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Assessment of Occupational Lead Exposure Potential for Carpenters and Painters Perfoming Small scale Renovations and Repairs at the University of Connecticut-Storrs, and the Subsequent Establishment of a Worker Lead Awareness Program

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Introduction

In 1993 the Occupational Health and Safety Administration (OSHA) expanded lead exposure regulations for non-construction industry employees (e.g. lead smelters and battery production) to also include construction industry workers. Until this expansion lead exposure to workers employed in painting and construction had not been a well recognized health risk. (1) Until very recently, and despite the implementation of the lead in construction standard in 1993, there had not been a broad awareness by the generally self-employed and small company-based painters and carpenters that, regardless the lead-in-paint concentration, certain surface preparation techniques could result in airborne lead exposures above the OSHA limits. Historically accepted techniques of surface preparation, including dry sanding, scraping, and demolition, are now being replaced with methods that prevent airborne exposure levels above the OSHA Action Level [1] (AL) of $30 \mu g/m^3$.

With over three-hundred-fifty buildings ranging in age from essentially brand new to well over 100 years old, there is ample opportunity for the painters and carpenters employed at the University of Connecticut - Storrs to encounter lead-coated surfaces during the course of their daily work routines. It is well documented that buildings constructed prior to 1978 are known to contain varying levels of lead based paint both on interior and exterior surfaces.(2) However, even those buildings constructed after the Consumer Product Safety Committee (CPSC) banned the use of lead in 1978 as an additive to residential

[1] Action Level: A time weighted average air concentration that is based on an 8-hour work day. Meeting or exceeding the action level initiates General Industry and Construction standard requirements such as worker training, education, exposure monitoring, and medical surveillance.

paint may have lead paint concentrations high enough to result in worker exposure beyond the OSHA Action Level of $30 \mu g/m^3$ if the paint is aerosolized into respirable lead fumes or attached to dust particles.(3)

At the University, maintenance department painters and carpenters undertake relatively small-scale individual office and laboratory space related renovations, remodeling, and repair requests that occur on a regular basis throughout campus. Conversely, large scale building renovations and building demolition procedures are routinely contracted to commercial vendors who are required to address lead exposure potential, and any remediation efforts as part of the agreed upon contract terms. Until recently, the University-employed painters, carpenters, and their supervisors, like their privately employed counterparts were relatively unaware of the potential lead exposures that could occur during routine pre-painting surface preparations and minor demolition.(4) Accordingly, the workers implemented few precautionary steps towards reducing their exposure to lead via surface preparation procedures.

A study of lead exposure in residential and commercial painters released in February 2002, by the Occupational Health Branch of the California Department of Health, clearly demonstrated that manual and mechanical dry surface preparation techniques, consistent with the then existent practices at the University, could result in airborne levels of lead exceeding the OSHA Permissible Exposure Limit [2] (PEL) of $50 \mu g/m^3$.(5) As a result of this study, the University's Department of Environmental Health and Safety (EH&S) determined

[2] Permissible Exposure Level: The maximum worker exposure to lead in air as averaged over an 8-hour workday.

it was necessary to more formally introduce an employee lead awareness program with the intent that management would in turn support the processes necessary to better protect their workers from inadvertent lead exposures associated with minor renovations and repairs on painted surfaces. As part of this effort it was decided to conduct controlled surface preparation/minor demolition work-related lead exposure assessments involving painted surfaces having known lead concentrations while using previously documented and recommended safe-work surface preparation techniques designed to control/reduce the generation of airborne lead.[1, 6, 7, 8, 9] The intent of these industrial hygiene assessments, conducted in accordance with OSHA 1926.62 guidelines, was to assess a specific simple, relatively inexpensive, painted surface preparation/light renovation process with the intent that employee exposure to lead at or above the OSHA Action Level of $30 \mu g/m^3$ would not occur. [10] Based upon the successful results of these assessments, combined with the similar results from the California Department of Health study, and a similar study conducted in a privately owned building undergoing renovation, it was decided to implement the safe-work processes. This was done via a lead awareness training program for University-employed painters and carpenters detailing the specific surface preparation processes to be utilized and the basis for this action.[1]

It is the intent of this thesis to (1) review the results of the EH&S conducted assessments, (2) conduct an expanded lead exposure analysis, (3) compare the results of both analysis , and (4) establish and implement safe-work

policies, procedures and a training program for University-employed painters and carpenters.

The content of this paper initially reviews the historical use, toxic properties, and development of occupational lead exposure guidelines and regulations. In addition, due to the particular sensitivity of children to lead, the author reviews the association between parental occupational exposure and childhood exposure. Also included is a detailed description of the lead exposure assessment methodologies, the results of those assessments, and the establishment of occupational worker safe-work procedures and training. Finally, the author will conclude with several recommendations for OSHA to consider as an alternative to the present financially based occupational permissible exposures levels.

Statement of the Issues

The National Institute of Occupational Safety and Health (NIOSH) estimates that in excess of three million workers in the United States are exposed to lead in their places of employment.[11] Data from 1994 demonstrate that 95% of cases of lead intoxication in adults is due to occupational exposures.[11, 12] It is also generally understood that enforcement of existing standards is inadequate and the OSHA standards themselves are subject to differing interpretations and therefore are somewhat confusing and arguably difficult to comply with.[13] Current OSHA lead standards are based solely upon measured airborne concentrations of lead and do not provide a de minimis cutoff for lead content of surfaces in the work place that would correspond to acceptable airborne lead levels. Having no such de minimis lead paint concentration at which it is considered safe, or legal, to work necessitates either (1) a specific process lead exposure analysis, or (2) a labor intensive commitment to conduct lead sampling and analysis for each and every task involving any painted surface. The necessity to perform either process is unaffected by the date of construction or renovation. [14, 15] Besides the University of Connecticut, other educational institutions have similarly encountered this confounding situation in formulating their respective lead awareness programs. [14, 15] The University of Connecticut, due largely to insufficient staffing levels necessary for such an undertaking, has subscribed to a process of simply assuming that any work (i.e. surface preparation or minor

renovation processes) that is required on any painted surface may result in an airborne lead situation. [14, 15]

Another confusing aspect of the various U.S. lead regulations is the Consumer Product Safety Commission's definition of lead-free paint as paint with less than 0.06% (600 ppm) lead by dry weight, as compared to the Housing and Urban Development (HUD) Title X of the 1992 Housing and Community Development Act criteria that defines lead-based paint as paint with greater than 0.5% (5000 ppm) lead content. What then is the status of lead levels lying in the range between 0.06% and 0.5% lead content? The University of Connecticut has answered that question by assuming that any building or any painted surface, regardless the age and regardless the 1978 Consumer Product Safety Committee ban on lead in paint, may have paint containing minimal, yet legally compliant, lead concentrations. These concentrations may be high enough, when subjected to specific abrasive surface preparation treatments, to result in worker exposure beyond the OSHA Action Level (AL) of 30μg/m^3 if the paint is aerosolized into respirable lead fumes or attached to dust particles. [3, 16, 17]

The University EH&S Department intends, as a result of this thesis, to implement good industrial hygiene practices designed to minimize lead exposures instead of relying on air concentration presumptions based on the OSHA Lead in Construction Standard. These historically accepted presumptions have been demonstrated by Scholz, et.al. as being technically inaccurate.[5] This methodology is consistent with approach by Senn (1990) that it is more prudent to practice industrial hygiene with no limits rather than to rely upon air sampling

results that are subject to wide variances of lead paint concentrations and mechanical surface preparation. [18, 19]

Historical Perspective of Lead Utilization and Exposure

Humans knew of lead and its many useful characteristics as early as 4,000 BC. The Egyptians and Hebrews regularly utilized lead in their day-to-day lives for artistic, monetary, and other, even insidious, purposes. For example, the Egyptians were found to have discovered the harmful effects of lead and lead compounds as evidenced by papyrus scrolls describing homicide by lead poisoning. [20] Following its discovery, large quantities of lead were mined and smelted in southwest Asia and Europe and utilized primarily for construction. The low melting point gave it high malleability and therefore it was easy to manipulate in the primitive forges of that time. [21] The use of lead was wide spread in Europe and Asia but there was no heavy concentrated use until the time of the Roman Empire. The Romans constructed a vast and very reliable system of lead-lined aqueducts, and used copious quantities of lead for water piping, pottery glaze, wine vessels, cooking utensils, and even a sweet-sour seasoning for food.[21] For approximately four hundred years the Romans utilized lead at a rate of approximately 60,000 tons per year. Included in this amazing amount of lead use was a single water system siphon unit that consisted of approximately 12,000 tons of lead. [22] Though lead poisoning was recognized by the Romans, their infrastructural dependence on the metal resulted in a passive, almost accepting, concern for the chronic illnesses it caused. Lead exposure through food, water, and wine (a favored beverage of the times) consumed primarily by aristocratic members of the Roman society, was likely the main contributor to the epidemic of gout and sterility in the wealthy young men, as well

as a major contributor to a high incidence of infertility and stillbirths among the wealthy women of the empire. [21] The chronic effects would in the end contribute to the decline and ultimate collapse of the Roman Empire. In support of this theory, archeological analysis of Roman patrician bones have revealed higher concentrations of lead as compared with bones found in the plebian graves of the same era. [20]

In the Middle Ages lead continued to be utilized for a wide range of industrial, domestic, and medicinal purposes. However, despite its continued heavy use, few literary references were produced during these times that describe the deleterious effects. However, it is known that in German countries between 1498 and 1577, it was considered a crime punishable by death to use lead acetate (i.e. lead sugar) as a sweetener in cider and wine. [20] In France ground lead was commonly referred to as succession powder for its ability to eliminate higher standing family members. [21]

In the pre-industrial period lead was being increasingly utilized in the so-called New World of colonial America. Much progress made by the colonists was owed to the use of the abundant metal in pottery, shipbuilding, window making, printing, and firearms manufacturing. [20, 21] In England, in 1767, George Baker, a physician to the royal family, produced a paper on the cause of Devonshire colic at the College of Physicians. [20] Drawing on statistics compiled by the newly opened Devon and Exeter Hospital, Sir Baker successfully demonstrated that there existed a far greater incidence of palsy, encephalopathy, pallor, and abdominal cramps (i.e. colic) and overall higher fatality rate in Devon than in

other cider producing counties. He dismissed acidity as a cause, suggesting that the use of lead in the Devon cider making equipment, specifically the dissolving lead weights used to crush the apples, as a probable cause. [20, 23]

In the early 1800s, with the dawning of the Industrial Revolution, the utilization of lead increased as did the awareness of the medical complications associated with its use. Industrial workers at this time began to fully recognize the etiology of lead exposure. [20] For example, women working in lead industries knew that lead caused abortions, and increased the risk of stillbirth and an overall higher mortality of their newborn children in their first year of life. It was also known that lead would reduce the fertility of men working with lead. [20]

In 1832 clinical lead poisoning was referred to by Thackrah as "plumbism." As such, it may be said that modern day plumbers owe their job title to a description of the horrible set of ailments that were intrinsic to lead exposure. [20] Modern day plumbers were themselves exposed to the lead prior to the 1986 and 1988 Safe Drinking Water Act Amendments which prohibited the continued use of lead in solders, flux, and pipes. [55]

In 1899, the practice of counting stippled cells as a methodology of determining lead exposure was first described by Behrend. This practice though neither specific nor sensitive in its ability to qualify or quantify lead exposure would continue in use until the 1960s. [20]

The United States emerged as the world's largest producer and consumer of lead by the turn of the twentieth century. Consumption was primarily in the form of a gasoline additive (tetra-ethyl lead) invented by General Motors

engineers in 1921 to improve combustion engine performance. [21] In 1925, due to dramatic adverse health effects suffered by workers involved in the synthesis of tetra-ethyl lead at several U.S. refineries, the U.S. Surgeon general temporarily suspended the production and sale of leaded gasoline. However, despite the efforts by Dr. Alice Hamilton, an early pioneer of U.S. occupational medicine from Harvard University, and at that time a primary opponent of any form of lead use, the Surgeon General-convened panel soon ruled there were no substantial grounds for the prohibiting the use of tetra-ethyl lead. Leaded gasoline would remain in use until the Clean Air Amendment of 1970, at which time the use of tetra-ethyl lead consumption was required to be phased out. Tetra-ethyl lead would be banned in the U.S. as a gasoline additive in 1986. [20, 21]

The other primary source of lead exposure and lead in the environment, second only to leaded gasoline at the time, involved the use of what was known then as white lead paint. Lead has been historically used in paints to improve adhesion, reduce flaking and chipping, and reduce drying time. In 1921 an International Labor Conference produced an outcome known as the White Lead Convention, in which several nations agreed to a prohibition of the use of white lead paint in indoor painting. However, the U.S. Lead Industries Association successfully lobbied and blocked the U.S. government from signing the convention. The use of leaded paint in buildings continued in the U.S. for several decades until its eventual banning as a paint additive in 1978. [20, 21] Since 1910 it is estimated that approximately 4.2 million tons of lead have been used in white

lead paint alone. In addition to the white paint, prior to 1978 several of the red, yellow and orange colors contained upwards of 16% lead by weight. [24, 25]

Medical surveillance and treatment of lead poisoning at this time was primarily post-exposure based. However, there were sporadic efforts on the part of industry to enact lead exposure preventative measures. Examples of the more effective practices were wet methods for dusty processes, good worker hygiene programs (i.e. hand washing, clothing changes, etc.) and other common sense practices. However, drinking milk as a lead blocker, the use of chelating agents as a therapeutic and prophylactic agents against lead poisoning were either not effective or had more disadvantages than advantages. [20]

Better methods for detecting lead in the human body were developed in the late 1960s. Analyses such as Blood Lead Level (BLL) were made more accurate and reproducible due to the development of atomic absorption spectrophotometry and ultimately replaced the counting of stippled cells as the primary method of determining lead exposure. [20] BLL was utilized in several studies at that time as a means to associate a toxic manifestation with a specific BLL. However at the time, as with many new technologies, there were inconsistent lab practices and methodologies that did not successfully produce consistent results demonstrating any specific safe or harmful level of lead exposure. This situation was successfully exploited by the U.S. lead industry experts to successfully defend the continued use of lead and to justify elevated worker exposures. Amazingly, despite today's standards and increased knowledge, it was argued successfully that workers utilizing lead actually

developed an inherent immunity to the detrimental effects of lead as demonstrated by their apparent normal dispositions. Accordingly it was successfully argued there were in fact safe levels of lead. [20]

Lead Toxicity

With a long history of known toxicity and numerous publications documenting the adverse effects of lead, lead is likely the most studied occupational toxin of all time. [26] Therefore it could be reasoned that occupational lead exposures have since been reduced to the lowest degree possible. However, with lead remaining in buildings and homes, and the continued industrial applications of smelting and battery manufacturing/disposal and other lead-using cottage industries, there remains today a population of occupationally exposed workers. [26]

It is well known that lead serves no known beneficial effects in the body. Lead exerts its toxic effects on the various organs of the body across a various range of exposures from acute/severe to chronic/sub-clinical.

Acute effects of lead exposure (BLL 70-80µg/dl or greater, ASTDR 1999) in adults include anemia, peripheral neuropathy (i.e. wrist or ankle drop) abdominal colic, central nervous system effects, kidney disorders and sterility. [28] In very severe acute lead doses (BLL 100µg/dl or greater) the effects may include tremors, stupor, seizures, coma, and death. [10, 27] Chronic or acute lead exposure may also result in a reduced reproductive metabolism of vitamin D and calcium, kidney ailments, hypertension, reproductive effects, and developmental effects in children. [10, 27] Persons experiencing low level chronic or recurrent exposures to lead may not exhibit outward symptoms of lead poisoning or may develop clinically vague symptoms (e.g. fatigue, myalgia, irritability, or headaches) which may not be easily attributed to lead exposure. [10]

The absorption and biological uptake of lead is dependent upon a variety of factors. The most important is the physiological make-up of the exposed person, including their age, general health, and nutritional status. Pregnant women and children are potentially the most severely affected by exposure to lead and can have body absorption rates of approximately 70% of the ingested or inhaled lead as compared to a typical adult who would absorb only around 20%.[27] The chemical form of the lead is also a key factor in its effect upon the body. Organic lead (e.g. tetra-ethyl lead) is readily absorbed through the skin, but since the 1986 ban on leaded gasoline it is no longer readily present in the U.S. today. By contrast, inorganic lead, as found in lead paint, is primarily either ingested or inhaled and remains present in large quantities throughout the U.S. [10, 26]

Once inside the body lead is distributed by the bloodstream to the blood forming cells, soft tissues, and the bones. [27] In the blood forming cells, beginning at BLLs of 10µg/dl, lead inhibits several enzyme-based steps necessary for the synthesis of hemoglobin, the iron containing protein which carries oxygen from the lungs to body tissues. [10] Inhibition of ferrochelatase, the mitochondrial enzyme, results in an accumulation of zinc protoporphyrin (ZPP) in the red blood cells. [10] ZPP assays indicate elevated levels of protoporphyrin in the blood due to the substitution of zinc for iron in the hemoglobin, which is a result of lead's inhibition of iron. ZPP assays can be used to reflect average exposure over a three month period of lead exposure due to ZPP remaining in the blood cell for about 120 days, the average life span of

red blood cells. However, normal ZPP levels are usually less than 35μg/dl, a level which corresponds to BLLs in the range of 30-80μg/dl. Therefore, ZPP readings are not nearly sensitive enough to detect low level lead exposures and may result in false negatives. [27]

Most lead that is taken into the body is excreted through the urine or fecal matter. Adults retain only approximately 1% of the absorbed lead whereas children retain upwards of 33% of the absorbed lead. [28] Children with deficient levels of other minerals, such as calcium or iron, will have a much higher level of lead absorption. [28] The biological half-life of lead in the human bloodstream is approximately 28 days. Lead's relatively short biological half-life is the factor that limits the meaningfulness of BLL lead exposure measurements (the most commonly used biomarker of lead) as an indicator of anything except a recent (i.e. within the last twenty-eight to thirty days) lead exposure. [27] The blood stream also distributes the absorbed lead to various organs. Several studies in animals have demonstrated that the liver, lungs, and kidneys are the primary organs that store lead following an acute lead exposure. [27, 29] ZPP and BLL should be used concomitantly to assess occupational and environmental exposures, acute and chronic.

The mineral components of the body (e.g. teeth and bones) serve as a long term reservoir for absorbed lead. The bio-accumulation of lead in teeth and bone is a lifelong process. [27] However, lead stored in the teeth and bones is slowly released throughout life to the rest of the body thus serving as a source of chronic low dose to the human body despite the person's removal from a lead-

laden environment or work process. The rate of lead release from bones may increase during periods of pregnancy, lactation, menopause, psychological or physical stress, chronic disease, hyperthyroidism, kidney disease, broken bones, and advanced age. The rate of bone to blood lead release may be increased by a deficient calcium level. [27]

Due to the body's deposition of lead in bone, the use of X-Ray Fluorescence (XRF) technology to measure lead content of bone is being increasingly used to determine the total body content of lead and thus long term assessment of lead exposure. [10]

On a molecular level, lead has the ability to mimic calcium, particularly at the receptor site of membranes where it can replace calcium and thus adversely affect neuromuscular and synaptic transmissions. [27, 29] Possibly the most serious effect of a low-level lead exposure is as a potent neurotoxin. The nervous system, especially those of rapidly developing fetuses and young children, is perhaps the most vulnerable to lead because the blood-brain barrier is incomplete. [27, 29] Acute lead poisoning (BLL 70-80µg/dl or greater, ASTDR 1999) in children may produce encephalopathy as presented by hyperirritability, convulsions, ataxia, stupor, coma, and even death. [27, 28, 61] However, the developing central nervous system of children can be adversely affected at BLLs of less than 10µg/dl, which is the CDC's current action level of concern for children. [27, 61]

Childhood Lead Exposure as Related to Occupational Exposure

Recent data demonstrates that even low levels of lead exposure (below the CDC's action level) may result in adverse effects in children. [27, 61] The effect of lead on childhood learning ability appears to result from one or both of two phenomena: first, lead-induced delays or deficits in maturation and inter-neuronal connectivity of the central nervous system, and second, lead-induced disturbances in brain biochemistry.[29] Young children, especially those under the age of six, are particularly vulnerable because the blood-brain barrier (which largely, though not completely) protects the mature brain from lead, is not fully developed until some time after birth. [29]

There is a large and growing body of evidence that associates a decrease in IQ and other neuropsychological effects with lead exposure. [27] Probably one of the best studies demonstrating how a low-level lead exposure in children can affect their school performance was conducted by Needleman and associates. Needleman compared lead-in-bone measurements, using XRF technology, of 194 youth criminal offenders to 146 non-offenders. It was shown that those individuals who had committed a criminal offense had a significantly higher lead concentration in their bones than the non offenders. [20, 30] In 1979, Needleman found an association between lead in teeth and IQ among children not exhibiting any outward signs of lead poisoning. [59] Children having higher levels of lead in their teeth had on average lower I.Q. scores, shorter attention spans, and poorer language skills. [20, 27, 30, 31] A 2003 study by Canfield, et.al, found that blood lead concentrations in children were inversely and significantly associated with IQ.

This study demonstrated that for each blood lead level increase of 10μg/dl there was a 4.6-point decrease in IQ. [60]

There is also growing evidence that hearing and peripheral nerve function have more chance to be impaired in children as BLL increases. [27]

Lead exposures and lead levels for U.S. children have decreased markedly over the last three decades due primarily to the bans on leaded gasoline, lead-seamed food cans, and the addition of lead to paint. [32] However, several studies have identified continued significant lead exposure of children as a direct result of inadvertent transferal of lead particulate contamination from workplace to the home via the occupationally exposed worker. The National Institute for Occupational Safety and Health (NIOSH) released a study in 1995 that found that 26% of construction workers' children had BLLs equal to or exceeding the CDC action level of 10μg/dl. [32] A companion study referenced in the same report discovered that construction workers' occupational exposures were the primary cause of lead contamination discovered in their personal vehicles and private homes. [32]

It is becoming increasingly common for invisible toxins such as lead to be carried home on inadequately protected shoes, pants, coveralls, or even bodies. [33] It may be argued that the current OSHA requirement for employers to provide protections for workers exposed to airborne exposure levels above the 50μg/m^3 Permissible Exposure Limit (PEL) is not adequately addressing the problem of childhood lead exposures. Occupational parental lead exposures occur in over

one-hundred types of industries, and are encountered in dozens of others, including the construction industry. (33)

An Overview of OSHA and OSHA Standards Development

The Occupational Safety and Health Act of 1970 is the source of the Occupational Safety and Health Administrations (OSHA) authority. The Act, which contains no standards itself, serves as the basis for OSHA itself and for every subsequently established standard that has since followed. Due to the technical aspect of occupational safety regulations Congress recognized that it would be unable to satisfactorily legislate the multifaceted regulations effectively. Accordingly, the Act simply created the agency and provided it the authority to establish and enforce occupational safety and health standards. [34] The Act's General Duty Clause (which requires employers to provide a safe and healthy work place and to eliminate "recognized hazards" in the absence of a specific standard) serves as OSHA's main tool used to improve worker safety. Congress authorized OSHA to cite employers immediately for violations of the General Duty Clause.

As a result of the pro-worker environment existent during that period, Congress authorized OSHA to adopt binding standards without requiring public (including industry) participation during the first two years of the agency's existence. However, to limit the effect OSHA could have on industry, OSHA was only allowed to adopt existing federal agency (other than OSHA) or national consensus standards (i.e. American National Standards Institute – ANSI, and the National Fire Protection Association - NFPA) as binding standards. Congress felt this would help satisfy industry, as most businesses were already operating in

accordance with, and had participated in, the creation of these standards, while simultaneously satisfying much of organized labor. [34]

In general, OSHA can start the process of creating standards in response to petitions from state and local governments, other federal agencies (primarily NIOSH – National Institute of Occupational Safety and Health), nationally recognized standards institutes (e.g. ANSI or NFPA), organized labor groups (i.e. Unions), interested parties, or of its own initiative. [13] OSHA relies upon an advisory committee to develop specific recommendations if it determines that a standard is called for. The primary committee that serves the purpose of appointing ad-hoc committees to examine specific areas that may concern OSHA is the National Advisory Committee on Occupational Safety and Health (NACOSH). This committee was established under the Act to advise the secretaries of Labor and Health and Human Services on occupational safety and health programs and policies. Members of the 12-person advisory committee are selected based upon their knowledge and experience in occupational safety and health. [35]

OSHA must publish in the United States Federal Register a "Notice of Proposed Rulemaking" if they intend to establish new standards, or amend or revoke existing standards. The "Notice of Proposed Rulemaking" is used by OSHA to solicit public input and information that can be used in the formulation, modification, or removal of the standard. If OSHA judges that a proposed standard addition or modification may be controversial they may solicit very early

input by publishing in the federal register an "Advance Notice of Proposed Rulemaking." (13)

Public input solicited in the either the notice of proposed rulemaking or the advanced notice of proposed rulemaking may be submitted in written or oral formats and be entered into consideration by OSHA. Following the closing of a commentary period and, if called upon, any public hearings, OSHA will have published in the federal register a full and final text version of any new, amended, or revoked standard. An explanation of the standard and any the input or considerations put into it, along with an effective date, are also included in the final rule. Concerned parties may bring, at any time, legal action on their own behalf if they consider any component of the final ruling to be either arbitrary or capricious in nature. If the court rules in favor of the plaintiff all or selected portions of the final rule may be remanded to OSHA for further investigation, documentation, commentary, and the process of publication up and to the final rule is repeated.

Genesis of the Occupational Health and Safety Standard for Occupational Exposure to Lead in Industry and Construction

At the beginning of the 20th century studies became available that directly associated high levels of lead in the blood with diseases of the kidneys and central nervous systems. At approximately this time an airborne lead exposure suggested limit of 500µg/m^3 was generally accepted by the U.S. Government and industry. [36] In 1933 a limit of 150µg/m^3 was recommended by the United States Public Health Service. 150µg/m^3 was the most commonly utilized airborne exposure goal until 1957, when the American Conference of Governmental Industrial Hygienists (ACGIH) increased the recommended exposure limit to 200ug/m^3. [37] This recommended, voluntary worker exposure level, remained in effect until 1971 when the ACGIH recommended (for reasons unknown) lowering the acceptable level down to 160µg/m^3. [37] The initial OSHA-based standard of 200µg/m^3 for lead was established in 1971 (Table Z-2 of 29 CFR 1900.1000) and was the first mandatory lead standard. This limit, applicable to both general industry and construction, was referred to as a Permissible Exposure Limit (PEL). [38] The PEL was an 8-hour time weighted average and was based upon the national consensus ANSI standard "Acceptable Concentrations of Lead and its Inorganic Compounds" (Z37.11-1969, revision of Z37.11-1943). [36]

On January 5, 1973, NIOSH submitted to the Secretary of Labor criteria for organic lead that recommended lowering the PEL to 150µg/m^3. [36, 37, 39] However, this recommendation was not acted upon. On August 4, 1975, NIOSH, based upon a review of newly available scientific data, sent notice to OSHA

recommending the PEL be reduced from 200µg/m^3 to lower levels. [36] As a result of this data, on October 3, 1975, OSHA published in the Federal Register a notice of proposed rulemaking to begin a new occupational safety and health standard dedicated to occupational exposure to lead. Included in this proposal was the intent to lower the PEL from 200µg/m^3 to 100µg/m^3 plus provisions for medical surveillance, environmental monitoring, training, and protective measures. [36] The designation of this standard was to be 29 CFR 1910.1025 and the existent lead exposure standard, as then contained in Table Z-2 of 29CFR1900.1000, was to be deleted. [37] Interested parties were given until December 2, 1975 to submit written data either in support or objection to the proposed rule. This end of submittal date was subsequently extended to January 10, 1976. OSHA received over one hundred written comments including approximately forty requests for public rule-making hearings. [40]

Construction industry representatives argued against including themselves in an amendment that they considered more appropriate for true lead industries. They based their argument upon the following four premises; (1) construction work resulted in only brief exposures to lead, and these were insignificant or inconsequential as compared to industrial sources and therefore did not necessitate further regulation, (2) the site to site temporary location nature of construction work would result in varying exposure levels that would be impossible to monitor in a meaningful comprehensive manner, (3) the construction industry employed a large percentage of temporary employees that would be impossible to track in order to maintain medical surveillance, and (4)

the infrastructure (i.e. engineering controls, wash stations, etc.) necessary to ensure compliance would be impractical for the mobile construction industry. [41]

In January 1977 OSHA announced the availability of preliminary technical feasibility and economic impact statements prepared for OSHA by a private contractor. Several weeks of public hearings were conducted in 1977 at which OSHA presented fifteen expert witnesses from around the world. [42] In addition, hundreds of industry, construction, labor, individual, and concerned parties presented their opinions and recommendations regarding the pending regulation. [42]

In May 1978, NIOSH made a formal recommendation to OSHA advising; (1) a lowering of the PEL from 150µg/m^3 to 100µg/m^3, (2) lowering the maximum blood lead level from 80µg/100g to 60µg/100g, (3) revised recommendations for respiratory protection, and (4) modifications for work practices and sanitation. [39]

On November 14, 1978, OSHA published in the final standard (29 CFR 1910.1025) for occupational exposure to lead which excluded the construction industry. OSHA would require its Advisory Committee on Construction Safety and Health to review the rulemaking record and produce a recommendation (with no specific deadline) for protecting construction workers from lead. [38, 41] OSHA explained the exclusion as due to a lack of sufficient information regarding lead use in construction. [43]

The OSHA standard required industry employers achieve a PEL of 50µg/m^3 based upon an 8-hour time-weighted average. [42, 44] This was to be accomplished solely via engineering and/or work practice controls. OSHA

sought to remove the option of respirators as a means to reduce employee lead exposure in order to minimize the opportunity for industry to inappropriately manipulate employee-working hours as a way to prevent worker exposures to lead above the PEL. Several petitioners including various representatives from the lead, glass, paint, battery, printing, recycling, automobile, telephone/telegraph, mining, and minerals industries challenged the standard in court as being invalid. [44, 45]

The petitions of these organizations, as well as those of labor and individual court challenges, were compiled together in one case and eventually heard by the U.S. Court of Appeals in Washington D.C. (United Steelworkers of America v. Marshall, 647 F.2d 1189 (D.C. Cir. 1980), 453 U.S. 913 (1981). [46] In these proceedings the Court did not vacate any portion of the standard. However, the Court did stay the feasibility of meeting the PEL (paragraph (e)(1) of 1910.1025) by utilizing only engineering or work practices for ten industries: primary lead production, secondary lead production, can manufacturing, lead-acid battery manufacturing, paints and coating manufacturing, ink manufacturing, wallpaper manufacturing, electronics, printing, and grey-iron foundries. However, the Court also determined that OSHA had failed to establish the feasibility of restricting lead exposure control to only engineering and work practices for thirty-eight other industries, not including construction. The Court remanded the record for OSHA to re-establish the feasibility of complying with paragraph (e)(1) of the regulation and postponed (stayed) the enforcement of this for the other thirty-eight industries. [45, 47] However, the Court held that the thirty-eight remanded

industries were required to meet the PEL by a combination of engineering controls, work-practice controls, and respiratory protection. [44]

In December 1981, OSHA published in the Federal Register, and simultaneously filed with the Court, a statement of reasons that compliance with paragraph (e)(1) is feasible for all but nine of the thirty-eight remanded industries. The nine remaining remanded industries included: brass and bronze ingot manufacturing/ production; collection and processing of scrap (including independent battery breaking), lead chemicals, lead chromate pigments, leaded steel, non-ferrous foundries, secondary copper smelting, shipbuilding and ship repairing, and stevedoring. [44]

On July 11, 1989 OSHA published in the Federal Register, and filed with the Court, an additional statement of reasons that compliance with the PEL solely by means of engineering and work practice controls was feasible for eight of the remaining nine industries. The remaining industry, remanded due to a lack of economical feasibility, was small non-ferrous foundries. On January 30, 1990 OSHA published and filed with the court a determination that small (fewer than 20 employees) non-ferrous industries could comply with an alternative PEL of 75µg/m^3 measured as an 8-hour time weighted average. Eventually, based upon a July 19, 1991 Court decision the small non-ferrous industry was allowed five years to implement engineering and work-practice controls that would ensure workers were not exposed to lead airborne concentrations exceeding 75µg/m^3 measured as an 8-hour time weighted average. [44, 48]

Six of the nine industries filed court challenges regarding OSHA's finding (brass and bronze ingot manufacturing/production; collecting and processing of scrap; lead chemicals; leaded steel; non-ferrous foundries; and secondary copper smelting). Three industries (lead chromate pigments, shipbuilding and ship repairing, and stevedoring) did not file court challenges and were subsequently allowed five years from an eventual July 19, 1991 Court decision to implement engineering and work-practice controls that would ensure workers were not exposed to lead airborne concentrations exceeding 50µg/m^3 measured as an 8-hour time weighted average. [44, 48]

On March 8, 1990, as a result of OSHA's findings, the court removed the stay on paragraph (e)(1) for all thirty-nine remanded industries, except the six industries listed above that challenged OSHA's feasibility findings. The thirty-nine industries were allowed until September 8, 1992 to comply with the PEL by means of engineering and work-practice controls alone. [44, 48]

On July 19, 1991, in AISI v. OSHA, 939 F.2d 975 (D.C. Cir. 1991), the Court affirmed OSHA's findings of technical and economic feasibility for five of the six contested industries and removed the stay on paragraph (e)(1) as it applied to them. These industries were the non-ferrous foundries (large and small), secondary copper smelting, collection and processing of scrap (including independent battery breaking), leaded steel manufacturing, and lead chemicals manufacturing. The Court ruled though OSHA had shown it was technologically feasible for the brass and bronze ingot manufacturing industry to achieve the 50µg/m^3 by engineering and work-practice controls alone, OSHA had not shown

it was economically feasible. Therefore the Court remanded that portion of the record to OSHA for additional consideration and continued the stay of paragraph (e)(1) for the brass and bronze ingot manufacturing industry. On June 27, 1995 OSHA entered into an agreement with the brass and bronze ingot manufacturing industry and the Institute of Scrap Recycling Industries that an airborne lead concentration of 75μg/m^3, measured as an 8-hour time-weighted average, is economically feasible for the industry as a whole. (44, 48)

Of the five industries that had judicial stays lifted, the leaded steel and the scrap collection and processing industries were given until January 19, 1994 to achieve the PEL by means of engineering and work-practice controls. Employers in the non-ferrous foundries, secondary copper smelting, and lead chemicals manufacturing had until July 19, 1996, to comply. (44, 48)

In August 1991, by publishing the document Lead Poisoning in Construction Workers, NIOSH called attention to the plight of construction workers exposed to lead, primarily the highly exposed bridge workers. (18) Simultaneously, as part of their own regulations, the Department of Housing and Urban Development (HUD) had recognized the need to protect lead abatement contract workers from the exposures possible in lead containing pre-1978 built homes and developed their own set of guidelines. (41)

Consequentially, as a result of the HUD program that protected what were technically construction workers from lead exposures and the subsequent pressure from the political arena, OSHA began development of a comprehensive standard regulating lead exposure in construction. (41) In October 1992, as a

result of the unexplainable lead exposure limit discrepancies between two federal government agencies, Congress passed the Housing Community Development Act of 1992 which required OSHA to issue an interim final lead standard until OSHA could issue a final standard. [43] The final Construction Lead Standard 1926.62 was made effective June 3, 1993.

The construction standard is very similar in content to the industry standard. Minor differences include the use of HEPA vacuum cleaners and exhaust ventilation recirculation filters. The more significant differences noted between the two standards includes the BLLs at which the medical removal program (MRP) for workers must be activated and the addition of a definition of a competent person. According to the construction standard a competent person is a designated person capable of identifying existing and predictable lead hazards and who has the authorization to take steps to eliminate them. The industry standard does not define nor require such an individual to be in a role as a lead treatment/abatement expert.

The MRP is a protective and preventative health-based provision of both standards that provides a means for workers, identified via BLL as being at risk, to be temporarily removed from the lead exposure situation/environment. The general industry standard specifies a single BLL of 60µg/dl, or an average 6-month BLL exceeding 50µg/dl as the triggers for entering a worker into the MRP. The construction standard specifies a single, more conservative BLL of 50µg/dl, or greater, as the trigger value placing a worker into the MRP.

The lead–exposed workers are placed into a MRP while maintaining their employment and salary status. The employer may not legally terminate an employee based upon their enrollment in the MRP.

A Simple Lead Exposure Compliance Assessment: Materials and Methods

The University of Connecticut EH&S Department, with the cooperation of the University's maintenance department management, planned a lead exposure assessment demonstrating personnel exposure data by obtaining air sampling results during an employee's regular daily activity while using engineering controls. Utilizing a soon-to-be-demolished University-owned building referred to as House 36A, an assessment of lead exposure levels, while utilizing wet sanding, scraping, and minor demolition preparatory techniques, was conducted. In compliance with the OSHA 1926.62 guidelines for exposure assessment, three University painters and carpenters volunteered to wear appropriate personal protective equipment (PPE) and perform typical scraping, sanding, and minor demolition techniques on designated painted surfaces with known lead concentrations. As a prerequisite for the eventual building demolition a private consultant, utilizing an XRF lead concentration-detecting unit, had previously determined painted surface lead concentrations present in each building. [49] These XRF readings were verified by EH&S personnel by submitting representative paint chips for analysis. The three workers were provided the required lead awareness training that included a briefing on the purpose of the assessment, safe work methods, engineering controls, and personal hygiene practices to be utilized. They were also provided all necessary PPE, including half-face respirators, disposable tyvek-type hooded suits, disposable gloves, and shoe covers. As a requirement of the EH&S University Respirator Program, each worker had previously received the required training, fit-testing, and medical

approval to wear the required respiratory equipment. [50] At the time of assessment each worker was outfitted with a calibrated personal air sampler, as provided by the independent environmental consultant contracted by EH&S, and a simple garden-type hand pressurized spray apparatus. Each worker then performed approximately 90 minutes of surface preparation and light demolition while concurrently lightly misting affected surfaces with tap water utilizing the sprayer. At the conclusion of the 90 minutes, the workers carefully stepped out of the assessment areas into a staging area, removed the disposable suits, gloves, and shoe covers, rinsed their tools and respirators in a dilute solution of tri-sodium phosphate (TSP) and water followed by a fresh water rinse. The independent environmental consulting representative collected the personal air samplers for eventual testing. All shavings, scrapings, and demolition by-products were either respectively collected for proper disposal as lead contaminated hazardous waste or sealed off from access until the time the building was fully demolished. Collected rinse water was retained for eventual lead concentration level testing and proper disposal. Final results of the approximately five gallons of rinse water revealed a lead concentration of 536 µg/L. Therefore, in accordance with the Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) defining the lead-containing waste hazardous limit as 5000 µg/L, this rinse water was ultimately treated as a non-hazardous waste by EH&S personnel.

Tests results (as conducted by an AIHA accredited analytical laboratory) of the lead chips acquired from the designated work surfaces, revealed that the

affected surfaces contained between 0.04% and 22.0% lead concentration utilizing the lead in paint chips test Flame AAS (SW 846, 7420). Personal air monitoring results, as provided by the independent contractor utilizing the lead analysis in air test NIOSH 7082, for each of the three workers were as follows:

Table 1: Personal Air Monitoring Results (Wet Methods Only)

Worker	Surface Prep. Technique	Environ-mental Conditions	Laboratory Results (μg/m^3)	Detection Limit (μg/m^3)	8-hr Time Weighted Avg. (μg/m^3)
Carpenter 1	Wet Light Demolition	Indoors	BDL	9.9	BDL
Painter 1	Wet Sanding & Scraping	Indoors	BDL	12.2	BDL
Painter 2	Wet Sanding & Scraping	Outdoors	21.2	11.5	3.0

BDL: Below Detectable Levels

These results demonstrated that the safe work practices (wet-misting) were successful in reducing the airborne lead concentrations to levels below the OSHA action level of 30μg/m^3.

As an additional source of data and following the assessment conducted by EH&S and University painters and carpenters, EH&S personnel conducted a lead exposure assessment utilizing both dry and wet surface preparatory

methods on an unoccupied University owned house known as House 7A. This assessment was conducted in accordance with the OSHA 1926.62 guidelines for exposure assessment and in compliance with Institutional Review Board criteria. The intent of this assessment was to address "side-by-side" comparisons of different work methods on the same surface area and thus eliminate a potential confounder as done in the California Department of Health study. [5] At the time of this study it was the University's intention for the lead present in this structure to be abated and/or encapsulated prior to re-habitation.

As with House 36A an independent consultant, utilizing XRF lead testing equipment, had previously determined lead concentrations at this facility as a preparatory step for eventual abatement or encapsulation. [51] These XRF generated measurements guided EH&S personnel to those areas with the greatest lead concentrations. To verify the XRF readings, lead chip samples were collected from those areas selected for both safe work practices and standard surface preparation techniques and sent for lab AAS analysis.

EH&S personnel, in accordance with the OSHA 1926.62 guidelines for exposure assessment, donned appropriate personal protective clothing, including a respirator, and proceeded to conduct four two-hour sessions each of dry scraping, dry sanding, wet scraping, and wet sanding on the selected lead containing painted surfaces. To minimize the potential differences in sample areas, each session, consisting of the four previously defined surface preparation processes, was conducted in the same room, on the same wall, and on an area having similar painted surface conditions (e.g. paint color and condition). Testing

of the representative lead chips revealed that the affected surfaces contained on average 11.0% lead concentration utilizing the lead in paint chips test Flame AAS (SW 846, 7420). Personal air sampling results, utilizing lead in flame AAS (NIOSH 7082) for each of the four surface preparation techniques were as follows:

Table 2: Personal Air Monitoring Results (Wet and Dry Methods)

Surface Preparatory Technique	Airborne Lead Concentration (μg/m^3)	8-hr Time Weighted Average (μg/m^3)
Wet Scraping	<9.0	<2.25
Wet Sanding	<9.0	<2.25
Dry Scraping	15.0	3.75
Dry Sanding	340.0	85

Detectable Limit: 9μg/m^3

These results demonstrated that the safe-work practices (wet-misting) were successful in reducing the airborne lead concentrations to levels below the OSHA Action Level of 30μg/m^3 while simultaneously verifying that dry sanding can result in personal exposures well in excess of the Action Level as well as in excess of the OSHA Permissible Exposure Limit (PEL) of 50μg/m^3.

Establishment of Safe-Work Procedures for University Carpenters and Painters

With the success of the two lead exposure assessments the described "safe-work" procedures will be implemented in order to ensure that workers, and any incidental personnel, would not be exposed to unsafe levels of lead during the process of surface preparation and light demolition. Safe-work procedures will consist of three basic functions:

1. Minimizing the generation of dust by maintaining slightly damp surfaces utilizing a simple over-the counter garden-type hand pressurized spray apparatus filled with tap water.
2. Minimizing lead exposures by utilizing appropriate disposable PPE, disposable plastic drop clothes and wiping materials, completing follow-up housekeeping consisting of wet wiping or HEPA filtered vacuuming of affected areas and tools, and the proper collection and segregation of any accumulated waste. In addition work will be conducted at times and in a manner, in which incidental personnel (e.g. office workers, students, etc.) are not physically present at the time of surface preparation.
3. Practicing good personal hygiene, including not eating or drinking on the job site, thoroughly washing hands and face frequently, and changing out of work clothes and showering as soon as possible following the completion of the work shift.

Implementation of Lead Paint Debris and Contaminated Waste Collection Procedures

As an integral part of this program, it was necessary to (1) address the issues of what is to be considered hazardous lead waste, (2) how to handle that waste and (3) how to properly dispose of it in a cost efficient manner.

In accordance with the EPA Resource Conservation and Recovery Act (RCRA) regulations (40CFR261.24) lead is defined as a hazardous waste at concentrations exceeding the Maximum Concentration Limit (MCL) of 5.0mg/L as determined by the Toxicity Characteristic Leachate Procedure (TCLP). As part of the program, two waste streams will be established in hopes of reducing the quantity of hazardous waste generated by the surface preparation techniques. The first waste stream will consist of the collected paint scrapings, shavings, and chips along with any disposable drop cloths or wall coverings. The other waste stream will consist of any used disposable gloves; paper suits, booties, and rags/paper towels used by the workers during the surface preparation and final clean up of equipment and tools. The waste generated at the work site will be segregated into the two distinct waste streams, tagged, and removed to the maintenance facility where it will be placed into designated containers to await final collection by EH&S staff. Tools and equipment will be placed into sealable plastic bags and returned to the central maintenance facility where they will be wiped clean utilizing dilute TSP wetted disposable rags/paper towels. These spent rags/paper towels will be placed into the designated collection containers along with the already collected disposable PPE. The use of wetted rags/towels

precludes the generation of lead contaminated rinse water, which is rather bulky to handle, more susceptible to spillage and thus potential contamination, and more costly to dispose of. It is intended for the waste stream of disposable gloves, paper suits, booties, and rags/paper towels to be tested to determine if the lead concentration of those collected materials exceeds the waste-defining limit of 5.0mg/L. If the collected materials do not exceed the limit, they may be disposed of as regular bulk waste at a large cost savings. Any materials collected and verified as hazardous waste, will be placed into approved shipment containers. A high efficiency particulate air (HEPA) filtered drum compactor unit will be utilized in an effort to reduce the overall volume and associated disposal costs of lead contaminated waste.

Employee Lead Awareness Training

Based upon the combined results of the California Department of Health and the University of Connecticut assessments it was decided to implement a lead awareness training program for the painters and carpenters. This training would define and describe the safe-work procedures for the workers to follow in order to minimize their risk of lead exposure. It would also include a detailed description of the formal collection and testing procedures for any waste generated (e.g. scrapings, shavings, and disposable PPE) during surface preparation.

An approximately 45-minute Power-Point™ presentation was developed by the author. This training presentation consisted of the following topics:

1. An introduction of the history, properties, and locations of lead.
2. An overview of the University's lead exposure assessments.
3. The paths of lead entry into and subsequent effects on the human body
4. Occupational exposure limits.
5. Activities involving lead exposure, and how to minimize that exposure utilizing safe-work methodologies.
6. Medical surveillance and monitoring.

After several revisions, training presentations were conducted in the fall of 2004 for approximately thirty-five carpenters and painters. The program appeared to be generally well received based upon several attendees' comments

to the instructor. Future training presentations will be coordinated and conducted by personnel in the Occupational Health and Safety Section of EH&S.

Conclusions and Recommendations for Improving the Occupational Health and Safety Administration Standard for Occupational Exposure to Lead

The current PEL of 50µg/m^3 does not appear to be an effective means of protection for occupationally exposed lead workers. The utilization of airborne lead concentration as the method to gauge worker exposure to "safe" levels of lead is somewhat controversial. As discussed previously, it is well understood that there is not any amount of lead, however minimal, that is beneficial to human health. There are therefore industrial hygiene experts who would like to see regulations written that do not simply minimize lead exposures, but eliminate them completely. (19)

OSHA, throughout the process of establishing a regulation intended to ensure a work place safe from harmful exposures to lead, was effectively pressured to compromise with industry, construction, and political entities to adopt less restrictive occupational exposure criteria than health data would suggest. As part of the regulation development process OSHA performed an extensive review of numerous scientific studies and received advice from industry/construction experts. As a result of these factors, OSHA determined that a BLL of 60µg/100g, and the associated airborne concentration of 50µg/m^3, would provide a significant and effective level of protection against the clinical and sub-clinical effects of lead intoxication. (37) However, OSHA also admitted that establishing any safety level, or margin, is at best extremely difficult as the empirical data to set such a level may not be in existence at the time of its adoption. (37)

Following a period of public comment, OSHA published their view that $50\mu g/m^3$ was the most prudent level achievable and thus met their goal of providing an adequate margin of worker safety. (37) OSHA published this reasoning while simultaneously citing existing scientific evidence that BLLs as low as 20µg/100g have a known and demonstrated effect upon heme synthesis in the human body. (57) In addition, OSHA stated for the record that, due to the biological variability of individuals, BLLs should be kept below 40µg/100g to minimize the possibility of sub-clinical and eventual clinical disease. (57) Despite these admissions, and despite their belief that "good health should not be limited to the narrow definition of absence of clinical symptoms," OSHA supported (and continues to support today) an occupational exposure level to lead below which there are confirmed harmful effects. (57)

In the years following the promulgation of the General Industry and Construction lead standards, several additional scientific studies have been published that demonstrate BLLs lower than 30µg/100g have detrimental effects on human health. (58)

Feasibility: OSHA is required to determine both the technological and economic feasibility of proposed regulations. Initially, OSHA reasoned that it should be expected that a determination of technological feasibility alone would be the guiding criteria towards determining specific industry applicability of the $50\mu g/m^3$ PEL. However, strong industry and construction opposition to a purely technological feasibility requirement forced OSHA to address both technological and economic feasibility. This resulted in OSHA being forced to relax the PEL for

those industries that successfully argued the cost of compliance would essentially put them out of business. [45] The health and well-being of the employees was therefore balanced against the "ability" of an industry to pay for administrative, engineering, and work-process controls.

PEL as applied to human reproductive considerations: The October 2000 ATSDR Lead Toxicity guide states there is increasing evidence indicating that lead readily crosses the placental barrier and adversely affects the fetus. [27, 61] In addition this same document specifies that maternal BLLs as low as 14µg/dL may increase the risk of premature birth and lowered birth weight. [27, 28] OSHA, despite this information and other validated scientific data demonstrating that BLLs for men or women planning a pregnancy should be maintained well below 30µg/dL, has maintained its recommendation that men or women planning pregnancies not be exposed to airborne lead levels that would result in BLLs exceeding 30µg/dL. In addition, the suggestion that there need be special considerations made, primarily for women (especially pregnant women), will, and has, led to instances of sexual discrimination. [52] It has been documented that women in lead-related occupations have been, due to their "potentially pregnant" status, unwillingly removed from their positions and offered positions of lower pay and/or lower job stature. [52] To prevent such discrimination from occurring, OSHA could move to implement a policy modeled after the U.S. Nuclear Regulatory Commission's pregnant female worker policy that allows the pregnant female to formally and legally declare her pregnancy. This legally eliminates the option for an employer to remove (for either chivalrous or protective reasons) the

pregnant worker from lead exposure.[52, 53] Such a personal decision is left to the worker's discretion and the only responsibility the employer retains is ensuring the PEL, and/or safe-work processes, are adhered to.

Safe-work processes: Absent a de-minimus lead paint concentration, (below which it would be determined safe to work without additional lead safety controls) OSHA could better serve workers by formally introducing, implementing, or encouraging lead-exposure-preventing safe-work processes. By promoting safe-work processes, negligible (i.e. near zero exposure) worker exposure would become the focus of the regulation versus the existing program which attempts to protect workers by minimizing, but not eliminating, airborne lead exposure. However, the ability of OSHA to create new standards or modify existing ones is strongly affected by politically motivated parties, such as the lead and construction industries. As such, and absent the vocal uproar from present-day lead-exposed workers (as compared to their 1970's and 1980's predecessors), there is not at the time of this thesis, the political will to enact such a change. Therefore, in its present status, the regulation will continue to encourage employers to establish legally conforming programs even if they do not eliminate occupational lead exposures. The safe-work processes as described in this paper demonstrate the relatively simple and inexpensive methods that may be undertaken to preclude occupational exposure to a toxin that has no known nutritional benefit to the human body.[27]

Safe-work practices education: Employee awareness of safe-work practices, such as the wet-method process described in this paper, is generally

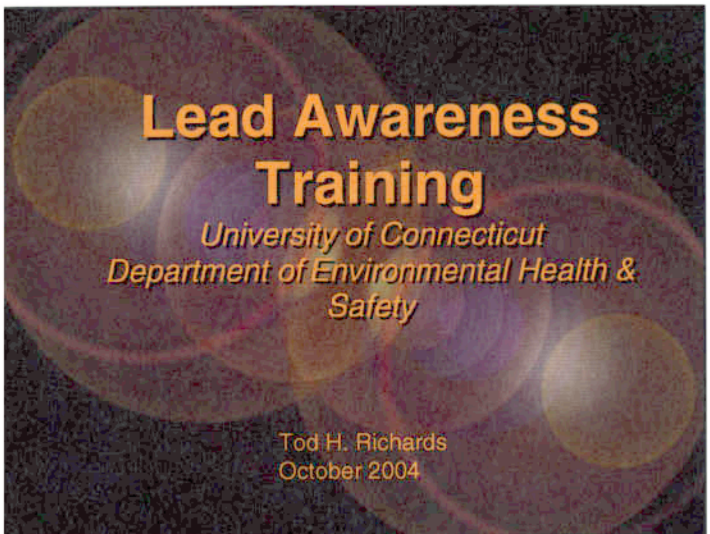
lacking. Occupationally exposed workers, along with property owners, contractors, and the general public would be better served if the appropriate state and federal agencies would mount an educational campaign intended to improve access and dissemination of guidance documents detailing safe-work processes. The following are a few of those agencies and organizations that could take additional actions to increase overall knowledge of the manageable lead exposure hazards associated with home and building renovations.

- OSHA/HUD/EPA: Improve dissemination of their various lead awareness programs such as the September 1999 EPA document detailing the TSCA-implemented Lead-Based Paint Pre-Renovation Education Rule for painting contractors.
- Employee unions and home renovation product retailers: Take a more active role promoting lead paint awareness by enhancing the availability of government-produced lead-based paint guidance publications.
- State and Local Health Departments: Building Inspectors could work towards improving the lead paint regulations knowledge of homeowners and contractors. In addition, public service announcements targeting painting contractors could be produced.

To paraphrase a statement by the Laborers' International Union of North America "as long as workers toil inside houses that are decades old they will likely encounter paint or dust that contains lead. And though we cannot remove all element of risk for their occupations, we can, and must, do our utmost to ensure that they return home at the end of a long day healthy and safe." [54]

Appendix 1: Lead Awareness Training Presentation

Slide 1



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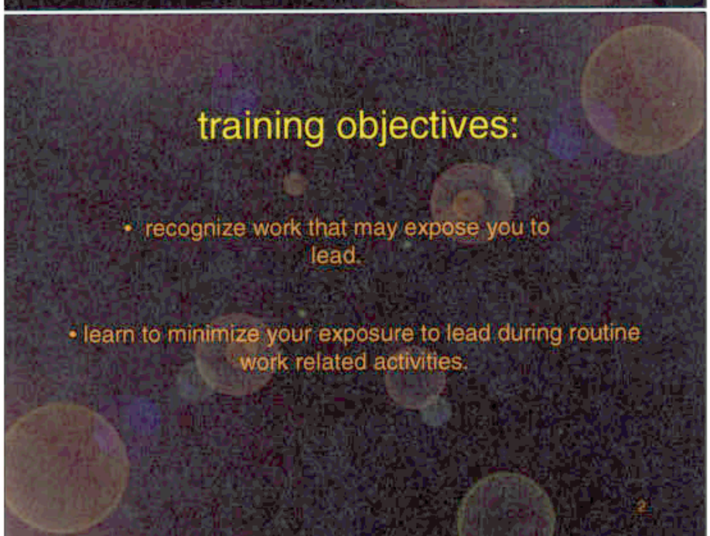

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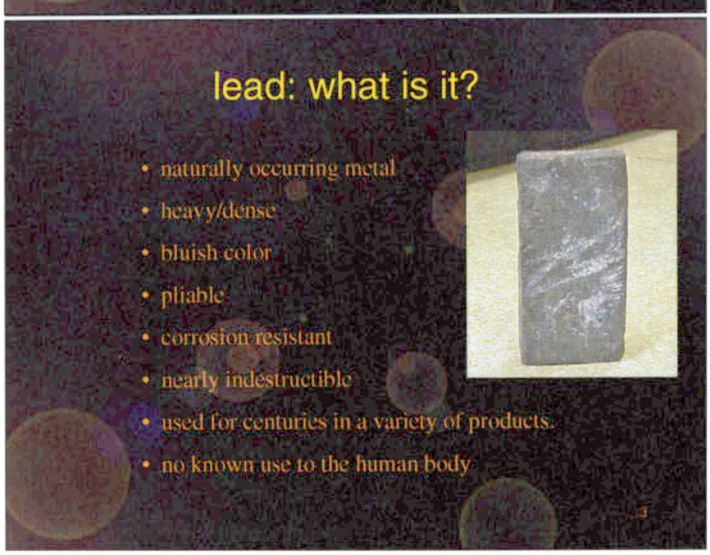

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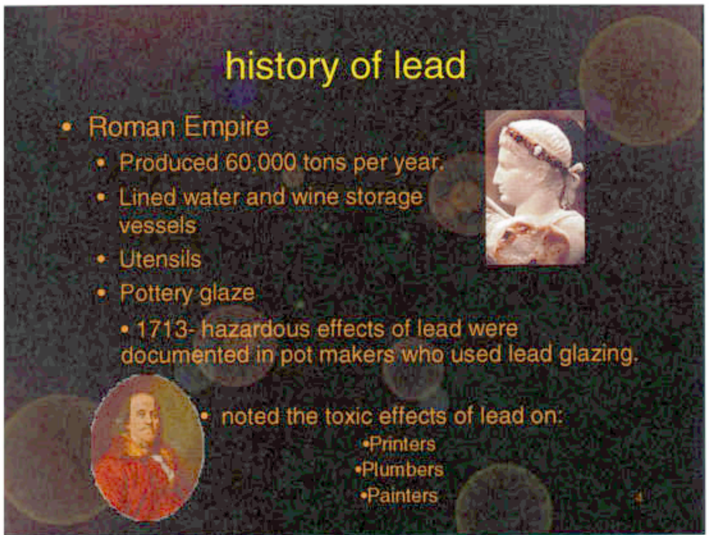

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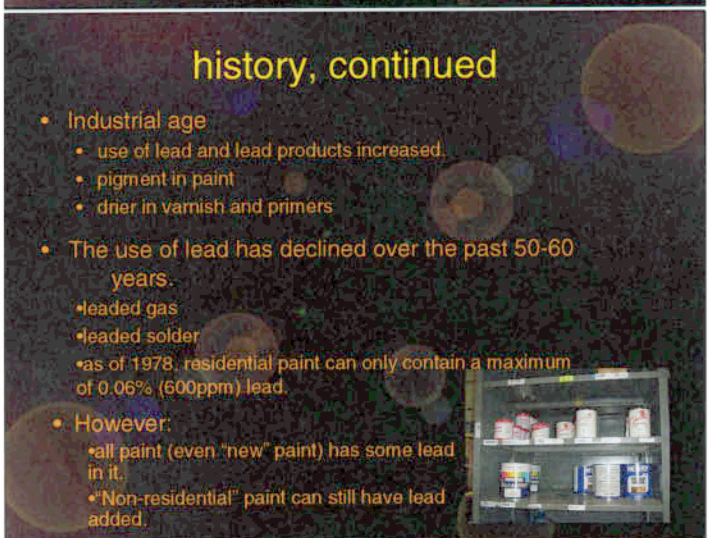

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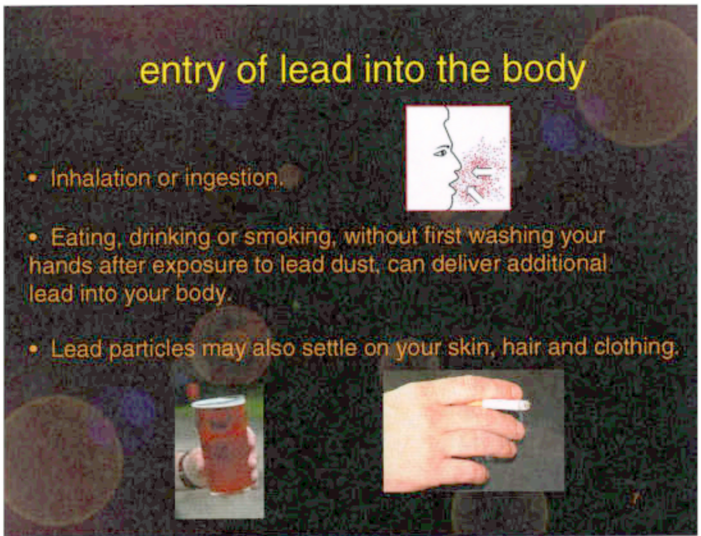

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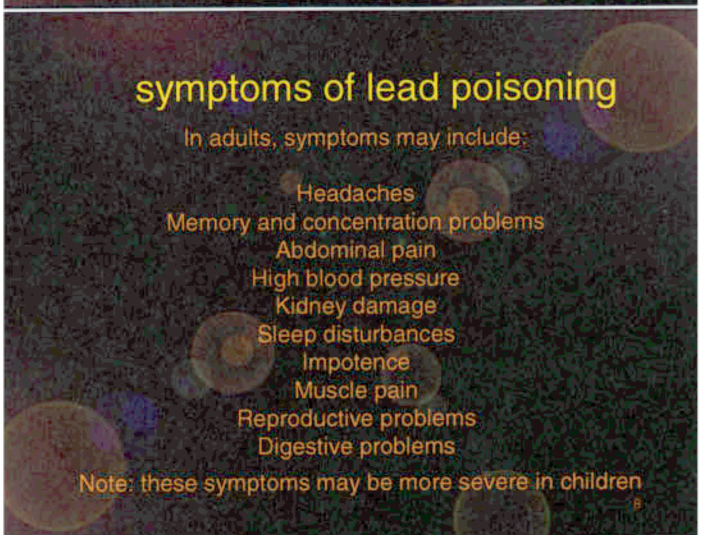

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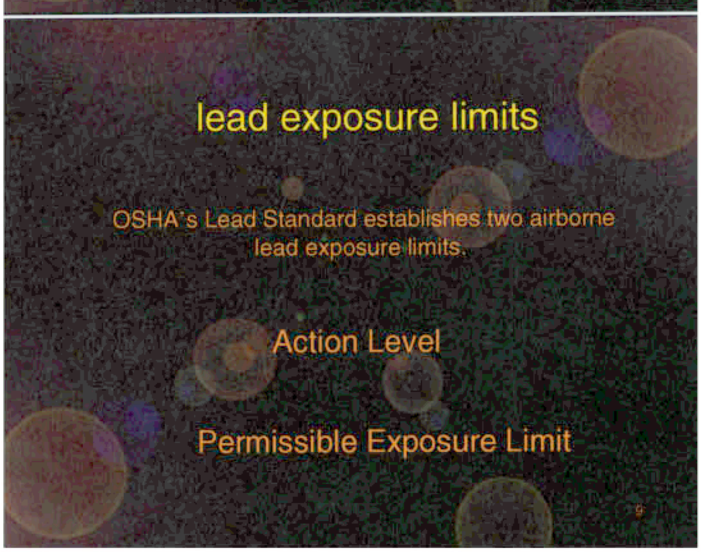

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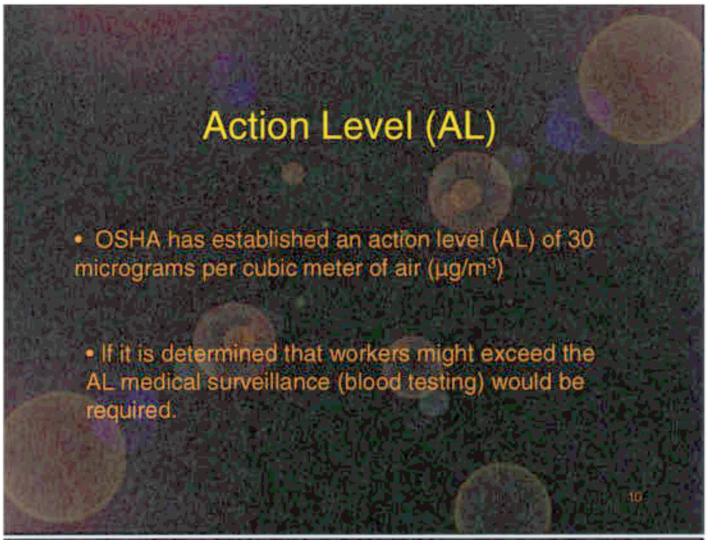

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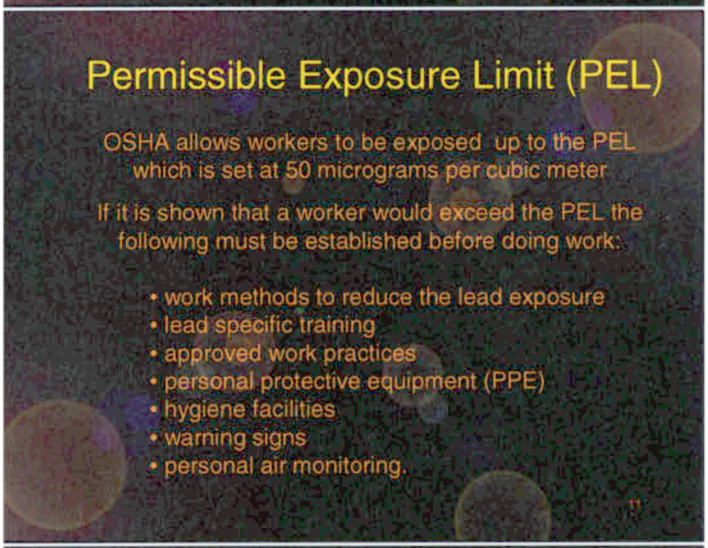

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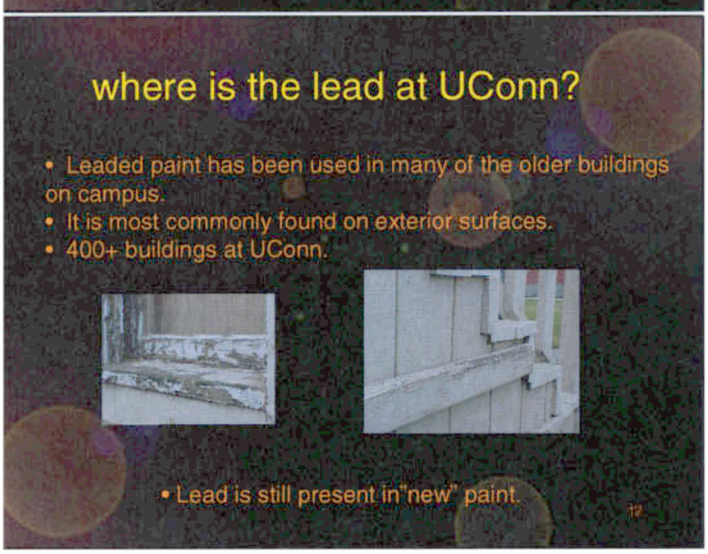

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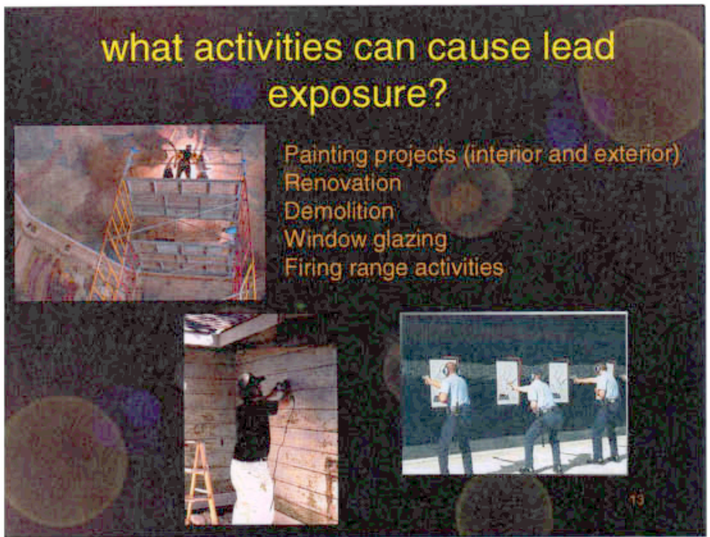

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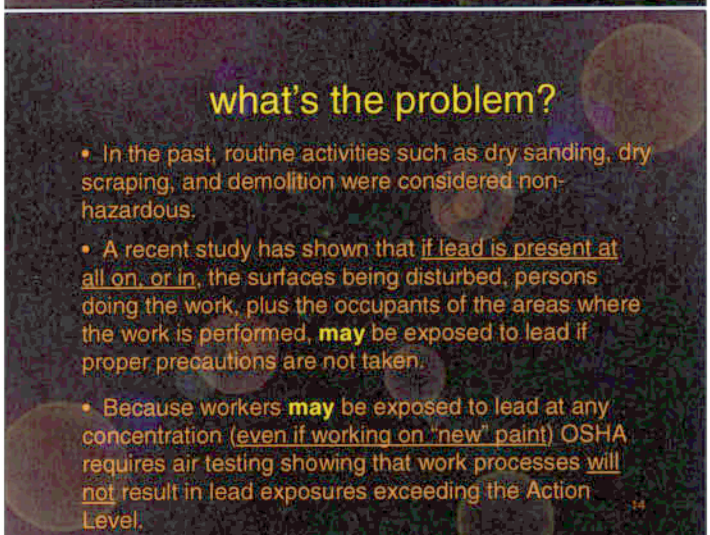

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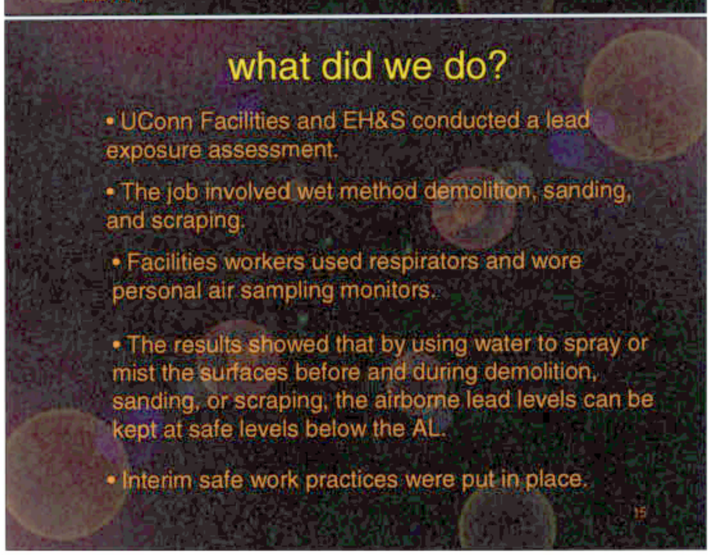

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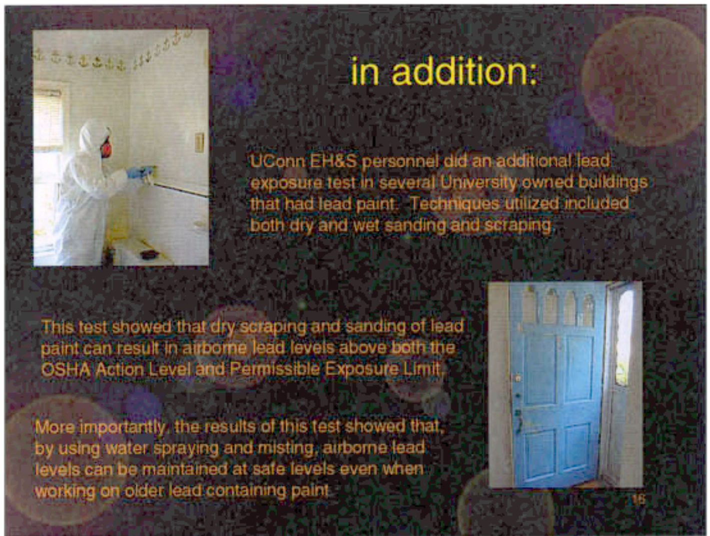

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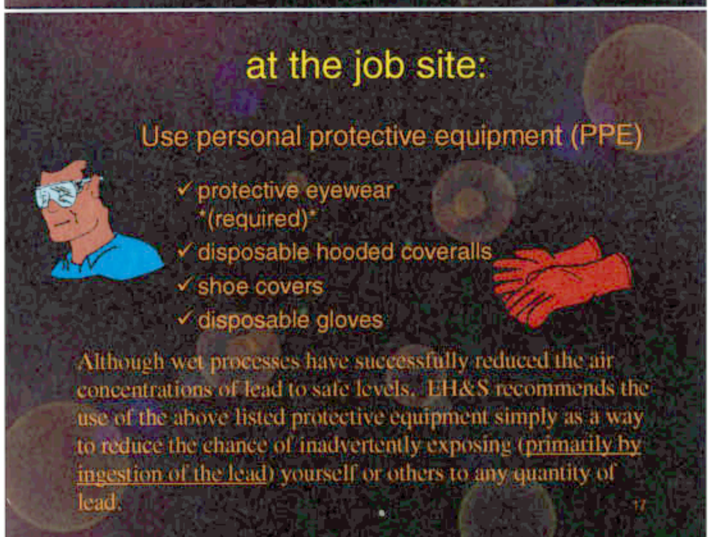

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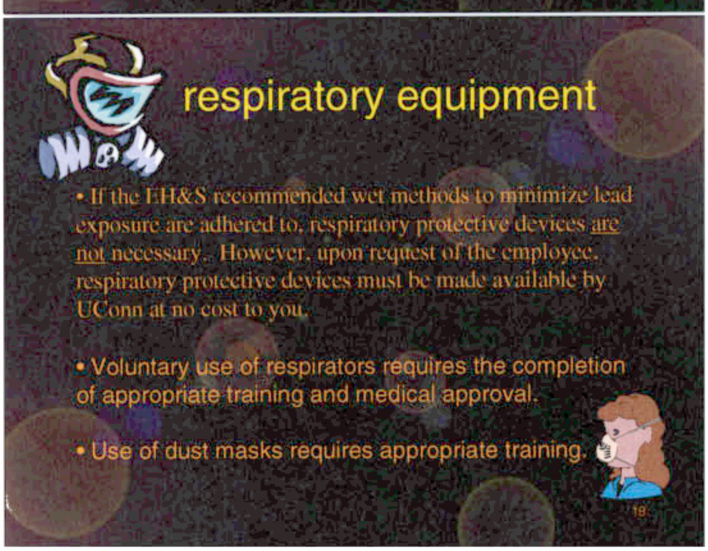

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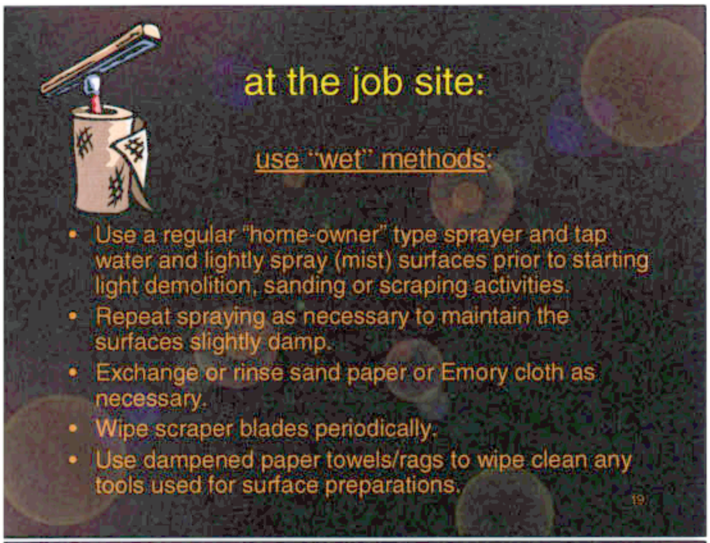

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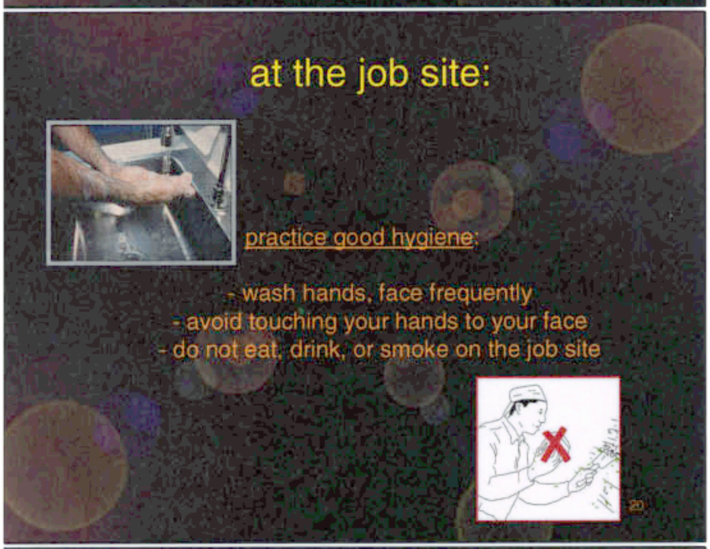

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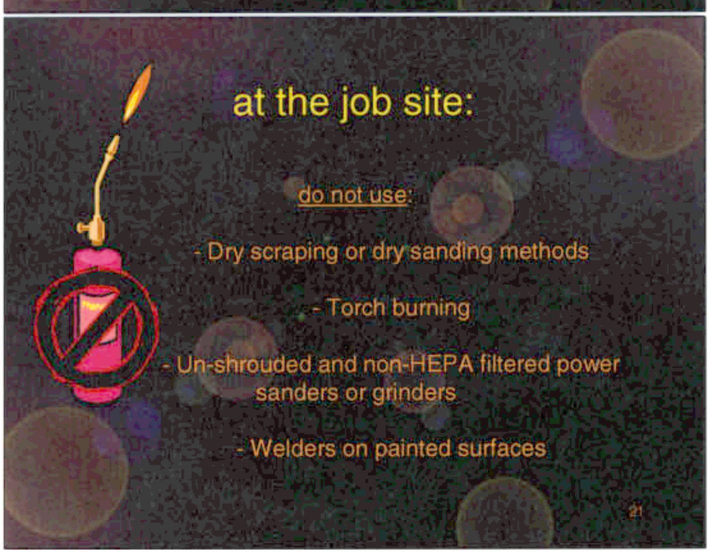

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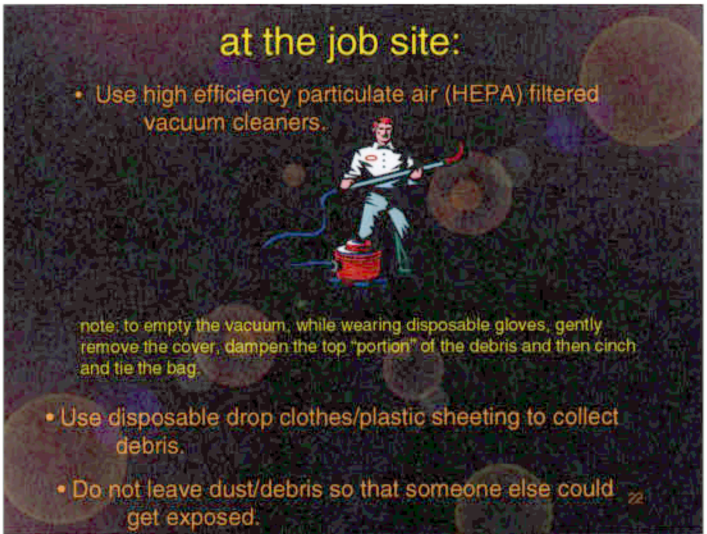

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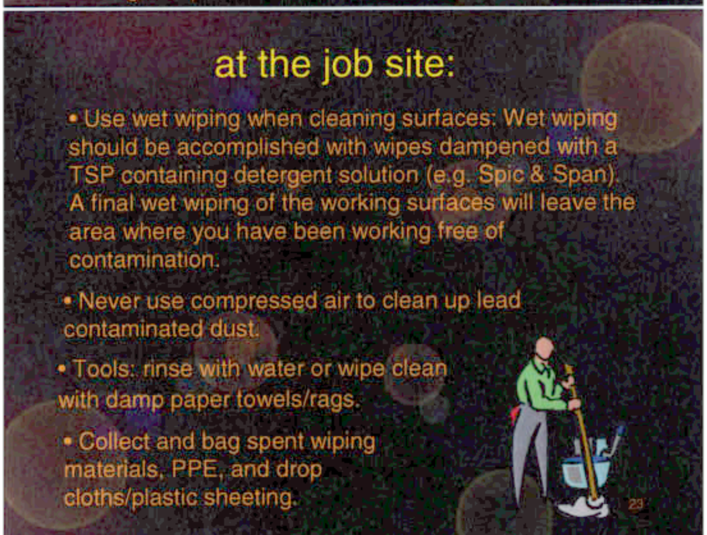

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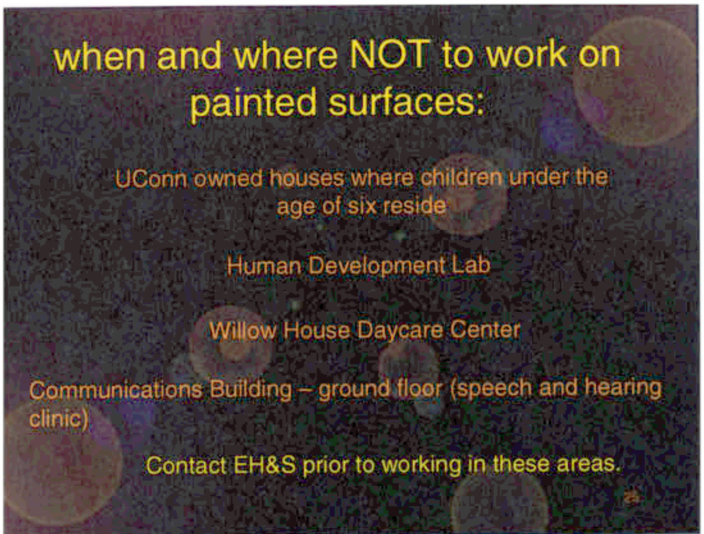

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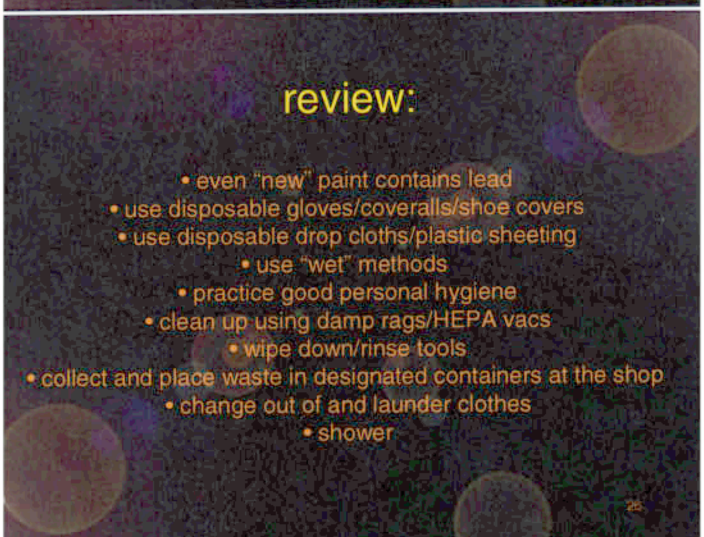

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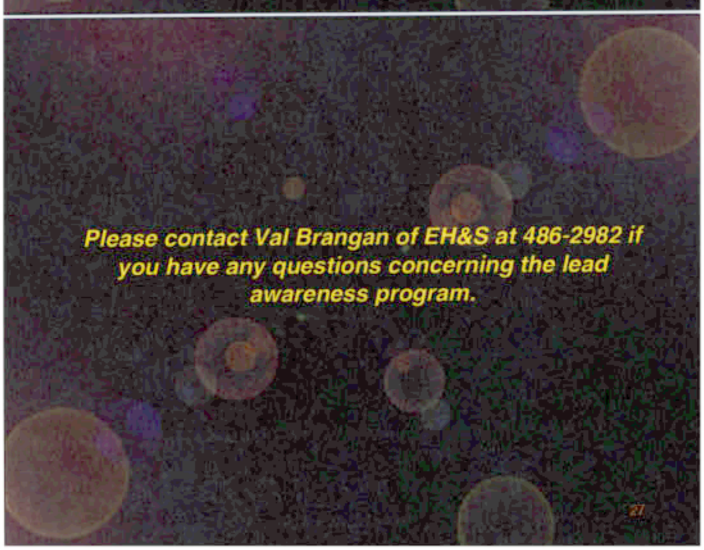

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