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The Cost of Compliance: A Case Study

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Three Oregon electronics companies collaborate to develop RoHS-compliant products.

Being first to produce environmentally-friendly electronics products that meet challenging standards for European RoHS compliance is the mission of Portland, Oregon's Electronic Controls Design, Inc. (ECD), Sunstone Circuits and MEC Northwest. The trio -- a circuit board manufacturer, an instrumentation tools manufacturer and a contract assembly manufacturer -– are working feverishly to beat the competition before the July '06 European compliance date. Their collaboration utilizes the knowledge, experience and expertise of companies in different fields and will have a major impact on the electronics industry because it makes RoHS compliant products available before the required RoHS date and provides RoHS compliant thermal profiling tools that can be used by other companies to make their own RoHS compliant products.

This story shows how partners can work together to create RoHS compliant circuit boards or other electronic products and the great value in sharing information and understanding of what the other side sees and how to jointly solve problems. This collaboration provides information that the companies can share with their customers to help them resolve issues they may encounter in moving to lead-free circuit boards and creating RoHS compliant products.

We will describe the collaboration, what each of the three companies encountered in creating RoHS compliant products and provide tips on what they learned and advice they have for any company trying to meet RoHS compliance.

The Collaboration between ECD, MEC Northwest and Sunstone Circuits

The three Portland companies are applying their combined knowledge to create RoHS compliant products well in advance of the required July 06 RoHS European compliance date requiring removal of various chemicals, such as lead, from electronic products sold in Europe to make them more environmentally friendly. The three companies were originally all divisions of ECD and were later spun off into separate companies.

Big companies who develop electronics and telecommunications products are making great strides in terms of creating lead-free circuit boards but most small companies have not made much progress in this area. The three companies are taking the high-road in the RoHS area and hope to be the first in producing lead-free/RoHS compliant circuit boards and other electronic products for the electronics and test measurement instrumentation industry.

The Workflow

RoHS compliant products will be manufactured, assembled, tested and sold by the three companies. In the first step in the collaboration process, ECD evaluated all the components and processes used to make a thermal profiler and a RoHS compliant circuit board and made the required component changes to meet the RoHS directive. Next, Sunstone Circuits built the RoHS compliant bare circuit board. MEC Northwest took Sunstone's RoHS compliant bare board and assembled a RoHS compliant circuit board using the ECD components list, a newly developed lead-free solder alloy paste and its upgraded assembly line that includes ECD's thermal profiling tools. ECD will be the OEM that markets and sells the RoHS compliant profiler developed by the three companies.

Developing RoHS Compliant Products at ECD

ECD was instrumental in the development of the RoHS compliant circuit board produced by the three companies. The first step for ECD was in modifying the design of the ECD thermal profiling product to make it RoHS compliant. ECD had to look at every component and assess its level of compliance to the RoHS directive and get documentation from each

manufacturer to prove the compliance. If not compliant, the component had to be modified to make it compliant. In October 2005, ECD released the new SuperM.O.L.E. Gold and Xpert-Ready SuperM.O.L.E.® Gold thermal profiling tools—the first thermal profiler tools that are RoHS compliant.

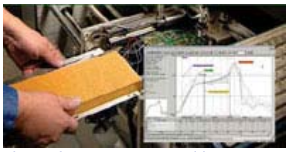


Photo of SuperM.O.L.E. Gold.

ECD also determined the requirements for all RoHS compliant components that would be used in the circuit board and altered the assembly drawings to specify RoHS compliant processes. ECD generated a new Bill-of-Materials specifying for MEC Northwest the parts that were RoHS compliant and should be used to build a RoHS-compliant product. ECD conducted tests on test boards to determine what oven recipe will work best to produce its lead-free/RoHS compliant products since boards with different thermal properties require different recipes. Once the optimal recipe has been determined, the three companies started developing a lead-free solder circuit board product for sale.

ECD made major changes to produce the RoHS compliant products. ECD segregated all non-RoHS compliant parts and developed a dedicated process for RoHS complaint products on the manufacturing floor. Converting to RoHS compliant products will ripple through ECD's entire product line. ECD will convert all of their products over time to meet RoHS compliance. The main cost for ECD was the engineering and testing time required to develop the RoHS compliant products as well as indirect costs relating to changes in internal processes and training.

Developing RoHS Compliant Products at Sunstone Circuit

Sunstone Circuits manufactures bare circuit boards to drawings, print or data files specified by their customers. They then ship the unpopulated boards to manufacturing assembly firms, such as MEC Northwest, who assemble the circuit boards. In preparation for creating a RoHS compliant circuit board, Sunstone Circuits conducted surveys to determine what finishes (tin, gold, silver) would be acceptable, when customers planned to start using RoHS compliant circuit boards, the percentage of RoHS compliant boards customers would need for Europe, and the percentage of leaded boards that customers planned to use. In addition, Sunstone talked to the suppliers to find out the kind of finishes being offered and their perspective of each option. Sunstone also talked to MEC Northwest and ECD about how coating decisions made by Sunstone Circuits would affect product assembly, product testing and sales opportunities.

Sunstone Circuits is starting the conversion to RoHS compliant circuit boards and other products now so that they can conduct adequate research, shape the product and work out any other issues. This will let the company understand from both a technical and a costing standpoint exactly what needs to occur. It will also allow them to pass on the information learned to their customers.

Most of Sunstone's current "leaded" circuit boards have a tin-lead coating that can be applied in either a reflow or a hot air-level process. Sunstone Circuits had to develop a completely different process for manufacturing the base circuit boards that will become lead-free/RoHS compliant.

Sunstone Circuits began by using a different material for the board itself because the board must withstand higher glass-transition temperatures. Circuit boards are typically coated with a coating such as tin-lead, tin or gold for boards that use leaded solder. To create circuit boards that can become "lead-free" and RoHS compliant, the company had to phase out the use of lead as a coating for this product and also change the board substrate material.

There was very little information available on where to start in developing a coating for the board. Sunstone Circuits tried various substances and then did tests at MEC Northwest to determine the solderability (whether the lead-free solder alloy paste would work on the base board and could be soldered with adequate results.) Sunstone learned it was a matter of finding the right process—whether to use substances such as silver or tin. Testing found that silver was best.

Sunstone Circuits developed a silver process where they coat the board with a thin 5-10 micron coating of silver over the bare cooper. The silver protects the copper, since uncoated copper will oxidize, and provides a non-lead base for a RoHS complaint product. Sunstone had to develop a new production line to handle the silver process.

After extensive research, it was determined the material needed for the board substrate. With the leaded version of a circuit board, the soldering temperatures can be lower. Moving to lead-free boards requires soldering at higher temperatures. This forces companies to go to a different material for the circuit board. Of these three laminate properties; Tg (Glass transition temperature), Td (time to delamination) and C.T.E (Coefficient of


Photo of board being dipped.

thermal expansion), Td and C.T.E become more important than Tg because of the higher temperatures used in assembly. Sunstone Circuits selected a material with higher Td and lower C.T.E, meaning their circuit board material is more stable at higher temperatures.

It found there were a number of direct and indirect costs associated with developing a base lead-free/RoHS complaint circuit board. These costs include the material itself and opening a new product line as well as indirect costs such as keeping an inventory of different types of materials, modifying the company web site, and changes in work order and handling practices. At this stage of the project, Sunstone does not expect that it will have a major influence on cost structure. Sunstone Circuits hopes to minimize the cost of developing lead-free/RoHS compliant circuit boards. Currently, they plan to offer customers a choice of leaded and lead-free/RoHS complaint circuit boards without having to increase the price.

Developing RoHS Compliant Products at MEC Northwest

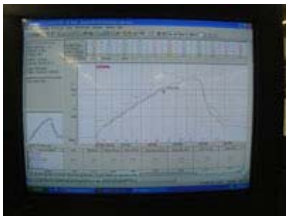
MEC Northwest is a contract manufacturing facility that assembles circuit boards and other products according to customer specifications. Its Screaming Circuits division offers a 24 hour product turnaround. Pooling the knowledge of Sunstone Circuits, MEC Northwest, and ECD is a big benefit and will pay off for the three companies as well as their customers. This collaboration is a great partnership for all companies and they see it as just the beginning of future collaboration in this developing area.

MEC Northwest assembles the RoHS compliant circuit boards. MEC takes the circuit board supplied by Sunstone Circuits and applies a unique solder alloy paste designed specifically for the lead-free process to the board stencil. This alloy paste is a different alloy mix than the SAC305 solder paste typically used to create circuit boards soldered with lead. The board is inspected for obvious defects. If the board passes, it is moved to a pick and place machine where components are placed on the board based on the Bill-of-Materials created by ECD listing all the RoHS compliant components that should be used on the board. Each part has a unique part number assigned to it. When a product is programmed to run on the SMT equipment, the part is assigned and the machine will then pick the correct part.


Photo of the board in the pick and place machine.

The final step is placing the board in the oven where the solder paste is melted to form a metallic bond between the component and the circuit board pad. The lead-free process requires higher temperatures, so the reflow solder machine needed to be changed to the increased temperatures needed to correctly melt the solder and form proper solder bonds to the parts and board pads.

The oven utilizes ECD's newly developed thermal profiling tools and software. Because the lead-free process requires higher temperatures closer to the material limits, the process window for reflowing good quality lead-free solder has decreased—this makes thermal profiling even more important.



The ECD thermal profiler tools provide proof that the critical time and temperature phases of the soldering process (the thermal profile) were met during the reflow soldering process. Tests include the initial ramp in temperature, time above the melting temperature, determining if the required maximum temperature was reached, that the cooling rate was not too fast to damage the components and testing to verify that all the critical components progressed through the thermal profile within the specified range of acceptability.

Multiple tests were performed on the RoHS compliant circuit boards starting with testing done at Sunstone Circuits to evaluate the bare board. MEC Northwest conducted testing right after soldering looking for manufacturing defects. ECD performed extensive thermal stress testing on the test boards to see if the lead-free components will cause early failure, tests for condensation and to discover any issues with new parts from vendors used in the boards.

Major changes were required by MEC Northwest to produce RoHS compliant products. Direct costs include the cost of a new solder alloy, RoHS complaint parts, and the investment in new assembly equipment including new ovens, wave solder and associated auxiliary equipment. Assembling the lead-free circuits will be more expensive. The material itself is more expensive and there will be a higher hourly cost compared to the old process.

MEC Northwest will also change its Part Numbering system so that unique part numbers can be assigned to all lead-free and RoHS complaint part numbers. There are a number of indirect costs relating to process changes and training staff. If MEC Northwest is not able to use all the parts and solder containing lead in the production process, they will face a cost of disposing of obsolete materials.

How RoHS Compliant Products Will Impact Sales

ECD, MEC Northwest and Sunstone Circuits are developing RoHS compliant electronics products as quickly as possible. The three companies see expanded sales for their RoHS compliant circuit boards, thermal profilers and other electronic products. Sunstone Circuits expects having RoHS compliant products may increase sales to companies who export to Europe and Asia. The companies believe that being “first to market” with RoHS compliant products will give them a both a technical and sales advantage and allow them to take a leadership role in developing RoHS compliant products.

ECD plans to phase out all non-compliant products, MEC and Sunstone will continue to offer non-RoHS compliant products, such as circuit boards using lead solder, because companies who don’t sell into Europe may continue to use the “standard” non-RoHS complaint products.

Lessons Learned

- Work with your customers and suppliers to determine the solder paste alloy, laminate and coating that will work best for them.
- If using a reflow solder oven or wave solder machines, be aware that older reflow ovens and wave solder machines may not be able to withstand the additional heat required for lead-free solder and may not be compatible with the different chemistry of the same alloys. This can cause extensive corrosion when using the lead-free process. Companies should either purchase a new WAVE machine or at least replace the solder pot AND perform testing to determine if corrosion will occur.
- Don't mix leaded and lead-free parts in the lead-free process; run the parts on two separate product lines.
- Install a parts tracking system that can track lead-free parts before starting to receive and work with lead-free parts.
- An additional cost is changing all of your engineering and quality documentation systems for these part number changes.
- Lead-free solder requires higher temperatures and has a tighter temperature profile range, so thermal profiling becomes even more important.
- Lead-free solder looks different than leaded solder after it has been soldered, training will be required to help staff evaluate lead-free solder defects.
- There are direct cost increases associated with creating a RoHS compliant board and indirect costs such as training costs, keeping an inventory of different kinds of materials, changes in web sites, as well as work order and handling practices.
- If parts that contain lead cannot be used, then they must be disposed and/or recycled.
- Separating non-RoHS compliant processes from compliant processes is not simple. Consider things such as soldering irons, solder wick, tinning pots, rolls of solder and other common materials around the manufacturing floor. Soldering irons and solder containing lead cannot be used on RoHS compliant products and must be kept separate.
- If any rework is needed after the reflow solder process, make sure the tools and processes used in rework are RoHS compliant.
- In contacting the manufacturer for the parts, check to see if they are RoHS compliant and not just lead-free complianct—be aware that lead-free may not mean RoHS compliance because there are other substances banned by the RoHS directive.

The RoHS directive will require environmentally friendly electronic products developed by July 2006. The three Oregon companies are taking a leadership role in developing RoHS compliant products well in advance of this requirement. This mission will benefit the three companies, the electronics industry and reduce the impact of dangerous chemicals on our environment.