加工无铅焊料会引起释放比锡/铅配方更多的有害气体，因为焊接温度较高，而且需要使用更强的助焊剂以便形成可靠的焊点。在考虑选择过滤或排放有害气体时，过滤是成本最低而且灵活性最强的方法。HEPA过滤器很关键，但有很多不同种类，性能可相差百倍。应该选购有效捕捉超微颗粒的设备。具有强力抽吸性能的三级过滤系统形成最佳系统的基础。其它性能包括便携性以及系统装在工作台以外场所的能力。

Airing It Out

Karl Schuepsthul

Fumes from lead-free solders are more harmful than those of tin-lead. What precautions are you taking?

Will lead-free soldering cause more harm to employees inside the factory than tin-lead does? A study by the Danish Toxicology Centre assessed the toxicity of lead and the metals used in lead-free alloys. While lead was found to be highly toxic to humans, silver, a standard constituent of lead-free alloys, was found to be several orders of magnitude more eco-toxic than lead.[1] In addition, some other metals used in lead-free alloys were shown to have uncertain toxicological results.

So, is switching to lead-free without increasing risk to employees possible? Moreover, can environmentally friendly practices be implemented without bursting already overstretched budgets? The short answer: Yes. Employee risk can be reduced, while retaining a tight grip on finances. Financial gain is even possible. Here's how.

Any soldering process using rosin-based flux generates colophony. This substance contains a range of materials known to be harmful, such as carbon monoxide and acetone. Medical research conducted in the U.S. by the Occupational Health and Safety Administration and others has linked colophony with occupational asthma.[2] This debilitating breathing condition, once developed, is irreversible. These findings are supported by other research around the world.

Using non-rosin flux can have even worse effects on health. These fluxes contain many alcohols, acids and other chemicals that OSHA has deemed harmful to workers and a threat to the workplace.

The only safe way to deal with the problem of fumes is to prevent them from being inhaled in the first place by removing contaminated air from the employees' workspace using effective fume extraction.

Harmful fumes are generated when volatile substances such as fluxes, pastes, adhesives and cleaning solvents are heated above room temperature. During lead-free processing soldering tem-

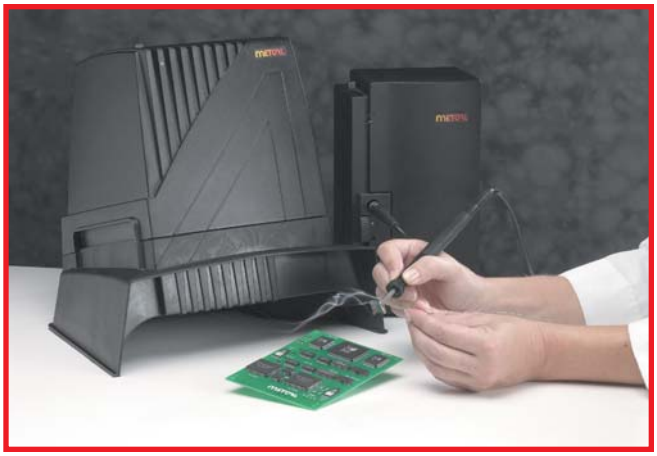

FIGURE 1: Nozzles on filtration units are positioned close to the fume source, a more efficient way of capturing airborne contaminants.

peratures are much higher than for conventional tin-lead, so the effects and potential harm are that much greater.

For example, eutectic tin-lead solders melt at around 180°C, while soldering temperatures peak around 210°C. A typical lead-free solder, on the other hand, melts at around 220°C, with peak soldering temperatures of around 250°C. Potentially harmful chemicals and particulates are therefore more likely to become airborne and in much greater concentration.

Higher processing temperatures are not the only reason why lead-free solders are potentially more harmful to employees. Lead-free also requires more powerful flux activators, which contain chemicals that are allergenic and irritating to the skin and eyes. For the joints to form successfully, the concentration of activators is typically double that needed for tin-lead.

Some countries already legislate against harmful emissions from solders. In others, including the U.S., it is not necessarily an offense, but does create the potential for future liability, as well as risk of staff absenteeism, health-care costs and lower productivity.

Assuming that manufacturing with lead-free alloys is safer than with tin-lead is unwise. The most sensible step forward is to tackle the problem of harmful fumes directly, using fume extraction equipment.

Filter or Vent?

Some filter systems have a very weak suction force. Their filters might seem clogged when in fact the suction force of the fan has failed. Replacing the filters too often is a common mistake that hikes maintenance costs.

However, filtration units are generally preferable to venting systems because they are more economical to operate. The reason: "conditioned" factory air does not have to be replaced. Venting fumes from soldering stations using a 10" diameter duct, leading to a fan on the factory roof, can easily carry 1200 cfm (2000 m^3/h) of factory air outside. Replacing this with cooled or heated "make-up" air increases energy costs.

With filtration units, the fume-capturing nozzles are located close to the fume source, which reduces the total volume of captured air (**Figure 1**). Applying high-efficiency filtration to the captured air permits it to be recirculated safely in the factory, immediately reducing the need for make-up air.

Other benefits of fume filtration units over venting systems include: flexibility to rearrange the production floor layout without having to move fixed ducting; no landlord permits for duct penetrations; fast, low-cost setup; and ductwork maintenance.

Most fume extraction systems are similar, theoretically, insofar as they feature a pump that suctions fumes away from the breathing zone through a filter system. But effective fume extraction is achieved by employing multistage filtration, with the best

units offering a three-stage approach comprising pre-filter, main (HEPA) filter and further activated carbon filter.

Off-the-shelf air purifiers – the type found in local hardware stores – give a false sense of security. These units are often based on simple carbon filtration that removes visible smoke particles, leaving the impression of cleaner air. But they leave behind particulates that are smaller and invisible – and more dangerous. A good quality unit should offer at least 99.5% efficiency for removing particles of 0.3 µm or larger.

A HEPA filter is crucial, but be aware that many different types of HEPA papers cover a range of grades that can differ in effectiveness by as much as 100 times.

An effectiveness rating is only as good as its accompanying qualification. A unit that claims to be greater than 99.9% efficient sounds good. But the most harmful constituents of fumes are also the smallest and can penetrate deep into the lungs, so the efficiency of capturing submicron particulates is what really counts. An extra, third stage of activated carbon filtration is required to cope with the harmful, nonparticulate gases and vapors released when solders, adhesives and solvents are heated.

Highly efficient, multistage filters are rendered useless, however, if no air is being drawn through them. Thus, the unit's pump rating is an important parameter. A free-blowing airflow of 75 cfm (125 m^3/h) per station for a 50-mm diameter exhaust arm should be more than sufficient, and look for a suction force of 850 Pa or higher.

Other features to consider in a good fume extraction system include the size of the unit and whether it can be situated on a benchtop (**Figure 2**). Portability means flexibility; systems that can be set on the floor (under the bench) will increase workspace for the operator. ■

References

1. Danish Toxicology Centre, Environmental Project no. 778, 2003.
2. U.S. Occupational Health and Safety Administration, osha.gov, search "occupational asthma."

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FIGURE 2: Fume extractors that can be set on the floor increase operator workspace.