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SUBJECT: Ceramic Tile Lead Hazards and Miscellaneous Other Lead Risks in Residential Remodeling and Construction

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I am a builder-remodeler in Houston, Texas. Several months ago I contracted to demolish an existing ceramic tile shower in a house and to install a new ceramic tile shower. I have done many such jobs, so I thought I fully understood all of the environmental concerns. The old shower had a lead pan under it. This pan is a continuous piece of sheet lead, which is installed under the ceramic tile floor so as to form a waterproof barrier. I instructed the tile contractor to remove it intact and to not grind or heat it so as to produce either a dust or vapor. After the demolition was finished the homeowner asked me to test the concrete slab under the old shower for the presence of lead. She was especially concerned about lead because she had an eighteen month-old child. I used the swabs from a LEAD CHECK home lead test kit. I felt confident that all of readings would be negative. To my surprise, the reading on the slab indicated the presence of lead. Why was lead present if all of it had been hauled off to the dump in the form of the lead pan? My curiosity then got the best of me. I tested some dust in the bathroom but outside of the shower. I got a weak positive reading for lead. Further testing of some of the dust in the bathroom convinced me that I was dealing with some type of lead problem, which I did not fully understand, so I needed to get some professional help.

I called a company that does lead-based paint testing. One of their technicians came to the job and assisted me in taking what are referred to as wipe tests. These involve using baby wipes to collect dust in an area of defined size. At this time, he suggested that the lead may have come from the ceramic tile during demolition; but this could not be confirmed because all of this tile had been placed in a dump. These wipe samples were then sent to a certified testing laboratory for evaluation. The laboratory report indicated that all of the test samples exceed EPA and HUD guidelines for lead. Some of these readings were ten times acceptable levels.

I now faced the problem of cleaning up all of the affected areas. This cleanup involved vacuuming with a HEPA vacuum (see Endnotes), scrubbing the durable surfaces with a TSP (tri sodium phosphate) solution and scrubbing less durable surfaces with a mild solution of dishwashing detergent and water. All of the wastewater was dumped into the sanitary sewer system. Wipe tests taken after this intensive cleanup effort confirmed that lead concentrations on all of the tested surfaces were under the HUD and EPA allowable concentrations.

I still faced one more problem. The plumber was going to install a new shower drain. This involved the demolition of the concrete around the old lead drainpipe. I knew that this concrete contained lead from the results of the first tests that I had run using the home test kit swabs. This lead apparently came from the deterioration of the sheet lead shower pan as a result of its contact with the concrete. The lead had gone into solution and penetrated the concrete matrix. I isolated the bathroom with polyethylene sheeting, taped over the heating and air conditioning register, purchased disposal coveralls and half-faced respirators for the plumbers, taped a high efficiency air conditioning filter over the window, and placed an electric fan outside the window so that it put a small negative air pressure on the bathroom. Cleanup of the bathroom and the adjacent bedroom followed. Wipe tests confirmed that the cleanup was successful.

The original plans and specifications for this job called for leaving an existing sheet vinyl floor in place. The homeowner changed her mind and decided to install a new ceramic tile floor to complement the shower. When I removed the vinyl in preparation for the new installation, I discovered that the same ceramic tile that was in the old shower was also on the floor. This was the suspected lead-containing tile. There was no way that I was going to demolish this tile if any alternative was available. I called the lead-based paint-testing technician for help. He tested the floor tiles with an x-ray fluorescence (XRF) instrument. This device non-destructively indicates the concentrations of lead in the glaze in an area of specified size, usually one square centimeter. The tile showed high concentrations of lead. While the technician was at the job, he tested the old, original tile in the other bathroom. All of it was negative. This illustrated the fact that you cannot tell whether or not tile contains lead just by knowing its age or time of installation.

I knew that ceramic tile could be installed over existing, sound ceramic tile. A local manufacturer of tile setting materials recommended that I use an epoxy mortar because of its enhanced bond strength to old tile. This is a two-component product which produces great results, but which is difficult to work with. The floor tile went in without any unanticipated problems and effectively encapsulated the lead-containing tile. Final wipe tests confirmed that all tested surfaces were well within limits for lead concentration. The job was finished. The homeowners were satisfied with the work; all of the lead issues and concerns had been addressed and remedied; the lead dust had not adversely affected anyone's health; and I had learned a valuable lesson. I am writing this article now, in no small part, so that others who face similar situations will benefit from my experience.

The toxic effects of lead have been well documented in both general literature and in public health literature. It may be worthwhile to summarize these findings. Lead can enter the respiratory and digestive systems of a person where it is released to the blood

and distributed throughout the body. The most important aspects of lead toxicity are its effects on the central nervous system, which may be irreversible; however, lead affects all organs and functions of the body to varying degrees. The frequency and severity of symptoms among exposed persons depends on the level of exposure¹. Children and pregnant women are especially susceptible. For those who want additional information on the toxicological effects of lead, please refer to the references in the Endnotes.

Prior to 1978 United States manufacturers of ceramic tile used compounds of lead in the glaze on tile. These lead compounds enhanced the glass-like properties of the glaze and

offered the manufacturers a wider range of pigment colors. The process of firing the glaze at high temperatures fused the lead compounds into the glaze; and in normal use these lead compounds remained locked in the glaze and presented no health risk to people. When lead compounds are locked up in such a form that renders them benign to human health, they are referred as being bioavailable.

The crushing, abrading or shattering of a glaze can release a fine dust in which the lead becomes bioavailable. Many variables can affect the bioavailability of lead in glaze: the physical and chemical composition of the constituent materials, the kiln firing temperature, the atmospheric conditions in the kiln, body (bisque)-glaze interactions, etc. In addition, mild acids, such as citric acid from orange juice, can leach the lead compounds out of a glaze. If these compounds of lead are ingested or inhaled in large quantities or for an extended period of time, they can produce a toxic effect. As noted, the chemistry and biology behind this is fairly complex and is best left to those trained in toxicology and the ceramic sciences. For the layman, the safe course of action is "to prudently reduce the exposure of all people to all compounds of lead". It should be noted that sheet lead, which is pure lead and not a compound of lead, does not pose a risk to people who handle it assuming it is not vaporized or ground into a fine dust and assuming workers wash up on completing their work.

There is virtually nothing in published literature on the problems with lead in ceramic tile from the perspective of homeowners, builders, remodelers, and tile contractors. Information sources on lead address the problems associated with its presence in paint. Fortunately many of the methods used to deal with the lead issue in paint also apply to the lead issue in ceramic tile. Some of these sources are listed at the end of the article. In the absence of specific published guidelines for dealing with lead in ceramic tile, I offer the following:

1. Assume that existing ceramic tile and any new imported ceramic tile contains lead unless you verify that it does not. While lead was removed from United States produced tile in 1978 that is no guarantee that the tile in a house built after 1978 does not contain lead. Tile, which contains lead, is still, to this day, being imported into this country. I have confirmed this by doing a survey of imported floor tiles, which I obtained from various distributors in the Houston area. I must state at the outset that this was not a rigorous scientific survey and that the sample size was small. As such, my results may not be indicative of what someone would find under different circumstances. A certified risk assessor using a portable XRF instrument measured the lead content in these tiles. Thirty-nine tiles were checked; six (15 %) of them had measurable levels of lead in them. The lowest reading was 1.0 milligram of lead per square centimeter; the highest was 7.9 milligrams. While there is no recognized standard for lead in ceramic tile glaze, the EPA and HUD consider paint to be "leadcontaining" if it contains 1.0 milligram of lead per square centimeter. In addition, I have been told by reliable sources that floor tiles in other cities contain similar levels of lead.

I ran no tests on wall tiles; but to the best of my understanding, they are more likely to contain lead in their glaze. This is because they are produced in more decorative colors and in more intricate patterns. This should be an area for additional investigative work. I have also heard that some wall tiles are being salvaged from old buildings so that they can be used in new buildings to produce an "old-world" appearance.

As best I can determine, there are no regulations or laws in either the United States or in those countries, which export tile to the United States, which restrict the use of lead in ceramic tile glaze. There are also no requirements that such tile be labeled as "lead containing".

The best way to verify the lead content of installed tile is to get a lead-based paint detection professional to conduct a lead inspection and risk assessment of the tile and any other building materials, which are to be altered. This analysis should include x-ray fluorescence tests and confirmatory laboratory test where field tests are inconclusive. This highly reliable test process should run between \$100.00 & \$150.00 for TILE ONLY in most areas of the country. A complete lead measurement and risk assessment for a home, which includes paint and soil lead measurement, costs between \$300.00 and \$450.00. Many of these inspectors will not do a limited inspection (tile only) of a house because of constraints placed on them by regulations, civil liability, and professional standards.

You can also have a laboratory test a tile sample for its lead content. Try to select a laboratory, which has the National Lead Laboratory Accreditation from the EPA. The laboratory only needs a small sample; one square inch is sufficient. Be sure to control the dust when you remove the tile sample from its installed location. Cleanup afterwards and be sure to wash your hands. Place the sample in a small freezer bag. The test runs about \$20.00.

The Consumer Product Safety Commission (CPSC) considers any paint or similar surface coating with more than .06% lead (a trace amount) to be a "lead-containing" material. A .06% lead concentration equals 600 parts per million or 600 milligrams per kilogram. I tried to use this paint standard for ceramic tile, and I encountered some results, which could lead someone to believe that no lead hazard exposure problem exists when it actually does. In addition to the floor tiles, which I had tested, I had a small sample of the tile from the shower-remodeling job tested. The XRF measurement on this tile was 7.9 milligrams per square centimeter. That is notably higher than EPA and HUD's paint standard of 1.0 milligram per square centimeter. The laboratory test for this same tile was 101 milligrams per kilogram or 101 parts per million. This is markedly lower than the CPSC's paint standard of .06% (600 parts per million). It should be noted that the XRF instrument measures the lead in the glaze while the laboratory test measures the "total lead" in the entire sample piece of tile (glaze and backing). I must reiterate that this is the tile, which produced the dust that caused high levels of lead loading on surfaces immediately outside of the demolished shower, so I knew from experience that it could cause an above-standard dust situation.

I made no formal attempt to reconcile the XRF readings with the laboratory results. My assumption is that the proportionally large mass of the tile backing as compared to the thickness of the film-like glaze accounts for some of the wide variations in the readings. Essentially the lead is a high proportion of the glaze but a relatively low proportion on the entire tile. Another factor could have been the dissolvability of the lead compounds in the hydrochloric acid that was used for the test. Until some industry standard has been established and published, I recommend that protective and containment methods be employed if any lead is detected in a laboratory test.

It must be emphasized that if lead is present in any amount OSHA standards-of-worker protection (See Endnotes) may become effective. It also needs to be noted that altering

materials, which contain even low concentrations of lead, can produce dusts and residues with lead-loading measurements, which exceed both HUD and EPA standards. Lead concentrations are measured in parts per million while lead loading is measured in micrograms per square foot. A substantial accumulation of a material with a low CONCENTRATION of lead can LOAD an area with an unacceptable amount of lead (See Endnotes).

There is one additional method for testing the-a home lead test kit. You can usually find these test kits at paint stores, home centers, and some hardware stores. There are several different brands of these home test kits on the market. They use different chemicals or combinations of chemicals (reagents) to produce a color change when they are placed on or in contact with lead-containing material. They are primarily designed to test for lead in paint although; some contain instructions for use on glazed surfaces.

Many variables can affect the reliability of the readings obtained from these test kits (i.e. reagents used, operator skill, type of lead, color of material being tested, dissolvability of the lead, concentration of the lead, etc.). As a result, EPA and HUD do not recommend using these test kits for risk assessment based on their tests of these test kits on lead-containing paint (EPA747R 95-002a, May 1995). I was not able to locate any independent, third party evaluations of these test kits for use on glazed ceramic tile. Special instructions for the LEAD CHECK test kit indicate that their product will detect leachable lead in ceramic tile. As a note of caution, it must be emphasized that some of the lead in ceramic tile may not be leachable. Lead in tile glaze, which is not leachable under test circumstances, may still be a problem when the glaze is broken up during installation or demolition.

Evaluating the reliability and effectiveness of these test kits is a complex undertaking and well beyond the scope of this article. Suffice it to say that the EPA and HUD have their opinion and the manufacturers have somewhat different opinions. I can only relate my personal experience with one of these test kits. I used the LEAD CHECK home test kit to initially determine that I had a problem with lead on the previously mentioned remodeling job. This test kit only indicated the presence of lead, not its concentration. It worked for me, but this is no endorsement of this brand of test kit or of the use of test kits.

If cost and reliability are both important factors, send a tile sample to a laboratory for evaluation. To do this you must plan ahead because most laboratories have a "turnaround" time of one week. If time is of the essence and the budget allows it, employ a lead-based paint detection professional to do an assessment. If you decide to use a home lead test kit, make sure it can be used on ceramic tile, follow the instructions carefully, and be fully aware that there is some probability that you will get test results of unknown accuracy.

2. If lead is present in existing tile, decide whether or not the tile needs to be removed. If it can remain in place, covering it up will encapsulate it so that it does not present any health hazard.

If it must be removed, follow the guidelines published by HUD, OSHA (Regulations for Lead 1926.62), and the EPA. During the demolition, contain the dust and debris, protect workers, clean up on completion, and verify the quality of the cleanup by independent

testing, and dispose of the trash and clean-up water properly. If circumstances allow, spray a light mist of water on the lead containing material as you demolish it to control the dust. It should be noted that workers could be exposed to a crystalline silica hazard even if a lead hazard is not present.

According to EPA regulations, homeowners and contractors can place lead-containing paint waste from a HOUSEHOLD in a local dump, which is certified to accept construction trash (www.epa.gov/lead/fslbp.htm for the document "Lead-based Paint for Residential Contractors"). The EPA regulations do not specifically address the issue of lead in ceramic tile. Common sense dictates that it would be covered under the same regulations for household waste; but do not assume that that is the case. Local regulations are sometimes more restrictive than EPA regulations. Check with you local or state health department. In circumstances where sheet lead is considered a hazardous waste, you may be able to take it to a certified recycling center.

If all of these regulations and methods pose too daunting a challenge for you, get a certified lead removal contractor do the job. This will be expensive, but it will buy you piece of mind. Note of caution: According to EPA regulations, you are not required to have a certified lead abatement contractor remove the lead containing materials if your INTENT is to do renovation work. If your INTENT is to abate the lead containing materials, you are required by law to have the work done by a lead abatement contractor. Some state regulations are more restrictive.

3. Do not prepare food on ceramic tile counter tops where lead is present. This especially applies to foods, which contain mild acids like tomatoes, oranges and lemons.

4. Does existing floor tile, which contains lead, present a hazard? Is the abrasive action of foot traffic generating a small amount of lead-containing dust? Most industry experts believe that such tile is so hard that normal foot traffic will not produce enough dust to create any hazard. Some consumers to whom I have talked are more cautious. They tend to err on the side of caution especially if young children crawl on the floor. This issue suggests the need for additional study and research. In the interim, cleaning lead-containing floor tile with mild, phosphate-based detergents regularly should control any lead-containing dust if it is present.

5. If you are installing new, imported tile have it tested for lead. Caveat emptor; let the buyer beware. If the tile tests positive for lead, that is not a definite indication to not use it. Consider where it will be used and how much physical and chemical abuse it will receive. If you choose to use a lead-containing tile, specify that the tile installer control any dust or residue associated with the installation process. Dispose of the water and the tile slurry associated with the wet cutting of the tile properly. The water can go into the sanitary sewer (Most communities allow small quantities of lead-containing water to go into the sanitary sewer). Place the slurry in heavy plastic bags and dispose of it as construction waste. The same cleanup and clearance recommendations for demolishing lead containing tile apply to the installation of new tile. The tile installer needs to take precautions to avoid the toxic effects of the lead and he needs to be sure that he does not carry tile dust home on his clothes or in his truck. Bob Knowles, a professional lead risk assessor, made the importance of this clear to me. On several occasions, the New Mexico Health Department asked him to trace down the source of lead that was causing elevated levels of blood to show up in school children. In some of these cases, he verified that the lead was coming from the professional activities of these children's

parent or parents who were tile installers. The tile dust was in their pick-up trucks and it was on the clothes, which they were wearing home. The pick-up trucks were used as work vehicles and for family transportation.

If you sell your house after installing lead-containing tile, you may have to fully explain that fact to a prospective buyer. HUD regulations require that the sellers of pre-1978 houses disclose known information on lead-based paint and lead-based paint hazards. In addition, the prospective buyers are given a 10-day period to conduct tests for lead-based paints and hazards at their own expense. It is reasonable to assume that the person who conducts these tests could note the presence of the lead-containing tile. This may cast a shadow of doubt and uncertainty over the whole transaction. All people, including many prospective home purchasers, do not view the presence of lead-containing material with dispassionate objectivity. This is especially true where children are involved.

6. If a lead shower pan is removed as part of the demolition of an old shower, assume that the contiguous building materials contain lead unless tests confirm differently.

7. Contractors could incur some liability if their activities cause elevated levels of lead in or on the property. Also, a contractor could be accused of causing lead contamination if he does not follow lead control procedures rigorously or if he does not establish baseline lead level measurements. Neither the contractor nor the property owner wants to get into a disagreement about whether new tile work or old deteriorating paint caused a high level of lead. If above-standard levels of lead are discovered on a property after tile work has been performed but before a stated or implied warranty period has expired, it may be necessary to designate any clean-up efforts as a "lead abatement" instead of a clean up of job-related waste. Such a designation would require that a certified lead abatement contractor do the clean up.

In a perfect scenario, a contractor would have a professional lead inspection and risk assessment done before any work is started. This would establish baseline lead level readings. All industry standards for the control of lead would be observed as the work progressed. All areas of potential contamination would be thoroughly cleaned at the completion of the work. The lead inspector would conduct final clearance tests and compare them to the baseline measurements. All of the documentation associated with this would be given to the property owner.

This perfect scenario costs money, and most, or all, of these costs usually get passed on to the property owner. A middle ground position involves the contractual assumption of some of the risks and costs by the property owner. This can involve arcane legal procedures and language, which is well beyond the scope of this article.

8. The presence of lead in a house does not mean that the lead is hazardous to the health of the people living in the house. All of the situations mentioned so far are manageable provided that you are aware of the lead. Lead is not like asbestos, which can travel considerable distance from its source as light, airborne particles. Lead is a heavy molecule, which quickly falls from the air as dust. Good housekeeping procedures and personal hygiene go a long way to reduce exposure. Some of the good news is that the lead content of all tiles around the world has been dropping, and this appears to be continuing. If you are having trouble assessing the risks involved, get some help from

local qualified professionals. The peace of mind, which you purchase, is well worth the price.

Some additional points of information about lead in the home:

The glazes on some old bathtubs can contain leachable lead. It is important to verify this if children are using these tubs. The older the tub, the more likely it is that it contains lead. As best as I can determine, lead is no longer used in bathtub glazes.

Old floor varnishes can contain small amounts of lead. When sanding floors during a refinishing process, control the dust and then do a thorough clean up afterward.

Old, exterior lead-containing paint will deteriorate (chalk) over time. Rain can wash the loose lead compounds into the adjacent soil. Do not allow children to play in such soil, and be sure to locate a vegetable garden away from such areas.

In conclusion, I believe that all new and salvaged tiles offered for sale should be labeled as "lead-containing" if it has lead in it. The actual amount of lead in the tile should be noted and this should be correlated to industry standards for worker protection, job site containment and clean up. Tile manufacturers, distributors and importers working in conjunction with government regulatory agencies should also set standards for XRF and laboratory tests for lead in tile.

Trade organizations, consumer groups and government agencies should publicize the risks attendant to the demolition of "lead-containing" tile. Professionals who do lead inspections and risk assessments on houses should check all of the tile installations and record their findings in a permanent records for the houses. Homeowners and contractors could use this information to make informed decisions on how to properly manage a job where "lead containing" tile was present.

The health risks associated both with the installation of new "lead containing" tile and the demolition of old "lead containing" tile should be fully researched. How are such activities directly or indirectly affecting tile installers, homeowners, and their families? Concerned people need answers to these questions. Such answers will establish a framework within which prudent and balanced industry and regulatory policies can be developed.

ENDNOTES

EPA-United States Environmental Protection Agency

HUD-United States Department of Housing and Urban Development Milligram = 1/1000 of a gram

Microgram = 1/1,000,000 of a gram

EPA Clearance Levels for Lead (Lead Loading)

Uncarpeted and Hard Floors 100 micrograms per sq. foot

Interior Window Sills 500 micrograms per sq. foot

Window troughs 800 micrograms per sq. foot

A window trough is the area between the upper and lower window sashes immediately outside of the window stool (sill). Lead loading measures the amount of lead in a designated area. Lead concentration indicates the amount of lead in parts per million. Lead loading is the best method to measure lead hazard risk. It is easily measured by the wipe sampling test method (settled dust on a baby wipe).

The EPA has proposed lowering the clearance level standards above to half of the cited levels. This proposal has not been formally approved.

HEPA-HIGH EFFICIENCY PARTICULATE AIR Filter is one, which will remove 99.97% of particles as small as .3 microns (micrometers). Such particles are so small that the unaided human eye cannot see them. A true HEPA vacuum has a sealed air pathway. There are many "HEPA like" vacuums on the market now. They are better than traditional vacuums at filtering the airflow, but they are not true HEPA vacuums because they lack a sealed air pathway. HEPA vacuums are relatively expensive (\$500.00+) and the filters, which go in them, are expensive. These vacuums can be rented at some rental service stores. It should be noted that some preliminary EPA field research indicates that the better quality "HEPA like" vacuums do a reasonably good job of picking up and controlling the dispersion of lead particles. Use such vacuums ONLY if a true HEPA vacuum is not available. For further information on HEPA vacuums go to www.ristenbatt.com, the website for Ristenbatt Vacuum Cleaner Service.

PUBLICATIONS:

PROTECT YOUR FAMILY FROM LEAD IN YOUR HOME, EPA747-K-99-001

REDUCING LEAD HAZARDS WHEN REMODELING YOUR HOME, EPA 747-K97-001

OSHA Standard Number 1926.62. This "applies to all construction work where an employee may be occupationally exposed to lead".

Websites: WWW.HUD.gov/lead WWW.EPA.gov/lead

Other Information Sources:

National Lead Information Clearinghouse 1-800-424-LEAD HUD Office of Lead Hazard Control 202-755-1785

Home Lead Test Kits: LEAD CHECK, 508-651-7881, www.leadcheck.com. LEAD SMART, 800-604-1995, www.hometest.com, this kit contains supplies that allow the user to mail wipe samples into their laboratory for testing. Approx. \$20.00. Many people, from literally around the world, contributed advice and information to make this article

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Jim Moss, Industrial Ceramist, Ceramic Tile Consultant, Pachuca, Mexico Franco Ambri, Chemical Engineer, Ceramic Tile Consultant, Modena, Italy

1. Protecting Workers Exposed to Lead-based Paint Hazards: A Report to Congress, U.S. Department of Health and Human Services (NIOSH), Publication No. 98-112

2. Toxicological Profile for Lead, U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Publication No. TP-88/ 17

3. CDC (1991) Preventing Lead Poisoning in Young Children, U.S. Department of Health and Human Services, Public Health Service

4. Criteria For a Recommended Standard: Occupational Exposure to Inorganic Lead, NIOSH, Publication No. 78-158

The author assumes full responsibility for any error or oversights