

Reflow Soldering of SMD Products To Printed Wiring Boards (PWBs) Using Lead-Free Solder Nov. 2004

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- Considerations
 - PWB
 - Stencil
 - Type of Solder
 - Reflow soldering profile
 - Tests and results

- Many different Printed Wiring Board materials are offered on the market today
- We did not test them all. However, our tests and a review of the available literature indicates that most standard, available PWB materials are compatible with the requirements associated with Pb-Free soldering.
- We evaluated Polyimide and FR4 PWB materials
 - Both are acceptable
 - We used FR4 for our final evaluations

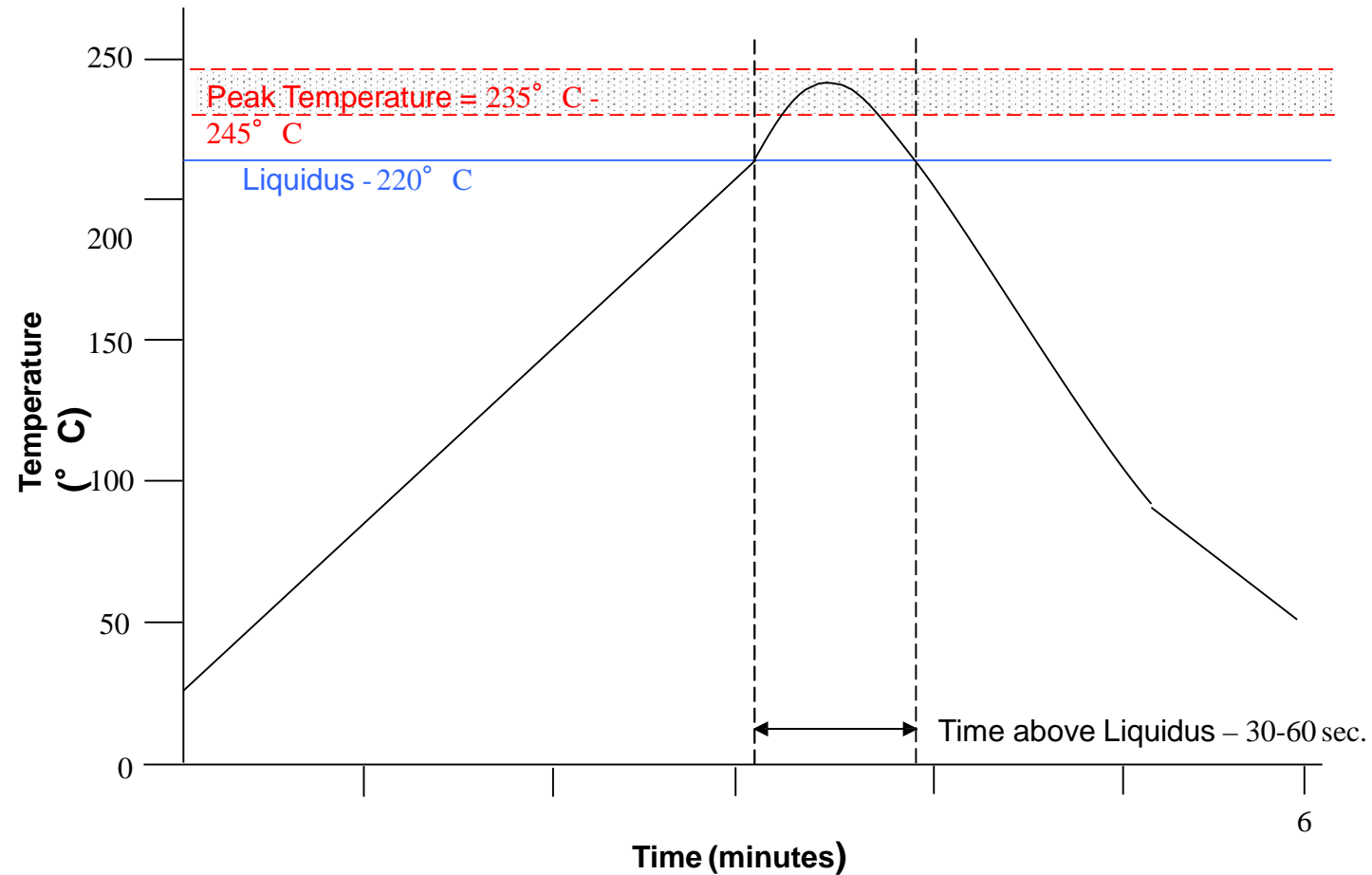
- Standard PWB finishes, such as solder plating, gold plating, tin plating, Hot Air Solder Leveling (HASL), OSP, and ENIG have a direct impact on Pb-Free solder joint quality.
 - Visual appearance of reflow solder joints made with Pb-Free solders is not a good indicator of quality
 - Tin plating can contribute to tin whisker formation
 - Pb-Free solder plating is not available at present (mixed joints have been determined to be unreliable.)
 - Percentage of voids in the solder joint is considered to be a better indicator of solder joint quality
 - Gold plating on PWB's contributes to voids in the solder joints
- We chose to use Pb-Free HASL for PWB finish since significantly fewer voids resulted with its use compared to the others.

- We found that the latitude one normally has with regard to stencil openings with Lead-bearing solders doesn't exist with Pb-Free solders.
- Pb-Free solders don't flow as readily as Pb-Bearing solders, making the sizes of the openings in the stencil critical.
- We determined that we needed the openings in the stencil to be the same size as the PWB solder pads in order to get acceptable pad coverage.

Types of Pb-Free Solder

- Pb-Free solders are known as “SAC” solders since their main components are tin (Sn), silver (Ag) and copper (Cu) – SnAgCu
- Many SAC solders have been evaluated by the industry – the ones with the most widely reported best results have:
 - Composition range = 95.1-96.5%Sn/3-4%Ag/0.5-0.9%Cu
 - Liquidus (melting point) = 220°C
 - Solidus (freezing point) = 217°C
 - Approximate metal content = 84%
- These solders are available from numerous sources
- We evaluated several different solder compositions

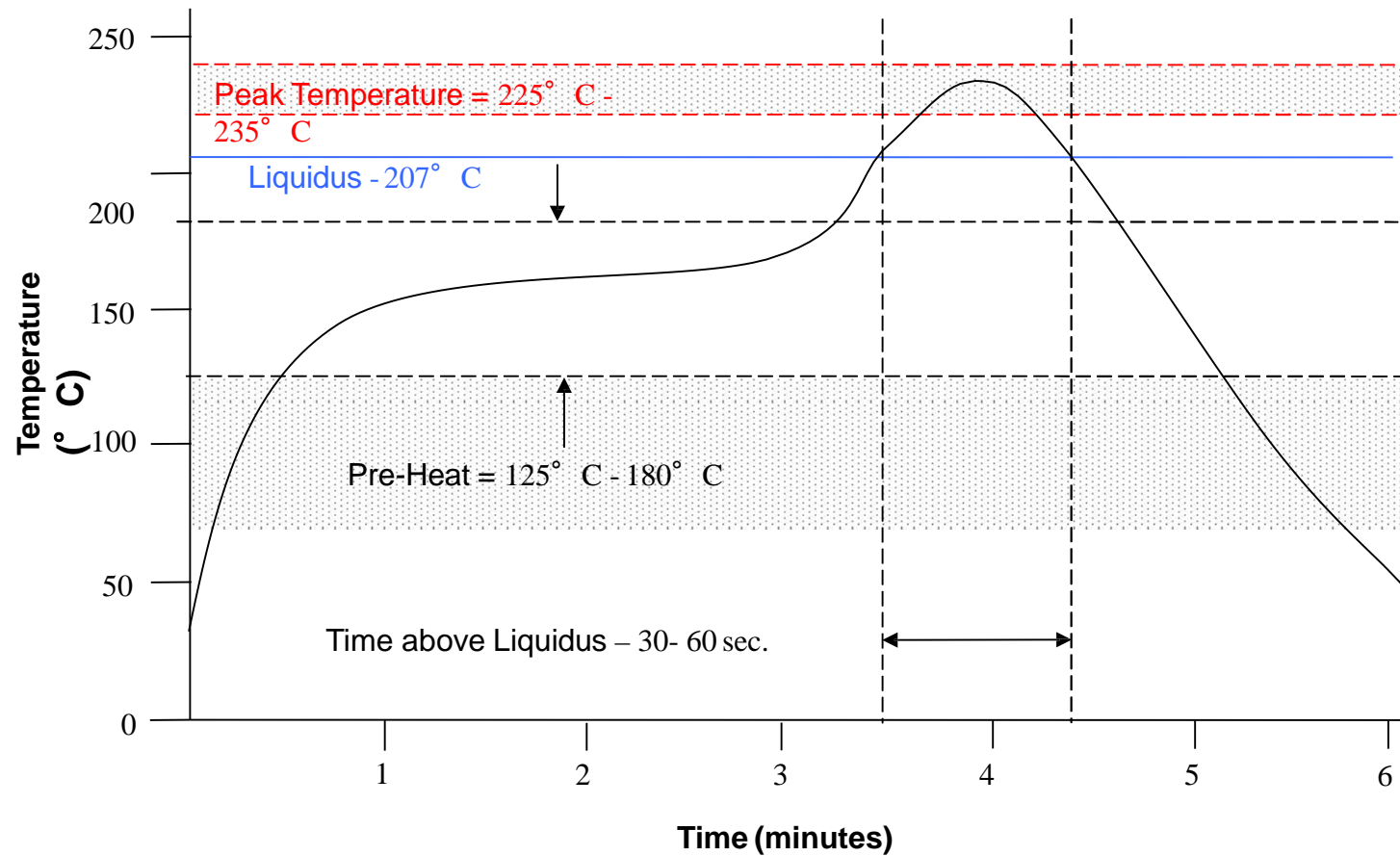
Typical SAC Solder Reflow Profile



Maximum allowable Temp =
260° C

- We got our best results using “Enhanced” SAC solder
 - Approximate composition = 88.5%Sn/4%Ag/0.5%Cu/7%In
 - Liquidus (melting point) = 207°C
 - Solidus (freezing point) = 201°C
 - Approximate metal content = 89%
- Reflow profile is the same as SN63 (Sn-Pb) reflow profile.
- No changes required to base components, PWB material or reflow equipment
- Does not require N2 process environment

Enhanced SAC Solder Reflow Profile



- All evaluations were done with solder pastes containing “No- Clean” or water soluble fluxes
- Acceptable electrical testing results have been obtained without cleaning devices assembled with Pb-Free solder paste containing “No-Clean” flux.
 - The visible residue does not effect electrical performance
 - We decided to clean the visible residue off of the assembly
- With many fluxes, cleaning after assembly is recommended for “Long Term Reliability” reasons
 - Poorly cleaned PWBs may exhibit:
 - Shorts/Signal Loss
 - Degradation of performance over time
 - Pb-Free Solder paste manufacturers will provide recommendations for cleaning residue from PWB assemblies.

- Soldering heat resistance
 - Rework profile simulation cycle with peak temperature of 260°C
 - Customers required 1-3 cycles
 - Testing was done for 1, 5 and 10 cycles
 - **Results:** No degradation in device performance.
- Solderability
 - Wetting balance test method per J-STD-002B (Test Method F) with solder bath temperature of 263°C and a 2% no-clean flux
 - **Results:** Excellent wetting of device terminals with average wetting time < 2.5 sec and average wetting force of .20 mN/mm.
- Metallization dissolution resistance
 - Per J-STD-002B (Test Method D)
 - **Results:** Excellent resistance to pad dissolution.

- Solder joint reliability
 - Devices soldered to PWB (surface finish of Pb-Free HASL) and then temperature cycled at -55°C to +125°C for 1000 cycles per IPC-9701 (Test Condition 4)
 - HASL was done by a subcontractor using Nihon Superior Co., Ltd. SN100C solder (99.3Sn/0.7Cu + trace Ni)
 - Testing done using both “standard” SAC and “Enhanced” SAC produced the same results.
 - **Results:**
 - No degradation of device performance
 - No visible cracks in solder joints
 - Voiding met the requirements of IPC-A-610C

- Good test results using “Standard” and “Enhanced” SAC solders to assemble our products to FR4 PWBs with Pb-Free HASL pad finish
 - Electrical performance to specifications
 - Passed all customer required physical/environmental tests
- We will use “Enhanced” SAC solders for our assembly work
 - Same reflow profile and equipment as needed for SN63 solders
 - No need to have separate production lines for SAC and Sn/Pb solders
- We will use Pb-Free HASL PWB finish for our assemblies
 - Acceptable percentage of voiding in solder joints
 - No tin whisker issues