HOW MUCH CLEANING IS ENOUGH?

AN EVALUATION OF ALTERNATIVE POST-LEAD HAZARD INTERVENTION CLEANING PROCEDURES

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Abstract

This study evaluated and compared two procedures to clean lead dust and debris after lead hazard control activities were completed in housing with lead-based paint hazards. 1995 Federal guidelines prepared by the U.S. Department of Housing and Urban Development for the control of lead-based paint hazards in housing strongly recommend that after lead hazard control interventions all walls, ceilings, floors and other horizontal surfaces be cleaned using a three step process – an initial HEPA vacuum, wet wash with a lead cleaner, and a final HEPA vacuum. This study evaluated the effectiveness of the recommended three step procedure and compared this process to a two step procedure that omits the final HEPA vacuum. Cleaning procedures were evaluated in twenty-seven dwelling units that had undergone significant lead hazard control interventions likely to produce lead dust. Dust lead samples were collected on floors and in window sills and troughs prior to the lead hazard intervention, after the wet wash step of the cleaning procedure, and after completion of the second HEPA vacuuming. The results of the study demonstrate that dust lead surface loading on smooth and cleanable surfaces following both the three step and two step cleaning procedures can achieve 1995 Federal guidance dust clearance levels and levels substantially lower. Dust lead levels measured after the two step cleaning procedure are similar to levels measured after a three step cleaning procedure. While the benefits from a second HEPA vacuum are difficult to measure, the results suggest that the time saved by omitting the second HEPA is small relative to the other elements of the cleaning process.

Keywords: lead dust, cleaning after lead controls

INTRODUCTION

Children living in housing with deteriorated lead-based paint and lead in household dust are at risk of having elevated blood lead levels.1 Current lead hazard control strategies are designed to control lead-based paint hazards. (Lead-based paint hazards are defined by the Residential Lead-Based Paint Act of 1992 -- commonly known as "Title X"-- as: deteriorated lead-based paint; lead-contaminated dust and soil; and lead on friction, impact or accessible surfaces.) Numerous studies have documented that lead hazard control work where special precautions are not taken to contain lead dust and debris is associated with increases in blood lead levels of children who reoccupy such units.2,3,4

Cleaning has been shown to be an effective means of controlling lead-contaminated dust and is a critical element of lead hazard reduction strategies. Several studies have demonstrated the importance of cleaning lead dust in achieving low dust lead levels after the lead hazard reduction work and reductions in children's blood lead levels.5,6 Over a decade ago researchers concluded "if in our zeal to remove lead-based paint we fail to clean up after ourselves, we could be increasing the quantity of bioavailable lead in the child's environment."7 More recent studies continue to demonstrate how critical cleaning is at the conclusion of interventions to remove lead-based paint or control lead-based paint hazards.8 One comprehensive review of studies examining whether lead hazard control interventions are successful at reducing dust lead levels and children's blood lead levels concluded that "regardless of the method used, however, neither abatement nor interim control measures can be considered "safe" until the dwelling has been thoroughly cleaned and passed clearance testing."9 These studies collectively have led the U.S. Department of Housing and Urban Development (HUD) in its current Guidelines For The Evaluation and Control Of Lead-Based Paint Hazards in Housing (the HUD Guidelines) to state that cleaning is a recognized element of all lead hazard control activities.10

Despite this widespread recognition of the value of cleaning, there are relatively few published studies addressing the practical issues associated with cleaning. This is particularly troubling because contractors often fail to clean sufficiently to achieve clearance levels. For example, 28% of the first 2217 dwellings undergoing lead hazard control activities as part of the National Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program (the National Evaluation) failed to pass 1995 Federal dust clearance levels on the first attempt (i.e., at least one dust sample collected in a dwelling unit after the intervention and cleaning was above applicable standards).11 1995 Federal dust clearance levels specified in HUD and U.S. Environmental Protection Agency (EPA) guidance are 100 µg/ft2 for floors, 500 µg/ft2 for window sills and 800 µg/ft2 for window troughs.12 The implication of the clearance failures in the National Evaluation is that nearly one third of the units required additional cleaning and a second set of dust clearance samples resulting in significant additional costs.13

Practical advice to improve dust clearance rates is scant. One published study noted substantial differences in cleaning efficiencies on uncarpeted floors versus carpeted floors.14 This study concluded that it is very difficult to remove lead dust from carpets even when a combined vacuuming and shampooing process is followed. Further, the study concluded that the efficiency of vacuum cleaners on bare floors varied considerably according to the type of surface. The relative efficiencies of a wide range of wet cleaners (both lead-specialized and commercial cleaners) was assessed by EPA in a laboratory using smooth, cleanable surfaces. That report concluded that commercial cleaners hold promise as alternatives to lead specialized cleaners (i.e., trisodium phosphate) in removing lead dust.15

Given the scarce resources available for lead hazard controls, we must strive to make units safe to reoccupy after lead interventions without incurring unnecessary costs. The greatest variable in cleaning costs is typically labor and thus strategies to minimize cleaning will reduce costs. The HUD Guidelines instruct contractors to conduct post lead hazard intervention cleaning procedures necessary to meet dust clearance levels. Although the HUD Guidelines do not require the use of one specific procedure, the HUD Guidelines strongly recommend that all walls, ceilings, floors and other horizontal surfaces (e.g., window sills and troughs) be cleaned using a three step process – 1) initial HEPA vacuum, 2) wet wash with a lead cleaner, 3) final HEPA vacuum.16

This paper evaluated and compared the effectiveness of the three step cleaning procedure identified above and a two step cleaning procedure (one that omits the final HEPA vacuum).

METHODS

Units Enrolled

27 units from the state of Vermont were included in the study. All study units participated in the National Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program. Units undergoing lead hazard control work between February 1996 and April 1997 were enrolled in the study if:

- deteriorated lead-based paint or contaminated lead dust (as defined in the HUD Guidelines) was identified during pre-intervention sampling; and
- the lead hazard control measure pursued was window replacement or window treatment in combination with one or more of the following: paint stabilization, paint removal, enclosure.17

Description of Cleaning Protocol

A Vermont certified lead contractor conducted the cleaning. Cleaning crews consisted of a supervisor and up to two additional workers. The supervisor had completed a Vermont lead abatement supervisor course and workers had completed a Vermont lead worker course.

All horizontal surfaces, walls and ceilings were HEPA vacuumed using one of three machines (NilfiskVT 60 wet/dry HEPA vacuum; Activac 84150 dry only HEPA vacuum; or an Abatement Technologies model V1600 wet/dry HEPA vacuum). These same surfaces were then wet washed using trisodium phosphate (TSP). TSP was diluted at a ratio of 15:1 when mopping floors. Smaller areas (e.g., windows, baseboards), walls and ceilings were wiped clean with disposable towels that had been sprayed with the TSP solution diluted at a 3:1 ratio. A final HEPA vacuum of all horizontal surfaces as well as walls and ceilings was completed after the dust wipes were collected following the wet wash.

Data Collected

Data on the housing characteristics of each dwelling unit and the resident household were obtained through a questionnaire at the time of enrollment. Data were also collected on the types and costs of lead hazard control work and non lead renovation work (done in conjunction with the lead work) as well as the time expended during cleaning.

Dust wipes samples were obtained prior to the lead hazard intervention and at two stages during the cleaning procedures following the lead hazard control work – after the HEPA vacuum/wet wash and after the second HEPA vacuuming step. Dust wipes samples were collected on uncarpeted floors, window sills and window troughs. (A window trough is the exterior portion of a window sill where the window sash rests when closed. The trough extends out to the storm window or sill ledge if no storm window is present.) The condition of the surface sampled was characterized at the time samples were collected as good, fair or poor using criteria defined by the National Evaluation.18 All data were electronically entered into a customized database system and underwent QA/QC procedures followed by the National Evaluation.19

Floor dust samples were collected using a 7” by 7” template in 1 to 3 of the following locations: interior entry, kitchen, child’s play room (or living room), or youngest child’s bedroom (or smallest bedroom). Pre-intervention samples were collected from an area slightly to the left of the center of the doorway, post wet-wash samples were collected four feet inside the doorway, while samples collected after the second HEPA vacuum were taken slightly to the right of the center of the doorway. Window dust samples (sill or trough) were collected in 1 to 3 of the following locations: kitchen, child’s play room or living room, youngest child’s bedroom, or next youngest child’s bedroom (if present).

Pre-intervention and post-wet wash samples were collected on the left side of the sill or trough while samples collected after the second HEPA vacuum were taken on the right side. The possible "cleaning effect"of the pre-intervention dust wipe on the post-wet wash (which was collected in the same location) was expected to be minimal since the surfaces were either replaced during the lead work or significant dust generation occurred during the work which would likely overwhelm the initial cleaning effect.

Laboratory Analyses of Dust Samples

Dust samples were submitted to an EPA-recognized laboratory for analysis. One blank sample was submitted each day. Samples with known quantities of lead were also submitted to the laboratory as a means of assessing the ability of the laboratory to accurately and reliably measure known or "true" values at a rate of 1 every 50 samples submitted. During the time period of sample analysis, the laboratory met the National Evaluation quality control criteria.20 Dust samples were analyzed by flame atomic absorption. The detection limit was less than 10 µg per sample.

Data Analysis

The analysis used data from uncarpeted floors, window sills and window troughs where dust lead levels were measured on the same surface after the wet wash and after the second HEPA vacuum. There was a total of 122 sample locations from 82 rooms in 27 units: 49 uncarpeted floors from 26 units, 43 window sills from 26 units and 30 window troughs from 24 units. No room had more than one sample of a specific surface type (i.e., uncarpeted floor, sill, trough).

RESULTS

Description of Units

The study was conducted in 27 units (nine buildings) located throughout the state of Vermont. All of the units were constructed prior to 1920. Twenty-five of the units were in buildings with three or more units, two were in duplexes.

Pre-Intervention Description of Surfaces Included in This Study

Table I presents: the median, maximum and minimum pre-intervention dust lead loading levels for all study locations; the percentage of the samples that exceed the 1995 Federal guidance for lead-contaminated dust indicating that a lead-based paint hazard exists; and the percentage of sample surfaces in fair or poor condition.

Description of Lead Hazard Control Work

Significant lead hazard control work that had the potential to generate lead contaminated dust was undertaken in all study units. The average lead hazard control cost was $4,500/unit. These costs ranged from $1,200/unit to $12,300/unit. 81% of the units also underwent significant non lead renovation work directly after the lead work was completed. The average cost of the non lead renovation work was $32,300/unit. As expected with significant lead hazard control work, many of the study surfaces were treated. The dominant treatment for window troughs and sills was enclosure and paint removal, respectively. Many more study surfaces were treated as part of non lead renovation work. Dust clearance testing occurred after completion of the lead hazard control work, and, in units where non lead renovation work occurred, dust clearance testing was done after all work was completed. At clearance, 98% of floors and all windows sills and troughs were rated as being in "good" condition indicating that they were smooth and cleanable.

Description of Cleaning Procedures

Table II provides information on the cleaning procedures followed. Cleaning time is expressed in person minutes to provide a common metric. The first HEPA, wet wash and second HEPA averaged 67 minutes, 88 minutes and 16 minutes, respectively. The overall cleaning procedure averaged 171 minutes or 18 minutes per 100 square feet of living space. The first HEPA took significantly more time than the second. One explanation may be because the majority of debris is picked up in the first two steps. Cleaning costs ranged from $99/unit to $570/unit, with an average cost of $287/unit. Cleaning accounted for approximately 5% of the total lead hazard control costs.

Dust Lead Levels Post-Wet Wash and Post-Second HEPA Vacuum

The majority of dust lead levels observed after the wet wash and after the second HEPA vacuum were below the laboratory's limit of detection. Although the laboratory's limit of detection was less than 10 µg per sample, the effective limit of detection in terms of lead loading (µg/ft2) is frequently higher than 10 µg/ft2 since the sampling area is often less than one square foot.

Table III gives the percentage of samples below a range of potential clearance levels. For each surface, post-wet wash and post-second HEPA vacuum dust lead levels were very low. In fact, 96% of the uncarpeted floors and 100% of the sills and troughs passed 1995 Federal clearance levels following both the wet wash and the second HEPA vacuuming (see Table III). Although 4% and 0% are generally acceptably low clearance failure rates, further assessment is needed since the sample sizes are relatively small. Assuming the dust samples taken as part of this study are a sample from a larger population of units undergoing similar lead hazard control activities, dust testing and cleaning procedures, the overall clearance failure rate for the larger population can be considered as the "true" clearance failure rate for this larger population. To determine if there is 95% confidence that the "true" clearance failure rate is sufficiently low given the observed failure rate, the upper bound for the "true" clearance failure rate was considered.21 Table IV gives the 95% upper confidence bounds for the "true" clearance failure rate after the wet wash. The 95% upper confidence bound of the "true" clearance failure rate was 12.9% for floors, 6.7% for sills and 9.5% for troughs after completion of the HEPA/wet wash and identical probabilities were estimated after completion of the HEPA/wet wash/HEPA. Although the observed clearance failure rates are acceptable, due to the small sample sizes the upper confidence bounds are probably not acceptable. EPA is considering lowering clearance levels for floors and window sills in forthcoming standards.22 If these clearance levels were divided in half for floors and sills, over 98% of sill samples and 90% of floor samples would have passed clearance even though the contractor was asked to meet the existing less stringent standard.

Clearance passage rates are similar post-wet wash and post-second HEPA across all cut-offs considered in Table III. However, in some cases there were different clearance outcomes post-wet wash and post-second HEPA. If the dust lead level is lower after the second HEPA, it appears that the second HEPA worked in lowering dust lead levels. If the level is higher after the second HEPA, it is possible that the surfaces were contaminated during the cleaning process by worker activity and/or equipment. Using 1995 Federal dust clearance levels: one floor fails post-wet wash and passes post-second HEPA; one passes post-wet wash and fails post-second HEPA; one fails at both times; and forty-three floors pass clearance post-wet wash and post-second HEPA. No sills or troughs fail Federal dust clearance levels at either point in the cleaning process.

The levels observed post-wet wash and post-second HEPA were so low that the majority of the surfaces were below the laboratory's limit of detection at both times: 80% of uncarpeted floors, 63% of window sills and 37% of the window troughs. Thus, the quantitative difference in dust lead loading between the two cleaning cycles were not investigated.

DISCUSSION/CONCLUSIONS

This study showed that it is possible to achieve extremely low dust lead levels that pass 1995 Federal dust clearance levels with a significant margin of safety following both a three step HEPA vacuum/wet wash/HEPA vacuum and even a more limited two step HEPA vacuum/wet wash cleaning protocol. In addition, it was difficult to measure any further reduction in dust lead levels resulting from a second HEPA vacuum following the wet wash during a post-intervention cleaning procedure because of the detection limits utilized. All of the window sills and window troughs and 96% of the floors achieved clearance following both a three step and two step cleaning procedure and the upper confidence bound of the clearance failure rate was identical after the wet wash and final HEPA. EPA is considering lowering these clearance levels on floors and window sills in forthcoming standards. Even at half the current clearance levels for floors and sills, over

90% of floors and 98% of sills would have achieved clearance after the two pass or three pass cleaning procedures. It is important to recognize that these results were achieved in units where substantial lead hazard control work occurred, surfaces were left in a smooth and cleanable condition, and no visible lead debris or dust was present before beginning the cleaning process. The results may not be applicable to units in different physical condition.

While there did not appear to be any measurable reduction in dust lead levels following a second HEPA vacuum, the results also suggest that the time saved by omitting the second HEPA is small relative to the other elements of the cleaning process. The second HEPA vacuum took on average 10% of the overall cleaning time (for an average unit 16 minutes out of a total of 171 minutes was devoted to the final HEPA).

Although these results showed promise that a two pass cleaning procedure can be effective, the sample size was not sufficient to conclude that an acceptably low proportion of surfaces fail clearance after the wet wash or after the second HEPA. With this limitation in mind, this study suggests that contracts for lead hazard control work may not need to require a three step cleaning process if the contractor can demonstrate that they can achieve acceptably low dust lead levels following a more streamlined protocol. Given the promise of a two step cleaning protocol, additional studies are needed to examine the effectiveness of each element of the cleaning process. Any such follow up studies require laboratories to meet a low detection limit (e.g., 2 µg/ft2) to allow for more extensive analysis of the dust lead levels measured after clearance.

Table I: Descriptive Statistics for Study Surfaces Prior to Intervention

	Uncarpeted Floors	Window Sills	Window Troughs
Sample SizeA	42	30	23
Median (minimum, maximum) Dust Lead Loading (µg/ft2)	165 (<10,7340)	2200 (<15, 124000)	9660 (628,77000)
Percentage of Samples Exceeding 1995 Federal Guidance for Lead-Contaminated DustB	57%	50%	96%
Percentage of Surfaces in Fair or Poor Condition	69%	61%	96%

A Pre-intervention dust lead levels were not measured in all locations where dust samples were collected during the cleaning process. Hence, the sample size at pre-intervention is less than those reported in Table III.

B 1995 Federal guidance for dust lead levels constituting a lead-based paint hazard are: 100 µg/ft2, 500 µg/ft2, and 800 µg/ft2 for floors, window sills and window troughs, respectively.

Table II: Description of Cleaning Procedures

Procedure	Mean (Minimum, Maximum)
First HEPA (minutes)	67 (20, 150)
Wet Wash (minutes)	88 (30, 240)
Second HEPA (minutes)	16 (10, 30)
Total Cleaning Time (minutes)	171 (80, 410)
Living Space (square feet)	1067 (450, 2200)
Total Time per 100 Square Feet of Living SpaceA	18 (8, 45)

A This represents time taken to clean all appropriate surfaces (e.g., floors, walls, ceilings, windows, other horizontal surfaces) per 100 square feet of living space.

Table III: Percentage of SurfacesA Below Dust Lead Loading Cut-Offs on Uncarpeted Floors, Window Sills and Window Troughs

	Uncarpeted Floors		Window Sills		Window Troughs	
Dust Lead Loading Cut-Off (µg/ft2)	Post-Wet Wash	Post-Second HEPA	Post-Wet Wash	Post-Second HEPA	Post-Wet Wash	Post-Second HEPA
30	86	88	71	67	44	63
50	90	94	83	81	73	73
100	96	96	93	93	87	87
200	96	98	100	98	93	100
300	98	100	100	98	93	100
400	98	100	100	100	93	100
500	98	100	100	100	97	100
600	100	100	100	100	100	100
800	100	100	100	100	100	100

A Calculations based on: 49 uncarpeted floors, 43 window sills and 30 window troughs.
Note: The shaded areas represent 1995 Federal dust lead clearance levels.

Table IV: Upper Confidence Bounds For the "True" Clearance A Failure Rate Post-Wet WashB

Surface	Sample Size	Observed Probability of Clearance Failure	95% Upper Confidence Bound
Uncarpeted floors	49	0.041	12.9%
Window Sills	43	0.000	6.7%
Window Troughs	30	0.000	9.5%

A 1995 Federal guidance for dust lead levels constituting a lead-based paint hazard are: 100 µg/ft2, 500 µg/ft2, and 800 µg/ft2 for floors, window sills and window troughs, respectively.

B Note that since the same number of failures were observed after the wet wash and after the second HEPA, the values in the table are identical if the post-second HEPA values are considered instead of the post-wet wash.

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[1] Centers For Disease Control: Preventing Lead Poisoning in Young Children: A Statement By the Centers for Disease Control. Atlanta, GA: U.S. Department of Health and Human Services;. DHHS publication No. (PHS/CDC) 1992-633-627. 1991.

[2] Farfel M.R., Chisholm J.J.: An Evaluation of Experimental Practices For Abatement Of Residential Lead-Based Paint: Report On A Pilot Project. Environmental Research 66:217-221 (1994).

[3] Rabinowitz M., Leviton A., Bellinger D.: Home Refinishing, Lead Paint, and Infant Blood Lead Levels. American Journal of Public Health. 75(4):403-404 (1985).

[4] Chisholm J.J., Mellits E.D., Quaskey S.A.: The Relationship Between The Level of Lead Adsorption In Children and The Age, Type and Condition of Housing. Environmental Research 38:31-45 (1985).

[5] Charney, E., Kessler, B., Farfel, M., Jackson, D.: "A Controlled Trial of the Effect of Dust-Control Measures on Blood Lead Levels," New England Journal of Medicine 309(18):1089-1093 (1983).

[6] Milar, C.R. and Mushak, P.: "Lead Contaminated Housedust: Hazard, Measurement and Decontamination," Absorption in Children: Management, Clinical, and Environmental Aspects, eds. Chisholm, J.J. and O'Hara, Urban & Schwartzenberg, Baltimore-Munich pp.143-152 (1982).

[7] Milar, C.R. and Mushak, P.: "Lead Contaminated Housedust: Hazard, Measurement and Decontamination," Absorption in Children: Management, Clinical, and Environmental Aspects, eds. Chisholm, J.J. and O'Hara, Urban & Schwartzenberg, Baltimore-Munich pp.143-152 (1982).

[8] Farfel, M.R., Chisholm, J.J.: An Evaluation of Experimental Practices For Abatement of Residential Lead-Based Paint: Report On A Pilot Project. Environmental Research 66:217-221 (1994).

[9] National Center For Lead-Safe Housing: Does Residential Lead-Based Paint Hazard Control Work? A Review Of The Scientific Evidence. Columbia, MD (April 1995).

[10] U.S. Department of Housing and Urban Development: Guidelines For The Evaluation and Control Of Lead-Based Paint Hazards in Housing, (June 1995).

[11] National Center For Lead-Safe Housing and The University of Cincinnati Department of Environmental Health: Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program, Fifth Interim Report (March 1998).

[12] U.S. Department of Housing and Urban Development: Guidelines For The Evaluation and Control Of Lead-Based Paint Hazards in Housing, (June 1995). U.S. Environmental Protection Agency: Guidance on Residential Lead-Base Paint, Lead-Contaminated Dust and Lead-Contaminated Soil. (June 1994).

[13] National Center For Lead-Safe Housing and The University of Cincinnati Department of Environmental Health: Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program, Fourth Interim Report, (February 1997).

[14] Ewers, L., Clark, S., Menrath, W., Succop, P., Bornschein, R.: Clean-Up of Lead In Household Carpet and Floor Dust, American Industrial Hygiene Association, 55:650-657 (1994).

[15] U.S. Environmental Protection Agency: Laboratory Study of Lead-Cleaning Efficacy, (EPA #747-R-97-002) (March 1997).

[16]U.S. Department of Housing and Urban Development: Guidelines For The Evaluation and Control Of Lead-Based Paint Hazards in Housing (June 1995).

[17] Lead hazard control terms are defined as follows. Paint stabilization **-** The process of repainting surfaces coated with lead-based paint, that includes the proper removal of deteriorated paint and priming. Paint Removal **-** The complete removal of lead-based paint by wet scraping, chemical stripping, or contained abrasives. Enclosure **-** The application of rigid, durable construction materials that are mechanically fastened to the substrate to act as a barrier between lead-based paint and the environment. Window Treatment **-** The process of eliminating friction and impact surfaces on windows through the removal of paint or enclosure of certain window components.

[18]National Center For Lead-Safe Housing and Department of Environmental Health, University of Cincinnati. Evaluation Of The HUD Lead-Based Paint Hazard Control Grant Program In Private Housing. Overall Design and Data Collection Forms and Procedures, Columbia, MD (February 1994).

[19]National Center For Lead-Safe Housing and Department of Environmental Health, University of Cincinnati. Evaluation Of The HUD Lead-Based Paint Hazard Control Grant Program In Private Housing. Overall Design and Data Collection Forms and Procedures. Columbia, MD (February 1994).

[20] Department of Environmental Health, University of Cincinnati. Evaluation of HUD Lead-Based Paint Hazard Control Grant Program in Private Housing, Quality Assurance/Quality Control Plan.

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[21] Beyer, W. H., Handbook of tables for probability and statistics. Chemical Rubber, Cleveland, Ohio. 1968.

[22] U.S. Environmental Protection Agency, Briefing Materials for November 12, 1997 public meeting on standards for lead-contaminated dust, EPA Docket # 62151B.