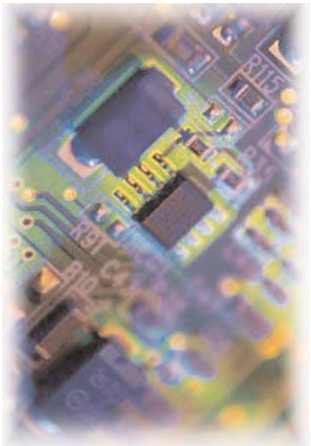
Proven Vapor Phase Reflow Accommodates Higher Temperatures of Lead Free Solders

Taking lead out of manufacturing processes as well as from the final product has become a worldwide initiative for the semiconductor industry. One evidence of this drive, fostered by market, political, and environmental forces, has been the development of lead free printed circuit boards (PCB). Solder alloys containing tin, silver, and copper are replacing traditional lead-based solders. Vapor phase reflow, a popular electronic assembly method used in PCB manufacturing, deftly accommodates the higher melt temperatures required for the use of these lead free solders.

Lead based solders such as Sn63/PB37, many in use for over 60 years, melt at 183ºC, with a typical reflow temperature of 200-205ºC. Industry practice has established a safety margin of 30ºC to reduce potential for defects caused by excessive heat. Lead free solders with a eutectic temperature of 217ºC require a minimum peak reflow temperature of 230ºC. The same 30ºC safety margin brings the maximum reflow temperature to 260ºC.

Soldering temperatures as well as heat issues in general are ongoing concerns of PCB assemblers. Board assembly has become more complicated due to increased component density and size diversity. Assemblers must ensure that their process is compatible with the thermal tolerance of components made with various materials and as boards become more complex in design. Since smaller components heat up faster and reach a higher temperature than larger, denser components, boards containing a mixture of sizes and densities offer a heat differential challenge. More homogeneous assemblies designed for consumer products such as cell phones are more readily adapted to lead free soldering. On the other hand, larger assemblies bearing more complex geometries prevalent in the automotive and large-scale communications applications will demand more attention.



PCB assembly methods are typically infrared (IR), convection, or vapor phase reflow. Unlike soldering methods, which rely on ovens for heating, vapor phase reflow delivers consistent heating across the board. According to Dave Suihkonen, president of R & D Technical Services, Inc. "vapor phase brings several advantages to the lead free process. One of the most significant benefits is the ability to limit the absolute maximum temperature. Because the reflow temperature is tied to the boiling point of the vapor phase fluid, it is impossible to exceed this temperature in the reflow process. With the higher melting points of most lead free solders, this becomes an important issue. For example, the use of a 230ºC or 240ºC fluid will not exceed the assembly's temperature limit. This is not the case for more traditional reflow systems such as convection or IR where excessive heat may be required to perform proper reflow."

GALDEN®

"vapor phase brings several advantages to the lead free process..."

Another advantage to vapor phase", Suihkonen adds, "is the way it transfers heat to the product. Convection and IR rely on air movement or radiation to transfer heat to the product. These heat transfer methods can cause deflection, shadowing and reflection of the heat, which in turn, can cause uneven heating of the product such as hot or cold spots. These issues only become more problematic as mass differentials and package densities increase. Vapor phase, on the other hand, uses a condensation method of heat transfer. This condensation method uses a saturated vapor to transfer heat. Saturated vapor is much more uniform and able to transfer its heat to all surfaces of the product evenly regardless of mass or geometry. Saturated vapor insures that all surfaces of the product, including shadowed or densely populated areas, are heated in a uniform fashion."

The elevated reflow temperature of lead free solders can be a challenge for most vapor fluids that have a typical operating temperature range of 155-230ºC. Only one fluorinated fluid, Galden® PFPE from Solvay Solexis, offers the widest service temperature range to process lead free solders up to 260ºC.

Perfluorinated fluids used in vapor phase reflow are non-corrosive, nonflammable, non-toxic and leave no residue after evaporation. In addition, the vapor phase reflow process transfers heat faster than infrared and convection oven heating.

"Because the fluorinated fluid can't be overheated and the condensation of the vapor delivers uniform heat transfer, the guess work is taken out of the PCB assembly process", cites Doug Kelly, Sales Manager for Galden PFPE fluids. However, he cautions, assemblers need to choose carefully among the PFPE fluids on the market. Not all brands deliver a high enough boiling temperature required for lead free solders.

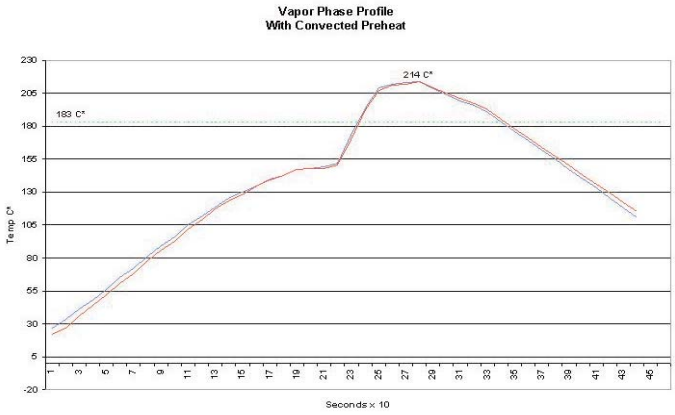
Recognizing that lead replacement initiatives are in their future, trade associations and other interested groups sponsored programs to study the implications of lead based solder for their industries. Among their concerns was the thermal stability of components and equipment when exposed to the solder's higher melting temperatures. In some instances processing heat exceeds the component manufacturers' current specifications. Redesign and validation by the manufacturers and requalification by the assemblers are likely outcomes of lead based solder replacement.

One of the programs undertaken to identify and test potential replacements for lead based solders was formed by the National Electronic Manufacturing Initiative (NEMI, Herndon, VA). The NEMI project focused on the efficacy of the solder joint. It compared lead based to lead free solder joints based on the performance of tests and analyses. It found that lead free solders yielded joints of equivalent or superior quality to the tin-lead benchmark.

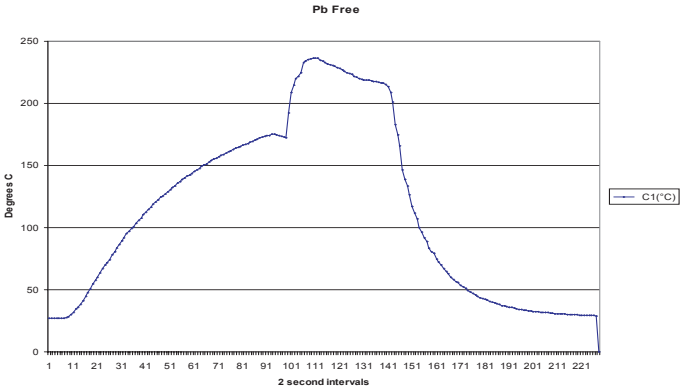
Another research project focusing on alternatives to tin-lead solders was initiated by the Jet Propulsion Laboratory (JPL) on behalf of NASA Electronic Parts and Packaging (NEPP). Vapor phase reflow equipment was employed to produce the lead free solder joints using a Galden grade with a 240ºC boiling point. JPL chose the vapor phase reflow method to deliver uniform heating and consistent soldering outcomes. The project sponsors found that there were no opens after reflow for the lead free joints, a satisfactory conclusion.

Despite any process adjustments board assemblers will have to make to switch to lead free solders, there's no looking back. The environmental community has expressed its concerns over lead usage for decades, leading to its elimination from paint, household goods and other items. Most recently, attention has been given to discarded computer equipment, all containing printed circuit boards, whose lead content could contaminate landfill and water supplies. Recycling processes, given today's technology, could also result in land and water contamination. In Europe impending legislation affecting the electronic industry mandates lead solder replacement by 2008. The Japanese government has been compliant since 2003. In Japan strong consumer demand for "green" products adds impetus to the changeover to lead free content.

Already lead free solders are making inroads in major U.S. industries. Some of the applications include military, aerospace, automotive, telecommunications and consumer products. Most cell phone manufacturers have changed over to lead free solder. Consumer product suppliers are promoting the "green" qualities as a way to differentiate their offerings. While PCB assemblers will be required to test and qualify replacement solders, they can rely on a familiar soldering method, available vapor phase equipment and proven perfluorinated fluids to meet lead free mandates.



Above: Eutectic solder reflow profile using Vapor Phase with integrated convection preheat and 215ºC fluid.



Above: Pb free solder reflow profile using Vapor Phase with integrated IR preheat and 240ºC fluid.

[1]Sohn, John E., Ph.D., Circuits Assembly, June 2002

[2]Bonner, J.K. "Kirk", del Castillo, L. and Mehta, A., "Hi-Rel Lead-free Printed Wiring Assemblies, www.seas.ucla.edu/ethinfilm/Pb-freeWorkshop/abs/bonner.html

Solvay Solexis, Inc.
Tel: 800-323-2874
Fax: 856-853-6405
www.solvaysolexis.com

Solvay Solexis

SOLVAY