
EXPERIMENT #	Work Room	Total # of Samples	Date of Collection	Date Shipped to Lab

STAGE: FINAL CLEARANCE (FC)

SAMPLE ID	DESCRIPTION	ROOM	LOCATION	COMMENTS

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

SAMPLE ID	DESCRIPTION	ROOM	LOCATION	COMMENTS

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

FORM 15: Composite Soil Sample Data Collection Form For Interior Jobs

UNIT ID	Street Address			
EXPERIMENT #	Work Wall	Total # of Samples	Date of Collection	Date Shipped to Lab

Please record the location of the first sub-sample and plot and label the subsequent FOUR (4) sub-samples relative to the first one for a total of FIVE (5) subsamples.
Sampling method: C → Coring method, S → Scoop method, W → Dust wipe (composite samples not required for wipes)

SAMPLE ID	DESCRIPTION	LOCATION	SAMPLING METHOD	COMMENTS
Pre – Experiment				
	Near Main Entrance to Unit	___ft. AWAY ___ft. from WALL ___	C S W	
	Near Path from Contractor Vehicle to Entrance to Unit	___ft. AWAY ___ft. from WALL ___	C S W	
	Near Window Closest to Work Area	___ft. AWAY ___ft. from WALL ___	C S W	

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

SAMPLE ID	DESCRIPTION	LOCATION	SAMPLING METHOD	COMMENTS
Post – Experiment				
	Near Window Closest to Work Area		**DUST WIPE**	
	Near Main Entrance to Unit	___ft. AWAY ___ft. from WALL ___	**C S W**	
	Near Path from Contractor Vehicle to Entrance to Unit	___ft. AWAY ___ft. from WALL ___	**C S W**	
	Near Window Closest to Work Area	___ft. AWAY ___ft. from WALL ___	**C S W**	

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	EXPERIMENT #

FORM 16: Composite Soil Sample Data Collection Form for Exterior Jobs

UNIT ID	Street Address			
EXPERIMENT #	Work Wall	Total # of Samples	Date of Collection	Date Shipped to Lab

Please record the location of the first sub-sample and plot and label the subsequent FOUR (4) sub-samples relative to the first one for a total of FIVE (5) subsamples.
Sampling method (circle one): C → Coring method, S → Scoop method, W → Dust wipe (composite samples not required for wipes)

SAMPLE ID	DESCRIPTION	LOCATION	SAMPLING METHOD	COMMENTS
Pre – Experiment				
	Near Foundation of Unit	___ft. AWAY ___ft. from WALL ___	C S W	
	Edge of "Rule" Containment	___ft. AWAY ___ft. from WALL ___	C S W	
	Edge of "Protection" Containment	___ft. AWAY ___ft. from WALL ___	C S W	
Post – Experiment				
	Near Foundation of Unit	___ft. AWAY ___ft. from WALL ___	C S W	
	Edge of "Rule" Containment	___ft. AWAY ___ft. from WALL ___	C S W	
	Edge of "Protection" Containment	___ft. AWAY ___ft. from WALL ___	C S W	

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

FORM 17: Interior Air Sample Data Collection Form

UNIT ID	Street Address			
EXPERIMENT #	Work Room	Total # of Samples	Date of Collection	Date Shipped to Lab

AIR MONITOR INFORMATION:

Please record the specifications of the air pumps and filters used for air sampling, as well as any comments.

ROOM	LOCATION	AIR PUMP	FILTER	COMMENTS
Personal Air Monitor				
Work Room				
Indoor Air Monitor				
Work Room	Height: ____ft. ____ft. from WALL1 ____ft. from WALL2			
Tool Room	Height: ____ft. ____ft. from WALL1 ____ft. from WALL2			
Observation Room	Height: ____ft. ____ft. from WALL1 ____ft. from WALL2			

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

SAMPLE ID	STAGE	AIR SAMPLE TYPE	START TIME	STOP TIME	COMMENTS
Work Room					
	Work	Personal			
	Work	Indoor			
	Cleaning	Personal			
	Cleaning	Indoor			
	Verification	Personal			
	Verification	Indoor			
Tool Room					
	Work	Indoor			
	Cleaning	Indoor			
	Verification	Indoor			

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

UNIT ID	EXPERIMENT #

SAMPLE ID	STAGE	AIR SAMPLE TYPE	START TIME	STOP TIME	COMMENTS
Observation Room					
	Work	Indoor			
	Cleaning	Indoor			
	Verification	Indoor			

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

FORM 18: Exterior Air Sample Data Collection Form

UNIT ID	Street Address			
EXPERIMENT #	Work Wall	Total # of Samples	Date of Collection	Date Shipped to Lab

AIR MONITOR INFORMATION:

Please record the specifications of the air pumps and filters used for air sampling, as well as any comments.

	AIR PUMP	FILTER	COMMENTS
Personal Air Monitor			

SAMPLE ID	STAGE	AIR SAMPLE TYPE	START TIME	STOP TIME	COMMENTS
	Work	Personal			

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

FORM 19: Exterior Meteorological Data Collection Form

UNIT ID	Street Address
EXPERIMENT #	Work Wall

WIND INFORMATION:

Please record the specifications of the wind gauge used for wind speed determination.

	MAKE	MODEL	COMMENTS
Wind Speed Gauge			

TIME	DESCRIPTION OF WORK ACTIVITY	WIND SPEED	DIRECTION	COMMENTS

Inspector	Initials	Date Completed
Reviewer	Initials	Date Completed

UNIT ID	EXPERIMENT #

PRECIPITATION INFORMATION:

Please record all precipitation events and appropriate protective action taken

START TIME	END TIME	DESCRIPTION OF WORK ACTIVITY	ACTION TAKEN	COMMENTS

Inspector	Initials	Date Completed
Reviewer	**Initials**	**Date Completed**

APPENDIX E

SAMPLING PROTOCOLS

ASTM E1727-05 Standard Practice for Field Collection of Soil Samples for Subsequent Lead Determination

ASTM E1728-03 Standard Practice for Collection of Settled Dust Samples Using Wipe Sampling Methods for Subsequent Lead Determination

ASTM E1729-05 Standard Practice for Field Collection of Dried Paint Samples for Subsequent Lead Determination

ASTM standards in this appendix were deleted from this electronic version of the Quality Assurance Project Plan because the standards are copyrighted by ASTM International.

APPENDIX F

ANALYTICAL METHODS

EPA Method 3050B – Acid Digestion of Sediments, Sludges, and Soils

NIOSH 7082 – Lead by Flame AAS

EPA Methods 7420 – Lead (Atomic Absorption, Direct Aspiration)

METHOD 3050B

ACID DIGESTION OF SEDIMENTS, SLUDGES, AND SOILS

1.0 SCOPE AND APPLICATION

1.1 This method has been written to provide two separate digestion procedures, one for the preparation of sediments, sludges, and soil samples for analysis by flame atomic absorption spectrometry (FLAA) or inductively coupled plasma atomic emission spectrometry (ICP-AES) and one for the preparation of sediments, sludges, and soil samples for analysis of samples by Graphite Furnace AA (GFAA) or inductively coupled plasma mass spectrometry (ICP-MS). The extracts from these two procedures are not interchangeable and should only be used with the analytical determinations outlined in this section. Samples prepared by this method may be analyzed by ICP-AES or GFAA for all the listed metals as long as the detecion limits are adequate for the required end-use of the data. Alternative determinative techniques may be used if they are scientifically valid and the QC criteria of the method, including those dealing with interferences, can be achieved. Other elements and matrices may be analyzed by this method if performance is demonstrated for the analytes of interest, in the matrices of interest, at the concentration levels of interest (See Section 8.0). The recommended determinative techniques for each element are listed below:

FLAA/ICP-AES		GFAA/ICP-MS
Aluminum	Magnesium	Arsenic
Antimony	Manganese	Beryllium
Barium	Molybdenum	Cadmium
Beryllium	Nickel	Chromium
Cadmium	Potassium	Cobalt
Calcium	Silver	Iron
Chromium	Sodium	Lead
Cobalt	Thallium	Molybdenum
Copper	Vanadium	Selenium
Iron	Zinc	Thallium
Lead		
Vanadium		

1.2 This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment. If absolute total digestion is required use Method 3052.

2.0 SUMMARY OF METHOD

2.1 For the digestion of samples, a representative 1-2 gram (wet weight) or 1 gram (dry weight) sample is digested with repeated additions of nitric acid (HNO_3) and hydrogen peroxide (H_2O_2).

2.2 For GFAA or ICP-MS analysis, the resultant digestate is reduced in volume while heating and then diluted to a final volume of 100 mL.

2.3 For ICP-AES or FLAA analyses, hydrochloric acid (HCl) is added to the initial digestate and the sample is refluxed. In an optional step to increase the solubility of some metals (see Section 7.3.1: NOTE), this digestate is filtered and the filter paper and residues are rinsed, first

with hot HCl and then hot reagent water. Filter paper and residue are returned to the digestion flask, refluxed with additional HCl and then filtered again. The digestate is then diluted to a final volume of 100 mL.

2.4 If required, a separate sample aliquot shall be dried for a total percent solids determination.

3.0 INTERFERENCES

3.1 Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed in accordance with the quality control requirements given in Sec. 8.0 to aid in determining whether Method 3050B is applicable to a given waste.

4.0 APPARATUS AND MATERIALS

4.1 Digestion Vessels - 250-mL.

4.2 Vapor recovery device (e.g., ribbed watch glasses, appropriate refluxing device, appropriate solvent handling system).

4.3 Drying ovens - able to maintain 30°C ± 4°C.

4.4 Temperature measurement device capable of measuring to at least 125°C with suitable precision and accuracy (e.g., thermometer, IR sensor, thermocouple, thermister, etc.)

4.5 Filter paper - Whatman No. 41 or equivalent.

4.6 Centrifuge and centrifuge tubes.

4.7 Analytical balance - capable of accurate weighings to 0.01 g.

4.8 Heating source - Adjustable and able to maintain a temperature of 90-95°C. (e.g., hot plate, block digestor, microwave, etc.)

4.9 Funnel or equivalent.

4.10 Graduated cylinder or equivalent volume measuring device.

4.11 Volumetric Flasks - 100-mL.

5.0 REAGENTS

5.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. If the purity of a reagent is questionable, analyze the reagent to determine the level of impurities. The reagent blank must be less than the MDL in order to be used.

5.2 Reagent Water. Reagent water will be interference free. All references to water in the method refer to reagent water unless otherwise specified. Refer to Chapter One for a definition of reagent water.

5.3 Nitric acid (concentrated), HNO_3. Acid should be analyzed to determine level of impurities. If method blank is < MDL, the acid can be used.

5.4 Hydrochloric acid (concentrated), HCl. Acid should be analyzed to determine level of impurities. If method blank is < MDL, the acid can be used.

5.5 Hydrogen peroxide (30%), H_2O_2. Oxidant should be analyzed to determine level of impurities. If method blank is < MDL, the peroxide can be used.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must have been collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

6.2 All sample containers must be demonstrated to be free of contamination at or below the reporting limit. Plastic and glass containers are both suitable. See Chapter Three, Section 3.1.3, for further information.

6.3 Nonaqueous samples should be refrigerated upon receipt and analyzed as soon as possible.

6.4 It can be difficult to obtain a representative sample with wet or damp materials. Wet samples may be dried, crushed, and ground to reduce subsample variability as long as drying does not affect the extraction of the analytes of interest in the sample.

7.0 PROCEDURE

7.1 Mix the sample thoroughly to achieve homogeneity and sieve, if appropriate and necessary, using a USS #10 sieve. All equipment used for homogenization should be cleaned according to the guidance in Sec. 6.0 to minimize the potential of cross-contamination. For each digestion procedure, weigh to the nearest 0.01 g and transfer a 1-2 g sample (wet weight) or 1 g sample (dry weight) to a digestion vessel. For samples with high liquid content, a larger sample size may be used as long as digestion is completed.

> NOTE: All steps requiring the use of acids should be conducted under a fume hood by properly trained personnel using appropriate laboratory safety equipment. The use of an acid vapor scrubber system for waste minimization is encouraged.

7.2 For the digestion of samples for analysis by GFAA or ICP-MS, add 10 mL of 1:1 HNO_3, mix the slurry, and cover with a watch glass or vapor recovery device. Heat the sample to 95°C ± 5°C and reflux for 10 to 15 minutes without boiling. Allow the sample to cool, add 5 mL of concentrated HNO_3, replace the cover, and reflux for 30 minutes. If brown fumes are generated, indicating oxidation of the sample by HNO_3, repeat this step (addition of 5 mL of conc. HNO_3) over and over until no brown fumes are given off by the sample indicating the complete reaction with HNO_3. Using a ribbed watch glass or vapor recovery system, either allow the solution to evaporate to approximately 5 mL without boiling or heat at 95°C ± 5°C without boiling for two hours. Maintain a covering of solution over the bottom of the vessel at all times.

NOTE: Alternatively, for direct energy coupling devices, such as a microwave, digest samples for analysis by GFAA or ICP-MS by adding 10 mL of 1:1 HNO_3, mixing the slurry and then covering with a vapor recovery device. Heat the sample to 95°C ± 5°C and reflux for 5 minutes at 95°C ± 5°C without boiling. Allow the sample to cool for 5 minutes, add 5 mL of concentrated HNO_3, heat the sample to 95°C ± 5°C and reflux for 5 minutes at 95°C ± 5°C. If brown fumes are generated, indicating oxidation of the sample by HNO_3, repeat this step (addition of 5 mL concentrated HNO_3) until no brown fumes are given off by the sample indicating the complete reaction with HNO_3. Using a vapor recovery system, heat the sample to 95°C ± 5°C and reflux for 10 minutes at 95°C ± 5°C without boiling.

7.2.1 After the step in Section 7.2 has been completed and the sample has cooled, add 2 mL of water and 3 mL of 30% H_2O_2. Cover the vessel with a watch glass or vapor recovery device and return the covered vessel to the heat source for warming and to start the peroxide reaction. Care must be taken to ensure that losses do not occur due to excessively vigorous effervescence. Heat until effervescence subsides and cool the vessel.

NOTE: Alternatively, for direct energy coupled devices: After the Sec. 7.2 "NOTE" step has been completed and the sample has cooled for 5 minutes, add slowly 10 mL of 30% H_2O_2. Care must be taken to ensure that losses do not occur due to excessive vigorous effervesence. Go to Section 7.2.3.

7.2.2 Continue to add 30% H_2O_2 in 1-mL aliquots with warming until the effervescence is minimal or until the general sample appearance is unchanged.

NOTE: Do not add more than a total of 10 mL 30% H_2O_2.

7.2.3 Cover the sample with a ribbed watch glass or vapor recovery device and continue heating the acid-peroxide digestate until the volume has been reduced to approximately 5 mL or heat at 95°C ± 5°C without boiling for two hours. Maintain a covering of solution over the bottom of the vessel at all times.

NOTE: Alternatively, for direct energy coupled devices: Heat the acid-peroxide digestate to 95°C ± 5°C in 6 minutes and remain at 95°C ± 5°C without boiling for 10 minutes.

7.2.4 After cooling, dilute to 100 mL with water. Particulates in the digestate should then be removed by filtration, by centrifugation, or by allowing the sample to settle. The sample is now ready for analysis by GFAA or ICP-MS.

7.2.4.1 Filtration - Filter through Whatman No. 41 filter paper (or equivalent).

7.2.4.2 Centrifugation - Centrifugation at 2,000-3,000 rpm for 10 minutes is usually sufficient to clear the supernatant.

7.2.4.3 The diluted digestate solution contains approximately 5% (v/v) HNO_3. For analysis, withdraw aliquots of appropriate volume and add any required reagent or matrix modifier.

7.3 For the analysis of samples for FLAA or ICP-AES, add 10 mL conc. HCl to the sample digest from 7.2.3 and cover with a watch glass or vapor recovery device. Place the sample on/in the heating source and reflux at 95°C ± 5°C for 15 minutes.

NOTE: Alternatively, for direct energy coupling devices, such as a microwave, digest samples for analysis by FLAA and ICP-AES by adding 5 mL HCl and 10 mL H_2O to the sample digest from 7.2.3 and heat the sample to 95°C ± 5°C, Reflux at 95°C ± 5°C without boiling for 5 minutes.

7.4 Filter the digestate through Whatman No. 41 filter paper (or equivalent) and collect filtrate in a 100-mL volumetric flask. Make to volume and analyze by FLAA or ICP-AES.

NOTE: Section 7.5 may be used to improve the solubilities and recoveries of antimony, barium, lead, and silver when necessary. These steps are optional and are not required on a routine basis.

7.5 Add 2.5 mL conc. HNO_3 and 10 mL conc. HCl to a 1-2 g sample (wet weight) or 1 g sample (dry weight) and cover with a watchglass or vapor recovery device. Place the sample on/in the heating source and reflux for 15 minutes.

7.5.1 Filter the digestate through Whatman No. 41 filter paper (or equivalent) and collect filtrate in a 100-mL volumetric flask. Wash the filter paper, while still in the funnel, with no more than 5 mL of hot (~95°C) HCl, then with 20 mL of hot (~95°C) reagent water. Collect washings in the same 100-mL volumetric flask.

7.5.2 Remove the filter and residue from the funnel, and place them back in the vessel. Add 5 mL of conc. HCl, place the vessel back on the heating source, and heat at 95°C ± 5°C until the filter paper dissolves. Remove the vessel from the heating source and wash the cover and sides with reagent water. Filter the residue and collect the filtrate in the same 100-mL volumetric flask. Allow filtrate to cool, then dilute to volume.

NOTE: High concentrations of metal salts with temperature-sensitive solubilities can result in the formation of precipitates upon cooling of primary and/or secondary filtrates. If precipitation occurs in the flask upon cooling, do not dilute to volume.

7.5.3 If a precipitate forms on the bottom of a flask, add up to 10 mL of concentrated HCl to dissolve the precipitate. After precipitate is dissolved, dilute to volume with reagent water. Analyze by FLAA or ICP-AES.

7.6 Calculations

7.6.1 The concentrations determined are to be reported on the basis of the actual weight of the sample. If a dry weight analysis is desired, then the percent solids of the sample must also be provided.

7.6.2 If percent solids is desired, a separate determination of percent solids must be performed on a homogeneous aliquot of the sample.

8.0 QUALITY CONTROL

8.1 All quality control measures described in Chapter One should be followed.

8.2 For each batch of samples processed, a method blank should be carried throughout the entire sample preparation and analytical process according to the frequency described in Chapter One. These blanks will be useful in determining if samples are being contaminated. Refer to Chapter One for the proper protocol when analyzing method blanks.

8.3 Spiked duplicate samples should be processed on a routine basis and whenever a new sample matrix is being analyzed. Spiked duplicate samples will be used to determine precision and bias. The criteria of the determinative method will dictate frequency, but 5% (one per batch) is recommended or whenever a new sample matrix is being analyzed. Refer to Chapter One for the proper protocol when analyzing spiked replicates.

8.4 Limitations for the FLAA and ICP-AES optional digestion procedure. Analysts should be aware that the upper linear range for silver, barium, lead, and antimony may be exceeded with some samples. If there is a reasonable possibility that this range may be exceeded, or if a sample's analytical result exceeds this upper limit, a smaller sample size should be taken through the entire procedure and re-analyzed to determine if the linear range has been exceeded. The approximate linear upper ranges for a 2 gram sample size:

Ag	2,000 mg/kg
As	1,000,000 mg/kg
Ba	2,500 mg/kg
Be	1,000,000 mg/kg
Cd	1,000,000 mg/kg
Co	1,000,000 mg/kg
Cr	1,000,000 mg/kg
Cu	1,000,000 mg/kg
Mo	1,000,000 mg/kg
Ni	1,000,000 mg/kg
Pb	200,000 mg/kg
Sb	200,000 mg/kg
Se	1,000,000 mg/kg
Tl	1,000,000 mg/kg
V	1,000,000 mg/kg
Zn	1,000,000 mg/kg

NOTE: These ranges will vary with sample matrix, molecular form, and size.

9.0 METHOD PERFORMANCE

9.1 In a single laboratory, the recoveries of the three matrices presented in Table 2 were obtained using the digestion procedure outlined for samples prior to analysis by FLAA and ICP-AES. The spiked samples were analyzed in duplicate. Tables 3-5 represents results of analysis of NIST Standard Reference Materials that were obtained using both atmospheric pressure microwave digestion techniques and hot-plate digestion procedures.

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TABLE 1

STANDARD RECOVERY (%) COMPARISON FOR METHODS 3050A AND 3050B[a]

Analyte	METHOD 3050A[a]	METHOD 3050B w/option[a]
Ag	9.5	98
As	86	102
Ba	97	103
Be	96	102
Cd	101	99
Co	99	105
Cr	98	94
Cu	87	94
Mo	97	96
Ni	98	92
Pb	97	95
Sb	87	88
Se	94	91
Tl	96	96
V	93	103
Zn	99	95

[a] All values are percent recovery. Samples: 4 mL of 100 mg/mL multistandard; n = 3.

TABLE 2

PERCENT RECOVERY COMPARISON FOR METHODS 3050A AND 3050B

Analyte	Percent Recovery[a,c]							
	Sample 4435		Sample 4766		Sample HJ		Average	
	3050A	3050B	3050A	3050B	3050A	3050B	3050A	3050B
Ag	9.8	103	15	89	56	93	27	95
As	70	102	80	95	83	102	77	100
Ba	85	94	78	95	b	b	81	94
Be	94	102	108	98	99	94	99	97
Cd	92	88	91	95	95	97	93	94
Co	90	94	87	95	89	93	89	94
Cr	90	95	89	94	72	101	83	97
Cu	81	88	85	87	70	106	77	94
Mo	79	92	83	98	87	103	83	98
Ni	88	93	93	100	87	101	92	98
Pb	82	92	80	91	77	91	81	91
Sb	28	84	23	77	46	76	32	79
Se	84	89	81	96	99	96	85	94
Tl	88	87	69	95	66	67	74	83
V	84	97	86	96	90	88	87	93
Zn	96	106	78	75	b	b	87	99

a - Samples: 4 mL of 100 mg/mL multi-standard in 2 g of sample. Each value is percent recovery and is the average of duplicate spikes.

b - Unable to accurately quantitate due to high background values.

c - Method 3050B using optional section.

Table 3
Results of Analysis of Nist Standard Reference Material 2704
"River Sediment" Using Method 3050B (µg/g ± SD)

Element	Atm. Pressure Microwave Assisted Method with Power Control	Atm. Pressure Microwave Assisted Method with Temperature Control (gas-bulb)	Atm. Pressure Microwave Assisted Method with Temperature Control (IR-sensor)	Hot-Plate	NIST Certified Values for Total Digestion (µg/g ±95% CI)
Cu	101 ± 7	89 ± 1	98 ± 1.4	100 ± 2	98.6 ± 5.0
Pb	160 ± 2	145 ± 6	145 ± 7	146 ± 1	161 ± 17
Zn	427 ± 2	411 ± 3	405 ± 14	427 ± 5	438 ± 12
Cd	NA	3.5 ± 0.66	3.7 ± 0.9	NA	3.45 ± 0.22
Cr	82 ± 3	79 ± 2	85 ± 4	89 ± 1	135 ± 5
Ni	42 ± 1	36 ± 1	38 ± 4	44 ± 2	44.1 ± 3.0

NA - Not Available

Table 4
Results of Analysis of NIST Standard Reference Material 2710
"Montana Soil (Highly Elevated Trace Element Concentrations)" Using Method 3050B
(µg/g ± SD)

Element	Atm. Pressure Microwave Assisted Method with Power Control	Atm. Pressure Microwave Assisted Method with Temperature Control (gas-bulb)	Atm. Pressure Microwave Assisted Method with Temperature Control (IR-sensor)	Hot-Plate	NIST Leachable Concentrations Using Method 3050	NIST Certified Values for Total Digestion (µg/g ±95% CI)
Cu	2640 ± 60	2790 ± 41	2480 ± 33	2910 ± 59	2700	2950 ± 130
Pb	5640 ± 117	5430 ± 72	5170 ± 34	5720 ± 280	5100	5532 ± 80
Zn	6410 ± 74	5810 ± 34	6130 ± 27	6230 ± 115	5900	6952 ± 91
Cd	NA	20.3 ± 1.4	20.2 ± 0.4	NA	20	21.8 ± 0.2
Cr	20 ± 1.6	19 ± 2	18 ± 2.4	23 ± 0.5	19	39*
Ni	7.8 ± 0.29	10 ± 1	9.1 ± 1.1	7 ± 0.44	10.1	14.3 ± 1.0

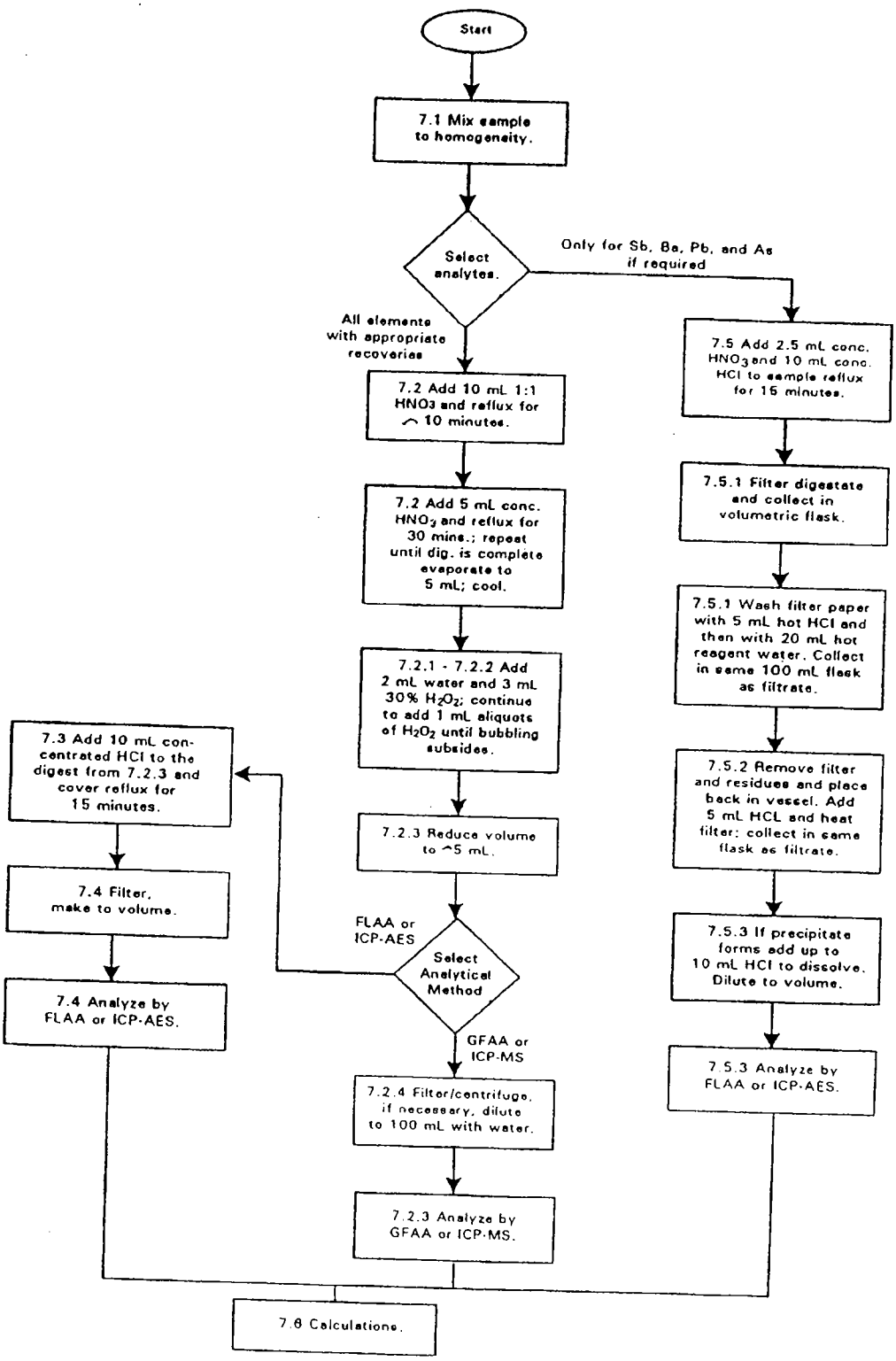
NA - Not Available * Non-certified values, for information only.

Table 5
Results of Analysis of NIST Standard Reference Material 2711
"Montana Soil (Moderately Elevated Trace Element Concentrations)" Using Method 3050B
(µg/g ± SD)

Element	Atm. Pressure Microwave Assisted Method with Power Control	Atm. Pressure Microwave Assisted Method with Temperature Control (gas-bulb)	Atm. Pressure Microwave Assisted Method with Temperature Control (IR-sensor)	Hot-Plate	NIST Leachable Concentrations Using Method 3050	NIST Certified Values for Total Digestion (µg/g ±95% CI)
Cu	107 ± 4.6	98 ± 5	98 ± 3.8	111 ± 6.4	100	114 ± 2
Pb	1240 ± 68	1130 ± 20	1120 ± 29	1240 ± 38	1100	1162 ± 31
Zn	330 ± 17	312 ± 2	307 ± 12	340 ± 13	310	350.4 ± 4.8
Cd	NA	39.6 ± 3.9	40.9 ± 1.9	NA	40	41.7 ± 0.25
Cr	22 ± 0.35	21 ± 1	15 ± 1.1	23 ± 0.9	20	47*
Ni	15 ± 0.2	17 ± 2	15 ± 1.6	16 ± 0.4	16	20.6 ± 1.1

NA - Not Available
* Non-certified values, for information only.

METHOD 3050B
ACID DIGESTION OF SEDIMENTS, SLUDGES, AND SOILS



LEAD by Flame AAS

7082

Pb MW: 207.19 (Pb) 223.19 (PbO) CAS: 7439-92-1 (Pb) 1317-36-8 (PbO) RTECS: OF7525000 (Pb) OG1750000 (PbO)

METHOD: 7082, Issue 2 EVALUATION: FULL Issue 1: 15 February 1984 Issue 2: 15 August 1994

OSHA: 0.05 mg/m³
NIOSH: <0.1 mg/m³; blood Pb ≤60 µg/100 g
ACGIH: 0.05 mg/m³

PROPERTIES: soft metal; d 11.3 g/cm³; MP 327.5 °C valences +2, +4 in salts

SYNONYMS: elemental lead and lead compounds except alkyl lead

SAMPLING		MEASUREMENT	
SAMPLER:	FILTER (0.8-µm cellulose ester membrane)	TECHNIQUE:	ATOMIC ABSORPTION SPECTROPHOTOMETER, FLAME
FLOW RATE:	1 to 4 L/min	ANALYTE:	lead
VOL-MIN: -MAX:	200 L @ 0.05 mg/m³ 1500 L	ASHING:	conc. HNO_3, 6 mL + 30% H_2O_2, 1 mL; 140 °C
SHIPMENT:	routine	FINAL SOLUTION:	10% HNO_3, 10 mL
SAMPLE STABILITY:	stable	FLAME:	air-acetylene, oxidizing
BLANKS:	2 to 10 field blanks per set	WAVELENGTH:	283.3 nm
ACCURACY		BACKGROUND CORRECTION:	D_2 or H_2 lamp, or Zeeman
RANGE STUDIED:	0.13 to 0.4 mg/m³ [1]; 0.15 to 1.7 mg/m³ (fume) [2]	CALIBRATION:	Pb^{2+} in 10% HNO_3
BIAS:	- 3.1%	RANGE	10 to 200 µg per sample [2,3]
OVERALL PRECISION($\hat{S}_{rT}$):	0.072 [1]; 0.068 (fume) [2]	ESTIMATED LOD:	2.6 µg per sample [4]
ACCURACY:	± 17.6%	PRECISION($\bar{S}_r$):	0.03 [1]

APPLICABILITY: The working range is 0.05 to >1 mg/m³ for a 200-L air sample. The method is applicable to elemental lead, including Pb fume, and all other aerosols containing lead. This is an elemental analysis, not compound specific. Aliquots of the samples can be analyzed separately for additional elements

INTERFERENCES: Use D_2 or H_2 continuum or Zeeman background correction to control flame or molecular absorption. High concentrations of calcium, sulfate, carbonate, phosphate, iodide, fluoride, or acetate can be corrected.

OTHER METHODS: This method combines and replaces P&CAM 173 [3] and S341 [4,5] for lead. Method 7300 (ICP-AES) and 7105 (AAS/GF) are alternate analytical methods. Method 7505 is specific for lead sulfide. The following have not been revised: the dithizone method, which appears in P&CAM 102 [5] and the lead criteria document [6]; and P&CAM 191 (ASV) [7]

REAGENTS:

1. Nitric acid, conc.*
2. Nitric acid, 10% (v/v). Add 100 mL conc. HNO_3 to 500 mL water; dilute to 1 L.
3. Hydrogen peroxide, 30% H_2O_2 (w/w), reagent grade.*
4. Calibration stock solution, 1000 µg/mL Pb. Commercial standard or dissolve 1.00 g Pb metal in minimum volume of (1+1) HCl and dilute to 1 L with 1% (v/v) HCl. Store in a polyethylene bottle. Stable≥ one year.
5. Air, compressed, filtered.
6. Acetylene
7. Distilled or deionized water.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: Cellulose ester filter, 0.8µm pore size, 37-mm diameter, in cassette filter holder.
2. Personal sampling pump, 1 to 4 L/min, with flexible connecting tubing.
3. Atomic Absorption Spectrophotometer with an air-acetylene burner head and background correction.
4. Lead hollow cathode lamp or electrode dischargeless lamp.
5. Regulators, two-stage, for air and acetylene.
6. Beakers, Phillips, 125-mL, or Griffin, 50-mL with watchglass covers.**
7. Volumetric flasks, 10- and 100-mL.**
8. Assorted volumetric pipets as needed.**
9. Hotplate, surface temperature 140°C.
10. Bottles, polyethylene, 100-mL.

** Clean all glassware with conc. nitric acid and rinse thoroughly with distilled or deionized water before use.

SPECIAL PRECAUTIONS: Concentrated nitric acid is an irritant and may burn skin. Perform all acid digestions in a fume hood. Hydrogen peroxide is a strong oxidizing agent, a strong irritant, and corrosive to the skin. Wear gloves and eye protection.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Sample at an accurately known flow rate between 1 and 4 L/min for up to 8 h for a total sample size of 200 to 1500 L for TWA measurements. Do not exceed a filter loading of ca. 2 mg total dust.

SAMPLE PREPARATION:

NOTE 1: The following sample preparation gave quantitative recovery (see EVALUATION OF METHOD) [4]. Steps 4 through 9 of Method 7300 or other quantitative ashing techniques may be substituted, especially if several metals are to be determined on a single filter.

NOTE 2: The Appendix gives a microwave digestion procedure which may be necessary for complete recovery of lead from some matrices, especially epoxy-based paint.

3. Open the cassette filter holders and transfer the samples and blanks to clean beakers.
4. Add 3 mL conc. HNO_3, and 1 mL 30% H_2O_2 and cover with a watchglass. Start reagent blanks at this step.
   NOTE: If PbO_2 is not present in the sample, the 30% H_2O_2 need not be added [2,4].
5. Heat on 140 °C hotplate until volume is reduced to about 0.5 mL.
6. Repeat two more times using 2 mL conc. HNO_3 and 1 mL 30% H_2O_2 each time.
7. Heat on 140 °C hotplate until ca. 0.5 mL liquid remains.
8. When sample is dry, rinse the watchglass and walls of the beaker with 3 to 5 mL 10% HNO_3. Allow the solution to evaporate to dryness.
9. Cool each beaker and dissolve the residues in 1 mL conc. HNO_3.
10. Transfer the solution quantitatively to a 10-mL volumetric flask and dilute to volume with distilled water.

NOTE: If the concentration (M) of any of the following is expected to exceed the lead concentration (M) by 10-fold or more, add 1 mL 1 M Na_2EDTA to each flask before dilution to volume: CO_3^{2-}, PO_4^{3-}, I^-, F^-, CH_3COO^-. If Ca^{2+} or SO_4^{2-} are present in 10-fold or greater excess, make all standards and samples 1% (w/w) in La[3].

CALIBRATION AND QUALITY CONTROL:

11. Prepare a series of working standards covering the range 0.25 to 20 µg/mL Pb (2.5 to 200 µg Pb per sample).
    a. Add aliquots of calibration stock solution to 100-mL volumetric flasks. Dilute to volume with 10% HNO_3. Store the working standards in polyethylene bottles and prepare fresh weekly.
    b. Analyze the working standards together with the blanks and samples (steps 14 and 15).
    c. Prepare a calibration graph of absorbance vs. solution concentration (µg/mL).
12. Aspirate a standard for every 10 samples to check for instrument drift.
13. Check recoveries with at least one spiked media blank per 10 samples. Use method of standard additions occasionally to check for interferences.

MEASUREMENT:

14. Set spectrophotometer as specified by the manufacturer and to conditions on page 7082-1.
    NOTE: An alternate wavelength is 217.0 nm [8]. Analyses at 217.0 nm have slightly greater sensitivity, but poorer signal-to-noise ratio compared to 283.3 nm. Also, non-atomic absorption is significantly greater at 217.0 nm, making the use of D_2 or H_2 continuum, or Zeeman background correction mandatory at that wavelength.
15. Aspirate standards, samples, and blanks. Record absorbance readings.
    NOTE: If the absorbance values for the samples are above the linear range of the standards, dilute with 10% HNO_3, reanalyze, and apply the appropriate dilution factor in the calculations.

CALCULATIONS:

16. Using the measured absorbances, calculate the corresponding concentrations (µg/mL) of lead in the sample, C_s, and average media blank, C_b, from the calibration graph.
17. Using the solution volumes (mL) of the sample, V_s, and media blanks, V_b, calculate the concentration, C (mg/m³), of lead in the air volume sampled, V (L):

$$C = \frac{C_s V_s - C_b V_b}{V}, \text{ mg/m}^3.$$

NOTE: µg/mL = mg/m

EVALUATION OF METHOD:

Method S341 [9] was issued on October 24, 1975, and validated over the range 0.13 to 0.4 mg/m³ for a 180-L air sample, using generated atmospheres of lead nitrate [1]. Recovery in the range 18 to 72 µg Pb per sample was 98%, and collection efficiency of 0.8-µm mixed cellulose ester filters (Millipore Type AA) was 100% for the aerosols. Subsequent studies on analytical recovery of 200 µg Pb per sample gave the following results [2,4]:

Species	Digestion Method	Analytical Recovery, %
Pb metal	HNO_3 only	92 ± 4
Pb metal	$HNO_3 + H_2O_2$	103 ± 3
PbO	HNO_3 only	93 ± 4
PbS	HNO_3 only	93 ± 5
PbO_2	HNO_3 only	82 ± 3
PbO_2	$HNO_3 + H_2O_2$	100 ± 1
Pb in paint*	HNO_3 only	95 ± 6
Pb in paint*	$HNO_3 + H_2O_2$	95 ± 6

*Standard Reference Material #1579, U.S. National Institute of Standards and Technology.

Additional collection efficiency studies were also done using Gelman GN-4 filters for the collection of Pb fume, which had geometric mean diameter of 0.1 µm [2]. Mean collection efficiency for 24 sampling runs at flow rates between 0.15 and 4.0 L/min was > 97 ± 2%. Overall precision, $\hat{S}_{rT}$, was 0.072 for lead nitrate aerosol [1,9] and 0.068 for Pb fume [2,4].

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METHOD REVISED BY:

Mark Millson, NIOSH/DPSE and R. DeLon Hull, Ph.D., NIOSH/DBBS; S341 originally validated under NIOSH Contract CDC-94-74-45; additional studies under NIOSH Contract 210-79-0058.

James B. Perkins, David L. Wheeler, and Keith Nicholson, Ph.D., DataChem Laboratories, Salt Lake City, UT, prepared the microwave digestion procedure in the Appendix.

APPENDIX - MICROWAVE DIGESTION FOR LEAD IN PAINT CHIPS (AND OTHER MATRICES)

This procedure is an alternative to the procedure presented in the Sample Preparation section of this method. It provides a rapid, complete acid digestion prior to analysis by flame atomic absorption (FAA), heated graphite furnace atomic absorption(HGFAA), and inductively coupled plasma spectroscopy (ICP) [10].

Apparatus and Material[11-16]

1. Microwave apparatus requirements
   a. The microwave unit provides programmable power with a minimum of 574 W and can be programmed to within ± 10 W of the required power.
   b. The microwave unit cavity is corrosion resistant as well as ventilated. All electronics are protected against corrosion for safe operation.
   c. The system requires Teflon PFA digestion vessels (120-mL capacity) capable of withstanding pressures up to 7.5 ± 0.7 atm (110 ± 10 psi) and capable of controlled pressure relief at pressures exceeding 7.5 ± 0.7 atm (110 ± 10 psi).
   d. A rotating turntable is employed to ensure homogeneous distribution of microwave radiation within the unit. The speed of the turntable should be a minimum of 3 rpm.
   e. A safety concern relates to the useof sealed containers without pressure relief valves in the unit. Temperature is the important variable controlling the reaction. Pressure is needed to attain elevated temperatures but must be safely contained [12].
   f. Polymeric volumetric ware in plastic (Teflon or polyethylene), 50- or 100-mL capacity.
   g. Disposable polypropylene filter funnel.
   h. Analytical balance, 300-g capacity, and minimum ± 0.001 g.

Reagents

1. Nitric acid, concentrated, spectroscopy grade.
2. Reagent Water. Reagent water shall be interference free. All references to water in the method refer to reagent water that meets the ASTM Type 2 standard.

Procedure

1. Calibration of Microwave Equipment
   Calibrate microwave equipment in accordance with manufacturer's instructions. If calibration instructions are not available, see EPA Method 3051 [11].
2. All digestion vessels and volumetric ware must be carefully acid washed and rinsed with reagent water. All digestion vessels should be cleaned by leaching with hot (1:1) nitric acid for a minimum of fifteen minutes, rinsed with reagent water, and dried in a clean environment.
3. Sample Digestion
   a. Tare the Teflon PFA digestion vessel.
   b. Weigh out 0.1 g paint chip sample to the nearest 0.001 g into the tared Teflon PFA sample vessel. With large paint chip samples, measure out a 2 cm^2 piece, weigh to the nearest 0.001 g, and quantitatively transfer it to the vessel.
   c. Add 5.0 ± 0.1 mL concentrated nitric acid to the sample vessel in a fume hood. If a vigorous reaction occurs, allow the reaction to stop before capping the vessel. Cap the vessehd torque the cap to 12 ft-lb (16 N-m) according to the manufacturer's directions. The sample vessel may be connected to an overflow vessel using Teflon PFA connecting tubes. Place the vessels in the microwave carrousel. Connect the overflow vessels to the center well of the unit.
   d. Place the vessels evenly distributed in the turntable of the microwave unit using groups of two, six,

or 12 sample vessels. Any vessels containing 5 mL of nitric acid for reagent blank purposes are counted as sample vessels. When fewer than the recommended number of samples are to be digested, i.e., three samples plus one blank, the remaining vessels should be filled with 5 mL of nitric acid to achieve the full complement of vessels. This provides an energy balance since the microwave power absorbed is proportional to the total mass in the cavity [14]. Irradiate each group of samples to achieve a temperature of 180 °C in five minutes at a pressure of 50 psi. Continue to irradiate to achieve a temperature of 180 °C at 100 psi after 25 minutes. Continue digestion for five minutes. A sample digestion program for 12 samples is presented in the following table.

PROGRAM VARIABLES FOR PAINT CHIPS SAMPLE DIGESTION WITH NITRIC ACID

Stage	(1)	(2)	(3)
Power	90%	90%	0%
Pressure, psi	50	100	0
Run Time, min	10:00	20:00	05:00
Time @ P, min	05:00	15:00	00:00
Temperature	180°C	180°C	0°C
Fan Speed	100%	100%	100%
Number of Vessels:	12		
Liquid Volume per Vessel:	5 mL		
Sample Weight:	0.1 g		

If the analyst wishes to digest other than two, six, or 12 samples at a time, use different values of power as long as they result in the same time and temperature conditions.

e. At the end of the microwave program, allow the vessels to cool for a minimum of five minutes before removing them from the microwave unit. If a loss of sample is detected (e.g., material in overflow collection vessel, liquid outside liner), determine the reason for the loss (e.g., loss of vessel seal integrity, use of a digestion time longer than 30 minutes, too large a sample, or improper heating conditions). Once the source of the loss has been corrected, prepare a new sample beginning at Section 2. If insufficient material is available for reanalysis, dilute remaining digestate and note that some sample loss may have occurred.

f. Uncap and vent each vessel in a fume hood. Add 20 mL reagent water, then reseal vessels and shake to mix thoroughly. Transfer the sample to an acid-cleaned polyethylene bottle. If the digested sample contains particulates which may clog nebulizers or interfere with injection of the sample into the instrument, allow the sample to settle or filter it:

Settling: Allow the sample to stand until the supernatant is clear (usually, overnight is sufficient). If it does not clear, filter the sample.

Filtering: The filtering apparatus must be thoroughly precleaned and rinsed with dilute nitric acid. Filter the sample through quantitative filter paper into a second acid-cleaned container.

The digestate is now ready for analysis for elements of interest using the appropriate method.

4. Calculations: Report the concentrations based on the actual weight of the original sample.

METHOD 7420

LEAD (ATOMIC ABSORPTION, DIRECT ASPIRATION)

1.0 SCOPE AND APPLICATION

1.1 See Section 1.0 of Method 7000.

2.0 SUMMARY OF METHOD

2.1 See Section 2.0 of Method 7000.

3.0 INTERFERENCES

3.1 See Section 3.0 of Method 7000 if interferences are suspected.

3.2 Background correction is required at either wavelength.

4.0 APPARATUS AND MATERIALS

4.1 For basic apparatus, see Section 4.0 of Method 7000.

4.2 Instrument parameters (general):

4.2.1 Lead hollow cathode lamp.
4.2.2 Wavelength: 283.3 nm (primary); 217.0 nm (alternate).
4.2.3 Fuel: Acetylene.
4.2.4 Oxidant: Air.
4.2.5 Type of flame: Oxidizing (fuel lean).
4.2.6 Background correction: Required.

5.0 REAGENTS

5.1 See Section 5.0 of Method 7000.

5.2 Preparation of standards:

5.2.1 Stock solution: Dissolve 1.599 g of lead nitrate, $Pb(NO_3)_2$ (analytical reagent grade), in Type II water, acidify with 10 mL redistilled HNO_3, and dilute to 1 liter with Type II water. Alternatively, procure a certified standard from a supplier and verify by comparison with a second standard.

5.2.2 Prepare dilutions of the stock solution to be used as calibration standards at the time of analysis. The calibration standards should be prepared using the same type of acid and at the same concentration as will result in the sample to be analyzed after processing.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 See Chapter Three, Section 3.1.3, Sample Handling and Preservation.

7.0 PROCEDURE

7.1 Sample preparation: The procedures for preparation of the sample are given in Chapter Three, Section 3.2.

7.2 See Method 7000, Paragraph 7.2, Direct Aspiration.

8.0 QUALITY CONTROL

8.1 See Section 8.0 of Method 7000.

9.0 METHOD PERFORMANCE

9.1 The performance characteristics for an aqueous sample free of interferences are:

Optimum concentration range: 1-20 mg/L with a wavelength of 283.3 nm.
Sensitivity: 0.5 mg/L.
Detection limit: 0.1 mg/L.

9.2 For concentrations of lead below 0.2 mg/L, the furnace technique (Method 7421) is recommended.

9.3 Precision and accuracy data are available in Method 239.1 of Methods for Chemical Analysis of Water and Wastes.

9.4 The data shown in Table 1 were obtained from records of state and contractor laboratories. The data are intended to show the precision of the combined sample preparation and analysis method.

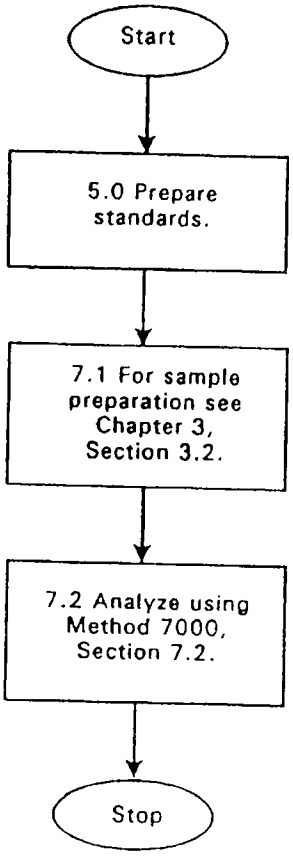
10.0 REFERENCES

1. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-82-055, December 1982, Method 239.1.

2. Gaskill, A., Compilation and Evaluation of RCRA Method Performance Data, Work Assignment No. 2, EPA Contract No. 68-01-7075, September 1986.

TABLE 1. METHOD PERFORMANCE DATA

Sample Matrix	Preparation Method	Laboratory Replicates
Wastewater treatment sludge	3050	450, 404 ug/g
Emission control dust	3050	42,500, 63,600 ug/g


Start
5.0 Prepare standards.
7.1 For sample preparation see Chapter 3, Section 3.2.
7.2 Analyze using Method 7000, Section 7.2.
Stop

APPENDIX G

HUD Guidelines for the Evaluation and Control of Lead-based Paint Hazards in Housing

Chapter 14: Cleaning

Chapter 15: Clearance

V. Order of Final Cleaning Procedures After Lead Hazard Control 14–19
A. Final Cleaning 14–19
1. Decontamination of Workers, Supplies, and Equipment 14–19
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Cleaning: How To Do It

1. Include step-by-step procedures for precleaning, cleaning during the job, and daily and final cleanings in project design or specifications.

2. Assign responsibilities to specific workers for cleaning and for maintaining cleaning equipment.

3. Have sufficient cleaning equipment and supplies *before* beginning work.

4. If contamination is extensive, conduct precleaning of the dwelling unit. Move or cover all furniture and other objects.

5. Conduct ongoing cleaning during the job, including regular removal of large and small debris and dust. Decontamination of all tools, equipment, and worker protection gear is required before it leaves containment areas. Electrical equipment should be wiped and high-efficiency particulate air (HEPA) vacuumed, not wetted down, to minimize electrocution hazards.

6. Schedule sufficient time (usually 30 minutes to an hour) for a complete daily cleaning, starting at the same time near the end of each workday after lead hazard control activity has ceased.

7. For final cleaning, wait at least 1 hour after active lead hazard control activity has ceased to let dust particles settle.

8. Use a vacuum cleaner equipped with a HEPA exhaust filter. HEPA vacuum all surfaces in the room (ceilings, walls, trim, and floors). Start with the ceiling and work down, moving toward the entry door. Completely clean each room before moving on.

9. Wash all surfaces with a lead-specific detergent, high-phosphate detergent, or other suitable cleaning agent to dislodge any ground-in contamination, then rinse. Change the cleaning solution after every room is cleaned.

10. Repeat step 8. To meet clearance standards consistently, a HEPA vacuum, wet wash, and HEPA vacuum cycle is recommended. For interim control projects involving dust removal only, the final HEPA vacuuming step is usually not needed (see Chapter 11). Other cleaning methods are acceptable, as long as clearance criteria are met and workers are not overexposed.

11. After final cleaning, perform a visual examination to ensure that all surfaces requiring lead hazard control have been addressed and all visible dust and debris have been removed. Record findings and correct any incomplete work. This visual examination should be performed by the owner or an owner's representative who is independent of the lead hazard control contractor.

12. If other construction work will disturb the lead-based paint surfaces, it should be completed at this point. If those surfaces are disturbed, repeat the final cleaning step after the other construction work has been completed.

13. Paint or otherwise seal treated surfaces and interior floors.

14. Conduct a clearance examination (see Chapter 15).

15. If clearance is not achieved, repeat the final cleaning.

16. Continue clearance testing and repeated cleaning until the dwelling achieves compliance with all clearance standards. As an incentive to conduct ongoing cleaning and a thorough final cleaning, the cost of repeated cleaning after failing to achieve clearance should be borne by the contractor as a matter of the job specification, not the owner.

17. Do not allow residents to enter the work area until cleaning is completed and clearance is established.

18. Cleaning equipment list:

    - HEPA vacuums.
    - Detergent.
    - Waterproof gloves.
    - Rags.
    - Sponges.
    - Mops.
    - Buckets.
    - HEPA vacuum attachments (crevice tools, beater bar for cleaning rugs).
    - 6-mil plastic bags.
    - Debris containers.
    - Waste water containers.
    - Shovels.
    - Rakes.
    - Water-misting sprayers.
    - 6-mil polyethylene sheeting (or equivalent).

Chapter 14: Cleaning

I. Introduction

This chapter describes cleaning procedures to be employed following abatement and interim control work. Dust removal as an interim control measure is covered in Chapter 11.

All lead hazard control activities can produce dangerous quantities of leaded dust. Unless this dust is properly removed, a dwelling unit will be more hazardous after the work is completed than it was originally. Once deposited, leaded dust is difficult to clean effectively. Whenever possible, ongoing and daily cleaning of leaded dust during lead hazard control projects is recommended. Ongoing and daily cleaning is also necessary to minimize worker exposures.

Cleaning is the process of removing visible debris *and* dust particles too small to be seen by the naked eye. Removal of lead-based paint hazards in a dwelling unit will not make the unit safe unless excessive levels of leaded dust are also removed. This is true regardless of whether the dust was present before or generated by the lead hazard control process itself. Improper cleaning can increase the cost of a project considerably because additional cleaning and clearance sampling will be necessary. However, cleaning and clearance can be achieved routinely if care and diligence are exercised.

A. Performance Standard

Although the cleaning methods described in this chapter are feasible and have been shown to be effective in meeting clearance standards, other methods may also be used if they are safe and effective. This performance-oriented approach should stimulate innovation, reduce cost, and ensure safe conditions for both residents and workers.

B. Small Dust Particles

Dust particles that are invisible to the naked eye remain on surfaces after ordinary cleaning procedures. A visibly clean surface may contain high and unacceptable levels of dust particles and require special cleaning procedures.

C. Difficulties in Cleaning

While cleaning is an integral and essential component of any lead hazard control activity, it is also the most likely part of the activity to fail.

Several common reasons for this failure include low clearance standards, worker inexperience, high dust-producing methods, and deadlines.

1. Low Clearance Standards

Because very small particles of leaded dust are easily absorbed by the body when ingested or inhaled, a small amount can create a health hazard for young children. Therefore, "clearance standards" are extremely low for acceptable levels of leaded dust particles on surfaces after hazard control activities, and careful cleaning procedures are required. Although it is not possible to remove *all* leaded dust from a dwelling, it is possible to reduce it to a safe level.

Clearance standards are described more fully in Chapter 15. The permissible amount of leaded dust remaining on each of the following surfaces following lead hazard work is as follows:

- 100 $\mu g/ft^2$ on floors.
- 500 $\mu g/ft^2$ on interior window sills (stools).
- 800 $\mu g/ft^2$ on window troughs (the area where the sash sits when closed).
- 800 $\mu g/ft^2$ on exterior concrete.

These levels are based on wipe sampling. Clearance testing determines whether the premises or area are clean enough to be reoccupied after the completion of a lead paint hazard control project. A cleaned area may not be reoccupied until compliance with clearance standards has been established. To prevent delays, final testing and final cleaning activities should be coordinated.

2. Worker Inexperience

To understand the level of cleanliness required to meet the established clearance standards for hazard control cleanup, new hazard control personnel often require a significant reorientation to cleaning. Many construction workers are used to cleaning up only dust that they can see, not the invisible dust particles that are also important to remove.

3. High Dust-Producing Methods and/or Inadequate Containment

High dust-generating methods, inadequate containment during hazard control work, and poor work practices can all make achievement of clearance particularly difficult. Work practices necessary to prevent spreading of dust throughout a dwelling (e.g., by tracking dust out of work areas) are essential but sometimes tedious. Essential work practices are sometimes mistakenly considered to be "flexible guidelines" rather than necessary standards that are designed to ensure that the job is completed, not only safely, but also on time and within budget.

4. Deadlines

Daily and final cleanings have sometimes been compromised due to project deadlines, since cleaning comes at the end of the job. Hurried efforts often result in clearance failure. Delayed and over-budget hazard control projects are often the result of repeated, unplanned recleanings that are necessitated by inadequate containment and sloppy work practices.

II. Coordination of Cleaning Activities

A. Checklist

The owner or contractor may use the following cleaning checklist before any lead hazard control activity:

- ✓ Is the critical importance of cleaning in a hazard control project understood?
- ✓ Have all workers been trained and certified for hazard control work?
- ✓ Have the precleaning, daily, and final cleanings been scheduled properly and coordinated with the other participants in the hazard control process?
- ✓ Have cleaning equipment and materials been obtained?
- ✓ Do the workers know how to operate and maintain special cleaning equipment, and do they have directions for the proper use of all cleaning materials?
- ✓ Have all workers carefully studied the step-by-step procedures for precleaning (if needed), in-progress cleaning, and daily and final cleanings?
- ✓ Are all workers properly protected during the cleaning processes (see Chapter9)?
- ✓ Have provisions been made to properly contain and store potentially hazardous debris (see Chapter 10)?
- ✓ Have dust-clearance testing and related visual inspections been arranged (see Chapter 15)?
- ✓ Are the clearance criteria to be met fully understood?
- ✓ Have all appropriate surfaces been properly painted or otherwise sealed?
- ✓ Have appropriate records been maintained that document participants' roles in the hazard control project?

B. Equipment Needed for Cleaning

The following equipment is needed to conduct cleaning: high-efficiency particulate air (HEPA) vacuums and attachments (crevice tools, beater bar for cleaning rugs), detergent, waterproof gloves, rags, sponges, mops, buckets, 6-mil plastic bags, debris containers, waste water containers, shovels, rakes, water-misting sprayers, and 6-mil polyethylene plastic sheeting (or equivalent).

C. Waste Disposal

Regulations governing hazardous and nonhazardous waste storage, transportation, and disposal affect both the daily and final cleaning procedures. The hazard control contractor and the disposal contractor should work together to establish formal written procedures, specifying selected containers, storage areas, and debris pickups, to ensure that all relevant regulations are met.

III. Cleaning Methods and Procedures

Many of the special cleaning methods and procedures detailed in this chapter are not standard operating procedure for general home improvement contractors. Therefore, project designers, responsible agencies, or owners must ensure that contractors follow the methods and procedures recommended herein or specially designed alternative procedures, even though some may appear to be redundant and unnecessary. These methods have been shown to be feasible and effective in many situations and skipping steps in the cleaning procedures can be counterproductive.

A. Containment

Because of the difficulty involved in the removal of fine dust, dust generated by hazard control work should be contained to the extent possible to the inside of work areas. Inadequately constructed or maintained containment or poor work practices will result in additional cleaning efforts, due to dust that has leaked out or been tracked out of the work area (see Chapter 8).

B. Basic Cleaning Methods: Wet Wash and Vacuum Cleaning Techniques

Because leaded dust adheres tenaciously, especially to such rough or porous materials as weathered or worn wood surfaces and masonry surfaces (particularly concrete), workers should be trained in cleaning methods. As a motivator, some contractors have awarded bonuses to workers who pass clearance the first time.

Two basic cleaning methods have proven effective, when used concurrently, in lead-based paint hazard control projects: a special vacuum cleaner equipped with a HEPA exhaust filter, followed by wet washing with special cleaning agents and rinsing, followed by a final pass with the HEPA vacuum.

Although HEPA filtered vacuums and trisodium phosphate (TSP) cleaners have been considered the standard cleaning tools for lead hazard control projects, new research, discussed under the "Alternatives Methods" section in this chapter, suggests that other tools and products may also be effective in efficiently cleaning dust while providing adequate worker protection from airborne exposure risks. Some of these innovations may even be superior.

1. HEPA Vacuuming

HEPA vacuums differ from conventional vacuums in that they contain high-efficiency filters that are capable of trapping extremely small, micron-sized particles. These filters can remove particles of 0.3 microns or greater from air at 99.97 percent efficiency or greater. (A micron is 1 millionth of a meter, or about 0.00004 inches.) Some vacuums are equipped with an ultra-low penetration air (ULPA) filter that is capable of filtering out particles of 0.13 microns or greater at 99.9995 percent efficiency. However, these ULPA filters are slightly more expensive, and may be less available than HEPA filters.

Vacuuming with conventional vacuum machines is unlikely to be effective, because much of the fine dust will be exhausted back into the environment where it can settle on surfaces. A recent Canadian study revealed that fine-dust air levels were exceedingly high when a standard portable vacuum with a new bag was used, although partially filled bags were found to be more efficient (CMHC, 1992). Considerations for the proper use of a HEPA vacuum are listed below.

Operating Instructions

There are a numerous manufacturers of HEPA vacuums. Although all HEPA vacuums operate on the same general principle, they may vary considerably with respect to specific procedures, such as how to change the filters. To ensure the proper use of equipment, the manufacturer's operating instructions should be carefully followed and if possible, training sessions arranged with the manufacturer's representative.

Although HEPA vacuums have the same "suction" capacity as ordinary vacuums that are comparably sized, their filters are more efficient. Improper cleaning or changing of HEPA filters may reduce the vacuum's suction capability.

Special Attachments

Because the HEPA vacuum will be used to vacuum surfaces other than floors, operators should buy attachments and appropriate tool kits for use on different surfaces—such as brushes of various sizes, crevice tools, and angular tools.

Selecting Appropriate Size(s)

HEPA vacuums are available in numerous sizes, ranging from a small lunchbucket-sized unit to track-mounted systems. Two criteria for size selection are the size of the job and the type of electrical power available. Manufacturer recommendations should be followed.

Wet-Dry HEPA Vacuums

Some hazard control contractors have found the wet-dry HEPA vacuums to be particularly effective in meeting clearance standards. These vacuums are equipped with a special shut-off float switch to protect the electrical motor from water contact.

Prefilters

HEPA filters are usually used in conjunction with a prefilter or series of prefilters that trap the bulk of the dust in the exhaust airstream, particularly the larger particles. The HEPA filter traps most of the remaining small particles that have passed through the prefilter(s). All filters must be maintained and replaced or cleaned as specified in the manufacturer's instructions. Failure to do so may cause a reduction in suction power (thus reducing the vacuum's efficiency and effectiveness). Failure to change prefilters may damage the vacuum motor and will also shorten the service life of the HEPA filter, which is far more expensive than the prefilters.

HEPA Vacuuming Procedures

Surfaces frequently vacuumed include ceilings, walls, floors, windows, interior and exterior sills, doors, heating, ventilation, and air conditioning (HVAC) equipment (heating diffusers, radiators, pipes, vents), fixtures of any kind (light, bathroom, kitchen), built-in cabinets, and appliances.

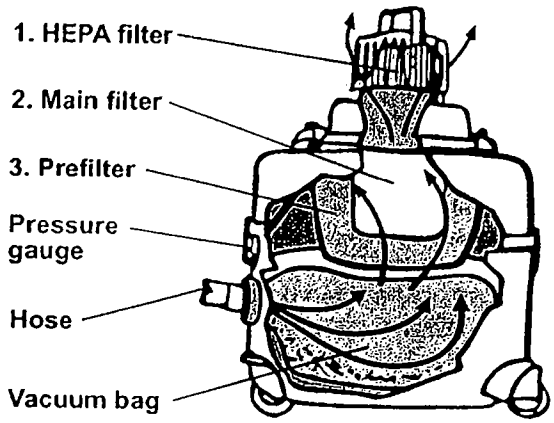
To aid in dislodging and collecting deep dust and lead from carpets, the HEPA vacuum must be equipped with a beater bar (agitator head) that is fixed to the cleaning head. This bar should be used on all passes on the carpet face during dry vacuuming (see Chapter 11 for details on carpet and furniture cleaning).

All rooms and surfaces should be included in the HEPA vacuum process, except for those that (1) were found not to have lead-paint hazards *and* were properly separated from work areas before the process began (see Chapter 8), or (2) were never entered during the process. Porches, sidewalks, driveways, and other exterior surfaces should be vacuumed if exterior hazard control work was conducted, or if debris was stored or dropped outside. Vacuuming should begin on the ceilings and end on the floors, sequenced to avoid passing through rooms already cleaned, with the dwellings' entryway cleaned last.

Emptying the HEPA Vacuum

Used filters and vacuumed debris are potentially hazardous waste and should be treated accordingly (see Chapter10). Therefore, operators should use extreme caution when opening the HEPA vacuum for filter replacement or debris removal to avoid accidental release of accumulated dust into the environment. This may occur, for example, if the vacuum's seal has been broken and the vacuum's bag is disturbed.

Figure 14.1a Vacuum With a HEPA Filter.



Parts of a HEPA-vacuum

Most HEPA-vacuums have three filters: HEPA filter, main filter, and prefilter. Debris gets sucked in through the hose into the vacuum bag. The air and dust get filtered through the prefilter, the main filter, and the HEPA filter. The HEPA filter captures the lead dust before the air is released into the work area again.

Operators should also wear a full set of protective clothing and equipment, including appropriate respirators, when performing this maintenance function, which should be done in the containment area or offsite.

2. Wet Detergent Wash

Several types of detergents have been used to remove leaded dust. Those with a high-phosphate content (containing at least 5 percent trisodium phosphate, also known as TSP) have been found to be effective when used as part of the final cleaning process (Milar, 1982). TSP detergents are thought to work by coating the surface of dusts with phosphate or polyphosphate groups which reduces electrostatic interactions with other surfaces and thereby permits easier removal. Because of environmental concerns some States have restricted the use of TSP, and some manufacturers have eliminated phosphates from their household detergents. However, high-TSP detergents can usually be found in hardware stores and may be permitted for limited use, such as lead hazard control.

Other non-TSP cleaning agents developed specifically for removing leaded dust have also been found to be effective (possibly more effective than TSP) in limited trials by several

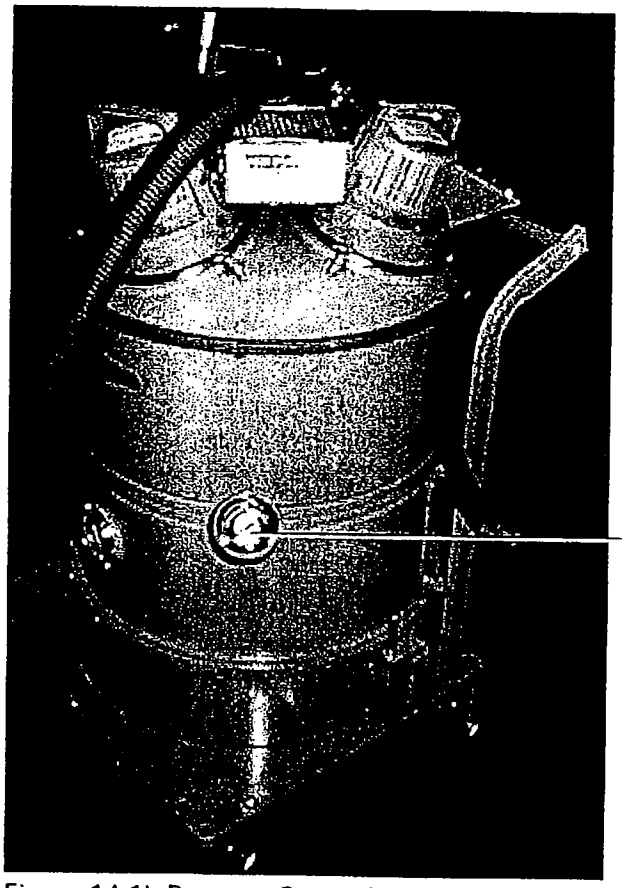
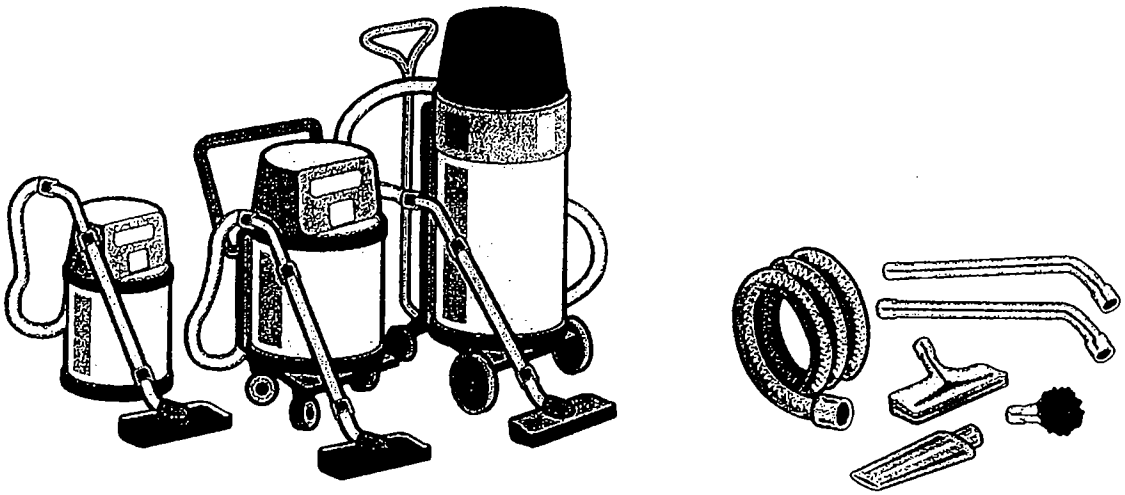


Figure 14.1b Pressure Gauge Indicator Shows When Filters Require Changing.

Figure 14.2 HEPA Vacuum Sizes and Tools.



investigators (Grawe, 1993; Wilson, 1993) and may also be safer, since TSP is a skin and eye irritant. See section VII for more information on non-TSP detergents. Proper procedures for using high-phosphate detergents also apply to most other types of detergents and include the following steps:

Manufacturer's Dilution Instructions

Users of cleaning agents for leaded dust removal should follow manufacturer's instructions for the proper use of a product, especially the recommended dilution ratio. Even diluted, trisodium phosphate is a skin irritant and users should wear waterproof gloves. Eye protection should also be worn, and portable eyewash facilities should be located in or very near the work area. Consult manufacturer's directions for the use of other detergents.

Appropriate Cleaning Equipment

Because a detergent may be used to clean leaded dust from a variety of surfaces, several types of application equipment are needed, including cleaning solution spray bottles, wringer buckets, mops, variously sized hand sponges, brushes, and rags. Using the proper equipment on each surface is essential to the quality of the wet-wash process.

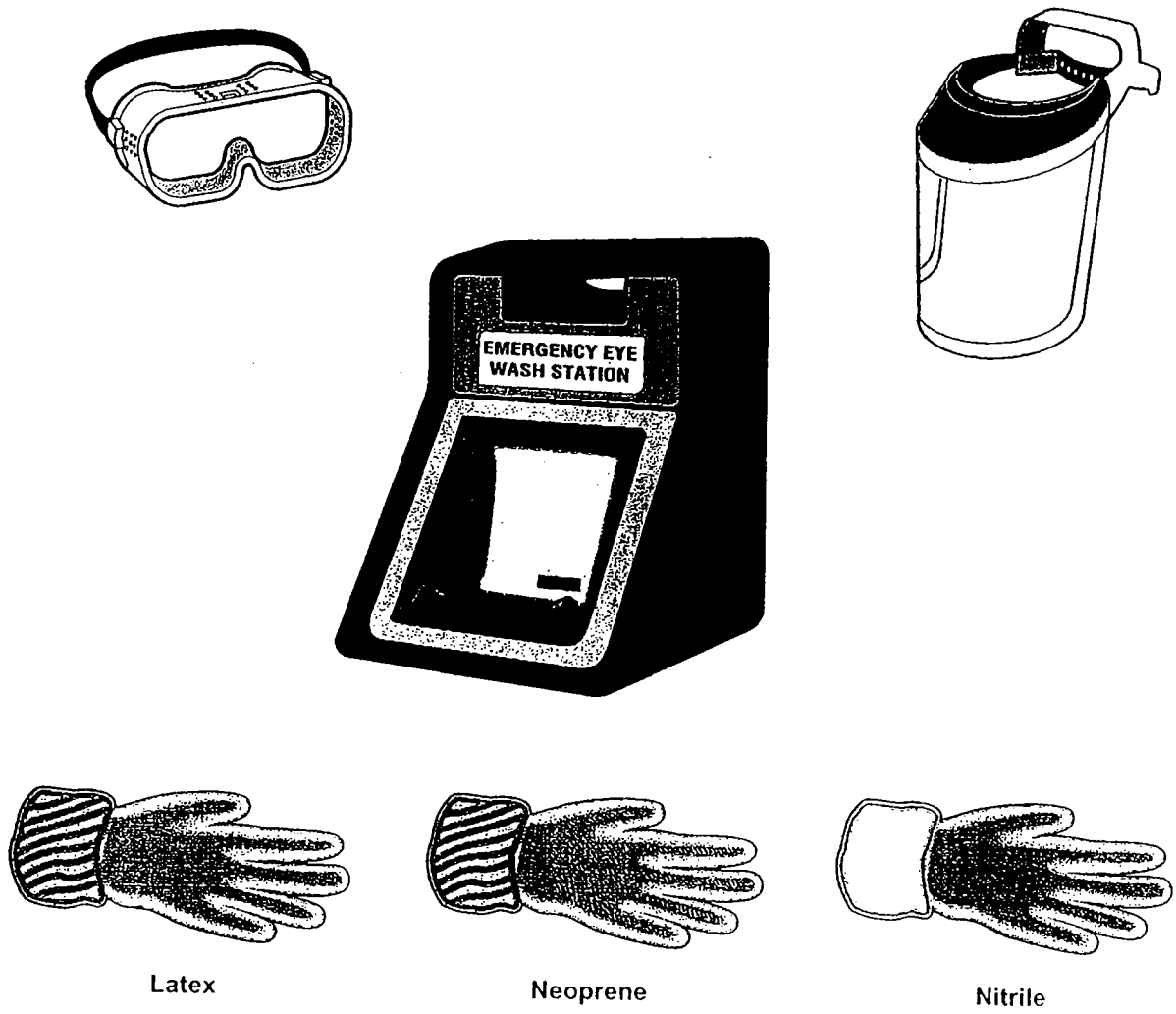
Proper Wet-Cleaning Procedures

At the conclusion of the active lead hazard control process and the initial HEPA vacuuming, all vacuumed surfaces should be thoroughly and completely washed with a high-phosphate solution or other lead-specific cleaning agent (or equivalent) and rinsed. Select a detergent that does not damage existing surface finishes (TSP may damage some finishes). Work should proceed from ceilings to floors and sequenced to avoid passing through rooms already cleaned.

Changing Cleaning Mixture

Many manufacturers of cleaners will indicate the surface area that their cleaning mixture will cover. To avoid recontaminating an area by cleaning it with dirty water, users should follow manufacturer-specified surface-area limits. However, regardless of manufacturers' recommendations, the cleaning mixture should be changed after its use for each room. As a rule of thumb, 5 gallons should be used to clean no

Figure 14.3 Goggles, Face Shields, Gloves, and Eye Wash Facilities Should Be Available When Used With Chemicals Such as TSP.



more than 1,000 square feet. Used cleaning mixture is potentially hazardous waste (see Chapter 10); consult with your local water and sewage utility for directions on its proper disposal. Wash water should never be poured onto the ground. The wash water is usually filtered and then poured down a toilet (if the local water authority approves).

3. The HEPA/Wet Wash/HEPA Cycle

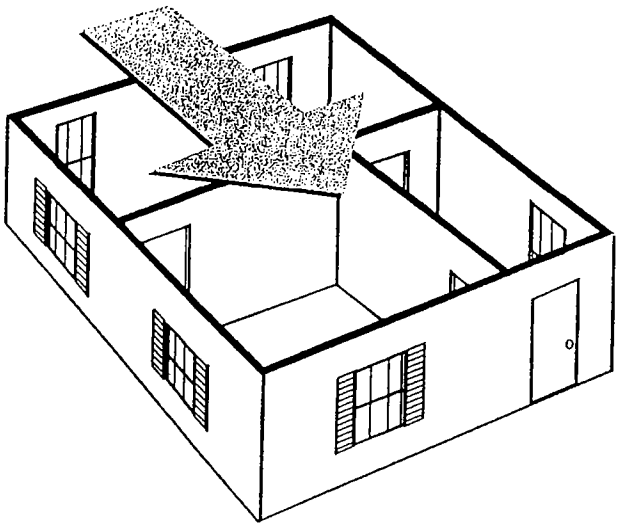
Typical Procedures

The usual cleaning cycle that follows lead hazard control activities is called the HEPA vacuum/wet wash/HEPA cycle and is applied to an entire affected area as follows:

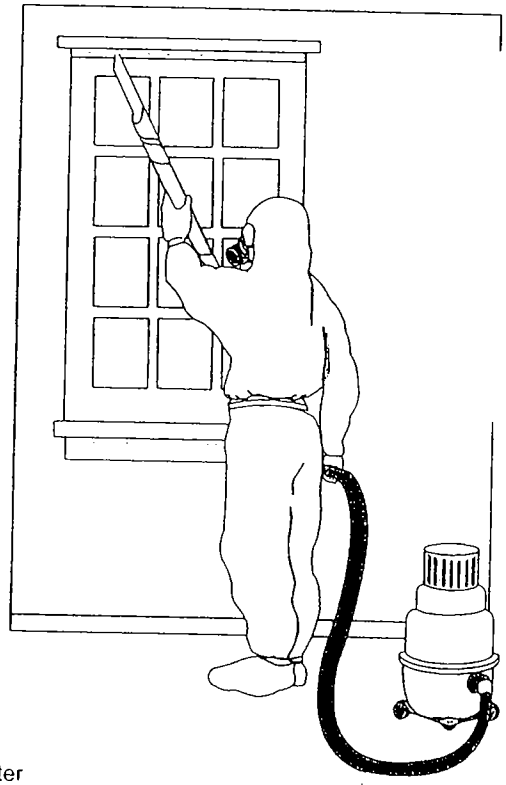
- First, the area is HEPA vacuumed.

Figure 14.4a The HEPA Vacuum, Wet Wash, HEPA Vacuum Cycle Helps in Meeting Clearance Standards.

HEPA vacuum all surfaces
Start at the end farthest from the main entrance/exit. As you vacuum, move towards the main exit and finish there.



Begin at the top of each room and work down. For example, start with the top shelves, the top of the woodwork, and so on, and work down to the floor. Do every inch of the windows, especially the window troughs.



Courtesy: Alice Hamilton Occupational Health Center

- Next, the area is washed down.
- After drying, the area is again HEPA vacuumed.

The rationale for this three-pass system is as follows:

- The first HEPA vacuum removes as much dust and remaining debris as possible.
- The wet wash further dislodges dust from surfaces.
- The final HEPA cycle removes any remaining particles dislodged but not removed by the wet wash.

Single-Pass Wet Wash/HEPA Vacuum

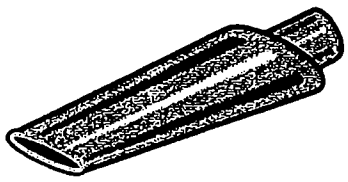
Some lead hazard control contractors have found HEPA spray cleaner vacuums to be a cost-effective alternative to the three-pass system. Similar to home carpet-cleaning machines, these vacuums simultaneously deliver a solution to the surface and recover the dirty solution. Theoretically, this process combines two of the steps in the HEPA vacuum/wet wash/HEPA cycle into one step. While anecdotal evidence indicates that the spray cleaner wet wash/HEPA is effective for some uses, limitations have been noted in its use for ceilings, vertical surfaces, and hard to reach areas. This device may be used as long as clearance standards are met.

Figure 14.4b (continued)

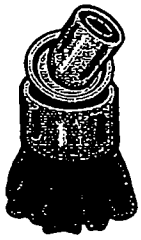
Use special attachments
Use the rubber cone where the floor meets the baseboard and along all the cracks in the floor boards. Use the brush tool for walls and woodwork.

Use the wheeled floor nozzle for bare floors and the carpet beater for rugs.

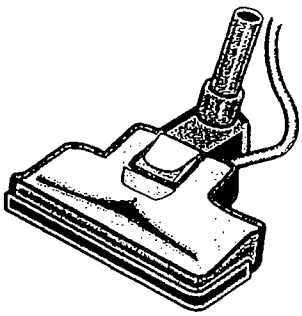
Move slowly
Vacuum slowly so the HEPA vacuum can pick up all the lead dust.



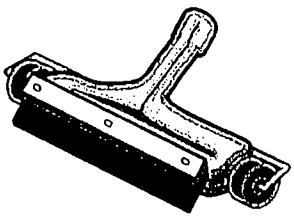
Rubber Cone



Dust Brush



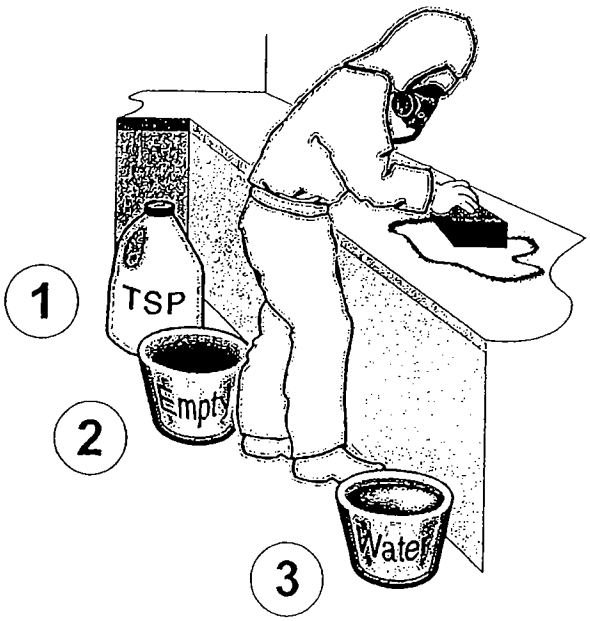
Powered Carpet Beater



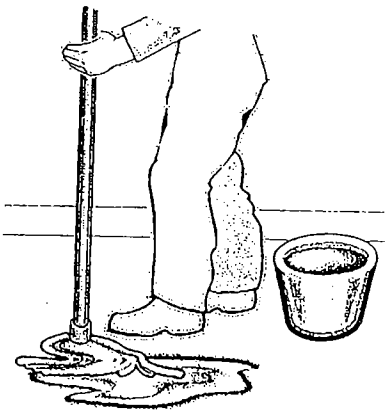
Wheeled Floor Nozzle

Figure 14.4c (continued)

Wash all surfaces with suitable detergents
Wash *all surfaces* in the work area with suitable detergents, including areas that had been covered with plastic. Some wallpaper should only be HEPA vacuumed, since it may be damaged by the detergent.



Wipe All Surfaces



Wet Mop Floor

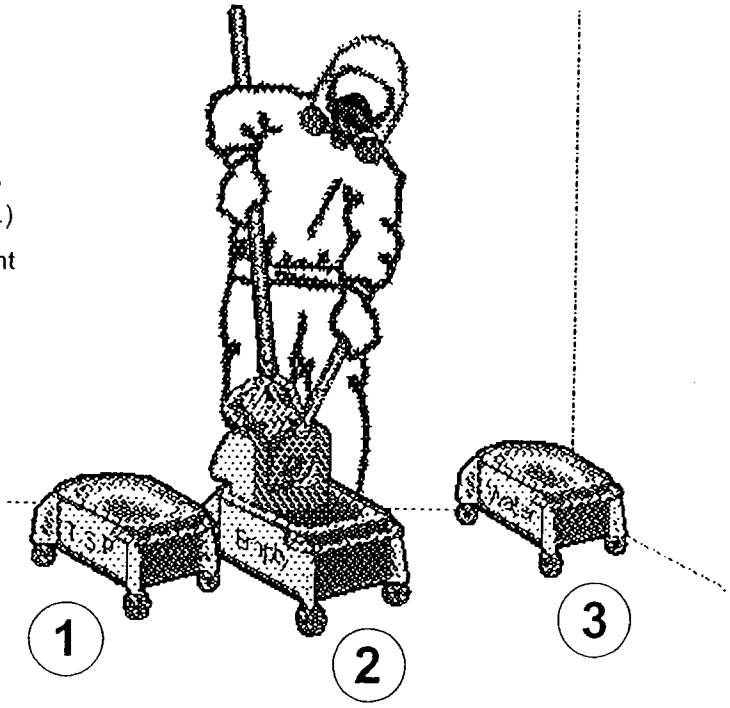
Don't Dry Sweep

Figure 14.4c (continued)

Use the 3-Bucket System.

To wash: Use string mops and mop buckets with wringers. (Some experts say NEVER use a sponge mop on the floor. Sponge mops may only push the lead around on the floor, not remove it.)

Dip the string mophead in the detergent wash in bucket #1. Mop the floor.



Squeeze out the mophead in empty bucket #2. Return to bucket #1 for more detergent solution and continue mopping. Repeat.

Use the third bucket for rinsing the floor.

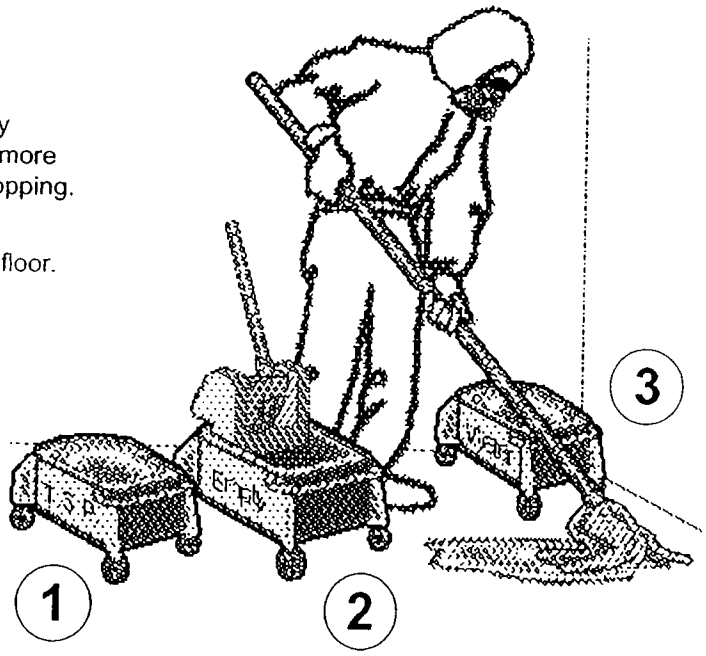
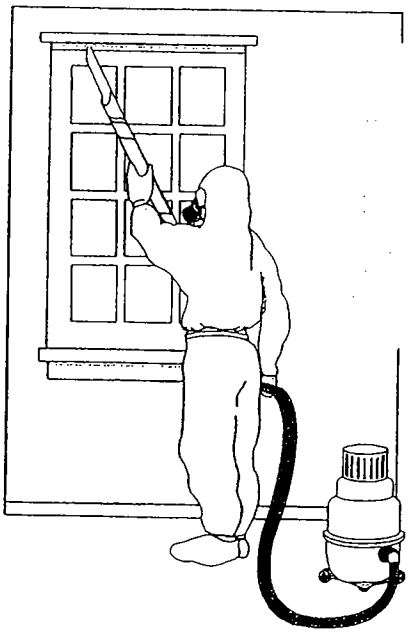


Figure 14.4d (continued)

HEPA vacuum all surfaces a final time
HEPA vacuum *all surfaces* in the work area, including areas that had been covered with plastic.

Starting at the far end, work towards the decontamination area. Begin with ceilings or the top of the walls and work down, cleaning the floors last. Do every inch of the windows, especially the troughs. Use the corner tool to clean where the floor meets the baseboard and all the cracks in the floor boards. Use the brush tool for the walls. Move slowly and carefully to get all the dust.



4. Sealing Floors

Before clearance, all floors without an intact, nonporous coating should be coated. Sealed surfaces are easier for residents to clean and maintain over time than those that are not sealed. Wooden floors should be sealed with a clear polyurethane or painted with deck enamel or durable paint. Vinyl tile, linoleum, and other similar floors should be sealed with an appropriate wax. Concrete floors should be sealed with a concrete sealer or other type of concrete deck enamel. However, if these floors are already covered by an effective coat of sealant, it may be possible to skip this step.

As an alternative to sealing, floors may be covered with new vinyl tile, sheet vinyl, linoleum flooring, or the equivalent to create a more permanent cleanable surface. New surfaces should be cleaned with a cleaning solution that is appropriate for that type of surface.

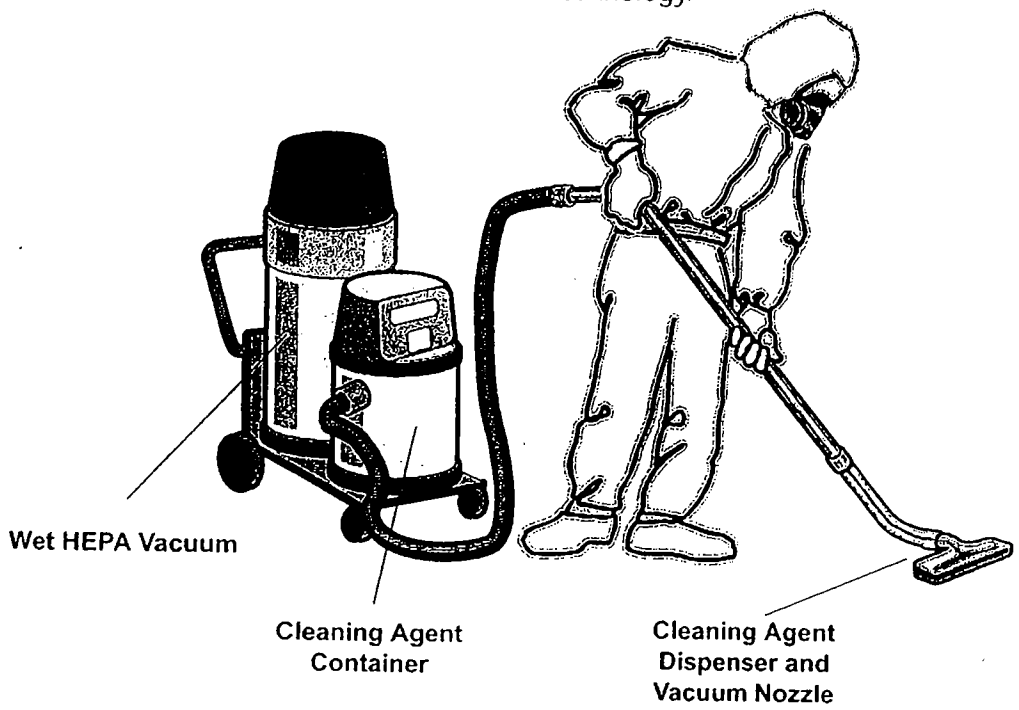
IV. Order of Cleaning Procedures During Lead Hazard Control

The special cleaning procedures to be followed during a lead-based paint hazard control project are discussed in chronological order below. Skipping steps in the process may result in failure to meet post-lead hazard control clearance standards.

A. Precleaning Procedures

Precleaning (i.e., cleaning conducted before lead hazard control is begun) is necessary only in dwelling units that are heavily contaminated with paint chips. Precleaning involves the removal of large debris and paint chips, followed by HEPA vacuuming. These steps may be followed by removal of occupant personal possessions, furniture, or carpeting, depending on the

Figure 14.5 Single-Pass HEPA Vacuum/Wet Wash Technology.



Worksite Preparation Level selected (see Chapter 8). If the furniture will not be cleaned, it should be removed from the area or covered with plastic prior to beginning the precleaning procedure. Carpeting should always be misted before its removal to control the generation of hazardous dust.

It is usually the resident's responsibility to remove most of his or her personal possessions. However, if necessary, owners or project management should be prepared to complete this activity before lead hazard control work begins. As a last resort, the contractor may pack any remaining belongings and carefully seal and move the boxes, supplying all necessary boxes, packing materials, and staff to complete the task. Following cleaning and clearance, the contractor should return all packed items to their appropriate places. Leaving these tasks to the contractor may be expensive and inefficient, since the contractor will need to be insured for this function if the occupant's

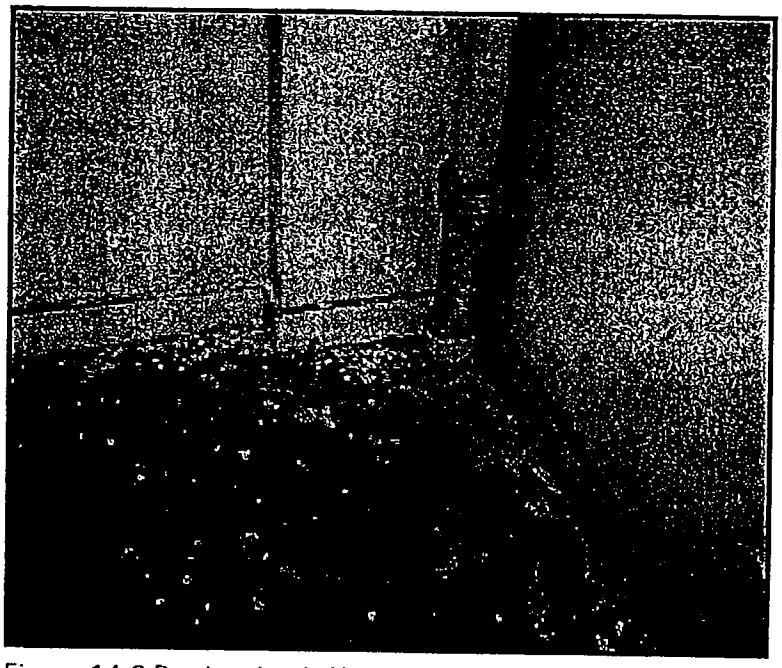


Figure 14.6 Precleaning Is Needed in Areas Where Contamination and Deterioration Are High.

belongings are damaged. Additionally, moving furniture, rugs, drapes, and other items owned by the occupant could increase leaded dust levels. Clearance should be conducted after cleaning but before resident items are moved back in.

B. Ongoing Cleaning During the Job

Periodic HEPA vacuuming during the lead hazard control work may be necessary to minimize tracking of dust and paint chips from one area to another (e.g., when a large amount of paint chips or dust is being generated).

C. Daily Cleaning Procedures

Cleaning activity should be scheduled at the end of each workday when all active lead hazard control throughout the dwelling has ceased. Sufficient time must be allowed for a thorough and complete cleaning (usually about 30 minutes to an hour). Daily cleaning helps achieve clearance dust levels by minimizing problems that may otherwise occur during final cleaning and limiting worker exposures. While daily cleaning can be skipped in vacant dwelling units, it is required when occupants will return in the evening. Under no circumstances should debris or plastic be left outside overnight in an unsecured area, even if the dwelling is vacant. Daily cleaning should consist of:

- Removing large debris.
- Removing small debris.
- HEPA vacuuming, wet clean, HEPA vacuuming (horizontal surfaces only).
- Cleaning exterior.
- Patching and repairing plastic sheeting.
- Securing debris/plastic.

Figure 14.7 Plastic Sheeting Should Be Repaired as Part of Daily Cleanup.

1. Large Debris

Large demolition-type debris (e.g., doors, windows, trim) should be wrapped in 6-mil plastic, sealed with tape, and moved to a secure area on the property designated for waste storage. All sharp corners, edges, and nails should be hammered down to prevent injury and minimize the tearing of plastic. It is not necessary to wrap each individual piece of debris in plastic if the entire load can be wrapped. A secure area either outside or inside the property must be designated as a temporary waste-storage area. Covered, secured, and labeled dumpsters placed on or near the property may be used. Proper segregation of waste should be enforced at this time (see Chapter 10).

2. Small Debris

After being misted with water, small debris should be swept up, collected, and disposed of properly. The swept debris should be placed in double 4-mil or single 6-mil polyethylene (or equivalent) plastic bags, properly sealed, and moved to the designated trash storage area. Trash bags should not be overloaded; overloaded bags may rupture or puncture during handling and transport.

3. Exterior Cleaning

Areas potentially affected by exterior lead hazard control should be protected via a containment system (see Chapter 8). Because weather can adversely affect the efficacy of exterior

containment, the surface plastic of the containment system should be removed at the end of each workday. On a daily basis, as well as during final cleaning, the immediate area should be examined visually to ensure that no debris has escaped containment. Any such debris should be raked or vacuumed and placed in single 6-mil or double 4-mil plastic bags, which should then be sealed and stored along with other contaminated debris. HEPA vacuuming is appropriate for hard exterior surfaces, not soil.

4. Worker Protection Measures

General worker protection measures are discussed in Chapter 9. Studies indicate that during daily cleaning activities, especially while wet sweeping, workers may be exposed to high levels of airborne dust. Therefore, workers should wear protective clothing and equipment, especially appropriate respirators.

5. Maintaining Containment

The integrity of the plastic sheeting used in a lead hazard control project must be maintained. During their daily cleaning activities, workers should monitor the sheeting and immediately repair any holes or rips with 6-mil plastic and duct tape.

V. Order of Final Cleaning Procedures After Lead Hazard Control

Before treated surfaces can be painted or sealed, final cleaning procedures must be completed. Because airborne dust requires time to settle, the final cleaning process should start no sooner than 1 hour after active lead hazard control has ceased in the room. See Appendix 11 for details regarding dust settling.

A. Final Cleaning

As the first stage in the final cleaning, floor plastic should be misted and swept as detailed earlier in this chapter. Upper-level plastic, such as that on cabinets and counters, should be removed first, after it has been misted with water *and cleaned.* All plastic should be folded carefully from the corners/ends to the middle to trap any remaining dust. Next, remove both layers of plastic from the floor.

Plastic sheets used to isolate contaminated rooms from noncontaminated rooms should remain in place until after the cleaning and removal of other plastic sheeting; these sheets may then be misted, cleaned, and removed last.

Removed plastic should be placed into double 4-mil or single 6-mil plastic bags, or plastic bags with equivalent (or better) performance characteristics, which are sealed and removed from the premises. As with daily cleanings, this plastic-removal process usually requires workers to use protective clothing and respirators.

After the plastic has been removed from the contaminated area, the entire area should be cleaned using the HEPA/wet wash/HEPA cycle, starting with the ceiling and working down to the floor. After surfaces are repainted or sealed, a final HEPA/wet wash/HEPA cycle may be necessary if accumulated dust caused by other work is visible.

1. Decontamination of Workers, Supplies, and Equipment

Decontamination is necessary to ensure that worker's families, other workers, and subsequent properties do not become contaminated. Specific procedures for proper decontamination of equipment, tools, and materials prior to their removal from lead hazard control containment areas should be implemented, as described below and in Chapters 9 and 10.

Work clothing, work shoes, and tools should not be placed in a worker's automobile unless they have been laundered or placed in sealed bags. All vacuums and tools that were used should be wiped down using sponges or rags with detergent solutions.

Consumable/disposable supplies, such as mop heads, sponges, and rags, should be replaced, after each dwelling is completed. Soiled items should be treated as contaminated debris (see Chapter 10).

Figure 14.8a Pick Up Corners of Plastic Sheeting.

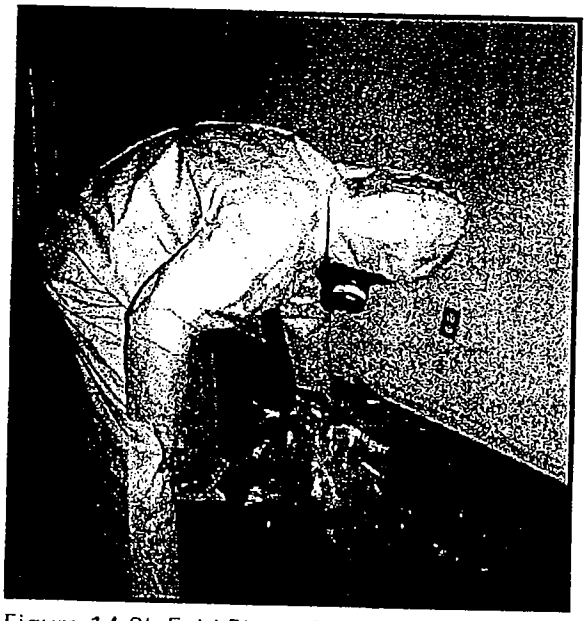


Figure 14.8b Fold Plastic Inward.

Durable equipment, such as power and hand tools, generators, and vehicles, should be cleaned prior to their removal from the site; the cleaning should consist of a thorough HEPA vacuuming followed by washing.

B. Preliminary Visual Examination

After the preliminary final cleaning effort is completed, the certified supervisor should visually evaluate the entire work area to ensure that all work has been completed and all visible dust and debris have been removed. While the preliminary examination may be performed by the lead hazard control supervisor, contractor, or owner as a preparatory step before the final clearance examination, it does not replace the independent visual assessment conducted during clearance.

If the visual examination results are unsatisfactory, affected surfaces must be retreated and/or recleaned. Therefore, it is more cost effective to have the supervisor rather than the clearance examiner perform this initial examination.

C. Surface Painting or Sealing of Nonfloor Surfaces

The next step of the cleaning process is painting or otherwise sealing all treated surfaces except floors.

Surfaces, including walls, ceilings, and woodwork, should be coated with an appropriate primer and repainted. Surfaces enclosed with vinyl, aluminum coil stock, and other materials traditionally not repainted are exempt from the painting provision.

D. Final Inspection

The final clearance evaluation should take place at least 1 hour after the final cleaning. Clearance has three purposes: 1) to ensure that the lead hazard control work is complete, 2) to detect the presence of leaded dust, and 3) to make sure that all treated surfaces have been repainted or otherwise sealed. Clearance is usually performed after the sealant is applied to the floor. See Chapter 15 for information on clearance examination procedures.

E. Recleaning After Clearance Failure

If after passing the final visual examination, the dwelling unit fails the clearance wipe dust tests,

the HEPA/wet wash/HEPA cleaning cycle should be carefully and methodically repeated. Failure is an indication that the cleaning has not been successful. Recleaning should be conducted under the direct supervision of a certified supervisor. Care should be exercised during the recleaning of "failed" surfaces or components to avoid recontaminating "cleared" surfaces or components.

VI. Cleaning Cost Considerations

An important consideration in determining lead hazard control strategies and methods is the cost and difficulty of required daily and final cleanup operations and the ease with which one can meet dust-clearance standards. A general rule of thumb is that lead hazard control strategies that generate the most dust will have higher cleanup costs and higher initial clearance test-failure rates.

A. Initial Clearance Test Failure Rates

The likelihood of passing final dust-clearance tests is highly correlated with the chosen intervention strategy, methods, and care exercised by the contractor. For example, in one study (HUD, 1991) initial wipe-test failure rates were 14 percent for interior window sills, 19 percent for floors, and 33 percent for window troughs. The pass/fail rates for each surface were strongly associated with the dwelling unit abatement strategy employed. Chemical removal and hand-scraping strategies experi-enced higher failure rates than replacement and encapsulation/enclosure strategies (see Table 14.1).

However, results of the HUD demonstration project indicated that clearance failure is not solely related to abatement method. The report stated that "the diligence and effectiveness of an abatement contractor's cleaning process ... had a major impact on ... the likelihood of the dwelling unit to pass the final wipe test clearance" (HUD, 1991).

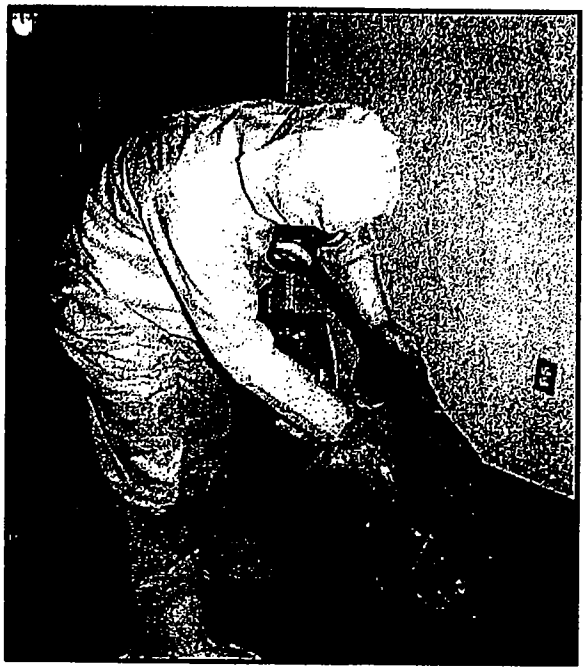


Figure 14.8c Dispose of Plastic Sheeting in a Plastic Trash Bag.

B. Key Factors In Effective Cleaning

Effective cleaning will be aided by adequate sealing of surfaces with polyethylene sheeting prior to lead hazard control, proper daily cleaning practices, good worker training, and attention to detail. Where poor worksite preparation is employed, additional cleaning may be required to meet clearance.

C. Special Problems

Surfaces such as porous concrete, old porous hardwood floors, and areas such as corners of rooms and window troughs pose especially difficult cleaning challenges. Porous concrete and corners of rooms normally require additional vacuuming to achieve an acceptable level of cleanliness.

The lead hazard control strategy of enclosure is frequently chosen for window troughs and for old porous hardwood floors due to the difficulty of adequately cleaning these surfaces. This

option provides not only a clean surface but a more permanently cleanable surface for dwelling occupants to maintain.

VII. Alternative Methods

Alternatives to the recommended cleaning tools and practices discussed in this chapter are available, some having significant potential for increasing effectiveness and lowering costs.

A recent Canadian study (CMHC, 1992) evaluated the effectiveness of contaminated dust cleanup activities using tools that would generally be available to construction contractors and homeowners. Vinyl flooring and carpeting were cleaned using several wet/dry vacuuming systems, sweeping, and wet mopping. The study found that regular vacuums with empty bags send a steady stream of fine particles into the air, while vacuums with partially filled bags were more efficient. This finding suggests the necessity for HEPA vacuums. Other vacuums may be used if workers do not experience increased exposures, if compliance with clearance standards is achieved, and if a variance from OSHA regulation (29 CFR 1926.62 (h)(4)) is obtained by the contractor or employer (if required).

Agitator heads on vacuums were demonstrated to significantly enhance vacuum effectiveness on carpets in cleaning up fine dust without increasing airborne dust levels. Table 14.2 suggests that a central vacuum with an agitator head is most efficient at removing dust and minimizing recontamination, probably because the vacuum exhaust is blown away from living areas. Because many houses do not have central vacuuming systems, a portable HEPA vacuum is the next best choice (see Table 14.2). Vacuums without agitator heads appeared to perform relatively poorly on carpets.

A. Vacuums

Regular (non-HEPA) dry vacuums potentially produce hazardous levels of airborne dust and therefore should be avoided. Externally exhausted vacuum units with adequate dust-retaining capability may be used. The OSHA lead standard requires the use of HEPA vacuum equipment (see 29 CFR 1926.62 (h)(4), which states, "where vacuuming methods are selected, the vacuums shall be equipped with HEPA filters").

B. Trisodium Phosphate and Other Detergents

TSP detergents have been used successfully for a number of years in lead hazard control work. However, in recent years, other new cleaning agents have been developed specifically for leaded dust removal. The need for alternatives has been fueled by the fact that TSP is an eye

Table 14.1 Initial Cleaning Wipe-Test Failure Rates for Various Abatement Strategies

Dust Test Location	Hand Scrape w/Heat Gun	Chemical Removal	Enclosure	Encapsulation	Replacement	All Methods
Floors	28.8%	22.7%	20.0%	13.8%	12.5%	19%
Sills	24.4%	24.1%	8.2%	4.8%	17.4%	14%
Wells	44.5%	45.7%	23.7%	25.7%	21.0%	33%

Source: U.S. Department of Housing and Urban Development (August 1991) The HUD Lead-Based Paint Abatement Demonstration (FHA)

and skin irritant and is increasingly restricted from household use and unavailable in many local jurisdictions. TSP also damages some finishes. Recently reported trials of two new products suggest that alternative lead-specific cleaning agents may be more effective and safer than TSP (Grawe, 1993; Wilson, 1993).

These *Guidelines* do not prohibit the use of non-TSP cleaning agents. HUD encourages further evaluation of alternative cleaning methods. Use of any cleaning agent that results in compliance with clearance criteria is encouraged.

Table 14.2 Mass Removal Efficiency for Extended Vacuuming Cycles

Cycle Number	Mass Removal Efficiency Percentages			
	Cleaning Method			
	Central Vacuum—Plain Tool	Central Vacuum—Agitator Head	HEPA Vacuum	Portable Vacuum—Plain Tool
1	34.7	71.0	55.4	17.5
2	47.0	80.2	61.2	23.0
3	51.9	85.9	66.3	26.6
4	56.0	87.8	67.0	29.4
5	59.3	88.9	72.1	32.5
6	61.6	91.2	74.4	34.9
7	63.8	93.1	76.4	36.5
8	67.5	95.4	77.5	38.1
9	67.5	97.7	78.7	40.1
10	67.2	100.0	80.2	41.7
11		102.3	80.2	41.7
12		104.6	84.1	44.8
13		104.6	84.5	46.8
14		103.8	84.5	48.4
15				49.6
16				50.8
17				52.4
18				53.6
19				54.4
20				55.2

Source: Canada Mortgage and Housing Corporation: Saskatchewan Research Council (December 1992) *Effectiveness of Clean-up Techniques for Leaded Paint Dust*

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Clearance: How To Do It

1. Decide who will conduct clearance. Clearance on all abatement projects and federally funded interim control work must be done by a certified risk assessor or inspector technician. The U.S. Department of Housing and Urban Development (HUD) strongly recommends the use of a certified risk assessor or inspector technician who is completely independent of the lead hazard control contractor to eliminate conflicts of interest. Some local jurisdictions may require a license to conduct clearance.

2. Finish the lead hazard control and cleanup effort. Seal floors before clearance testing (if necessary).

3. Wait 1 hour to allow any airborne dust to settle. Do not enter the work area during that hour.

4. Conduct visual examination.

   a. Determine if *all* required work has been completed and *all* lead-based paint hazards have been controlled.

   b. Determine if there is visible settled dust, paint chips, or debris in the interior or around the exterior.

5. Complete the Visual Clearance Form contained in this chapter; if all specified work was not completed, inform the owner and order completion of work and repeated cleanup, if necessary.

6. Conduct clearance dust sampling of floors, interior window sills, and window troughs using the protocol in this chapter.

7. Conduct clearance soil sampling if bare soil is present that was not sampled previously, or if exterior paint work was completed as part of the lead hazard control effort. Whenever exterior work has been done, it may be necessary to take samples from soil that is not bare to determine if contamination has occurred. If results are above 2,000 µg/g (or 400 µg/g in high contact play areas), compare the results to baseline soil sampling results to determine what additional measures are needed.

8. Complete the Dust and Soil Sampling Clearance Form contained in this chapter.

9. Submit samples to a U.S. Environmental Protection Agency (EPA) recognized laboratory participating in the National Lead Laboratory Accreditation Program (NLLAP) for analysis.

10. Interpret results by comparing them to the HUD Interim Clearance Standards contained in this chapter (until EPA issues its health-based leaded dust standards).

11. If clearance is achieved, go to step 15.

12. Order repeated cleaning or soil treatments if results are above applicable standards. Clean all surfaces the sample represents.

13. Continue sampling and repeated cleaning until the dwelling achieves compliance with all clearance standards.

14. Complete any related construction work that does not disturb a surface with lead-based paint (all work that does disturb painted surfaces or that could generate leaded dust should be completed as part of the lead hazard control effort).
15. Issue any necessary statements of lead-based paint compliance or releases and maintain appropriate records.
16. Permit residents into the cleared work area.

Chapter 15: Clearance

I. Introduction

A. Purpose of Clearance

Clearance refers to the various environmental evaluation procedures used to determine if:

- The lead hazard control work was actually completed as specified.
- The area is safe for unprotected workers to enter.
- The area is a safe place for residents and young children to live.

Since most lead hazard control work generates a considerable amount of leaded dust, and since previous studies have indicated that cleaning can be accomplished only with great care and skill (HUD, 1991), it is necessary to determine if the cleaning was successful. Some type of clearance is required for all forms of lead hazard control. Certified risk assessors or certified inspector technicians (clearance examiners) can best recommend the exact type of clearance testing to be employed on a specific project. The process outlined in this chapter provides a means of determining if lead hazards have been controlled.

B. Clearance as the Endpoint

If clearance criteria are met, the contractor who performed the work can conclude that the job is complete. However, if the clearance criteria are not met, the contractor must complete the work and/or repeat the cleaning process until the area is clean enough to meet clearance criteria. For example, if the job included the removal and replacement of all windows, but the clearance examiner determines that one window has been overlooked, the contractor must remove and replace it as originally specified (in addition to carrying out any necessary additional cleaning in that area). Similarly, if excessive leaded dust levels remain, the contractor's job cannot be considered complete until leaded dust levels are below clearance standards. Normally, the final payment to the contractor is withheld until compliance with clearance standards is achieved.

The clearance examination described in this chapter is similar to the punchlist that follows a typical construction or repair job. The major difference is that the normal visual check is almost always augmented with environmental testing since leaded dust and soil hazards are not visible to the naked eye.

The clearance examination protects *all* parties involved—the job contractor, the owner, and the resident. The process provides the contractor with an objective determination that the job was completed safely. The owner will have assurance that the abatement job was successful in correcting hazards and that the amount of leaded dust left after the work was completed is at a safe level. The resident can be certain that dangerous shortcuts were not taken during the work process and that resident children will be safe.

C. Conflicts of Interest

The owner should retain the services of a certified risk assessor or a certified inspector technician to determine compliance with clearance criteria. The clearance examiner must not be paid or employed, or otherwise compensated by the lead hazard control contractor and should have no vested interest in seeing that the job is completed on schedule. The clearance examiner's *only* concern should be that compliance with clearance standards has been achieved.

This does not mean that job supervisors should not perform their own visual assessments of the quality of the cleanup job performed by their workers. Such assessments will help ensure that clearance criteria are met the first time around.

Some owners of multiple dwelling units may wish to have lead hazard control work performed by their own trained crews, rather than

contract for such services. In this case it is essential that clearance testing be performed by an independent third party whose payment is not dependent on completion of the job within any particular time period.

The clearance procedures contained in this chapter should always be included in the job specifications so that performance responsibilities are clear.

II. Time Between Completion of Cleanup and Clearance

Clearance dust sampling should be performed no sooner than 1 hour after completion of the final cleanup to permit airborne leaded dust to settle. Clearance dust sampling is for *settled* leaded dust, not airborne leaded dust, since the main source of lead exposure for children is through contact with contaminated surfaces followed by ingestion. Most children in the United States. are *not* lead poisoned by inhalation (ATSDR, 1988). Airborne leaded dust sampling is not recommended for clearance purposes in lead hazard control work.

While often performed for asbestos abatement projects, air sampling does not appear to be a useful tool for determining if clearance has been achieved in lead hazard control work. Because asbestos fibers are known to have low settling velocities (that is, they take a long time to settle out of the air), air sampling can be used to determine the effectiveness of the cleanup effort in asbestos abatement jobs. But because dust particles typically generated during lead abatement jobs are larger, denser, more spherical, and heavier, settling time is much faster.

The U.S. Department of Housing and Urban Development's (HUD's) *Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing* recommended 24 hours as the minimum waiting period to allow airborne lead-contaminated particles to settle, although no justification for the 24-hour waiting period was provided (HUD, 1990a). The reduction in the waiting period before sampling from 24 hours to 1 hour marks an important change in the new recommendations. The current *Guidelines* recommend 1 hour because the additional amount of leaded dust that would settle onto floors after 1 hour is negligible. The analysis supporting this finding is summarized below. (A full description of the analysis can be found in Appendix 11.)

Analysis of the settling velocity of airborne leaded particulate has demonstrated that nearly all particulate greater than 5 μm in diameter will have settled out of the air within an hour. It is estimated that any remaining airborne particulate less than 5 μm would contribute no more than an additional 5 $\mu g/ft^2$ of lead to surface dust, even if all of it were to settle out of the air. This is well below the HUD Interim Clearance Standard for floors (100 $\mu g/ft^2$) and also well below the routine limit of quantitation for wipe sampling (25 $\mu g/ft^2$). Therefore, a reduction in the waiting period to 1 hour is justified. This change will contribute to significant cost savings by cutting 1 day off the length of the abatement job (reducing relocation costs and job delays). Entry into the area should be prohibited during the 1-hour waiting period to keep turbulence and re-entrainment of particulate matter to a minimum.

III. Visual Examination Procedures

Clearance occurs in two main phases: visual examination and environmental sampling (dust and, if exterior work was conducted, soil sampling). A standard Visual Clearance Form can be found at the end of this chapter (see Form 15.1).

A. Determination of Completed Work

A visual examination determines whether the work on all interior and exterior surfaces to be treated was in fact completed and to ensure that no visible settled leaded dust or debris are present. Visual clearance is a relatively straightforward process requiring an understanding of the scope of the job and a keen eye for detail. It is

essential that clearance examiners have full knowledge of the extent of the work and specifically which surfaces did *not* require treatment. The clearance examiner should have access to any risk assessment or paint inspection report as well as the job scope of work or specifications and a report from the owner or contractor that the work has been completed.

The visual examination of completed work should be done on a room-by-room basis to ensure that all areas are examined (this includes the exterior and common areas). In most cases the visual examination will be conducted by a clearance examiner when the environmental samples are collected.

When paint removal and repainting or soil removal and covering is planned, verification of the removal of the lead hazards will be necessary prior to the completion of work. In these instances the owner or a representative of the owner (which may be the hazard control contractor) may take responsibility for confirming that the hazard is removed prior to repainting or covering. This allows the owner to avoid the expense of having the clearance examiner travel to the job site twice—once to verify the hazard removal and again to collect environmental samples. On the other hand, owners may choose to have the clearance examiner confirm that the work was actually completed. Regardless of who verifies the hazard removal, verification should be documented on Form 15.1.

In multifamily housing of similar construction, it is not necessary to perform a visual examination of every single unit. Instead, a random sample of abated units can be visually examined before the paint is applied. The abatement contractor should not know ahead of time which units will be visually inspected prior to repainting. The random sample size can be determined by using the table for lead-based paint inspections (Table 7.3). Random sampling of single-family dwellings is not possible due to the large variability in construction and work. Therefore, each single-family dwelling should be cleared individually.

In the case of a child with an elevated blood lead level, local authorities may require that the treatment of all indicated surfaces be verified by a government employee or certified third party, especially in cases where the abatement has been ordered by local authorities. Clearance examiners should determine if the property they are investigating has been abated as a result of a legal or regulatory proceeding. If so, the enforcement agency should be contacted to coordinate clearance procedures, prevent duplication of effort and, most importantly, ensure that the private clearance process is not inadvertently overstepping the bounds of the normal practices of the local health department or childhood lead-poisoning prevention program.

1. Paint Removal and Repainting

All surfaces where paint has been removed should be visually examined *prior to repainting*. If clearance is conducted after new paint is applied, it is often impossible to determine if the old paint was actually removed. Areas commonly overlooked during paint removal projects include the underside of interior window sills and handrails, backside of radiator ribs, bottom edge of doors, top of doorframes, and the back edge of shelving.

For both onsite and offsite removal, the clearance examiner or the owner should examine the bare surfaces to ensure that there is no visible residue. If residue remains, the component should be cleaned prior to repainting or refinishing.

Wipe sampling and x-ray fluorescence (XRF) testing are not appropriate tools for determining the effectiveness of paint removal from a particular surface. Wipe sampling cannot dislodge any leaded dust that may have been absorbed into the substrate during the removal process, nor can it remove paint that is still bonded to the substrate. Wipe sampling is appropriate for measurement of settled leaded dust on floors, interior window sills, and window troughs. It is not appropriate to apply the settled leaded dust clearance standard to these components since the bare surface will be sealed with new paint,

thus rendering the dust inaccessible. Appendix 1 describes how much lead-contaminated dust can remain on a surface (at least 35,000 μg/ft²) before it would cause the newly applied paint to become lead-based paint (at 0.5 percent).

2. Building Component Removal and Replacement

If building components coated with lead-based paint were removed as a lead hazard control measure, the clearance examiner should have detailed knowledge of the scope of the replacement activities so that actual removal can be verified. Each building component specified for replacement should also be examined to determine if it was overlooked during the lead hazard control work.

3. Enclosures

Complete installation of enclosure systems, such as new drywall, paneling, or siding, can be best evaluated by direct visual observation. The clearance examiner should determine that the mechanical fastening system used to hold the enclosure to the substrate is adequate. This is especially important for ceilings. All seams and edges in the enclosure should be sealed to provide a "dust-tight," but not necessarily airtight, system.

4. Soil Treatments

Soil treatments, which typically consist of some form of covering or removal and/or replacement, can be assessed by direct visual observation to determine if the covering is present. For example, if sod or asphalt has been used as a soil covering, the clearance examiner should determine if all bare areas have been covered by the sod or asphalt, as specified.

No visible lead-based paint chips should be observed in soil following lead hazard control work. It is not necessary to turn over or rake soil to look for paint chips. A visual examination of the surface is adequate.

If exterior work on lead-based paint has been performed, baseline soil samples should have been collected but not necessarily analyzed until clearance soil samples have been collected, analyzed, and compared to clearance standards. It may be necessary to collect samples from soil that is not bare to determine if contamination has occurred. If post-hazard control soil levels are below applicable limits, the preabatement samples need not be analyzed. The clearance level for most soil is 2,000 μg/g (400 μg/g for small, high-contact play areas). If post-hazard control soil levels are greater than or equal to the applicable limits, the baseline samples should be analyzed to determine where additional work is needed. If paint chips originating from the work are identified in the soil, they should be picked up with a high-efficiency particulate air (HEPA) vacuum.

5. Encapsulants

Another category of lead hazard control that can best be assessed visually is the application of encapsulants. Assuming that the encapsulant was properly selected for the surface undergoing treatment and that patch tests were conducted as recommended in Chapter 13, the clearance examiner can determine if the encapsulant is in fact present.

6. Interim Controls

Visual examination of the wide variety of interim control measures consists of a confirmation that all lead-based paint (either suspected or identified through testing) is stabilized and that any friction, impact, and other surfaces marked for treatment in the risk assessment report or project specifications have all been properly treated. No known or suspected lead-based paint should be in a deteriorated condition in a cleared dwelling.

B. Visual Examination for Settled Dust and Debris

There should be no evidence of settled dust following a cleanup effort. If dust is observed, the contractor must be required to repeat the cleaning effort *before* clearance dust samples are collected to avoid conducting dust sampling twice. Any settled dust present following abatement or interim control work provides sufficient evidence that cleanup was not adequate (see Figure 15.1).

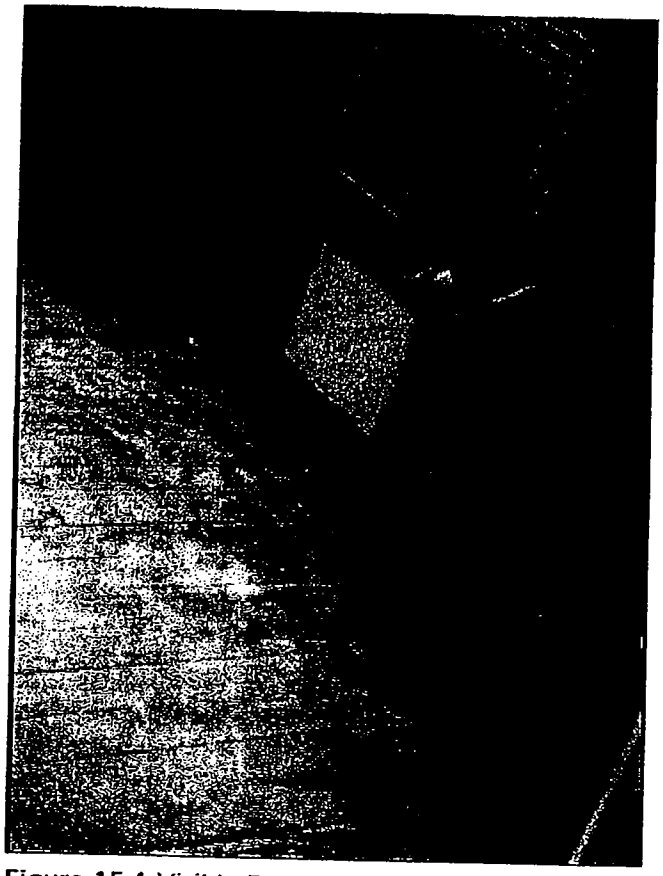


Figure 15.1 Visible Dust Indicates Cleaning Should Be Repeated.

Lead Tracking

Lead dust can be transported from one area to another on shoes.

Tracking lead dust from one area to another is a big problem on lead hazard control jobs. Lead dust can be tracked on shoes from the work area to the outside. Sometimes lead dust from the outside soil is tracked into the work area. Lead dust from a porch or nonwork area can get tracked into a cleaned area. When this happens, the whole area must be cleaned.

There are conflicting reports regarding the use of the so-called "white glove test" as part of the visual examination. Some housing agencies have indicated that they find this to be a useful preliminary examination tool, while others indicate that this test almost always shows some discoloration, even if surfaces have been cleaned well. Until it has been demonstrated to effectively predict leaded dust levels, use of the "white glove test" is left to the discretion of the examiner and is not recommended by HUD. The "white glove test" is not a substitute for laboratory analysis of dust samples.

Finally, the grounds around the dwelling should also be examined visually to make certain that all waste and debris have been removed and that leaded dust or paint chips were not transferred outside the dwelling. For example, waste should not be left at the curbside for trash pickup; all waste should be removed from the site. The examiner should be particularly conscientious about looking for paint chips when exterior components have been disturbed.

IV. Clearance Dust Sampling

A visual examination alone is not adequate for determining if a residence is safe for occupancy, since small dust particles are not visible to the naked eye. A person with normal eyesight cannot detect individual dust particles smaller than 50 μm in diameter (Olishifski, 1983). Data indicate that a significant percentage of the dust generated during abatement is smaller than 50 μm (Mamane, 1994; NIOSH,

1993b). Since these smaller dust particles are associated with an increased risk of lead poisoning, clearance dust testing is required to determine if a leaded dust hazard remains following lead hazard control work.

Unless U.S. Environmental Protection Agency (EPA) regulations establish different clearance levels, the following HUD clearance standards should be used, based on wipe sampling:

- 100 $\mu g/ft^2$ for floors.
- 500 $\mu g/ft^2$ for interior window sills.
- 800 $\mu g/ft^2$ for window troughs and exterior concrete or other rough surfaces.

There is no standard for vacuum sampling at this time.

Portable XRF analyzers have not yet demonstrated a capacity to detect dust lead levels in the range of interest. Wet chemical field test kits are also not sufficiently reliable for routine analysis of leaded dust at this time and do not yield quantitative data that can be compared to clearance standards.

Dust samples must be analyzed by laboratory methods such as atomic absorption spectroscopy, inductively coupled plasma-emission spectroscopy, laboratory XRF using standard methods, or other equivalent analytical methods (see Appendix 14). Only laboratories that participate in a national proficiency testing program and are recognized by EPA should be used.

If the dust sample from any surface indicates a leaded dust level above the clearance standard, all similar surfaces in the dwelling that sample represents (e.g., all interior window sills or floors) should be recleaned and retested. Only the similar components need to be recleaned, not necessarily the entire dwelling. If any such surface fails twice, the property owner should consider additional hazard control measures and/or further sealing of the surface. See sections D and VII for further disussion interpreting dust sampling results.

A. Multifamily Housing (20 or More Units)

It is possible to conduct clearance dust sampling in a number of randomly selected dwelling units in multifamily housing where similar dwelling units have undergone comparable types of lead hazard control activity. The random sampling can be performed for a portion of the housing development or for all of it. In either case the randomly selected units represent a specified group of housing units. The contractor must not know in advance which units will be sampled since this would bias the results. In addition, it is necessary to choose an adequate number of randomly selected units (Table 7.3). Significant cost savings could be realized with such a sampling plan.

However, the implications of random clearance sampling should be understood fully before it is used. First, if the random sampling shows that levels of leaded dust are too high, it will be necessary to reclean not only the affected component in the selected dwelling unit, but also the affected component in *all* the other units that the randomly selected unit was meant to represent. Alternatively, all the units represented by the randomly selected unit could be sampled individually to determine which ones need recleaning. The costs of repeated sampling should be compared with the costs of repeated cleaning. Regardless of whether all the represented units are sampled or recleaned, a further delay in permitting residents back into the area is possible when using random clearance sampling.

Second, insurance carriers covering lead hazard control work may demand a high degree of assurance that the work was performed properly in each and every dwelling. The extra cost of dust sampling in all units is likely to be minor compared to the liability of a child with an elevated blood lead level in an abated unit that was not sampled but was later found to contain high leaded dust levels.

Third, there has been a significant failure rate in attaining compliance with clearance dust standards in both the ongoing public housing program and the HUD Demonstration Project

(HUD, 1991). In the latter study, failure rates on the initial wipe tests were 19 percent for floors at 200 μg/ft², 14 percent for window sills, and 33 percent for window troughs. In one large abatement job for a public housing authority, 15 percent of the housing units failed the clearance tests and required recleaning (Jacobs, 1993a). While this failure rate can be partially attributed to abatement strategy, variable contractor performance, and perhaps the inexperience of the abatement industry, the high rate of failure argues for more extensive unit-by-unit testing.

In spite of all these caveats, there is one special situation that may lend itself well to random clearance sampling. A large *vacant* apartment building or housing development that will not be immediately reoccupied following abatement could conceivably be randomly sampled at the end of the project and, if necessary, completely recleaned. Alternatively, all units could be sampled to determine which ones require recleaning.

Whether random clearance sampling or unit-by-unit clearance sampling is performed, repeated sampling should *always* be performed in all units that required recleaning. In short, most cases of lead hazard control will require that clearance dust sampling be conducted in every unit treated. With additional research and innovative abatement and cleaning techniques that improve compliance rates with clearance dust standards, it may be possible to sample only a fraction of the units treated.

B. Single-Family Housing and Multifamily Housing (Fewer Than 20 Units)

Clearance dust sampling should be conducted in every single-family dwelling unit and in all multifamily housing with fewer than 20 units. Because treatment and housing conditions vary so greatly in these housing units, random sampling is inappropriate.

C. Clearance Dust Sampling and Floor Sealant Application

Wipe samples should be collected after application of a floor sealant, not before. In lead hazard control programs, coating floors with a sealant is often one of the final measures completed. The purpose of sealing floors is not to trap leaded dust underneath the sealant, but to provide a surface that can be cleaned effectively by the resident. The type of flooring determines the type of sealant. Wooden floors should either be painted with a deck enamel or coated with polyurethane, concrete floors should be sealed with a concrete sealant, and tile floors should be sealed with appropriate wax.

The maintenance and monitoring system should check the integrity of the floor sealant at least yearly.

D. Location and Number of Clearance Dust Samples

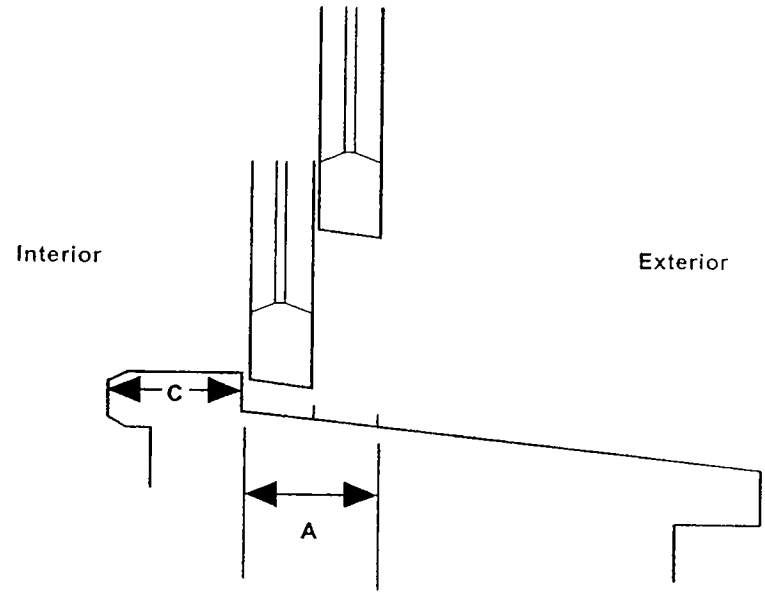
Clearance dust samples should be taken either from specific locations near the area where the lead hazard control treatment was done, from nearby high-traffic areas (around doorways, for example), or from other areas. The clearance examiner may determine which specific site is best based on the type of treatment, visual observation, and professional judgment. The abatement contractor must not know exactly where the clearance samples will be collected.

The number of clearance samples depends on whether composite or single-surface samples are collected.

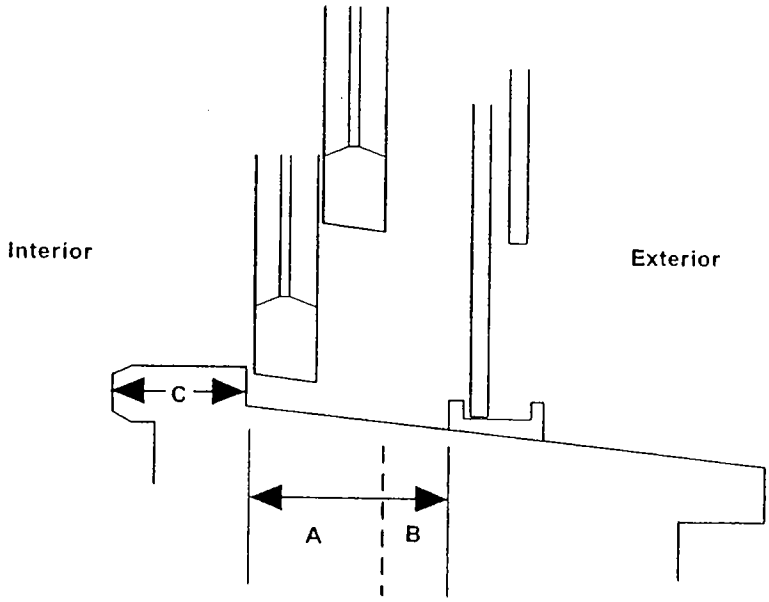
1. Single-Surface Sampling

Single-surface sampling can be conducted using essentially the same methodology as that described in Chapter 5 and Appendix 13. However, the number and location of clearance samples is based on the type of containment used and the number of rooms treated, not on the use pattern of the room (as is the case for risk assessment purposes). The three building components that should be tested are floors, interior window sills, and window troughs. A window trough is the part of the window in which both sashes sit when lowered. An interior window sill (sometimes called the stool) is the part of the window ledge facing the interior of the room (see Figure 15.2 for an illustration of areas to be sampled).

Figure 15.2 Window Locations for Dust Sampling.



1. Sectional view of window (with no storm window) showing window trough area, A, to be tested. Trough is the surface where both window sashes can touch the sill when lowered. The interior window sill (stool) is shown as area C. Interior window sills and window troughs should be sampled separately.



2. Sectional view of window (including storm window) showing window trough area, A and B, to be tested. Trough extends out to storm window frame. The interior window sill (stool) is shown as area C. Interior window sills and window troughs should be sampled separately.

Courtesy: Warren Friedman

The field sampling and analytical methods for collecting and analyzing wipe dust samples are in Appendixes 13 and 14, respectively. Until the EPA standards and protocols are established, wipe sampling should be performed on all surfaces. While vacuum samples can be collected, neither HUD nor EPA can provide standards to interpret vacuum sampling results at this time. Until vacuum sampling standards have been established, wipe sampling is the preferred method.

Readers should note that these *Guidelines* recommend the following precautions when conducting dust sampling (see Appendix 13.1):

- A standard sampling motion should be used.
- Only certain brands of wipes can be used (unless equivalence is demonstrated through side-by-side field sampling).
- Whatman™ filters and thick diaper wipes should not be used (Whatman™ filters are not sufficiently durable and some thick diaper wipes are too difficult for the laboratory to digest).
- Field-spiked wipe samples will need to be included in the sample stream in a blind fashion (i.e., the lab should not know the amount of lead spiked onto the wipe) to ascertain the efficiency of the laboratory digestion procedure.
- Hard-shelled containers (not plastic bags) must be used to contain wipe samples, since the container must be rinsed thoroughly and quantitatively. A nonsterilized 50-ml polypropylene centrifuge tube works well.

The minimum number of clearance samples recommended in each room is shown in Table 15.1. Field sampling data can be recorded on Form 15.2.

Further information on wipe sampling technique can be obtained from ASTM Standard ES-30-94.

2. Composite Clearance Dust Sampling

When lead hazard control treatments are similar in multiple rooms of the same dwelling, composite samples may be collected. For composite sampling each room treated must be included. The total number of required samples will depend on the number of rooms treated and whether those treatments are similar (see Table 15.1). Wipe samples are composited in the field, not in the laboratory, by inserting up to four wipes from four surfaces into the same tube. The laboratory analyzes all four wipes as one sample using a modified analytical procedure (see Appendix 13).

An example of a composite sampling scheme can be found in the example below. Field sampling data can be recorded on Form 15.2a.

The rules for combining subsamples into a sin-gle composite sample described in Chapter 5 for risk assessment also apply to clearance sampling. Those rules are as follows:

- Separate composite samples are required from carpeted and hard surfaces (e.g., a single composite sample should not be collected from both carpeted and bare floors).
- Separate composite samples are required from each different component sampled (e.g., a composite sample should not be collected from both floors and interior window sills).
- Separate composite samples are required for each dwelling.
- Floor surface areas sampled in each room should be approximately the same size (approximately 1 ft^2). Interior window sill and window trough sampling sizes are dependent on window characteristics, but should also be similar from room to room, if possible (e.g., the surface sampling area should not be skewed so that one room is oversampled).
- For composite wipe samples, a separate wipe must be used for each spot sampled (each subsample).

Table 15.1 Recommended Minimum Number and Location of Single-Surface Dust Samples

Clearance Category	Category Description	Number and Location of Single-Surface Wipe Samples in Each Area[1]	Number and Location of Composite Wipe Samples
1	Interior treatments No containment within dwelling	Two dust samples from at least four rooms in dwelling (whether treated or untreated): ✦ One interior window sill or window trough, alternating between rooms. ✦ One floor. AND ✦ For common areas, one for every 2,000 ft² of a common area room floor (if present).	Three composite samples for every batch of four rooms (whether treated or untreated): ✦ One floor composite. ✦ One interior window sill composite. ✦ One window trough composite. AND ✦ For common areas, one floor subsample for every 2,000 ft² (if present); up to 8,000 ft² can be sampled for each composite.
2	Interior treatments With containment (plastic sheeting as airlock on doors between treated and untreated areas)	Same as Category 1 but only in every *treated* room (up to four rooms) AND One floor sample outside the containment area but within 10 feet of the airlock to determine the effectiveness of the containment system. This extra single-surface sample is recommended in 20 percent of the treated dwellings in multifamily housing and *all* single-family homes. ✦ For common areas, one floor sample for every 2,000 ft² and one floor sample outside containment.	Same as Category 1 but only in every *treated* room AND One floor sample outside the containment area but within 10 feet of the airlock to determine the effectiveness of the containment system. This extra single-surface sample is recommended in 20 percent of the treated dwellings in multifamily housing and *all* single-family homes. ✦ For common areas, one floor subsample for every 2,000 ft² (up to 8,000 ft² for each composite) and one floor sample outside containment.
3	Exterior treatments	Two dust samples as follows: ✦ At least one dust sample on a horizontal surface in part of the outdoor living area (e.g., a porch floor or entryway). ✦ One window trough sample on each floor where exterior work was performed. An additional trough sample should be collected from a few lower floors to determine if troughs below the area were contaminated by the work above.	Two dust samples as follows: ✦ One composite on a horizontal surface in part of the outdoor living area (e.g., a porch floor or entryway). ✦ One window trough composite for every four floors where exterior work was performed, including lower floors where exterior work was not done, if present.
4	Routine maintenance work	At least 1 floor dust sample for every 20 high-hazard jobs near the work area (see Chapter 17 for definition of "high hazard").	Same as single-surface sampling.
5	Soil treatment	One dust sample from the entryway.	One dust sample from the entryway.

[1] A room includes a hallway or a stairway. If no window is present, collect just one floor sample. When a closet is treated, the room to which it is attached should be tested. A closet is not considered to be a separate room. If all rooms received similar treatments and cleaning, only four rooms need to be sampled for clearance purposes. More rooms may need to be sampled in larger dwellings. The room to be sampled should be selected based on where most of the dust-generating work was done or in the judgment of the clearance examiner.

- The same wipe should not be used to sample two different spots. All subsamples should be inserted into the same tube. No more than four different wipes should be inserted into a single container for a composite sample. Acceptable recovery rates have been found when no more than four wipes are analyzed as a single sample (Jacobs, 1993b).

Because composite sampling requires fewer samples than single-surface sampling, sampling costs may be reduced. Also, more surfaces are often sampled than would be possible for single-surface sampling. The drawback to composite sampling, however, is that if only one of the composite samples fails, all similar components in each room will have to be recleaned or each room will need to be sampled individually. In contrast, if one of the single-surface samples fails, only one room will have to be recleaned.

Composite samples should not be taken from rooms that have dramatically different conditions. For example, if the clearance examiner has some reason to believe that cleanup was not performed adequately in a room, a single-surface sample should be collected there. In some cases both single-surface samples and composite samples may be needed.

V. Clearance Soil Sampling

If no exterior lead hazard control work was performed, it is not necessary to conduct any soil sampling. Clearance soil sampling should be conducted following any abatement or interim control treatment on the exterior of a house or soil treatment. The purpose of such testing is to ensure that the treatment did not contaminate soil surrounding the dwelling.

Clearance soil sampling is typically conducted around the foundation of the house, although it is also important to collect samples in play areas that could have been contaminated as a result of the work. All soil samples should be composite samples. If the exterior work involved covering bare soil areas only, clearance soil samples are not needed; a visual examination is adequate. A detailed protocol for soil sampling is provided in Appendix 13 and ASTM ES–29–94. Sampling data can be recorded on Form 15.3.

There is evidence that soil lead levels can increase following abatement if proper precautions are not taken. For example, in one study, 6 percent of the dwellings had statistically significant increases in soil lead levels when compared to pre-abatement soil lead levels (NIOSH, 1990).

There should be no visible paint chips on the surface of the soil near the foundation. However, soil sampling near the foundations of dwellings is often complicated by the presence of paint chips embedded in or under the soil surface from previous repainting efforts. The hazard associated with these paint chips in the soil is difficult to assess since it is often not practical to sample all the different paint chips that may be present. Therefore, these paint chips should be considered a part of the soil. They should not be sampled preferentially or excluded when collecting or analyzing the soil. Laboratories should be instructed to disaggregate (force) paint chips through the soil sieve as part of the analytical process.

If the paint chips were generated by hazard control work, they should be picked up with a HEPA vacuum. A visual examination is usually adequate. If the clearance soil samples are above 2,000 µg/g in the yard (or 400 µg/g in bare, high-contact play areas), the baseline soil samples should be analyzed to determine if soil lead levels were already high before the work began. Soil samples collected during risk assessments (if one was performed) can be used for this purpose.

A. Multifamily Housing (20 or More Units)

If a large complex of multifamily housing has undergone similar lead hazard control work, random sampling of the soil around the buildings can be conducted using the sampling scheme for lead-based paint inspection. The drawbacks of conducting random clearance sampling are the same for soil as for dust (see the section on clearance dust sampling earlier in this chapter).

Example of Clearance Composite Sampling Scheme

A house has undergone an abatement job involving extensive interior paint removal (clearance category 1) and has passed a visual examination. The owner and the clearance examiner have agreed to use composite clearance dust sampling to minimize expenses. The house has eight rooms that were treated, four of which are carpeted, and all of which have windows.

At a minimum, the clearance examiner should collect the following samples:

No.	Description
1	Composite carpeted floor sample (one subsample from each of the four carpeted rooms).
1	Composite hard floor sample (one subsample from each of the four uncarpeted rooms).
1	Composite interior window sill sample, with a subsample collected from a location in four selected rooms.
1	Composite window trough sample, using the same procedure as for interior window sills.

This results in a total of four composite samples for analysis. If single-surface sampling had been completed under the recommendations in Table 15.1, it would have been necessary to collect eight samples (four rooms x two samples/room = eight samples/dwelling).

B. Single-Family Housing

If exterior lead hazard control work was done, composite soil samples should be collected near the building foundation close to the work area and in nearby play areas that could have been contaminated by the work. All single-family housing units should be cleared.

C. Number and Location of Clearance Soil Samples at Each Building

One composite soil sample should be collected around the perimeter of the building. If only selected faces of the building were treated, the samples should come from those faces.

A second composite soil sample should be collected from any nearby play areas.

In both cases bare soil should be sampled preferentially. If there is no bare soil, the soil covering should be sampled to determine if it has been contaminated by the lead hazard control work.

VI. Clearance Paint Testing

XRF testing of surfaces that have been stripped and repainted is not recommended. If the paint has been removed, removal should be assessed visually prior to repainting. If for some reason it is not possible to visually determine that the paint has been removed, then XRF readings can be taken. The protocols described in Chapter 7 apply.

Some forms of interim control involve paint film stabilization (repainting). In this case the clearance examiner must visually inspect all painted surfaces to determine if they are all sealed, intact, smooth, and cleanable.

VII. Interpretation of Clearance Testing Results

A. Visual Examination Results

Interpreting the results of the visual examination is a straightforward process. If there is visual evidence that work on building components or soil is incomplete, the clearance examiner should inform the owner and contractor and ensure that the work is completed *before collecting any dust or soil samples*. In situations where job specifications are used, they should clearly state that failure to pass the clearance visual examination means failure to comply with clearance standards.

Table 15.2 Interim HUD Clearance Dust Standards (Wipe Sampling Only)[1]

Surface	Leaded Dust Loading (µg/ft²)	Leaded Dust Loading (mg/m²)[2]
Bare and carpeted floors	100	1.08
Interior window sills	500	5.38
Window troughs	800	8.61
Exterior concrete or other rough surfaces	800	8.61

[1] No clearance standards are currently available for vacuum sampling.

[2] To convert from µg/ft² to mg/m², multiply by 0.01076.

B. Dust Results

Interim HUD clearance dust standards are shown in Table 15.2. These may be revised subject to EPA's issuance of regulations.

No standard method has been developed to correlate the wide variety of vacuum methods available with the wipe sampling standards. Until and unless EPA regulations state otherwise, all hard surfaces should be tested with wet wipe samples. While vacuum sampling is acceptable, there is no HUD Interim Clearance Standard for vacuum sampling at this time, making interpretation of vacuum sampling results against recognized standards impossible.

The results of dust samples collected using a vacuum method may be reported in lead concentration (µg/g) and loading (µg/ft²); wipe sampling results are reported in loading only. For clearance purposes, however, the lead concentration cannot be used to determine the effectiveness of the cleanup. It is possible to remove nearly all leaded dust from a surface, but not change its concentration significantly, since most cleaning methods do not preferentially remove lead from the dust. However, adding lead-free soil or dust to the area *will* reduce the concentration, even in the absence of cleaning. In short, leaded dust loading (not leaded dust concentration) should be used to determine if an adequate cleanup job has been completed. If leaded dust levels exceed those given in Table 15.2, the contractor must repeat the cleaning until compliance is achieved.

The recleaning should be focused on those surfaces where the sampling results indicate that the first round of cleaning was inadequate. For example, if floor leaded dust levels are above the standard, but interior window sills and window troughs are below the standard, only the floors need to be recleaned. Similarly, if single-surface samples fail in one room, then only that room and any rooms not sampled need to be recleaned. If composite samples fail, then *all* the surfaces the composite represents need to be recleaned (or resampled individually to determine which ones require recleaning). For example, consider the two examples shown in Tables 15.3 and 15.4.

In Table 15.3, only the floors in Rooms 1 and 2 require recleaning (assuming a four-room unit). In Table 15.4 the window troughs should be recleaned in all four rooms and any rooms not sampled. While the window troughs could conceivably be sampled individually to determine which ones require recleaning, it is likely to be far more cost-effective to simply reclean all of them. When cleaning troughs, the sills should also be cleared, even if they were not originally contaminated. In both examples, repeated sampling of the recleaned surfaces should be completed to ensure that the recleaning was sufficiently effective.

For composite sampling the HUD Interim Clearance Standard should *not* be reduced by dividing the standard by the number of subsamples in the composite. The purpose of the

Table 15.3 Hypothetical Example of Single-Surface Clearance Dust Sampling Data

Room	Floors (µg/ft²)	Interior Sills (µg/ft²)	Window Troughs (µg/ft²)
1	475	40	60
2	878	65	90
3	30	70	75
4	50	40	80

Table 15.4 Hypothetical Example of Composite Clearance Dust Sampling Data

Surface	Rooms Included in Composite	Leaded Dust (µg/ft²)
Floors	1, 2, 3, 4	30
Interior window sills	1, 2, 3, 4	129
Window troughs	1, 2, 3, 4	3,695

composite sample is to average the lead loading in all rooms sampled to determine if *all* the rooms require additional cleaning. Composite sampling is used to determine the average lead loading in a group of rooms, not individual rooms. Since composite sampling is done in units with the same hazard control technique and since the method of correction is always the same (i.e., recleaning), it is not necessary to determine the leaded dust level in each room. Even a single-surface sample only represents a small area on a larger surface, in much the same way as a composite represents many surfaces over a larger area, e.g., all floors within a unit. For paint chip sampling, however, it *is* necessary to know the concentration on each surface sampled, making it necessary to divide the paint standard by the number of subsamples contained in a composite sample (see Chapter 5).

C. Soil Results

If clearance sampling shows that post-abatement soil samples are more than 2,000 µg/g, additional soil treatment should be required. If the area sampled is a high-contact play area, the soil should be no more than 400 µg/g.

VIII. Recordkeeping and Issuance of Statement of Lead-Based Paint Compliance

A. Recordkeeping Responsibilities

Three parties should maintain records of all abatement, interim control, risk assessment, inspection, and clearance results:

- Property owner.
- Contractor.
- Clearance examiner.

Some jurisdictions will also require submission of such records to an enforcement agency or a lead-safe housing registry.

B. Record Content

The records should include all laboratory results, quality control/quality assurance procedures, dates of both visual examination and environmental sampling, completed forms,

and appropriate identifiers for the property—the owner, inspector, job contractor, and resident(s).

Depending on the jurisdiction and the type of abatement or interim control work undertaken, the owner may be awarded a Statement of Lead-Based Paint Compliance. One State now issues a statement indicating that the property is "Lead-Free" when all lead-based paint is removed and all other lead hazards are corrected. The property is "Lead-Safe" when all lead-based paint *hazards* have been rectified (Rhode Island, 1993).

C. Length of Time

Statements of lead-based paint compliance and records of all clearance testing should be kept for the duration of the life of the building, since it is to the benefit of the owners to retain this information.

IX. Clearance and Reevaluation Procedures

The clearance process evaluates the effectiveness of the lead hazard control efforts immediately following cleanup. Reevaluation determines the continued effectiveness of all lead hazard control treatments (except complete removal of all lead-based paint). Reevaluation also determines whether any new lead-based paint hazards have appeared. Because most forms of lead hazard control have limited lifespans, they will require ongoing monitoring by the owner and a reevaluation by a certified risk assessor based on the reevaluation schedule for the specific property. The method and frequency of reevaluation is detailed in Chapter 6.

In those cases where the owner did not have a risk assessment or inspection before hazard control, the clearance examiner should conduct a risk assessment at the time of clearance to ensure that all lead-based paint hazards were, in fact, addressed.

Form 15.1
Lead Hazard Control Visual Clearance Form

Date _____

Name of clearance examiner _____

License no. (if applicable) _____

Name of property owner _____

Property address _____ Apt. no._____

Date cleanup completed _____

Time cleanup completed _____

Abatement/interim control contractor name _____

Address _____

Telephone no. _____

Check if repeat clearance examination _____

Room identifier	List all building components required to be treated in each room	Work on each component completed? (yes or no)	Visible paint chips seen? (yes or no)	Visible settled dust seen? (yes or no)	Additional work required?

Exterior soil _____Treated _____Not treated

If treated, is bare soil present? _____Yes _____No

Was contaminated soil removed? _____Yes _____No

Is additional soil treatment required? _____Yes _____No

NOTES:

Signature _____

Form 15.2
Lead Hazard Control Clearance Dust Sampling Form (Single-Surface Sampling)

Date _____

Name of clearance examiner _____

License no. (if applicable) _____

Name of property owner _____

Property address _____ Apt. no. _____

Clearance categories:

1. Interior treatments without containment.
2. Interior teatments with containment.
3. Exterior work on painted surfaces.
4. Routine maintenance.
5. Soil work.

Sample number	Room number or identifier	Surface type (floor, interior window sill, window trough)	Clearance category number	Dimensions of sample area (inches)	Area (ft^2) (can be completed by lab)	Result of lab analysis ($\mu g/ft^2$) (can be completed by lab)	Pass or Fail

Total number of samples on this page_____

Page _____ of _____

Date of sample collection ____/____/____ Date shipped to lab ____/____/____

Shipped by _____ Received by _____
(Signature) (Signature)

Form 15.2a
Lead Hazard Control Clearance Dust Sampling Form (Composite Sampling)

Date _____

Name of clearance examiner _____

License no. (if applicable) _____

Name of property owner _____

Property address _____ Apt. no._____

Clearance categories:

1. Interior treatments without containment.
2. Interior treatments with containment.
3. Exterior work on painted surfaces.
4. Routine maintenance.
5. Soil work.

Sample number	Name of room or identifiers included in sample	Dimensions of surface sampled in each room (inches x inches)	Total surface area sampled (ft^2)	Type of surface sampled (smooth floors, carpeted floors, interior window sills, window troughs)	Clearance category number	Lab result ($\mu g/ft^2$)	Pass or fail
	_____ _____ _____ _____	_____ X _____ _____ X _____ _____ X _____ _____ X _____					
	_____ _____ _____ _____	_____ X _____ _____ X _____ _____ X _____ _____ X _____					
	_____ _____ _____ _____	_____ X _____ _____ X _____ _____ X _____ _____ X _____					
	_____ _____ _____ _____	_____ X _____ _____ X _____ _____ X _____ _____ X _____					

Total number of samples on this page _____

Page _____ of _____

Date of sample collection ____/____/____ Date shipped to lab ____/____/____

Shipped by _____ Received by _____
(Signature) (Signature)

Form 15.3
Lead Hazard Control Clearance Soil Sampling Form (Composite Sampling Only)

Date _____

Name of clearance examiner _____

License no. (if applicable) _____

Name of property owner _____

Property address _____ Apt. no. _____

Sample number	Location	Bare or covered	Lab result (µg/g)
	building perimeter		
	building perimeter		

Sketch soil sampling plot plan. Collect only the top 1/2" of soil.

Total number of samples on this page _____

Page _____ of _____

Date of sample collection ____/____/____ Date shipped to lab ____/____/____

Shipped by _____ Received by _____
(Signature) (Signature)