BY DON BRINKMAN • MOLEX

Designing for ROHS: Select the right lead-free-connector design for heat-sensitive applications

THE REMOVAL OF LEAD-BASED ALLOYS, WHICH MANUFACTURERS COMMONLY USE FOR SOLDER AND PLATING, HAS BEEN A MAIN AREA OF CONCERN FOR ENGINEERS DESIGNING ROHS-COMPLIANT ELECTRONICS. LEARN HOW LEAD-FREE ALTERNATIVES AND THEIR ASSOCIATED INCREASE IN REFLOW TEMPERATURES AFFECT CONNECTOR RELIABILITY AND PERFORMANCE.

The ROHS (restriction-of-hazardous-substances) directive, which the EU (European Union) enacted in 2006, aims to prevent environmental damage by restricting the use of lead, mercury, cadmium, hexavalent chromium, PBB (polybrominated biphenyl), and PBDE (polybrominated diphenyl ether). It places greater responsibility on the electronics and manufacturing industries to monitor and regulate the use of these potentially hazardous substances, often components in plastics, base-metal alloys, and the plating and solder processes for electronic-component design.

However, displacement of hazardous substances and compounds, such as those materials ROHS outlines, can affect not only cost and manufacturing time, but also system reliability and performance. As a result, design engineers must be more involved with the manufacturing process to determine the outcome of their end product upon removal of these hazardous materials.

Lead-free alternatives most commonly increase solder-reflow temperatures, heighten MSLs (moisture-sensitivity levels), and reduce elasticity, leading to increases in overall system cost. When selecting lead-free ROHS-compliant components, consider the effect of these changes on various manufacturing processes, such as plated-through-hole and surface-mount technologies.

Lead-free solder commonly requires higher liquidous temperatures—typically, 30 to 35°C more heat than lead-based solder (**Figure 1**). This temperature increase puts some heat-sensitive components at risk during the various soldering processes and can damage components that are not heat-resistant. Therefore, designers should account for all heat-sensitive parts and consult with their manufacturers to identify the necessary assembly-process requirements for lead-free components.

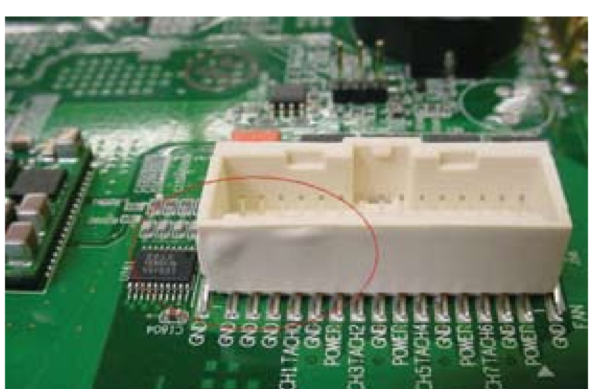

Figure 1 A plastic connector housing blistered after exposure to lead-free soldering temperatures that typically need 30 to 35°C more heat than lead-based solder.

Additional heat can also increase the MSL of the component. Moisture trapped inside the connector can expand and damage the low-profile connectors that slim networking and electronic devices employ. Both solder-temperature levels and the length of time a part is exposed to that temperature can influence a material's MSL. Because the reflow process typically exposes ROHS-compliant materials to more heat compared with leaded materials, they are at greater risk for damage, such as fracturing, joint stress, and delamination due to increased moisture sensitivity.

To prevent any unnecessary absorption of moisture, design engineers must ensure careful handling and packaging of their parts before soldering. Investigating board and part qualifications with the manufacturer before building a product aids in determining which manufacturing conditions are most appropriate for preventing moisture expansion. Some options to consider include baking components before assembly to remove any moisture and packaging the components in humidity-resistant bags.

Further, lead-free solders are more rigid and less elastic than those incorporating lead, making them more susceptible to breakage in harsh environments, when under stress, or when exposed to other post-soldering assembly processes, such as hand-soldering or final assembly. As a result, engineers must determine whether to modify a design before incorporating lead-free parts. To efficiently account for these factors when designing for ROHS compliance, designers must revisit the manufacturing process behind each product to better qualify which design is most appropriate.

Lead-free plated-through-hole designs use a wave-soldering process to assemble parts to the PCB (printed-circuit board). The technique is primarily for applications in which PCB-space savings is not important. Though the plated-through-hole-mounting style prevents some of the design obstacles associated with the transition to lead-free manufacturing, it does not eliminate all heat-related risks; components can still see exposure to elevated top- and bottom-side preheat temperatures. Studies suggest that wave soldering poses a greater risk of delamination than does oven soldering. *Delamination* refers to the separation of layers within the metal or PCB, causing its internal properties to change. It can be attributable to the repeated stress a PCB goes through as it is exposed to heat, and it affects the reliability of the final product.

Unlike the plated-through-hole process, you create SMT (surface-mount-technology) attachments by treating the board and its components in a reflow soldering oven. As smaller devices and miniaturization become more popular, SMT methods have gained acceptance as a replacement for the through-hole process.

SMT, although suitable for compact designs in cell phones, laptops, and other consumer electronics, increases lead-free components' susceptibility to problems that derive from excess heat. In this process, you screen-print the PCB with solder paste before placing the components on top. Next, the PCB goes through the solder reflow oven, which preheats the PCB and component leads, activates the flux within the solder paste, and reflows the solder paste to create the solder joint between the component leads and the PCB pads. Lead-free SMT parts typically use a tin-, silver-, and copper-solder mixture with a reflow temperature about 34°C greater than lead-based solder. To account for this additional heat, designs that use this mounting method call for high-temperature-resistant plastics, which are generally more expensive than their non-heat-resistant counterparts.

In some niche applications, the solder paste you use for SMT components requires a lower reflow temperature than does the current tin-lead process. In these cases, which use tin-bismuth solder, the liquidous temperature drops to 138°C—well below the 183°C reflow temperature of the tin-lead process—requiring no change in plastic material.

Consult the manufacturer or assembly house at the beginning of the design process to ensure that you are using the correct parts and assembly processes for the design engineer's application and budget requirements.

Unlike SMT components, parts that don't experience any thermal processes need not include high-temperature plastics to survive the manufacturing process. You typically fit compliant-pin, or press-fit, components after all heating steps are complete and lock them into place using friction. Other products in this category include wire-mounted parts, such as crimp terminals, crimp housings, and IDT (insulation-displacement-technology) connectors. These types of temporary mechanical attachments require no solder and rarely encounter heat.

Ideal for high-end-PCB design, these mounting methods help designers avoid problems associated with leadless solder and parts, such as moisture absorption and part malfunction. With an increasing number of initiatives driving the development of "green" design in the electronics industry, accounting for environmental regulations has become a necessary step in the design process.

For heat-sensitive, lead-free components, the displacement of hazardous substances and compounds significantly affects cost and manufacturing, as well as overall system reliability and electronic-component performance. Working closely with manufacturers at the beginning of the design process will help alleviate costs and time. Additionally, studying the methods used to assemble newly ROHS-compliant parts can help you avoid costly adjustments that may not always be necessary.EDN

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Don Brinkman is manager of engineering information at Molex, where he manages a cross-functional product-development-support group that focuses on engineering systems and processes. He has worked there since 1984 and has participated in the development of nine patents. He received a bachelor's degree in mechanical engineering from the University of Cincinnati (Ohio).