Remilling of salvaged wood siding coated with lead-based paint. Part 1. Lead exposure

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Abstract

It is well known that the lead contained in lead-based paint (LBP) can pose a serious human health risk if ingested. In our nation's building infrastructure, millions of meters of high quality salvageable lumber have been coated with LBP. The study presented in this and a companion paper investigated the feasibility of producing several standardized wood product profiles, including flooring, bevel siding, and paneling, from salvaged LBP-coated wood. This paper presents the results of an evaluation of worker and workplace exposure to lead during wood remilling operations. Approximately 2180 m (7,152 ft) of painted Douglas-fir drop siding salvaged from deconstructed U.S. Army barracks was evaluated. Results indicate that when properly sized and specified, commonly available woodworking machinery and dust collection systems can be used to safely profile, filter, and collect waste LBP shavings and dust from remachining operations. Lead exposure to workers in the vicinity of remanufacturing operations was found to be less than one-tenth that of the OSHA permissible exposure limit for indoor lead exposure. In addition, lead present on the produced wood product was found to be a fraction of that found on the original painted wood material.

Interest has been growing regarding the salvage and reuse of wood materials generated when buildings are deconstructed (dismantled). The reuse or remanufacture of salvaged wood materials has socio-economic incentives, including a reduction of waste sent to landfills, a net decrease in disposal costs, creation of local salvage business enterprises, wood resource conservation, and positive environmental impact. It also permits the reuse of a high quality old-growth wood that is for the most part unavailable from any other source. On the one hand, it is desirable to salvage and reuse this high quality wood resource. On the other hand, reuse must not expose workers and the public to detrimental health effects of any lead-based paint (LBP) on the wood.

The objective of this research project was to examine the viability of using conventional woodworking equipment to remove the LBP coating from salvaged wood siding while producing a marketable wood product. The siding was salvaged from demolition and deconstruction activities at several military barracks at Fort Ord, California, and Fort Campbell, Kentucky.

Because this project involved the potential for human exposure to the harmful effects of lead, careful thought was given to safety issues, especially for machinery operators and surrounding personnel, while the wood was remanufactured. In addition to evaluating the feasibility of using conventional woodworking machinery to remill this material, data were collected on air quality, worker exposure to lead, residual lead

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in the evaluated product, and lead exposure to installers of the manufactured product.

Background

Lead-based paint is found throughout our nation's building infrastructure and can be present in any residential home built before 1978, the year its use was banned. Heavily leaded paint was used in about one-third of homes constructed before 1940, about half the homes constructed between 1940 and 1960, and to a lesser extent until 1978, when lead content was limited to a maximum of 0.06 percent in any consumer product. With over 100 million housing units in the United States, two-thirds of the existing housing stock potentially contains LBP-coated material. As our building infrastructure ages, many of these buildings will reach the end of useful life and will need to be replaced or remodeled. The Environmental Protection Agency (Carliner 1996, EPA 1998) has estimated that the equivalent of 245,000 residential buildings are demolished each year in the United States. It is estimated that these buildings contain at least 1 billion (10^9) board feet (1.7 million m^3) of recoverable structural lumber. This volume represents 3% of the annual softwood harvest in the United States (Howard 2001). Millions of board feet of salvageable lumber are also contained in the military and commercial buildings demolished each year. While structural lumber is often free of paint, the highest quality sawn wood products, such as siding, trim, and moulding, are typically painted.

A large percentage of World War II U.S. Army buildings were constructed with horizontal lapped siding manufactured from solid wood, typically using Siding Pattern 105 (WCLIB 2001). Laid end-to-end, thousands of miles of this siding are installed on Army wood-framed buildings currently slated for disposal. Because of LBP, this siding is considered hazardous waste in California, and it must be disposed of in a hazardous waste landfill at costs considerably higher than those levied for normal demolition waste. Siding coated with LBP has the potential to be remanufactured into other valuable building products. However, the presence of LBP on the exterior face creates a challenge in processing this siding without exposing both processors and reusers of the wood to the harmful effects of lead.

Why salvage this wood? Most of the Army buildings that are candidates for deconstruction were constructed during the decades of old-growth timber harvest. The lumber is often of higher quality (e.g., higher number of growth rings per inch, higher density, fewer defects) than the lumber produced today. Moreover, to a great extent, wood of this quality is unavailable from any other source. As noted in a companion paper (Janowiak 2005), a visual inspection revealed that the siding evaluated in this study was of very high quality and a large number of the pieces had 30 to 40 growth rings per inch. The salvaged siding of southern pine from Fort Campbell was not the same clear quality as that from Fort Ord; the Fort Campbell wood contained more knots and many fewer growth rings per inch.

Regulation of lead exposure

Pure lead is a heavy metal at room temperature and pressure and is a basic chemical element. It can combine with various other substances to form numerous lead compounds, and it can be absorbed into the body by inhalation and ingestion. Chronic overexposure may result in severe damage to blood-forming, nervous, urinary, and reproductive systems. Children are especially vulnerable. In the case of LBP, chips or dust from flaking paint are the usual culprits in lead exposure.

Human and environmental exposure to lead is regulated by various federal agencies. Exposure to workers dealing with the manufacture, application, or clean-up of lead is regulated by the Occupational Safety and Health Administration (OSHA), while environmental exposure (air, soil, or water) is regulated by the Environmental Protection Agency (EPA). Exposure in housing (typically in LBP) has limits set by the Office of Housing and Urban Development (HUD). Furthermore, the Consumer Product Safety Commission (CPSC) regulates certain consumer products and declares products containing LBP as banned hazardous products (e.g., toys and other articles intended for use by children and products used by consumers after sale, such as paints used in residences, schools, hospitals, parks, and playgrounds). Many states further regulate the use and resale of products that contain LBP.

Existing regulations do not specifically address the remanufacture of LBP-coated wood materials, nor do they provide guidance on allowable limits of lead. Workplace exposure to lead through airborne means is measured by a permissible exposure limit (PEL) and is set at 50 µg of lead per cubic meter of air ($\mu g/m^3$), averaged over an 8-hour workday (OSHA 2003). In addition, longer term exposure is regulated by measures of worker blood lead (PbB) levels, which should be maintained at or below 40 µg per 100 g of whole blood (40 µg/100 g). The blood lead levels of workers (both male and female) who intend to have children should be maintained below 30 µg/100 g to minimize adverse reproductive health effects to the parents and to the developing fetus.

Lead or lead-containing dust exhausted to the outside environment is regulated by the EPA and is limited to an air volume measurement of 1.5 $\mu g/m^3$ averaged over a 3-month period. For existing housing, HUD action levels for lead in dust are surface measurements of 3.7 $\mu g/m^2$ for floor surfaces and 23.2 $\mu g/m^2$ for windowsills.

Though these levels are referenced for comparative purposes in this study, they may or may not have direct applicability to the remanufacture of LBP-coated wood. For example, the EPA outdoor limit on airborne lead (1.5 $\mu g/m^3$) was likely developed for large, continuously operating industrial output sources, such as a lead smelter. The lead dust action levels from HUD were established for existing housing and set to limit lead exposure to children from flaking paint. Lead dust generated and potentially settling in an industrial remanufacturing operation may call for different allowable levels.

Processes investigated

As detailed in the companion paper (Janowiak 2005), a conventional four-head molder (1966 vintage) was used to mold the salvaged siding into three profiles: tongue and groove (T&G) flooring, V-groove paneling, and bevel siding. These profiles represent common wood products that have final dimensions thin enough to be processed from 18-mm- (approximately 3/4-in-) thick salvaged siding. All operations were performed indoors.

A health and safety plan was initiated before any material was processed. In cooperation with the Health and Safety Officer of the Forest Products Laboratory (FPL), a monitoring program was developed to ensure as safe a work environment as possible. Issues included minimization of LBP exposure to

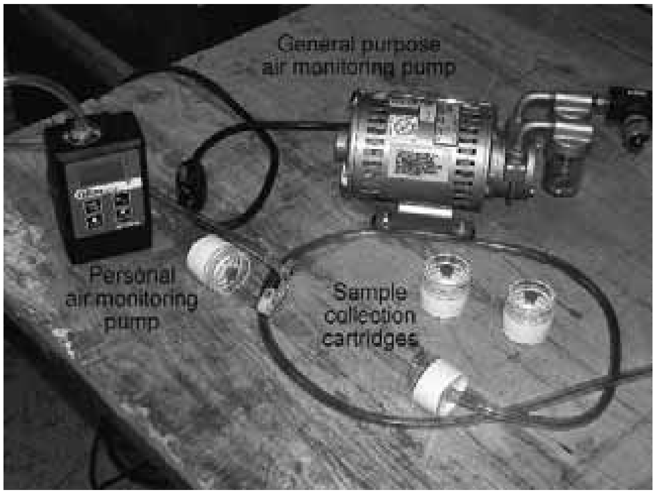

Figure 1. — Air monitoring pumps.

woodshop personnel working directly with machining operations, minimization of LBP exposure to other staff and the public, evaluation of indoor and outdoor air quality during machining operations per OSHA and EPA standards, and proper handling and disposal of LBP-contaminated waste products (shavings, cut-offs, etc.).

A new dust collection system was purchased to keep LBP from contaminating the existing dust collection system; the new system was vented to the exterior of the woodshop. This off-the-shelf unit was a cyclone design sized to match the output of the molder and was equipped with 1.0-μm (1 micron) cartridge filters. All personnel working on the project were fitted by a local safety company with a HEPA dust mask, of the type recommended by OSHA safety regulations for LBP dust exposure, and were given instructions for proper usage. Disposable Tyvek suits were provided to each worker to minimize the transfer of LBP dust to other parts of FPL or into the employees' homes.

Evaluation of air quality during machining

Air was sampled to determine if the woodworking operations produced unacceptable levels of airborne lead. Personnel performing specific milling operations were fitted with personal air monitoring pumps that operated continuously while the specific operations were performed. A constant volume of air was moved through the pump (2.0 L/min) and the time was recorded (**Fig. 1**).

In addition, a general purpose air monitoring pump was used to sample air outside the building, both as a means to establish a background control (clean) sample and to sample the air around the exhaust of the dust collection system. The air-sample collection cartridges were sent to a licensed State of Wisconsin laboratory for analysis.

The blood lead levels of all staff involved in this research project were checked by staff from a local hospital before the project started and immediately after all machining ended.

Residual lead on machinery surfaces

A test was performed to determine whether residual lead was present on the surfaces of surrounding equipment. American Society for Testing and Materials Standard E-1728 (ASTM 2002) specifies the use of a wiping cloth to collect settled dust for lead analysis. This method was used to sample the machinery. Total lead was measured in μg/m^2.

Figure 2. — Sanding of installed flooring. Note air monitoring pump on operator.

Depth of lead penetration

Previous testing of wood siding at Fort Ord (by others) suggested that the lead from LBP (or possibly from leaded gasoline used to thin the paint) might have penetrated the wood siding to a depth that would render it unusable for remanufacture. This premise was suspect because Douglas-fir is a refractory species (it resists the penetration of preservative treatment chemicals). To determine if lead penetration was possible, representative samples of siding were tested for total lead content. Specially purchased power woodworking equipment was used to plane the paint surface and subsequent layers of wood to produce specimens of varying thickness. These samples were then tested for total lead content.

Exposure of workers during installation of flooring

A portion of the T&G flooring produced in this study was installed in a 3.3- by 4.0-m office at FPL. After installation, a local wood floor finishing contractor was hired to sand the floor. The operator of the sanding equipment was fitted with a personal air monitoring pump in a similar fashion as were the woodshop operators (**Fig. 2**).

Results and discussion

Evaluation of air quality during machining

As stated earlier, the OSHA permissible exposure limit for indoor lead exposure is 50 μg/m^3 averaged over an 8-hour work shift. As shown in **Table 1**, indoor monitoring of air in the breathing zone of woodworking personnel during machining operations indicated that lead levels were considerably below this limit. This indicates that the off-the-shelf dust collection system chosen was very effective in removing LBP dust from the indoor workshop environment.

Table 1. — Results of indoor and outdoor air monitoring for lead in FPL remanufacturing operations.

Operation	Sampling period	Lead	
		Test results	Calculated exposure level (over 8-h period)
	(min)	---------(μg/m³)---------	
Indoor measurement			
Operation of molder	79	21	3.5[a]
Ripping on tablesaw	130	7	1.8[a]
Crosscutting	82	27	4.6[a]
Outdoor measurement			
Outdoor background	215	ND[b]	
Dust collector exhaust	102	9[c]	

[a]OSHA 8-hour work shift time-weighted average (TWA). Limit is 50 μg/m³.
[b]None detected (<1.2 μg/m³).
[c]EPA standard for outdoor airborne lead is 1.5 μg/m³ averaged over 3-month period.

Outdoor measurements were made using a stationary pump. The worst-case exposure was expected to be directly at the exhaust of the dust collector. Measurements at that location indicated a lead level of 9 μg/m³, which is greater than the 1.5-ug/m³ outdoor airborne lead level set by the EPA. Because the EPA level is averaged over a 3-month period, a continuous woodworking operation using LBP-coated materials would need to be continuously monitored to determine operational time limits, so that the 3-month limit would not be exceeded. Recall that a 1.0-μm filter was used with the dust collector. The use of a higher efficiency filter, such as a HEPA filter, which can filter down to 0.3 μm, would further reduce lead output.

Monitoring of blood lead levels

As indicated in **Table 2**, two of six employees had elevated blood lead levels at the end of the project; the blood lead level of employee E was slightly elevated (5.9 μg/dl) and that of employee A was more considerably elevated (13.7 μg/dl). OSHA considers a normal level of blood lead to be less than 10.0 μg/dl. The blood lead level of employee A was high (9.8 μg/dl) before the project was initiated. Discussions indicated that this individual had been recently involved in home remodeling projects involving LBP (sanding of exterior LBP-coated wood siding on an old home), which was likely the reason for the elevated starting value. Also, employee A conducted all clean-up after machining; i.e., emptying barrels of shavings, cleaning filters, etc. This employee admitted to not wearing a mask filter at all times and thereby received the highest exposure of all employees. As discussed earlier, the OSHA action level for blood lead is 40 μg/100 g.

Residual lead on machinery surfaces

The surfaces of machinery in close proximity to the molder were tested to determine if dust-containing lead had migrated during the moulding process. Lead was detected after machining approximately 1500 m of wood siding into profiles over a 4 hour period. At the first two locations monitored (tablesaw top and top of sander motor), higher levels of lead were detected before machining than after (**Table 3**). Because machining took place some days before these measurements were taken, some dust from the previous profiling had likely settled on these more remote locations. After machining, only moderate levels of lead were detected 6 m from the molder operation. As expected, surfaces closer to the molder had higher lead levels. Not surprisingly, high lead levels were found on the molder knives. Alhough some of the lead levels found were in excess of the HUD action levels discussed earlier, they may be acceptable for an industrial workplace. However, at this time, action levels for wood processing operations have not been established.

Table 2. — Tests of blood lead level.[a]

Employee	Initial value	Final value
	-------------- (μg/dl)--------------	
A	9.8	13.7
B	< 5.0	< 5.0
C	< 5.0	< 5.0
D	< 5.0	< 5.0
E	< 5.0	5.9
F	< 5.0	< 5.0

[a]Normal range of blood lead is 0.0 to 9.9 μg/dl. Values less than 5.0 μg/dl are not provided by medical testing laboratory. Concern about subtle health effects from lead exposure, including potential reproductive effects, generally arises for a blood lead level >20 μg/dl.

Table 3. — Lead detected on machinery surfaces near molder.[a]

Location	Area sampled	Lead detected	
		Before machining	After machining
	(mm²)	------(μg/m²)------	
Tablesaw top, 6 m from molder (north)	90	10	5
Top of sander motor, 6 m from molder (east)	90	19	9
Infeed bed of molder	90	51	60
Bottom of molder knives (blades only)	< 10	2	204
Top of in-line ripsaw, 1 m from molder	90	42	46

[a]All surfaces were cleaned by compressed air before sampling as part of normal machine cleanup.

Depth of lead penetration

For the six samples of siding evaluated from Fort Ord, surface lead concentration before planing averaged about 5500 mg/kg (**Table 4**). At an average depth of about 1.6 mm, lead concentration dropped to an average of about 26 mg/kg, an approximate 200-fold decrease. These results indicate that the lead contained in the paint did not penetrate the wood siding more than a few hundredths of an inch. This also indicates that as long as the painted wood is planed below this depth, the risk of high levels of residual lead in the manufactured product is low.

Exposure of workers during installation of flooring

A portion of the produced T&G flooring was installed in two rooms at FPL for display purposes. Though the lead penetration tests had indicated that lead was unlikely to be present on the surface of or in the flooring, the air was sampled while the floor was being sanded to ensure that those sanding the flooring would not be exposed to lead hazard. No lead was detected in the airborne sample, which suggests that the produced flooring was lead free. After the floor was finished, a swab test with polyurethane produced negative results, further

Table 4. — Penetration of lead in wood siding from Fort Ord buildings.

Sample no.	Total lead before planing[a]	Depth of cut[b]	Total lead after planing
	(mg/kg)	(mm)	(mg/kg)
1	5300	1.02	8.4
2	6500	1.27	6.9
3	1700	1.78	48.0
4	7500	1.27	65.0
5	5400	2.54	26.0
6	6500	2.03	2.4
Avg.	5480	1.65	26.1

[a]Indicates unplaned sample.
[b]Amount of material removed with planer from top painted surface of siding.

indicating that the exposed floor surface was free of residual lead.

Conclusions

The results of this study indicate that wood coated with LBP can be safely remilled, at least at the small scale of the operations used here, if proper equipment and common sense are utilized. No specialty equipment is needed, and commonly available woodworking dust collection systems safely filter and collect waste LBP shavings and dust from remachining operations. Lead exposure to workers in the immediate vicinity of remilling operations used in this study was found to be less than one-tenth that of the OSHA permissible exposure limit for indoor lead exposure. In addition, blood lead level monitoring indicated that if workers wear recommended safety equipment (face mask with HEPA filter, Tyvek suit) at all times when exposed to lead dust and use common sense in cleanup, they should not experience an elevation of blood lead level.

Testing of dust on surfaces in the vicinity of the woodworking operation indicated that the level of lead in the dust decreased relative to the distance from the planing operation. At 6 m from the machining operations, levels of lead found in the dust were below HUD standards for housing. (No standards exist for woodworking operations.)

Testing of the wood products indicated high concentrations of lead in the paint layer. However, the removal of as little as 1.6 mm of the painted surface decreased lead content considerably.

Finally, air monitoring of the sanding of installed flooring manufactured from the painted siding indicated that exposure of floor sanding operators to lead is minimal.

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