



## TECHNICALLY SPEAKING

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### Rework and Repair with Lead-Free Solder; the Technician's Perspective

Electronic devices already make up an estimated 70% of all hazardous waste being discarded. As the price of electronic devices decline even further, this waste amount will grow as it becomes more cost effective to replace a device rather than repair it. Companies are already considering disposal of a device after its effective lifetime in the product's design and construction. There are many factors that are currently driving the push to use lead-free solders in all electronic devices. The pending 2006 implementation of the WEEE and RoHS regulations in Europe, which are aimed at eliminating lead and other hazardous substances from landfills, are causing concern that de-facto trade barriers will be raised against domestic manufacturers exporting products to Europe. There is also concern over the possible enactment of similar regulations in the U.S. and the fear of becoming competitively disadvantaged for not being environmentally "green", as more and more products are marketed as "lead-free". As the electronics industry in the U.S. and abroad moves further in the elimination of lead from their products, the pressure will be on manufacturers to re-train technicians for hands-on rework and repair using new lead-free soldering materials. Technicians will have to re-think how they perform the basic operations of soldering, desoldering, and cleaning, and they will need to be re-trained in the use of new solder alloys, fluxes and cleaning products and procedures for lead-free applications. These new trends will impact the four basic parameters involved in rework: solder alloys, solder fluxes, soldering equipment and cleaning.

#### Solder Alloys

There are many candidate alloys currently being marketed as replacements for the common tin/lead eutectic. All have their advantages and disadvantages. Of all the possible candidates the Sn/Ag/Cu group of alloys seems to be the one on which the industry is now concentrating the most attention. Even though this group of solders properties of melting point, wetting ability and wetting spread seem to be the closest to standard tin/lead eutectic, there are still striking differences.

The most obvious difference is that this new solder group melts at higher temperatures than standard tin/lead solder. Tin/lead alloys melt at temperatures between 183 to 191 °C (361 to 374 °F), whereas the new Sn/Ag/Cu alloys melt at 217 to 227 °C (423 to 439 °F). Where the standard tin-lead solder, 63 Sn/37 Pb forms a eutectic (melting and solidifying at the same temperature of around 361 °F) many of the new lead-free alloys truly melt at temperatures that are many degrees higher than the temperature at which they solidify. The difference between the solidification temperature and the true liquid melting point creates a temperature range in which the physical state of the solder is "plastic" or "spongy". Technicians will have to be aware of this "plastic" temperature range on the solder they are working with and use equipment capable of quickly heating the solder through this range to its true melting point.



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Operating at higher melting temperatures will cause oxide films to form more rapidly and heavily on the metal surfaces being soldered. The new lead-free solders also tend not to “wet” or spread as evenly as the standard eutectic solder, and the heavier oxidation produced at the high soldering temperatures only increases this problem. The necessity at operating at higher temperatures has implications for the soldering flux being used, for the soldering equipment, and for any cleaning procedures used during PCB rework and repair.

## Soldering Equipment and Procedures

The “plastic” temperature range demonstrated by many lead-free solders necessitates soldering equipment with greater power, which can quickly raise the temperature of the solder through this range to the solder’s liquid state. For this reason existing equipment may have to be replaced with higher wattage soldering stations that have increased thermal recovery and can bring the soldering tip quickly to the solder’s liquid melting point. The higher melting points encountered when working with lead-free solders will mean operating the soldering iron at higher temperatures, usually 315.5 °C (600 °F) or greater. Higher soldering temperatures will lessen the life-time of standard soldering iron tips and equipment. The higher soldering temperatures required by the Sn/Ag/Cu solders also means more stress for heat-sensitive components, so new soldering techniques will have to be mastered to ensure that such components are not subjected to high temperatures for prolonged periods of time. Components will also have to be chosen in the design phase that can withstand the higher temperatures needed for soldering with these lead-free alloys.

During the transition period, as a manufacturer converts from the use of leaded solders to all lead-free soldering, there will be the risk of contaminating lead-free solder joints with trace amounts of lead and copper when both leaded and lead-free of solder alloys are being used on the same board. Such contamination must be prevented as even a small amount of lead or copper contaminating a lead-free solder joint can result in the formation of inter-metallic compounds that can weaken the solder joint. The best way to prevent such contamination is to segregate all lead-free solder use from leaded solder use. Repair technicians should be trained to use only the type of solder used during initial board manufacture, and not default to the solder that is the easiest to use. Even as little as 1% contamination with lead has been found to reduce the fatigue cycle reliability of a lead-free solder joint by as much as 50%. Even the process of soldering can cause copper to be picked up from the board surface, causing the formation of a copper inter-metallic compound that can weaken the solder joint. So much copper can be picked up that the composition of the solder alloy actually changes to the extent that the “new” alloy may now violate an existing patent if it is used to form solder joints. This is another reason for taking all steps necessary to reduce or eliminate metal contamination during soldering.



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### Solder Flux

The solder flux to be used with lead-free solders must be able to remove the heavier oxidation film created by the higher temperatures being employed. It must be able to withstand these higher temperatures without “charring” or decomposition, and it should be removed by the same cleaning methods used to remove the conventional fluxes in use today. To remove the heavier oxidation these new fluxes must have higher activation than those used with tin/lead solder, but they do not necessarily need to be RMA or RA type flux, which require post-soldering removal to avoid long term corrosion problems and later board failures. Charring of the flux needs to be avoided as the residues of burned flux can be extremely difficult to remove from the board. Even if charring is not a consideration, new fluxes must be removed by solvent flux removers or detergents cleaners used in on-line or batch aqueous cleaning systems. No-Clean fluxes, especially formulated for use with lead-free solder alloys, should be tested for corrosive residues to certify they will not cause future corrosion / shorting problems. Just as with conventional No-Clean flux, the new No-Clean flux formulations designed for use with lead-free solders will have to be removed from the board if conformal coating of the board is performed.

### Cleaning

The thermal stability of the soldering flux being used, its resistance to charring and the overall strength of the flux in terms of activation, are all factors that relate to the ease with which flux residues can be removed from the board after rework or repair operations have been performed. Some new fluxes that have been designed to compensate for the poor wetting and decreased spreading of the new lead-free alloys are more strongly activated than the conventional fluxes used with leaded solders. This more robust activation can make the residues from these fluxes harder to remove, even when the necessity for removing them may be greater. Under prolonged exposure to high heat these same fluxes may char or degrade and leave behind decomposition residues that are even harder to remove than any “non-burned” residues. These situations mean that it will take longer to clean the board, that cleaner concentrations will have to be increased over the amounts currently in use, and that different and more aggressive cleaning methods may have to be applied. Any new flux that is considered for use must be tested with the available cleaning method to insure that no removal problems will arise during board repair and rework.

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