EVERYTHING IN BALANCE
Solder bath management as an ongoing process for high-quality electronics manufacturing

THE INTERACTION OF MATERIALS AND SOLDERING EQUIPMENT, APPLICABLE LAWS AND ECONOMIC ASPECTS MAKE EFFECTIVE SOLDER BATH MANAGEMENT INDISPENSABLE IN ORDER FOR THE ALLOY SYSTEM TO REMAIN IN BALANCE. SOLDER BATH MANAGEMENT IS AN ONGOING PROCESS THAT NEVER ENDS BUT CAN HELP TO STAY ON THE SAFE SIDE IN TERMS OF QUALITY.

During each soldering process the metallisation of printed circuit boards and components dissolves to varying degrees in the solder bath. The amount of dissolved metals and thus the degree of contamination depends on the selected soldering temperature, contact time, solder pot size, the tools and alloys used. Lead-free alloys are more aggressive than lead-containing alloys due to the higher tin content, so that the associated dissolution effect is higher than with other metals. As a result, they contribute to a faster altering of the solder bath composition.

This interactions as well as applicable laws like ROHS and economic aspects make effective solder bath management indispensable in order for the alloy to remain in a proper condition to achieve good and stable wetting results. Is it equilibrium? Not really, but it implies that intervention limits should neither be exceeded nor fallen short of. This is the only way to ensure that the potential for soldering defects based on the alloy composition remain as low as possible, the properties of the solders do not change and consistent soldering quality can be maintained. The final result is a perfect first pass yield and low defect rates in your manufacturing process.

SAMPLING ACCORDING TO CLEAR RULES
The first step seems to be easy, just take samples of your solder bath on a regular base. This step has its pitfalls. If
mistakes are made, the validity of analytical results is highly compromised. Never mind how good the method of analysis is, it cannot make up for this. Usually, a clean sample dipper is used to take samples. The same applies as for any other tool: there must be a strict separation between lead-free and lead-containing production lines. That is why it is recommended to use two sample dippers instead of one.

When a defined operating time and homogeneous mixing of the solder has been reached after about two to three hours of operation time, a sample is taken from the middle of the solder wave or solder bath and poured in one step into a cold mould. Together with the corresponding information (machine type, alloy, date of sampling), these samples can be sent directly to the in-house laboratory of Stannol in Velbert, Germany. The laboratory assigns an analysis number to each sample which is then analysed by an appropriately prepared modern high-end optical emission spectrometer and its composition determined. In general, the customers receive the results of the analysis via email within 24 to 72 hours after the laboratory received the sample.

DEViations REQUIRE TAKING MEASURES
Stannol analysis certificates contain customer information, solder bath composition and the recommended alloy-specific intervention limits. Analysis results that deviate from the recommended limits are highlighted in colour. A value highlighted in red demands attention of the process engineer. In other words, action is required! Since intervention limits are not standardised, it is up to the responsible process engineer to take the required action.

No standard provides information on which contaminants a solder bath may contain. Only the American Joint Industry Standard 001F has developed guidelines in this regard. Over time, printed circuit boards, components and, in rare cases, eroded tools can change the composition of a solder, that action must be taken. When problems occur, copper, silver, gold, nickel and in part lead are usually the main culprits. Accordingly, these elements require special attention. Changes in the concentrations of these and other metals can often have consequences for a stable wave solder process.

USING LEAD-FREE SOFT SOLDERs
A challenge in the use of lead-free alloys is the regulation of the copper content. At levels from above 0.85% the changes.
risk of creating bridges is getting higher. Higher copper concentrations lead to brittle compounds and will increase in the liquidus of the solder. Usage of low-copper or re-fill solders can compensate the copper leaching in which the solder bath is enriched. Keeping the copper concentration below this recommended limit, it will help to reduce bridging. In rare cases, but especially at low process temperatures in cold zones of the solder bath, acicular intermetallic compounds (Cu₆Sn₅), which are not easily soluble, can be formed. Manual skimming or complete drainage is often the only way to remove them. The RoHS directive does not allow, among other things, a lead content of more than 0.1%. In most cases, components are the source of contaminants. But the inadvertent incorrect filling of the solder bath is another frequent cause. If the manufacturing process must comply with the RoHS directives, an exchange or dilution must take place immediately.

**INSPECTING TOOLS FOR DAMAGE**

Silver is rather undesirable in tin-copper alloys, impurities lead to duller surfaces. Nickel is often part of the composition in micro-alloyed solders. It acts as a grain refining element, which minimises copper leaching. Values above 0.1%Ni become critical, as they may lead to wetting problems. Rising gold concentrations (above 0.1%) make the solder pasty and reduce the shiny surface. Higher concentrations lead to brittleness. A critical element, however, is iron. It can contaminate the solder bath over a long period without being noticed. Erosion of pumps, risers, pats of the wave construction and other tools which are mounted underneath the solder bath surface can occur and erosion of these parts often remains undetected. Dissolved constituents distribute in a very inhomogeneous way. Even in properly taken samples, iron tends to segregate. This makes detection and quantitative determination difficult. Concentrations from about 0.03 percent result in brittle solder joints and a granular appearance.

Some metals, like titanium and chromium are used sometimes for tools and parts of the solder processes. This complicates a proper analysis, as these elements are not generally included in the analytical portfolio of solder manufacturer laboratories. That is the main reason why it is recommended to regularly inspect tools for damage and replace them if beginning erosion can be detected. Zinc, cadmium and aluminium have a great affinity for oxygen. This means, that these elements even at very low levels can oxidize and these oxides will accumulate on the surface and create a lot of unspecific soldering defects. Concentrations higher than 0.005% can already cause soldering defects. Arsenic causes dewetting, a replacement of the alloy is recommended when concentrations exceed 0.05%.

Like lead, high bismuth contents can be the responsible part of the solder to create a dull surface. Although bismuth provides, among other things, better thermal resistance, combinations with increased lead contamination should be avoided, as this may cause solder meniscus lift-off. Antimony increases the tensile strength of soft solders, concentrations higher than 0.5 percent may have adverse effects on the wetting of surfaces.

The monitoring of a solder bath requires a high degree of attention, as it is very difficult to make a general statement regarding necessary analysis intervals. Customer service offers complimentary solder bath analyses and further assistance about recommended for corrective actions.