

Protecting Children from Leaded Solder at The Crucible

Policy Statement:

Due to the potential of lead intoxication, it is the policy of The Crucible to not allow persons under age 18 to use solder that contains lead for electrical connections. Lead-free solder performs acceptably with far less possibility of toxicity.

Background:

This document is directed at multiple audiences:

- to the organization so they understand the additional expenses of maintaining a lead-free environment.
- to faculty so they understand the reasons for the shift away from an easier-to-work-with material.
- to parents so they understand how we are acting to protect children.

Solder is used with soldering irons in the Kinetics and Electronics department to make electrical connections. Solder composed of tin and lead is long established as a well performing product, but the dangers of working with lead are also well known. Even small amounts of ingested lead can cause irreversible neurological damage, especially in children. Large international efforts have been implemented to reduce human exposure to lead. Notably, leaded paint and gasoline were banned in the U.S. in the 1970's, the European Union banned lead in all electronics in the 2000's, and California's Electronic Waste Recycling Act of 2003 bans lead in some electronics.

Leaded solder remains legal and commonly used for electronics in the United States. It is generally understood that when leaded solder is used with proper precautions, it does not constitute a danger to the user. However, younger students may have trouble following these precautions and may put themselves at risk.

Important dangers for children using lead solder are:

- The difficulty of enforcing strict hand washing policies in a classroom environment with children
- The relatively high incidence of pica (habitual eating of non-foods) among children and the difficulty of recognizing this practice in the classroom
- The possibility of careless handling of solder by children
- The extremely long-term toxic effects of lead poisoning
- The low dose needed to reach toxic levels

Alternatives:

Lead-free solder is slightly harder to work with but the safety concerns far outweigh the time spent learning how to use the new material. Solder that is made with 96.5% tin, 3% silver, 0.5% copper is a popular substitute for leaded solder. Here is one vendor's product: <http://www.all-spec.com/products/KWLF27500.html> and another <http://www.techni-tool.com/488SO7871>. Solder made from 99.4% tin, 0.6% copper works almost as well as the tin-silver-copper solder and is less expensive. Other types of lead-free solder are also available.

Costs of switching:

Tin/lead solder costs about \$25/lb, tin-silver-copper solder costs about \$50/lb, tin-copper solder costs about \$35/lb. Both lead-free solders wear out the tip of a soldering iron in 1/3 the time as with tin-lead solder. A new tip costs about \$2-10.

A summer of classes typically goes through 1.5 lb of solder and 5 soldering tips. So switching to lead-free solder might cost an extra \$50 in solder and \$50 in tips.

Research on Leaded Solder:

"Lead poisoning has been reported in children after a single ingestion... Pica is a very well identified risk factor of lead intoxication in children."

- Sabouraud, S et al. Lead poisoning following ingestion of pieces of lead roofing plates: pica-like behavior in an adult., 46 Clinical toxicology (Philadelphia, Pa.) 267–269 (2008).

<http://doi.org/10.1080/15563650701639014>

In the Sabouraud et al. article above, a case study described a woman with a single 6mm bullet lodged in her body. Her blood lead level climbed to dangerous levels over a few months. This implies that if piece of lead-solder was lodged in a student's stomach, the negative consequences could be dramatic.

(paraphrased) A 45 year-old woman had lead shot pellet lodged in her stomach, probably from eating a hunted animal. Her blood lead level climbed to 550 µg/L before she excreted the pellet. There are several similar medical case studies described in this article.

- "Intoxication from an Accidentally Ingested Lead Shot Retained in the Gastrointestinal Tract" Environ Health Perspect. 2005 Apr; 113(4): 491–493. Per Gustavsson and Lars Gerhardsson.

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1278491/#!po=25.4717>

"one study showed that about 10% of children older than 12 years engage in pica"

- http://www.academia.edu/202338/Pica_An_Update

"Pica is observed most commonly in areas of low socioeconomic status and is more common in women (especially pregnant women) and in children. To our knowledge, the prevalence of pica is not known. Numerous complications of the disorder have been described, including iron-deficiency anemia, lead poisoning, and helminthic infestations."

- "Pica: Common but Commonly Missed" http://www.medscape.com/viewarticle/405804_1

The CDC recognizes that "[n]o safe blood lead level in children has been identified" and that a blood lead level above 5 micrograms per deciliter (µg/dL) should be treated.

- <http://www.cdc.gov/nceh/lead/>

"...the average blood lead levels from 4 to 10 years had the strongest association with the adult full-scale IQ. For each 1 µg/dL average blood lead levels, the adult full-scale IQ deficit was about two IQ points."

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<http://www.environmentalhealthnews.org/ehs/newscience/iq-effects-childhood-lead-exposure-persist-in-adults/>

"Lead in the body comprises 2% in the blood (t1/2 35 days) and 95% in bone and dentine (t1/2 20–30 years). Blood lead may remain elevated for years after cessation from long exposure, due to redistribution from bone."

- Gordon, J. N., Taylor, a., & Bennett, P. N. (2002). Lead poisoning: Case studies. British Journal of Clinical Pharmacology, 53(5), 451–458. <http://doi.org/10.1046/j.1365-2125.2002.01580.x>

"Early symptoms of lead neurotoxicity in both adults and children include irritability, headache, decreased attention span, memory loss, and low-level cognitive impairment... As childhood exposure increases, behavioral symptoms of impulsiveness, inability to follow sequences or directions, decreased play activity, lowered IQ, and poor attentiveness are seen at PbBs of 10-35 µg/dL. ... Recent studies evaluating the relationship between blood lead levels and neurobehavioral performance have shown evidence of effect at levels below 10 µg/dL -the current level considered excessive for pediatric exposure... [In one study] a significant inverse relationship was observed between blood lead levels and reading and math test scores and comprehension testing. The correlation was noted at levels as low as 2.5 µg/dL."

- Patrick, L. (2006). Lead Toxicity, A Review of the Literature. Part I: Exposure, Evaluation, and Treatment. *Alternative Medicine Review*, 11(1), 2-22. <http://europepmc.org/abstract/med/16597190>

A cursory review demonstrates that ingestion (accidental or otherwise) of even a single grain-of-rice sized piece of lead solder could be dangerous for a child. A grain of rice weighs about 0.01 grams. A 0.01 gram piece of 60/40 Tin/Lead solder has about 0.004 grams of lead. That could raise the blood lead level of a 50 kg child by 8 µg/dL, higher than the current proposed actionable level of 5 µg/dL. Accidental ingestion of piece of solder the size of a grain of rice is extremely plausible when a child eats their lunch in the same clothes they solder in.

Concerning the Dangers of Solder Flux:

Another potential danger to soldering are the fumes from the flux. People exposed to flux fumes for multiple years in the workplace have developed asthma-like symptoms. The danger to students appears to be very small owing to the short duration of exposure. Additionally, research on this topic continues to be inconclusive, even for people that have worked for many years with solder. No particular flux has been singled out as more toxic than another. As more research is found on this subject, the policy will be reviewed.

Research on Solder Flux:

"Research on the respiratory effect of exposure to solder fumes in electronics workers has been conducted since the 1970s, but has yielded inconsistent results. The aim of this meta-analysis was to clarify the potential association... Soldering may be a risk factor for wheeze, but may not be associated with a clinically significant impairment of lung function among electronics workers."

- Mendy, A, et al (2011). Work-related respiratory symptoms and lung function among solderers in the electronics industry: a meta-analysis, <http://doi.org/10.1007/s12199-011-0236-8>

"A cross-sectional study was conducted in four medium-sized electronics firms in which control measures to capture solder flux fume were absent or visibly ineffective... The odds ratios for 'all wheeze', shortness of breath, and work-related eye, nose and chest symptoms were all significantly greater (raised about 4-5 fold) in women who soldered > or = 37 h/wk when compared with those soldering < or = 20 h/wk."

- Palmer, K. (1997). Respiratory disease in workers exposed to colophony solder flux fumes: continuing health concerns. <http://www.ncbi.nlm.nih.gov/pubmed/9604483>

Tips on Using Lead-free Solder in Place of Leaded Solder

Be sure to leave a small blob of solder on the tip when putting it down. Leaded solder only needs the tiniest bit on the tip to keep going, lead-free needs a larger blob, lest it oxidize fully.

Lead-free solder needs a higher temperature than leaded, typically 700-750F instead of 600-650F. A temperature-controlled iron works better than a cheaper current-controlled iron put to a higher setting. The higher setting will contribute to the tip wearing out faster, especially so with a current-controlled iron. Common tip failures include the tip becoming uncleanable after fully oxidizing, and the tip gradually being melted away.

Leaded flux-core solder adheres to dirty metal better than lead-free solder. Cleaning your piece with 98% isopropyl alcohol or other chemical wipes can help with adhesion.

Using finer gauge wire for lead-free may help. 0.031" is popular for thru-hole and 0.023" for surface mount.

Using deionized water in the cleaning sponge may help.

Lead-free solder wears out tips about 3 times faster than leaded solder. Be sure to have spare tips on hand.

Here is a guide to lead-free soldering from a major solder manufacturer:

http://www.kester.com/kester-content/uploads/2013/06/Lead-free-Handsoldering.Final_4.19.06.pdf