UMassAmherst | Environmental Health & Safety

Soldering SOP

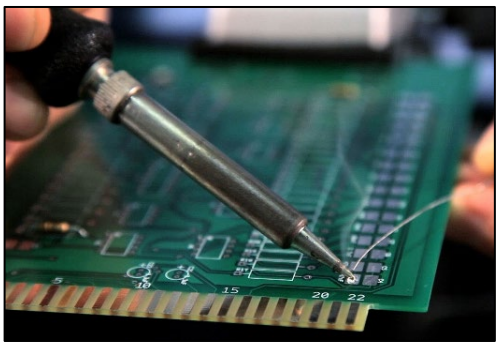
What is soldering?

Soldering is the process in which two or more metals are joined together using a filler metal (solder). The solder is a metal alloy that has a lower melting point than the metals to be joined. The metal alloy is heated using a hot iron such that it can melt into the desired join and "glue" the pieces together. This metallic "glue" allows electrical currents to flow through it, which makes soldering an important process in electronics work.

The compositions of solders vary, but they commonly consists of combinations of tin-lead, tin-zinc, lead-silver, cadmium-silver, or zinc-aluminum. The relative amounts of these metals in solder are also variable and depend in part on the types of materials to be joined.

In addition to the solder and metals to be joined, soldering operations may involve other materials, such as fluxes, coatings, and cleaning agents. Fluxes facilitate soldering by allowing the solder to flow more smoothly and by removing oxidation from the metals to be joined. Common fluxes include ammonium chloride, rosin, and zinc chloride. Fluxes may be used in soldering as a separate flux paste or liquid, or the solder itself may contain a rosin core. The type of flux used depends on the physical properties of metals to be soldered.

What are the hazards?



The hazards associated with soldering include physical hazards such as burns or fires, as well as health hazards from inhalation of fumes or ingestion of solder and/or fluxes.

Burns/fires

The soldering iron is heated to very hot temperatures (up to 600-700°F, or 315-370°C) for soldering work. Both the iron itself and parts that are heated by the iron will be extremely hot during and after soldering work, and they can easily burn the skin through contact. Moreover, they can also cause a fire if placed on flammable or combustible materials.

Ingestion

Lead exposure from lead-containing solder can lead to serious chronic health effects, such as neurological or reproductive problems. The primary route of exposure to lead through soldering operations is through accidental ingestion of lead particulates that get on the skin from handling the solder or from surface contamination.

Inhalation

Several soldering components may produce inhalation hazards (fumes, gases, or vapors) when they are heated. Strictly speaking, fumes refer to volatilized solid material that has condensed in air, but the term is also often used to describe gases and vapors that may be produced in soldering operations, and this SOP follows that convention. Because soldering fumes typically rise vertically in the air, they can easily enter a person's breathing zone if adequate ventilation is not used. The main sources of inhalation hazards in soldering operations are described below.

1. *Solder constituents* may be a source of fumes if soldering temperatures exceed the boiling point(s) of the metal(s) in the solder. While soldering operations for many constituents will be below boiling points, metal fumes may be a concern if temperatures exceed typical soldering temperatures (approximately 600-700°F).

2. *Oils, paints, or coatings* on surfaces that are heated during soldering can produce toxic fumes, gases, and vapors. This can occur even when the oil, paint, or coating is on the back of the object being soldered and not in direct contact with soldering materials. Materials made or coated with Teflon (PTFE or polytetrafluoroethylene) may produce fumes when heated above 625°F. Exposure to Teflon fumes can cause an influenza-like syndrome (polymer fume fever) and other toxic effects such as pulmonary edema or pneumonitis.

3. *Fluxes* may produce toxic fumes when heated, and the specific risks of these fumes is dependent on the type of flux used. Rosin-based fluxes (including those in fluxes and rosin-core solder) produce fumes that contain a range of resin acid particulates and aliphatic aldehydes, including formaldehyde. Rosin-based fluxes can cause dermatitis, respiratory irritation, occupational asthma, or a worsening of existing asthmatic conditions. In addition, the decomposition products of rosin-based solders can cause respiratory or skin sensitization, where an individual develops intense immunologic responses to exposure, even at low levels. Symptoms of respiratory exposure to rosin-core solder or rosin flux include watery eyes, runny or stuffed up nose, sore throat, coughing, or difficulty breathing.

   Other types of fluxes include organic and inorganic water soluble fluxes. Organic water soluble fluxes contain organic salts and acids, such as citric, lactic, benzoic, and glutamic. These acids may cause irritation of the skin and respiratory tract during soldering operations, and contact with concentrated acid solutions can cause severe burns. Inorganic water soluble fluxes commonly contain zinc chloride, stannous chloride, hydrochloric acid, and phosphoric acid dissolved in water. Zinc chloride may cause irritation of the respiratory tract.

4. *Gases and vapors from cleaning agents* may also pose an inhalation hazard. Acids, alkalis, and organic solvents may be used both to clean surfaces prior to soldering and to remove unwanted solder or flux residues after soldering.

What Activities Could Pose a Risk?

Activities that could pose a health hazard include:

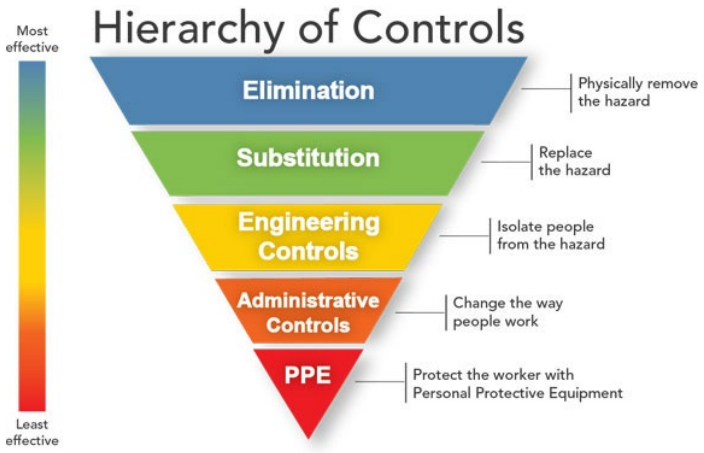
- the use of lead-containing solder;
- the use of fluxes, particularly rosin-core solder or rosin-based flux without adequate ventilation;
- soldering on surfaces that are coated or painted, particularly Teflon coatings; and
- inadequate/infrequent cleaning of surfaces in the work area;
- inadequate/infrequent hand washing before breaks and after soldering.

Activities that could pose a physical hazard include:

- the use of the soldering iron due to the high temperatures that are used in soldering; and
- the use of frayed or damaged electrical cords.

How Can Exposures Be Minimized?

When working with any hazardous material or process, always conduct a thorough risk assessment and employ the hierarchy of controls to minimize risk. Some specific applications of the hierarchy of controls to the unique hazards of soldering operations are listed below. Always apply the controls in the order of most effective to least effective (see graphic at right), and apply as many controls as possible to reduce the risk to the lowest achievable level.



Elimination/Substitution

- Use the smallest amounts of solder and fluxes possible for a given operation.
- Substitute lead-free solder for lead-containing solid when practical and feasible. Lead-free replacement solders generally have higher melting points and usually require re-engineering of components and materials to be soldered. There is also a potential for more fumes to be produced because of the higher soldering temperatures. If you have questions about implementing this substitution, please contact EH&S.

Engineering Controls

- Conduct soldering operations in fume hoods, below a snorkel, or with a fume extractor.

Administrative Controls

- Ensure laboratory personnel are thoroughly trained on the hazards associated with soldering operations, routes of exposure, symptoms of exposure, hazard mitigation techniques, and emergency procedures.
- Clean work area surfaces regularly using wet methods to remove particulates that settle out of the air. Work areas should be kept clean, and surfaces should be wiped with a damp paper towel to minimize lead dust.
- Do not store or consume food or drinks into rooms where soldering work is performed.
- Wash hands thoroughly with soap and water before breaks, before eating, and upon completion of soldering work.
- Keep soldering work away from flammable materials, such as chemicals, cardboard, paper, or styrofoam.
- Review the Safety Data Sheets (SDSs) for the fluxes, rosins, solders, and cleaning solvents to be used.

Personal Protective Equipment

- Wear a lab coat or long sleeve shirts and pants to protect skin from burns. Natural fibers such as cotton or wool are preferred because synthetic fibers can melt onto skin. Launder outer garments regularly.
- Wear closed-toed shoes while soldering (and at all times while working in a lab).
- Wear safety glasses or chemical splash goggles while soldering and clipping wires. Alternatively, wear a face mask over safety glasses if splashes are of concern.
- Wear heat-resistant gloves whenever there is a potential for hands to come into contact with hot surfaces. EH&S staff can assist with selecting appropriate gloves.

Emergencies

In the event of a fire or injury, follow the procedures outlined in the Chemical Hygiene Plan.

Sources and Additional Resources

1. Occupational Health and Safety Administration (OSHA) Technical Manual: Controlling Lead Exposures in the Construction Industry: Engineering and Work Practice Controls. https://www.osha.gov/dts/osta/otm/otm_v/otm_v_3.html.
2. Pengelly, M, Foster, R, Groves, J, Ellwood, P, Turnbull, G, Wagg, R. 1994. 'An Investigation into the Composition of Solder Fume'. *Annals of Occupational Hygiene*. vol. 38, No. 5, pp. 753-763.
3. Safe Soldering Work Practices. Lawrence Berkeley National Laboratory. https://eta-safety.lbl.gov/sites/default/files/Soldering%20Guidelines.pdf.
4. Soldering Safety – Guideline. Carnegie Mellon University, Environmental Health & Safety. https://www.cmu.edu/ehs/Laboratory-Safety/chemical-safety/documents/ehs-guideline---soldering-safety.pdf