Fume extraction reduces lead-free risks

Lead-free electronics may be good for the environment, but manufacturers need to be aware of the potential increased health risks on the shop floor, and the most effective way of dealing with them.

In the midst of all the facts and fiction circulating about lead-free soldering, there is at least one certainty; sooner or later every OEM and EMS provider will have to embrace the technology. Whether it comes about as a result of eventual government legislation, consumer pressure, or simply a realization that your competitors have moved on and left you behind, the fact is that it is here and here to stay.

Many electronics manufacturers, large and small, are already building products based on lead-free solders. And responsible organizations probably feel, quite rightly, that they are helping the environment in doing so.

However, while using lead-free solders may reduce the impact of electronics on the outside world, the actual soldering process could cause more harm to employees inside the factory than tin-lead ever did. A study by the *[1.] Danish Toxicology Centre assessed both the toxicity of lead and the metals used in lead-free alloys. While lead was 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. In addition, some of the other metals used in lead-free alloys were shown to have uncertain toxicological results. A worrying prospect considering that the whole movement towards lead-free soldering is ultimately being driven by a need to reduce any potential health risks.

So, is it possible to switch to lead-free without increasing the risk to employees? Moreover, can more environmentally friendly practices be implemented without busting already over-stretched budgets?

The short answer to both is yes. Employee risk can be reduced, while retaining a tight grip on finances. There could even be financial gain. The long answer is as follows.

The problem of fumes

Any soldering process that uses rosin-based flux generates colophony. This is a substance containing a range of substances known to be harmful, such as carbon monoxide and acetone Medical research in the US, including the *[2.] Occupational Health and Safety Administration (OHSA) has linked colophony with occupational

asthma. This is a debilitating breathing condition that once developed is irreversible. This research is also backed up elsewhere around the world.

Using non-rosin flux is no better, however, as these can have even worse effects on health. They contain many alcohols, acids and other chemicals that OHSA has deemed harmful to workers and a threat to the workplace.

The only safe way to deal with the problem of fumes is to remove contaminated air from the employees' workspace, using effective fume extraction, and so prevent it from being inhaled in the first place.

Harmful fumes are generated whenever volatile substances such as fluxes, pastes, adhesives and cleaning solvents are heated above room temperature. In lead-free processing, where the soldering temperatures are much higher than for conventional tin-lead, the effects and potential harm are that much greater.

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

The higher processing temperatures are not the only reason why lead-free solders are potentially more harmful to employees. Lead-free also requires the use of 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. And, in a global marketplace, there is a competitive edge to be had by employing environmentally friendly manufacturing practices as part of overall ISO14000 certification.

The need for effective fume extraction

Some countries already legislate against harmful emissions from solders. In others, including the US, it is not necessarily an offence, but does create the potential for future liability. Not to mention the costs of staff absenteeism and corporate healthcare, as well as lower productivity.

The biggest danger to avoid is that of assuming lead-free manufacturing is safer than with tin-lead. Indeed, the most sensible step forward is to tackle the problem of harmful fumes head on, using fume extraction equipment.

Fume extraction is often seen as an additional cost that does nothing to improve profitability or reduce costs. However, looking into it a little deeper will show that an effective system can actually produce costs savings and pay for itself many times over.

With fume extraction equipment, you get what you pay for in terms of quality and results. Many of the cheaper systems on the market appear to offer a good deal, with specifications claiming high efficiency, high airflow and low maintenance. The reality, however, can be somewhat different.

Many low-cost filter systems, for example, have a very weak suction force, which makes their filters seem clogged when it is in fact the suction force of the fan that has failed. The mistake here is to replace the filters too often, with the result that maintenance costs rise unnecessarily.

However, filtration as a rule is preferable to venting systems because they are much more economical to operate. This is mainly due to the fact that expensive '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 2000 m3/h 1200cfm of factory air to the outside. Replacing this with cooled or heated 'make-up' air is high in energy costs.

With filtration units, the fume capturing nozzles are located closer to the fume source, which reduces the total volume of captured air. Then, applying high efficiency filtration to the captured air allows it to be re-circulated safely back into the factory, immediately reducing the need for any expensive make-up air.

Other benefits offered by 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 and low-cost set-ups; no expensive ductwork maintenance.

An ideal filtration system

Most fume extraction systems are, theoretically alike, in so much as they feature a pump that provides suction to draw fumes away from the breathing zone through a filter system. But effective fume extraction is only achieved by employing multi-stage filtration, with the best units offering a three-stage approach comprising pre-filter, main (HEPA) filter and further activated carbon filter.

Opting for a low cost, off-the-shelf air purifier, of the type found in local hardware stores, will give a false sense of security. These units are often based on simple carbon filtration that removes the visible smoke particles to leave the impression of cleaner air. But they leave behind the more dangerous smaller and invisible particulates. A good quality unit should offer at least a 99.5% efficiency for removing particles down to 0.3-micron.

A HEPA filter is crucial to overall success, but be aware, there are many different types of HEPA papers covering a wide range of grades that can differ in effectiveness by as much as 100 times.

Any effectiveness ratings are also only as good as the qualification they come with. A unit that claims to be greater than 99.9% efficient sounds good in theory. But the most harmful constituents of fumes are also the smallest, as they can get deep into the lungs, and so it is the efficiency of capturing sub-micron particulates that really counts.

An extra, third stage of activated carbon filtration is required to cope with the harmful, non-particulate, gases and vapors released when the solders, adhesives and solvents used in electronics manufacturing are heated.

Highly efficient, multi-stage filters are useless, however, if no air is being drawn through them, so the unit's pump rating is also important. Look for a free-blowing

airflow of 75 cfm (125m3/h) per station for a 50 mm dia. exhaust arm to be more than sufficient, as well as a suction force around 850Pa or higher.

Other features to consider in a good fume extraction system include the size of the unit and whether it has to be located on the benchtop. The unit's overall size can influence whether it can be treated as a truly portable, and therefore flexible system, while the ability to locate it on the floor under the bench will free up valuable workspace for the operator.

Conclusion

Lead-free soldering technology is here to stay and will soon touch every manufacturer, if it has not already done so. Processing lead-free solders causes the release of more harmful fumes than tin-lead formulations, because the soldering temperatures are higher and more aggressive fluxes are required to form reliable joints.

Between the choice of filtration or venting fumes, filtration offers the lowest cost and most flexible approach. A three-stage filtration system, featuring powerful suction, forms the basis of an optimal system, with portability and off-bench location as bonus benefits.

Fume extraction systems may not be the most obvious item on the shopping list when switching to lead-free. But making sure it is will have a positive effect on employees, the environment and the company's bottom line.

*[1.] Danish Toxicology Centre - Environmental Project no. 778, 2003

*[2.] www.osha.gov search ‘occupational asthma’.