Workplace Lead Exposure

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Lead poisoning causes adverse health effects in adults and children in a dose-dependent fashion. Workplace lead exposures below the current permissible exposure limit (PEL) that result in blood lead levels (BLLs) much lower than those permitted by the US Occupational Safety and Health Administration (OSHA) can cause adverse health effects. To adequately protect American workers, new lead standards based on the most recent data need to be established.

The current OSHA lead standard was developed and adopted in the late 1970s when the geometric mean blood lead concentration in the US was 12.8 μg/dL. The removal of lead from gasoline, paints, and solder in food cans, as well as other public health measures, greatly reduced population mean BLLs, to the point that by, 2011 to 2012, the mean BLL in adults in the US had fallen to 1.09 μg/dL.[1] However, many lead industry workers continue to be exposed to lead at levels which can cause BLLs to greatly exceed these population averages. Many provisions of the current OSHA standard apply only to those workers exposed at the OSHA action level of airborne lead dust $\geq$30 μg/m^3 as an 8-hour time-weighted average, and mandatory medical removal provisions may not apply until a worker's BLL equals 50 or 60 μg/dL (depending on the setting, eg, in the construction industry or in general industry). For workplace standards to adequately protect workers, they must be updated to reflect current scientific knowledge on the adverse effects of overexposure to lead including the influence of ingested surface lead dust, irrespective of airborne lead concentrations.

Clinical and epidemiological studies published in recent decades have demonstrated the adverse impact of cumulative low- to moderate-level lead exposure and the development of significant adverse health effects (even with BLLs in the range of 10 to 20 μg/dL). The most notable effect is increased cardiovascular risks, but adverse pregnancy outcomes and other effects also occur at these levels. Many of the governmental agencies and expert panels that have evaluated the data since publication of the current standard have concluded that the PEL for lead exposure and BLLs permissible under current OSHA standards are not protective, and several groups have also recommended more stringent regulations regarding the exposure, biomonitoring, and medical removal of affected workers. These evaluations include those conducted by the National Institute for Occupational Safety and Health's Adult Blood Lead Epidemiology and Surveillance Program (ABLES)[2]; the Council of State and Territorial Epidemiologists[3]; the Association of Occupational and Environmental Clinics (AOEC) Medical Management Guidelines for Lead-Exposed Adults[4]; an expert panel publication on *Recommendations for Medical Management of Adult Lead Exposure*[5]; the California Occupational Lead Poisoning Prevention Program (OLPPP)[6]; the DHHS National Toxicology Program (NTP) Monograph on Health Effects of Low-level Lead (2012)[7]; the National Research Council (NRC) Potential Health Effects to Firing Range Personnel (2013)[8]; the Environmental Protection Agency (EPA) Integrated Science Assessment of Lead (2013)[9]; the Department of Defense (DOD) Provisional Blood Lead Guidelines[10]; and the Ontario Ministry of Labour (Canada).[11]

ACOEM POSITION

The American College of Occupational and Environmental Medicine (ACOEM) believes that OSHA should update its lead standard to adequately protect American workers. This standard should be applied to all workers who have the potential for significant lead exposure by inhalation or ingestion, even in the absence of documented elevations in airborne lead levels. Any exposure that is known to cause, or is reasonably anticipated to cause, an elevated BLL is considered significant, regardless of airborne lead dust levels. OSHA revisions should include more protective action levels, PELs for airborne and surface lead dust, workplace hygiene requirements, and medical removal protection provisions.

Among the most compelling evidence of the adverse effect of low- to moderate-level lead exposure available since the current OSHA standard was promulgated is the finding of increased cardiovascular morbidity and mortality in exposed populations with BLLs in the range of 10 to 20 μg/dL.[12–16] Numerous other adverse health effects, including reproductive/developmental risks posed by lead exposure to women who are or may become pregnant, have been associated with BLLs in this range as well.[17–28] In the case of pregnant women or those trying to become pregnant, ACOEM believes that a lower threshold for medical removal should be mandated. It is medically inadvisable for these women to continue to have lead exposures causing a BLL of more than 5 μg/dL, and most physicians would recommend removal from further exposure. Mandatory medical removal of all pregnant workers and those who are trying to become pregnant must occur when BLLs are more than 10 μg/dL.

In 2010, ACOEM sent a letter to OSHA urging the Agency to update its lead standard and to align itself with the overwhelming scientific evidence of adverse health effects in adults exposed below the current OSHA limits[29]; to date, no action has been taken by OSHA to effect such change. The California Department of Health's OLPPP has recommended keeping BLLs below 10 μg/dL, and lowering the BLL threshold that triggers medical removal to $\geq$20 μg/dL. It should be noted that removal from lead exposure is the most effective measure to lower BLL, and chelation has a role only in severely elevated BLL.

It is important to note that physicians and employers need not wait for OSHA to update the current lead standard to take protective action. Current OSHA regulations for medical monitoring of lead workers allow for more stringent levels for medical removal at the discretion of the examining physician, as well as

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additional testing the examining physician deems necessary for proper evaluation[30]:

> *"...if the examining physician recommends limitations on an employee's exposure to lead, then the employer must implement these recommendations. Recommendations may be more stringent than the specific provisions of the standard. The examining physician, therefore, is given broad flexibility to tailor special protective procedures to the needs of individual employees..."*

ACOEM recommends that employers of workers with lead exposure strive to follow the recommendations suggested in the table below, and not wait for federal OSHA to update the present standards for lead in general industry and in construction. ACOEM also continues to urge OSHA to update its lead standard and lower both the action level and the trigger/threshold for medical removal as outlined in this document. The current federal OSHA standard requires BLL and zinc protoporphyrin (ZPP) testing in workers exposed above the action level, but BLL is currently considered the best readily available measure for lead exposure. Since ZPP is insufficiently sensitive when BLLs are below 25 μg/dL, ZPP testing is no longer needed.

Several ACOEM component society leaders have begun efforts to petition state OSHA authorities to adopt these new, more protective guidelines to enhance lead workers' health and prevent occupational disease. ACOEM applauds and supports these component activities and hopes this document can enhance these efforts.

ACOEM RECOMMENDATIONS FOR BLL WORKER MONITORING AND MEDICAL REMOVAL

The following table (adapted from AOEC,[4] DOD,[10] NTP,[7] NRC,[8] OLPPP,[6] Ontario Ministry,[11] and EHP 2007[5]) should serve as a guideline for management of adult lead exposure. For the purposes of this document, a lead-exposed worker is defined as any worker who is handling or disturbing materials with a significant lead content in a manner that could reasonably be expected to cause potentially harmful exposure through lead dust inhalation or ingestion, regardless of airborne lead concentrations or surface contamination levels (Table 1).

Therefore, in addition to appropriate engineering controls and personal protective equipment to protect workers from airborne or surface contamination, workplaces should provide basic hygiene measures such as handwashing stations, lockers, and showering facilities, and lead-free eating and break areas to reduce lead dust ingestion. Workers should also receive annual training regarding lead health effects and exposure control, and understand that both airborne lead inhalation and surface contamination and ingestion can result in elevated BLLs.

It also must be noted that a worker with prior high lead exposure may have a body burden of bone lead that can cause a persistently elevated BLL due to prior occupations and not from current occupational exposures.[31] Body burden can be measured by x-ray fluorescence, but such testing is not widely or readily available. There is no role for chelation challenge testing to determine a "mobilizable pool" of lead.

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TABLE 1. BLL Worker Monitoring and Medical Removal Criteria for Worker with Significant Lead Exposure, Defined as an Airborne or Surface Lead Content Known or Reasonably Anticipated to Cause Elevated BLL

Category of Exposure	Recommendations
All workers with significant lead exposure: medical examination frequency	Baseline or preplacement medical history and physical examination, a baseline BLL, complete blood count, and serum creatinine before the worker is placed in a job with anticipated significant lead exposure. Additional medical examinations may also be recommended periodically in specific workers based on the findings or prior medical examinations and clinical test results
All lead workers: frequency of blood lead levels (BLLs)	BLL (measured in μg/dL) every 2 months for first 6 months of placement, or upon change to tasks resulting in higher exposure, then BLL every 6 months; goal should be <5 μg/dL for all pregnant workers. More frequent BLL monitoring may be needed for pregnant workers or those who are trying to or may become pregnant
Recommendations if BLL ≥5–9 μg/dL	BLL increases ≥5 μg/dL evaluate workplace exposure and protective measures. Increase monitoring if indicated. For women of childbearing age, levels between five and nine indicate possible risks for spontaneous abortion and possible risk for postnatal developmental delay; discuss health risks and reduce lead exposure for women who are or may become pregnant. It is inadvisable to allow pregnant workers or those who are trying to or may become pregnant continued exposure if BLL is >5 μg/dL, and medical removal is recommended; pregnant workers may return to work when two repeat BLLs are <5 μg/dL
Recommendations if BLL 10–19 μg/dL	BLL every 2 months; evaluate exposure, engineering controls, and work practices; revert to BLL every 6 months after two or three BLLs <10 μg/dL. Mandatory medical removal for pregnant women or those who are trying to become pregnant if BLL is >10 μg/dL; return to work when two repeat BLLs are <5 μg/dL
Recommendations if BLL >20 μg/dL	Evaluate exposure, engineering controls, and work practices, and remove from exposure if repeat BLL measured in 4 weeks remains ≥20 μg/dL, or if the first or any single BLL ≥30 μg/dL. Monthly BLL testing needed, and consider return to lead work after two BLLs <15 μg/dL 1 month apart, then monitor as above
Recommendations if BLL ≥30 μg/dL	Remove from exposure immediately. Evaluate exposure, engineering controls, and work practices. In addition, monthly BLL testing needed. Consider return to lead work after two BLLs <15 μg/dL 1 month apart, then monitor as above

considered. ACOEM emphasizes that the judgments expressed herein represent the best available evidence at the time of publication and shall be considered the position of ACOEM and not the individual opinions of contributing authors.

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APPENDIX

Reference blood lead levels for adults in the US.[32] Available at: http://www.cdc.gov/niosh/topics/ables/pdfs/Reference%20Blood%20Levels%20for%20Adults-2015-12-18_508.pdf.