Differences in Surface Lead Concentrations in a Steel Mill

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

While health effects and exposure assessments for lead have been well researched and documented, there are currently no areas of research on general industry, specifically the steel industry, that compares surface lead contamination in lead-designated areas versus non-lead-designated areas. At this time, there is no objective evidence establishing concentration levels that surfaces need not exceed to be considered safe. The U.S. Occupational Safety & Health Administration (OSHA) has established limits for occupational exposures to airborne lead and for blood lead levels. The OSHA general industry standard for surface lead contamination (29 CFR 1910.1025 (h)(1)) reads as follows: "All surfaces shall be maintained as free as practicable of accumulations of lead." Currently there is no general industry occupational exposure limit for surface lead contamination, nor is there a clear definition of how clean is clean. Employees who are enrolled in a lead exposure prevention program typically work in an area referred to as a lead-designated area, where special personal protective equipment (PPE), hygiene precautions and engineering controls are required. Employees who work directly adjacent to this department may not be included in the lead program if air sampling results are below the occupational exposure limits (OELs). Areas that are not included in the lead program are typically referred to as non-lead-designated areas. An occupational exposure that is typically overlooked that could potentially affect lead air samples and blood lead levels is surface lead contamination.

Employees who have lead on their hands and don't wash their hands can contaminate the things they touch, such as respirators, and items they put in their mouth, including food, cigarettes and chewing tobacco. If break rooms, restrooms and locker rooms are not kept on a cleaning schedule, cross-contamination can reach workers' homes. This contamination can accumulate in an employee's car, clothing and boots worn to work, lunch pails and coolers, thermoses, hair and safety equipment.

Though OSHA has no specific concentration for surface lead contamination for general industry, the Michigan Occupational Safety & Health Administration (MIOSHA) has adopted specific levels. A work surface that has lead dust accumulation in excess of 1,000 micrograms per centimeter squared ($\mu g/cm^2$) is considered significantly contaminated and must be thoroughly cleaned to minimize the potential for employee lead exposure. A surface on which food, drink or cigarettes are stored, prepared or consumed is considered significantly contaminated if it has a lead dust accumulation of 50 $\mu g/cm^2$. The MIOSHA regulation then states that surfaces must be thoroughly cleaned to minimize the potential for employee lead exposure. The determination of these concentrations has been accepted by MIOSHA from previous citations administered to facilities in the state of Michigan.

Purpose of Study

The intent of this study is to see if there is any statistical difference in mean surface lead concentrations between lead-designated areas and non-lead-designated areas against the MIOSHA 50 µg/cm² limit. The OSHA standard defines the need for air sampling procedures to determine who will need to be enrolled in the lead program. This may not be an adequate way to help predict the protection of our workforce. The workforce could be inadequately protected from all other meaningful exposure routes, such as dermal and ingestion, if only airborne exposures are assessed. By assessing only airborne exposures, other crucial exposures are not considered. Using the personal airborne lead level measurements as the requirement in the lead program overlooks possible dangerous ingestion exposures that can occur even when airborne lead levels are low. This raises the question: is our current lead standard truly protecting workers enough?

Lead is a heavy, dense metal that is toxic at very low exposure levels and has acute and chronic effects on human health. Lead is introduced into the body via inhalation of lead fumes or dusts, ingested and absorbed through the gastrointestinal tract and, to a limited extent, through the skin. Both epidemiological and toxicological studies have shown that levels of lead concentration affect many different organ systems. Once lead is absorbed, it is directed into the blood and soft tissue where it slowly deposits into the bone. Lead can penetrate and be absorbed into the bone by the displacement of calcium and its mimicking of calcium's action. It can accumulate in bone material and serve as a secondary source of exposure in the future. This can occur when lead leaves the bone and re-enters the bloodstream later in life. Lead accumulates preferentially in bone regions undergoing the most active calcification at the time of the exposure. Lead is distributed in bones, specifically the trabecular (patella) and more dense cortical bones like the tibia. On average, 80% is deposited in the trabecular bones and 20% in the cortical bones. Lead is excreted in urine, feces, sweat, breast milk, nails and hair. The personal hygiene of exposed people plays a major role in exposure; nail biting or infrequent bathing can promote prolonged lead exposure. The source of the lead is the key factor to consider when determining who will be exposed to lead. In steel mills, lead dust is suspended in the air as a fume from the melting of steel. There are several metals that are melted along with lead. Particle size and density are a factor in the travel of air contaminants and for predictive concentrations.

The relationship of blood lead to air lead exposure concentrations serves as a bridge between workplace atmospheric lead exposure and possible damage to workers' health. Hygienic improvements in the industry have resulted in reduced airborne lead levels, making routes of exposure other than inhalation increasingly more likely. Currently, personal hygiene and housekeeping in lead-exposed occupations and lead-designated work areas are perhaps the most important determinants of lead exposure. Employees may inhale dust containing lead while working, walking and cleaning work areas. These particles rarely penetrate the skin. However, contamination on hands, arms, or the face may allow for the ingestion of lead during eating, drinking, smoking or applying cosmetics if the skin is not adequately cleaned. Dust containing lead may be carried home on workers' bodies, clothing or tools. Workers may then potentially and inadvertently expose children and family, thus increasing risk of exposure to more individuals.

A letter of interpretation was written in 1979 about lead surface contamination, which is still the most recent interpretation regarding this issue. The letter states that engineering controls are in place (i.e., vacuuming, water hosing and tenant sweeping) until an effective in-house vacuuming system is installed. OSHA stated the following: "We have determined that the above housekeeping practices, if followed by the applicant, will constitute compliance with the housekeeping requirements of the lead standard in Section 1910.1025(h). Therefore, a variance is unnecessary. The application was discussed with the Kansas City area director, who concurred with the decision. This interpretation letter identifies no concentration for surface contamination but approves the controls necessary without any objective data." However, in the construction industry (29 CFR 1926), OSHA has

Table 1

Surface Lead Occupational Exposure Limits (OELs)	
OSHA construction 1926	200 µg/ft²
CAL OSHA[1]	TBD
MIOSHA 1910 (work area)[2]	1,000 µg/cm²
MIOSHA 1910 (consumable area)[2]	50 µg/cm²

[1]Current proposed OEL for change.
[2]Concentrations accepted by MIOSHA from previous citations upheld in court.

Table 2

8-Hour Airborne Lead OELs	
OSHA-AL 1910	30 µg/m³
OSHA-PEL 1910	50 µg/m³
ACGIH-TLV®	50 µg/m³
CAL OSHA-AL[1]	0.5 µg/m³
CAL OSHA-PEL[1]	2.1 µg/m³

[1]Current proposed OEL for change.

provided a level of acceptable lead loading (surface dust levels) for non-lead work areas (clean areas outside lead work areas, such as lunchrooms) of 200 µg/cm^2.

Professional judgment related to qualitative risk assessment has shown to be problematic, particularly as it relates to airborne exposure assessment and control. Airborne exposure assessment and control are perhaps the areas of highest expertise in industrial hygiene (IH) compared to dermal exposure assessment. Industrial hygienists have a better chance at making accurate qualitative judgments about airborne exposure and control than they do for dermal exposure. This begs the question: do we make even worse judgments about dermal exposure and control issues than we do for airborne? The potential risk of making poor risk assessments about dermal lead exposure may be quite high for the very fact that meeting the sole OSHA requirement regarding housekeeping and accumulation of lead dust relies entirely on professional judgment. This heightens the importance of assessing potential dermal exposure in lead operations and adjusting the lead-designated area boundaries accordingly. It also adds poignancy to an age-old problem often overlooked.

Methods

Fifty wipe samples were collected in each area throughout the steel mill on horizontal working surfaces. In order to avoid sample selection bias, a random number generation program was used to select sample locations. Wipe sampling was conducted via National Institute of Occupational Safety and Health (NIOSH) Method 9100, and analyses of wipe samples were conducted via Environmental Protection Agency (EPA) Method 6010C.

Figure 1

Fifty wipe samples were collected in each area of the steel mill on horizontal working surfaces.

Statistical analysis of lead concentrations was conducted using Statistical Package for the Social Sciences® (SPSS). A risk ratio was calculated from air sampling data provided by the facility.

Discussion

There is a statistical correlation between surface lead concentrations in a known lead-designated area versus those in the adjacent non-lead-designated area. The mean lead-designated area surface lead concentrations are above the MIOSHA 50 µg/cm^2 guideline. This area should be kept a lead-designated area even though only 38% of surface concentrations exceeded the guideline. The mean non-lead-designated area surface lead concentrations are below the MIOSHA 50 µg/cm^2 guideline. This area should be kept a non-lead-designated area. There is a statistically significant interaction between the lead-designated concentrations and those samples exceeding 50 µg/cm^2. Only three of the 50 (6%) non-lead-designated samples had concentrations that exceeded the MIOSHA guideline of 50 µg/cm^2. Thirty-one of the 50 samples collected (62%) in the non-lead-designated area were below limit of detection, while all the lead-designated area samples (100%) had detectable concentrations.

Conclusion

This study confirmed that the lead-designated area has a higher risk for potential dermal exposure than the non-lead-designated area. Based on the high number of no detections and the majority of detectable concentrations being below the guideline of 50 µg/cm^2, the non-lead-designated area is thought to have a low risk for potential dermal exposure. It can be predicted that lead-designated area surface lead concentrations are 3.6 times more likely to exceed the MIOSHA guideline.

Many facilities and companies evaluate only airborne lead exposures, and do not assess the risk of exposures that can come from surface dust contaminated with lead. But the results from this study document that employers at least need to evaluate surface concentrations to determine if they are keeping concentrations as low as practicable per the OSHA lead standard. Surface samples and observations are a vital piece of this determination. It is critical that there are periodic evaluations of all areas that have potential contamination to help prevent workers from cross-contaminating other areas within the plant, as well as their homes and families. ✦