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Lead Paint and Wooden Window Restoration

Revised 6/12/2010

Lead Paint Facts:

The EPA defines a Lead Based Paint (LBP) as any paint or finish that contains greater than:

.5% in volume of lead or
1mg/cm^2 (1 milligram per centimeter squared) or
5,000 ppm (parts per million)

Lead was used in paint for color, white lead being the most frequently used for toning colors, to improve durability, to resist moisture (lead is insoluble in water) and to keep the paint looking fresh.

Lead carbonate = white
Lead oxide = red
Lead chromate = yellow, red ,green
Lead monoxide = yellow

Black paint rarely contains lead since any of the pigments listed above added to black would change it from a true black.

The use of lead based paint was banned in residential use in 1978. Lead based paint can still be used in commercial and marine applications.

Lead Paint poisoning

Lead is absorbed by the human body through ingestion and inhalation. Ingestion is the most widely acknowledged method of lead poisoning. Everyone has heard about the dangers of kids chewing on the wood work. The reality is that the majority of lead ingestion is through hand to mouth activity especially in children.

When lead dust is present in the air, as when a building with lead paint is being renovated creating dust in the process, the dust is inhaled.
Whether inhaled or ingested the lead is absorbed into the blood stream and picked up by receptors in the blood that usually carry calcium, iron and zinc. The lead then interferes with the

bodies normal systems. High lead levels, 10 micrograms per deciliter of blood and higher can cause irreversible effects in young children. High lead levels slow or stop brain and bone development. Children under 6 years of age are particularly at risk since they are in a rapid cell development as well as the fetus in pregnant women. In adults high lead levels can lead to reproductive problems as well as high blood pressure.

Lead poisoning can only be determined through a blood test. High lead levels are the result of "prolonged exposure" to lead. Prolonged exposure can not be defined since there are too many variables in the amount of lead to which a particular individual might be exposed and absorb into their systems.

After a few weeks Adults excrete approximately 99% of lead absorbed into their body, children only excrete approximately 32% of lead absorbed. When there is prolonged exposure to lead the lead is absorbed into the body's tissues, organs, and especially teeth and bones.

Painters were adding the lead to paint on an individual basis. Each painter had their own formula for how much lead was the right amount and if they were going for a particular color that also affected how much lead was added to the paint. So every different surface with lead based paint can have a different amount of lead resulting in different concentrations of lead exposure. In testing six different windows in our shop test the amount of lead in the paint ranged from greater than 5 mg/cm^2 to 1.37 mg/cm^2. (Test results are found on pages 3 and 4 with tables on pages 6)

The other significant variable is the diet of the child or adult. A diet that includes fresh fruits and vegetables high in calcium and iron lowers the amount of lead that the body will absorb. Basically if the receptors in the blood are already carrying calcium and iron they will not pick up the lead. Higher lead absorption rates are also associated with an empty stomach verses a full stomach.

<u>Dangers of Lead Paint</u>

If the lead based paint is sound and stable it is not dangerous. If the paint is deteriorating and failing then it is available for ingestion and is a hazard. Sound lead paint is a hazard on windows and doors where there are friction surfaces that can create lead laced dust that can then be ingested through hand to mouth activities.

One other area of danger is when restoration and renovation work is taking place. Disturbing lead based paint in the process of working on a house can release high amounts of lead based dust into the surrounding environment. It is very important when working on a property where lead based paint is present to take precautions to control the dust. There is a new EPA ruling, effective 4/22/10 guiding the work practices used during restoration on all pre-1978 houses, schools and daycares. Homeowners working on their own properties are exempt from the rules.

86% of housing stock built before 1940 contains lead based paints
66% of housing stock built between 1940 and 1960 contain lead based paint
25% of housing stock built between 1960 and 1978 contain lead based paint

Restoring Historic Wooden Windows

In the restoration of wooden historic windows it is common practice to strip all paint off of the windows in order to remove lead based paint. However there have been few scientific studies produced to prove the effectiveness of paint stripping methods. It is know that the most common method for stripping windows 10 years ago, known as dip stripping, actually pushed the lead into the wood leaving high lead levels in the wood. How the dip stripping pushes the lead into the wood is clear when the structure of the wood is considered. The dip stripping chemicals are also pushed into the grain of the wood which is why the chemicals have to be neutralized prior to repainting.

It is a known fact that the wood has "absorbed" lead from the paint. Wood structure is composed of cells and vessels that appear as a bunch of straws bundled together when looked at from the end. These straws are held together with lignin. These straws are how the living tree moves the water and nutrients necessary for growth. Drying the wood essentially empties the water out of the straws leaving voids in the cell structure. The density of wood is determined by this cell structure and how closely packed the straws are. A wood of higher density is more rot resistant because there are less empty areas to absorb water. The end grain of wood absorbs more moisture than face grain.

When applying paint, the paint is brushed into the wood pushing it into the pores creating a good bond between the paint and the wood. The dryer the wood the more it will absorb the paint through capillary action. As the painted wood surface ages and weathers the paint vehicle (oil for oil based and water for latex paint) slowly dries out and weathers away. However, the lead being a heavy metal remains in the wood. The lead will penetrate only as deep as the paint was absorbed. We are sending paint and wood samples to a material testing lab to determine the depth of the lead absorption on an average sash. If the wood was sound when painted it should not be very deep at all.

How much paint is being absorbed by any species of wood differs, even within the same piece of wood. That amount is dependent on the density of the wood and the surface condition at the time of painting. If the wood was well weathered and not well prepped when the paint was applied it would have been sucked right in like a sponge absorbing water.

The earliest wooden sash were constructed of old growth wood that has very dense straight grain compared to the plantation grown wood used today. The earliest sash were being built using hand tools and therefore there was more thought process put into picking straight grained wood that would work better with hand planes.

The industrial revolution brought in the development of machines to reproduce sash parts as well as the railroads bringing wood from other areas. Less time was spent picking for grain but more often Southern Yellow pine or Douglas fir was shipped in for sash construction. Both species are of higher density and contain more resins than Eastern White pine. These are windows that were built in the second half of the 19th C. and beginning of the 20th C.

Lead Testing at S.A. Fishburn, Inc.

In an effort to truly understand the results of our work in preserving historic wooden sash and lead abatement we recently tested several different sash in our shop using three different methods of paint removal that are commonly used by window restoration specialists today.

The tests in my shop were done with an XRF gun that measures lead in mg/cm^2. The XRF gun measures to the depth of about 1 micron or equivalent to the thickness of a hair. The tests were conducted by Terry Churchill, a lead inspector located in Barton, VT.

The first sash samples were windows from the Danville Town Hall. These are two light windows constructed in the 1890's of Eastern White Pine. Three different methods were used for stripping the paint: Back To Nature multi-strip non-toxic chemical stripper, dry scraping, and scraping after softening the paint with infra-red heat. The Back To Nature stripping products line are non-toxic strippers that are available for the DIY market. The stripper is applied to the paint and the softened paint is scrapped off. They are in no way comparable to the dip stripping process. Prior to stripping the paint the glass was removed from the sash using a steam box to soften the glazing.

The lead levels in the paint in the six sample sections (three interior and three exterior) ranged from 1.37 mg/cm^2 up to 3.24 mg/cm^2. The sections of bare wood where the paint was removed without excessive scraping ranged from .03 mg/cm^2 to .27 mg/cm^2 lead. All well below the EPA's acceptable 1 mg $/cm^2$ lead. Those same sections cleaned further through either sanding or card scraping to remove any paint residue left showed lead levels of .03 mg/cm^2 to .1 mg/cm^2 lead. The highest reading at this point, .1 mg/cm^2 is one tenth of the EPA accepted lead level.

The second sash samples from the Old North Church, North Danville, VT showed >5 mg/cm^2 lead content. The XRF gun only measures up to 5 mg/cm^2. These sashes are twelve light sash constructed of Eastern White Pine in the 1830's.The section of wood that was striped showed a lead level of 1.28 mg/cm^2 however there was a visible residue of paint still on the wood. When that section was card scraped to remove the residue the lead content dropped to .2 to .42 mg/cm^2. Although these results are higher than in the first tests the results are still less than half of the acceptable limit.

I had another set of six light sash built in the first half of the 19^{th} century tested by a different XRF gun that measures in ppm. The paint on the sash measured extremely high, 190,000 ppm lead. The striped and sanded sash ranged from 280 to 630 ppm which is roughly on tenth or less than the EPA acceptable lead level.

All of these reading, except for the paint, were on bare wood prior to repainting the sash. The other note to make when stripping windows specifically for the removal of lead based paint is that all of the paint must be removed. That means that the build up in the corners where parts join and paint in surface gouges must be removed.

Alison Hardy, a window restoration specialist in Massachusetts has had identical results with sash that were tested before and after restoration on lead abatement jobs.

Once these window are repainted the lead in the wood, at $1/10^{th}$ of the EPA accepted lead level is effectively encased by painting the window with modern lead-free paint. The surfaces that are wearing are creating friction on the painted surface. Traditionally the edges of the sash were not painted so the wood there has not absorbed lead. Therefore any wear on the edges is not producing lead dust. Once the sashes are re-installed into the frame with care taken to correctly fit them the friction points are minimized. Prior to re-installing the sash in the frames all built up paint on the frames should be removed.

To aid in the functioning of the sash we also wax the edges of the sash prior to final installation further lowering any friction between the sash and frame and easing the movement of the sash.

If there is concern of the paint wearing down to the point where the wood is being rubbed then the sash should be primed with a color dramatically different from the final color. For example a sash that will be finished white can be primed red. It will be clearly visible when the finish coats of paint have been rubbed off and need to be refreshed in order to maintain the painted surface.

Conclusion:

There has been a movement that the only way to rid houses of lead dust is to remove the windows and replace them. The results from our testing (we are going to continue regular testing) show that this premise is incorrect. It is possible through currently used practices to effectively remove the lead paint and leave the wooden sash with such minute amounts of lead in the wood that they are not a hazard and once they are repainted there is no lead at the surface to be worn into dust. There is no reason to replace historic wooden windows in order to remove lead based paint issues.

Lead was regularly used in food containers, gasoline, plumbing solder and paint prior to the ban in 1978. Since that ban cases of lead poisoning dropped 90%. The residues of these uses still plague our homes. There is lead in the soil from gasoline exhaust and from previous maintenance of exterior paint. Many surfaces in older homes have lead based paint on them. If the finishes containing lead are sound they are not a hazard except in areas of friction where fine dust is made as in the opening and closing of wooden windows. Removing the lead based paint from the window sash during restoration effectively removes the hazard of lead dust produced by using historic wooden windows.

The EPA has found that education about lead hazards is the single most effective measure to lower lead poisoning. Regular cleaning of houses with damp rags and mops or a HEPA vacuum minimizes any lead dust that may be present and is the single most important measure that can be taken to reduce lead poisoning. Regularly washing hands before eating in houses with high levels of lead dusts greatly reduces the amount of lead dust ingested. As well a healthy diet including fresh vegetables and fruits increases the body's resistance to absorbing lead as a first defense.

Danville Town Hall 1890's Eastern White Pine

Pre-stripping lead levels ranged from 1.37/cm^2 to 3.4 mg/cm^2

	Interior	Exterior	EPA accepted level
Back to Nature Stripper	.11mg/cm^2	.12mg/cm^2	<1mg/cm^2
Dry scraping	.05mg/cm^2	.27mg/cm^2	<1mg/cm^2
Infrared heat and dry scraping	.25mg/cm^2	.08mg/cm^2	<1mg/cm^2
Sanding after scraping	.06mg/cm^2	.05mg/cm^2	<1mg/cm^2

Old North Church, Danville. 1832
Pre-stripping lead levels were more than 5 mg/cm

	Interior/exterior	EPA accepted level
Dry scraping	1.10mg/cm^2	<1mg/cm^2
Sanding after scraping	.23mg/cm^2	<1mg/cm^2

1800-1850 sash test with PPM gun
Pre-stripping lead levels were 190,000 ppm

	Interior/exterior	EPA accepted level
Infrared heat And dry scraping	546 ppm	<5,000ppm
Sanding after scraping	290ppm	<5,000ppm

Further Reading

Park, Sharon C. and Douglas C. Hicks *Preservation Brief 37: Appropriate Methods for Reducing Lead-Paint Hazards in Historic Housing.* Washington, D.C: U.S. Department of the Interior, National Park Service. 1995

U.S. Environmental Protection Agency's Brochure *Renovate Right: Important Lead Hazard Information for Families, Child Care Providers, and Schools.* U.S. Environmental Protection Agency and U.S. Department of Housing and Urban Development. 2009

Resource Material

Environmental Protection Agency's *Lead Safety for Renovators, Repair, and Painting: Certified Renovator Initial Training Course, Student Manual.* U.S. Environmental Protection Agency. 2009

www.epa.gov/lead 1-800-424-LEAD (5323)

Hoadley, R. Bruce. Understanding Wood: A Craftsmen's Guide to Wood Technology. The Taunton Press. 2000.

Flexner, Bob. Understanding Wood Finishing. The Rodale Press. 1994