U.S. Department of Housing and Urban Development

Office of Healthy Homes and Lead Hazard Control

"An Evaluation of Residual Lead Dust Following Lead Abatement Clean-up and Clearance Activities"

Final Report

September 10, 2003

Visit the OHHLHC Web Site www.hud.gov/offices/lead to find this report and others sponsored by HUD's Office of Healthy Homes and Lead Hazard Control. For a hard copy of this report call the National Lead Information Center at 1800-424-LEAD, or other number as appropriate.

“An Evaluation of Residual Lead Dust Following Lead Abatement Clean-up and Clearance Activities”

Final Report

Prepared for:

U.S. Department of Housing and Urban Development

Office of Healthy Homes and Lead Hazard Control

Prepared By:

Gary J. Centifonti, M.S., CIH

Donald R. Gerber, B.S.

New Jersey Department of Health and Senior Services
Division of Epidemiology, Environmental and Occupational Health
Consumer and Environmental Health Services

P.O. Box 369
Trenton, NJ 08625-0369

Contract No. NJLTS0083-00

Disclaimer

The contents of this report are the views of the New Jersey Department of Health and Senior Services, and do not necessarily represent the views or policies of the U.S. Department of Housing and Urban Development or the U.S. Government.

ACKNOWLEDGEMENT

The New Jersey Department of Health and Senior Services would like to acknowledge and express our appreciation to the New Jersey certified lead abatement contractors who participated in this project. These contractors provided their time and assistance in coordinating the lead abatement cleaning activities with our study team and also provided the manpower onsite to carry out the cleaning procedures outlined in the study design for this project. Their cooperation and participation made this project successful. The study team also acknowledges James A. Brownlee, Director and Joseph D. Eldridge, Assistant Director of the Consumer and Environmental Health Services for their administrative support and technical review of this report.

PREFACE

In housing built before 1978, deteriorated lead-based paint (LBP) is recognized as a major cause of elevated blood lead levels (EBL) in children. Lead abatement projects are designed to control lead-based paint hazards in housing and thereby reduce this exposure hazard for children. An effective final cleaning procedure following lead abatement is essential prior to re-occupancy of the home. The HUD guidelines (HUD, 1995) outline a series of feasible clean-up procedures that have been shown to be effective in reducing lead dust levels following lead abatement. The cleaning procedures require a series of steps that include HEPA vacuuming, wet washing/wiping of the work area and repeated HEPA vacuuming. Although these cleaning procedures are in place, information for determining their effectiveness was limited. In 1997, the New Jersey Department of Health and Senior Services-Consumer and Environmental Health Services conducted a study (NJDHSS, 2001b) to evaluate these cleaning procedures. The results from this previous study indicated that after cleaning floors following the recommended procedures, floors with semi-smooth and rough surfaces failed to achieve the HUD clearance requirements in 41% and 100% of the sites evaluated, respectively. The study results also indicated that there were significant variations in lead dust levels across floor surfaces at the time clearance samples are taken. Therefore, a single random sample may not be representative of the lead dust levels remaining on the floor surface.

The current study was conducted to further evaluate the effect floor surface condition, as well as the cleaning technique, had on achieving the 1999 HUD floor clearance criteria of 40 $\mu g/ft^2$. Additional evaluation was also conducted to assess the spatial deposition of lead dust levels on floors following clean-up. The data from this study may assist HUD in understanding how various floor types and conditions relate to cleaning effectiveness, cleaning techniques and ultimately the clearance lead dust levels after cleaning. The results could identify specific cleaning techniques required to achieve clearance based on the floor surface being cleaned. Achieving successful clearance initially could significantly reduce the costs of abatement by eliminating the need for re-cleaning, re-sampling and analysis and the associated cost of extended relocation of the occupants.

EXECUTIVE SUMMARY

Introduction

In housing units built before 1978, deteriorated lead-based paint (LBP) is recognized as a major cause of elevated blood lead (EBL) levels in children (HUD, 1995). Exposure to lead in paint can occur directly from paint chips ingested by children but more often from dust generated from deteriorated surfaces containing lead-based paint (HUD, 1995). Dust containing lead can also be tracked into the house from the outside by building occupants. Although the average blood lead concentration of children has dropped over the last twenty years, an estimated 300,000 children aged 1 to 5 still have blood lead concentrations greater than or equal to 10 μg/dL (CDC, 2003). In New Jersey, the Department of Health and Senior Services (NJDHSS) estimates that over 200,000 children under the age of six are at high risk of lead poisoning and that approximately 50% of housing stock was built before 1950 and may contain lead-based paint (NJDHSS 2001a). Research indicates that relatively low blood lead levels can cause significant damage to the nervous system, such as reduction in intelligence and attention span, learning disabilities and behavior problems (CDC 1991; Cranfield et al., 2003).

Lead Abatement Cleaning and Clearance Concern

Lead abatement projects are designed to control lead-based paint hazards in housing. However, lead abatement techniques such as lead-based paint removal and lead containing component replacement can create a large amount of lead dust that without proper clean-up, may present a hazard (HUD, 1991). A number of studies have documented that when improper lead abatement and inefficient clean-up were performed, significant health risks became apparent. Studies noted the lead dust and debris that remained after improper abatement and clean-up was associated with an increase in blood lead levels of children who reoccupy such units (Farfel and Chisholm, 1994; Chisholm et al., 1985; Charney et al., 1983; Milar and Mushak, 1982).

An effective final cleaning procedure is essential prior to re-occupancy. The HUD Guidelines (1995) outline a series of feasible clean-up procedures that have been shown to be effective after a lead abatement project. In 1995, New Jersey mandated the same cleaning procedures in the regulation codified as the Lead Hazard Evaluation and Abatement Code (N.J.A.C. 5:17). This regulation requires a series of cleaning steps that include HEPA vacuuming, wet washing/wiping of the work area with a lead specific detergent or trisodium phosphate (TSP), repeated HEPA vacuuming and time for drying. Although these work practices are currently in place, information for determining the effectiveness of the clean-up effort required to achieve clearance is limited.

While there has been significant improvement in cleaning methods due to trained and experienced workers and regulatory oversight on lead abatement projects, the cleaning standards have also become more stringent. The 1999 HUD Final Rule (24 CFR Part 35) specifies clearance dust lead levels of: 40 $\mu g/ft^2$, 250 $\mu g/ft^2$ and 800 $\mu g/ft^2$ for floors, window sills and window wells, respectively. In 2001, the EPA promulgated final rules regarding dangerous lead dust levels (40 CFR Part 745). This final rule mirrored the 1999 HUD rule for clearance lead dust levels except for samples collected from window wells. The EPA rule lowered the clearance criteria for window wells to 400 $\mu g/ft^2$. The 1999 HUD rule now incorporates these standards by reference and N.J.A.C 5:17 was amended to include the new standards.

In an effort to have abatement projects consistently meet acceptable clearance criteria under a variety of conditions, further field evaluation of the currently practiced clean-up methods is needed. This information could then be used to develop the most effective cleaning guidelines for achieving clearance standards under various conditions (e.g., surface condition, cleaning method used, etc.) for lead abatement, as well as for the renovation and remodeling (R & R) industry. Evaluation of cleaning techniques and the amount of time needed to perform the cleaning activities, based on the square feet of surfaces cleaned in the work area, would provide a basis for obtaining this information.

Clearance Lead Dust Levels and Spatial Distribution Concern

The HUD Guidelines require clearance samples to be taken within the work area to determine if the area is safe for re-occupancy. The sampling locations are specific for window sills and window troughs. For floors, a sample from a high traffic area (for example, around a doorway) or from specific locations near the area where the lead hazard control treatment was performed, is recommended. The certified individual has the freedom to use personal judgment to determine which specific floor location is best based on the type of abatement work and visual inspection. There is limited information available in the literature which establishes that the samples taken from floors in the location recommended in the1995 HUD Guidelines represents the lead loading throughout the work area. Recent studies have shown that the spatial distribution of lead dust on floors in the work area after renovation and remodeling projects can vary significantly (EPA, 1997). Lead dust samples taken randomly from floors simultaneously with clearance samples may identify the most representative location for floor clearance samples.

Prior NJDHSS/HUD Research

HUD has initiated a significant redevelopment program for lead-based paint in low and moderate-income housing. Funding to support this initiative became available to states through the Department of Housing and Urban Development Notice of Funds Availability (NOFA). As identified in these NOFA's, a major objective of the program was to investigate the effectiveness of the environmental intervention controls utilized in the selected housing units. The NJDHSS-Consumer and Environmental Health Services, a recipient of a portion of these funds in 1997, through a Memorandum of Agreement (MOA) with the New Jersey Department of Community Affairs (DCA), carried out a research project (NJDHSS 2001b) to complement the HUD initiative. The research project included an evaluation of the effectiveness of the post lead abatement cleaning and clearance activities. The HUD Guidelines recommend that after lead abatement activities, the work area be cleaned using a three-step cleaning method to reduce lead-contaminated dust and debris; however, other methodologies could be used to achieve clearance. The main objective of the NJDHSS study was to focus on the effectiveness of post-abatement cleaning and clearance activities.

The study units were located in five municipalities in New Jersey. All units were constructed before 1978 and located in low-income neighborhoods. The lead abatement work was awarded on a competitive basis and was coordinated by the DCA and the respective cities or towns. Cleaning methods and procedures were evaluated in 30 dwelling units that had undergone significant lead hazard reduction activities. The presence of lead dust in the work area was confirmed by taking post-abatement dust wipe samples from floors and windows. Four random lead dust wipe samples from the floor, one from the window sill and one from the window well were collected after each step of the cleaning process and during final clearance. One sample was also taken from the high traffic area per HUD recommendations.

Workers were not instructed on the effort and techniques of cleaning. Therefore, the data collected in this study represents real world values in the industry. The only limitation was the presence of NJDHSS employees at the site, which may have influenced the work practices noted. The abatement work varied from simple window replacement to the demolition of walls and ceilings containing lead-based paint. The results of post-abatement lead dust wipe samples indicated the presence of large quantities (several order of magnitude variations) of lead dust on the windows and floors.

The results indicated that the mean clearance lead dust loading for smooth floors was well below the 1995 federal guidance, as well as, the 1999 HUD clearance lead dust levels. For semi-smooth floor surfaces the final clearance levels were slightly above the 1999 HUD clearance standards. The clearance lead dust loading on rough floor surfaces did not meet either standard. It is interesting to note that the effectiveness of the wet wash procedure decreased with increasing floor surface roughness. The data indicated that there was no change in lead dust loading for rough floors before and after the wet wash procedure. Almost all wet wash cleaning procedures included one mophead and one bucket containing cleaning solution. At 80% of the sites, contractors did not follow the HUD recommended three-bucket technique and no additional cleaning efforts were made for rough or semi-smooth floor surfaces.

NJDHSS study results also indicated that the current field cleaning method was not adequate to meet the 1999 HUD clearance standards even for semi-smooth floor surfaces with a failure rate of 41%. For rough floors, the failure rate was 100% for both the 100 $\mu g/ft^2$ and 40 $\mu g/ft^2$ clearance standards. The floor failure cases were attributed to the surface roughness of floors and also noted that these deteriorated floors were difficult to clean using the HUD recommended three-step cleaning method. The spatial distribution of lead loading on floors indicated that considerable variation in lead dust exists when clearance samples are taken and that a sample collected in a high traffic area within the worksite may not represent the lead dust levels throughout the floor. As discussed above, very few studies have investigated field data associated with post-abatement cleaning and clearance activities.

Overview of the Current Research

This study investigated the impact both the cleaning procedures and floor surface condition have on achieving the 1999 HUD floor clearance standard and evaluated the lead dust loading on floors following the cleaning. This study evaluated any statistically significant difference in the surface lead dust concentration on floors as a function of the floor surface condition and cleaning techniques. The study also evaluated any relationships between clean-up procedures used in the field and floor surface conditions. The data from this study may assist HUD in understanding how various floor types and conditions relate to cleaning effectiveness, cleaning techniques and ultimately the clearance lead dust levels after cleaning. The results could identify specific cleaning techniques required to achieve clearance based on the floor type being cleaned. Achieving successful clearance initially could significantly reduce the costs of abatement by eliminating the need for re-cleaning, re-sampling and analysis and the associated cost of extended relocation of the occupants.

Study Objectives

The overall objective of this study was to assess the lead dust levels on floors following lead abatement and clean-up as a function of floor surface condition and cleaning technique. Specific objectives of this study were as follows:

1) Evaluate the effect different cleaning techniques have on achieving the 1999 HUD clearance level of 40 $\mu g/ft^2$ on floors based on the surface type;
2) Evaluate the effectiveness of current cleaning techniques in achieving the 1999 HUD clearance level of 40 $\mu g/ft^2$ on floors; and,
3) Evaluate the spatial distribution of lead dust on floors following lead abatement and clean-up.

This study was designed to be conducted in selected housing units undergoing lead abatement funded by government (local, state or federal) grants or private initiatives. The goal for the NJDHSS staff was to identify 40 abatement sites with either semi-smooth or rough floors for inclusion in the project. Following abatement, lead dust wipe samples were collected prior to the commencement of cleaning and during clearance from floors, in accordance with the HUD Guidelines and N.J.A.C. 5:17.

Summary of the Research Findings

Forty-one (41) study sites were identified in 20 pre-1978 buildings located in seven municipalities throughout New Jersey. The building types included both single and multi-family dwellings, were located primarily in low to moderate income neighborhoods and were undergoing lead hazard abatement, as well as, other renovation and remodeling work. Each building contained from one to eight study sites with each site consisting of two areas in which to conduct the study activities. The two areas within each study site were arbitrarily designated as either Area A or Area B. In 19 sites, the floor surface condition was categorized as rough while the remaining 22 sites were categorized as semi-smooth. At each study site, an average of 22 lead dust wipe samples were collected with 11 being collected in each selected area. Lead dust wipe samples were collected at the end of abatement before any cleaning took place and at clearance after all cleaning activities were completed. The abatement methods included paint removal (PR), building component replacement (BCR), encapsulation (ENCAP) and enclosure (ENCL).

During the data collection process, work practices employed by the contractors were documented. Commercial grade HEPA vacuums were used to perform the vacuuming at all study sites. The abatement contractors used trisodium phosphate (TSP), a high-phosphate detergent or Ledizolv™, a lead specific detergent, for wet washing the lead contaminated dust from surfaces. Although there is no evidence that TSP has a better cleaning efficacy than other commercially available cleaners do (EPA, 1997), Table C2 in Appendix C shows that at 63% (26 out of 41) of the sites TSP was used as the cleaning agent. At the remaining sites Ledizolv™ was used.

Pre-Cleaning Lead Dust Levels

The extent of abatement work varied from encapsulation and enclosure to building component replacement and paint removal. The lead dust generated from these activities may have been dependent on paint condition, lead concentration in the paint, and the work practices employed. Therefore, pre-cleaning lead dust wipe samples were collected to assess the lead dust level on the floors of the selected study sites. The data also demonstrated the variability of lead dust throughout the floor and provided a baseline lead dust level prior to the cleaning. All of the abatement sites were designed as “Interior Worksite Preparation Level 4” (N.J.A.C. 5:17) requiring the work area to be covered with polyethylene plastic prior to abatement to protect the floor area from additional lead dust accumulation. The pre-cleaning samples were collected after the removal of polyethylene plastic from the floors and subsequent broom cleaning of large debris. Therefore, the lead dust level on the sampling area represents the (1) background lead dust accumulation, (2) lead dust generated and settled since the removal of the polyethylene plastic, (3) lead dust tracked in by the workers after polyethylene plastic removal, and (4) the introduction of lead dust through any breaks in the polyethylene plastic (NJDHSS 2001b).

Paint removal (PR) and building component replacement (BCR) abatement methods generate a large amount of lead dust, whereas encapsulation (ENCAP) and enclosure (ENCL) generate very little (HUD, 1995). However, the pre-cleaning lead dust level data did not appear to show any trend associated with the type of abatement. For example, the mean floor lead dust level measured for BCR sites was 383 $\mu g/ft^2$ (s.d. 1233 $\mu g/ft^2$) whereas the sites doing a combination of methods such as BCR, ENCAP, ENCL and PR had a mean lead dust level of 752 $\mu g/ft^2$ (s.d. =1287 $\mu g/ft^2$).

Summary of Conclusions

Study Objectives 1 & 2

Study Objectives 1 and 2, were to evaluate the effect different cleaning techniques have on achieving the 1999 HUD clearance level of 40 $\mu g/ft^2$ on floors based on the surface condition and to evaluate the effectiveness of current cleaning techniques in achieving the 1999 HUD clearance level of 40 $\mu g/ft^2$ on floors. The cleaning techniques evaluated during the wet wash procedure of the HEPA-Wet Wash-HEPA cleaning method were 1) a single bucket technique used by the contractor and, 2) the HUD recommended 3-bucket technique. For these two objectives the conclusions are as follows:

Evaluation of the Cleaning Times Between Each Technique

- Substituting the HUD recommended 3-bucket wet wash technique (Area B) for the single bucket technique used by contractors (Area A) during the wet wash procedure of the HEPA-Wet Wash-HEPA cleaning method appeared to not add any significant amount of time to the overall cleaning activities. The average time to complete the entire HEPA-Wet Wash-HEPA cleaning method using the single bucket technique was similar to the average time when the HUD recommended 3-bucket technique was used (23 minutes compared to 24 minutes, respectively). The average time to complete only the wet wash procedure of the cleaning method using the HUD recommended 3-bucket technique was nine (9) minutes and the time to complete the wet wash procedure using the single bucket technique was eight (8) minutes. No statistical difference in the amount of time needed to complete the cleaning procedure for either technique was observed.

Evaluation of the Cleaning Techniques in Achieving the 1999 HUD Clearance Criteria of 40 $\mu g/ft^2$

- Both cleaning techniques, the single bucket (Area A) and the HUD recommended 3-bucket (Area B) technique, were effective in removing a large percentage of the lead dust from each study area. The single bucket technique removed 83% and the 3-bucket technique removed 82% of the mean pre-cleaning lead dust levels in each area.
- There was no statistical difference observed between the cleaning techniques in achieving the 1999 HUD floor clearance criteria of 40 $\mu g/ft^2$. Neither technique appeared to have a significant advantage over the other and passing or failing the clearance criteria was independent of the cleaning method. While the percentage of lead dust removal was high, neither technique appeared to

demonstrate a high percentage of sites passing the floor clearance criteria of 40 $\mu g/ft^2$. For the single bucket technique (Area A), 29% of the sites passed and for the 3-bucket method (Area B), 39% of the sites passed. Although the 3-bucket technique demonstrated a higher percentage of sites passing the clearance criteria, no statistical difference was observed.

- The areas cleaned using the 3-bucket technique (Area B) had a lower mean clearance lead dust level than areas cleaned using the single bucket technique (Area A). The mean clearance lead dust level in Area B was 119 $\mu g/ft^2$ and the mean clearance lead dust level Area A was 202 $\mu g/ft^2$, however the difference was not statistically significant.
- The time to clean each area, by either technique, did not show a strong relationship in reducing lead dust levels below the floor clearance criteria of 40 $\mu g/ft^2$ (Area A R^2=0.056 and Area B R^2=0.1147). The time to clean areas using the single bucket technique (Area A) ranged from 4 to 32 minutes/100 ft^2 and had mean clearance lead dust levels that ranged from 1 to 1243 $\mu g/ft^2$. The time to clean areas using the 3-bucket technique (Area B) ranged from 6 to 29 minutes/100 ft^2 and had mean clearance lead dust levels that ranged from 3 to 530 $\mu g/ft^2$.

Evaluation of the Floor Surface Condition in Achieving the 1999 HUD Clearance Criteria of 40 $\mu g/ft^2$

- Floor surface condition appeared to be an important factor in achieving the HUD clearance level of 40 $\mu g/ft^2$. Areas with floor surface conditions classified as semi-smooth demonstrated a higher percentage of sites passing the clearance criteria of 40 $\mu g/ft^2$ (36%), compared to areas with floor surfaces classified as rough (11%). Passing or failing the clearance criteria was dependent upon the floor surface condition in each study area.
- Floors with semi-smooth surface conditions appeared to clean better than rough floor surfaces. The mean clearance lead dust level for areas with semi-smooth floor surface conditions was 82 $\mu g/ft^2$ compared to 251 $\mu g/ft^2$ in areas with rough

floor surface conditions. The difference observed in mean clearance lead dust levels between the two floor surface conditions was statistically significant.

Evaluation of the Cleaning Techniques in Achieving the 1999 HUD Clearance Criteria of 40 $\mu g/ft^2$ Based on Floor Surface Condition

- There were no statistical differences observed between the cleaning techniques on either floor surface condition. Semi-smooth floors cleaned by the single bucket technique (Area A) had a mean clearance lead dust level of 97 $\mu g/ft^2$ compared to a mean of 68 $\mu g/ft^2$ for areas cleaned by the HUD recommended 3-bucket technique (Area B). Rough floor surfaces cleaned by the single bucket technique (Area A) had a mean clearance lead dust level of 324 $\mu g/ft^2$, compared to a mean of 178 $\mu g/ft^2$ for areas cleaned by the HUD recommended 3-bucket technique (Area B). Although the HUD recommended 3-bucket technique had lower mean clearance lead dust levels on both floor surface conditions the difference observed was not statistically significant.
- Floor surface condition again appeared to be an important factor in achieving the 1999 HUD clearance level of 40 $\mu g/ft^2$. Statistical differences were observed between the semi-smooth and rough floor surfaces for both cleaning techniques. An analysis of variance revealed that the interaction between floor surface condition and mean clearance lead dusts levels was statistically significant.

Study Objective 3

For Study Objective 3, to evaluate the spatial distribution of lead dust on floors following lead abatement and clean-up, the conclusions are as follows:

- The lead dust levels found on floors following the lead abatement and clean-up showed significant variation. Eighty percent (80%) of the study areas had at least a two fold difference between the minimum and maximum lead dust levels and 28% had a five (5) fold difference or more. Statistically significant differences were observed between; 1) the minimum and maximum lead dust levels, 2) between the minimum and the mean lead dust levels and 3) between the mean and the maximum lead dust levels. Therefore a single random sample taken from the floor may not represent the mean or maximum lead dust level on the floor.

- A sample collected from a high traffic area within the abatement worksite appeared to be an appropriate location to take a clearance lead dust wipe sample to represent the maximum floor lead dust level. No statistical difference was observed between the maximum lead dust levels and the lead dust levels found in the high traffic area samples. Although samples collected in this area may statistically represent the worst-case scenario, the data also indicates that in 55% of the sites, the maximum lead dust level was recorded in a location other than in the high traffic area. While this data may need further investigation, the lead dust levels collected from the high traffic area were statistically different from the mean and the minimum clearance lead dust levels, therefore collecting a sample in this area should be considered in lieu of a random floor sample.
- There were no apparent patterns in the distribution of lead dust on floors when comparing samples taken in the corners of the room, around the perimeter and in the center of the room. Although the mean of the samples taken in the center of the room (144 $\mu g/ft^2$) were lower than the means of the samples taken around the perimeter (161 $\mu g/ft^2$) and in the corner areas (179 $\mu g/ft^2$), the differences were not statistically significant.