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

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Assembly of SMD Products To PWBs Using Pb-Free Solder

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

Printed Wiring Board Materials

- *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*

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Printed Wiring Board Finish

- *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.*

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Stencil Design

- *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*

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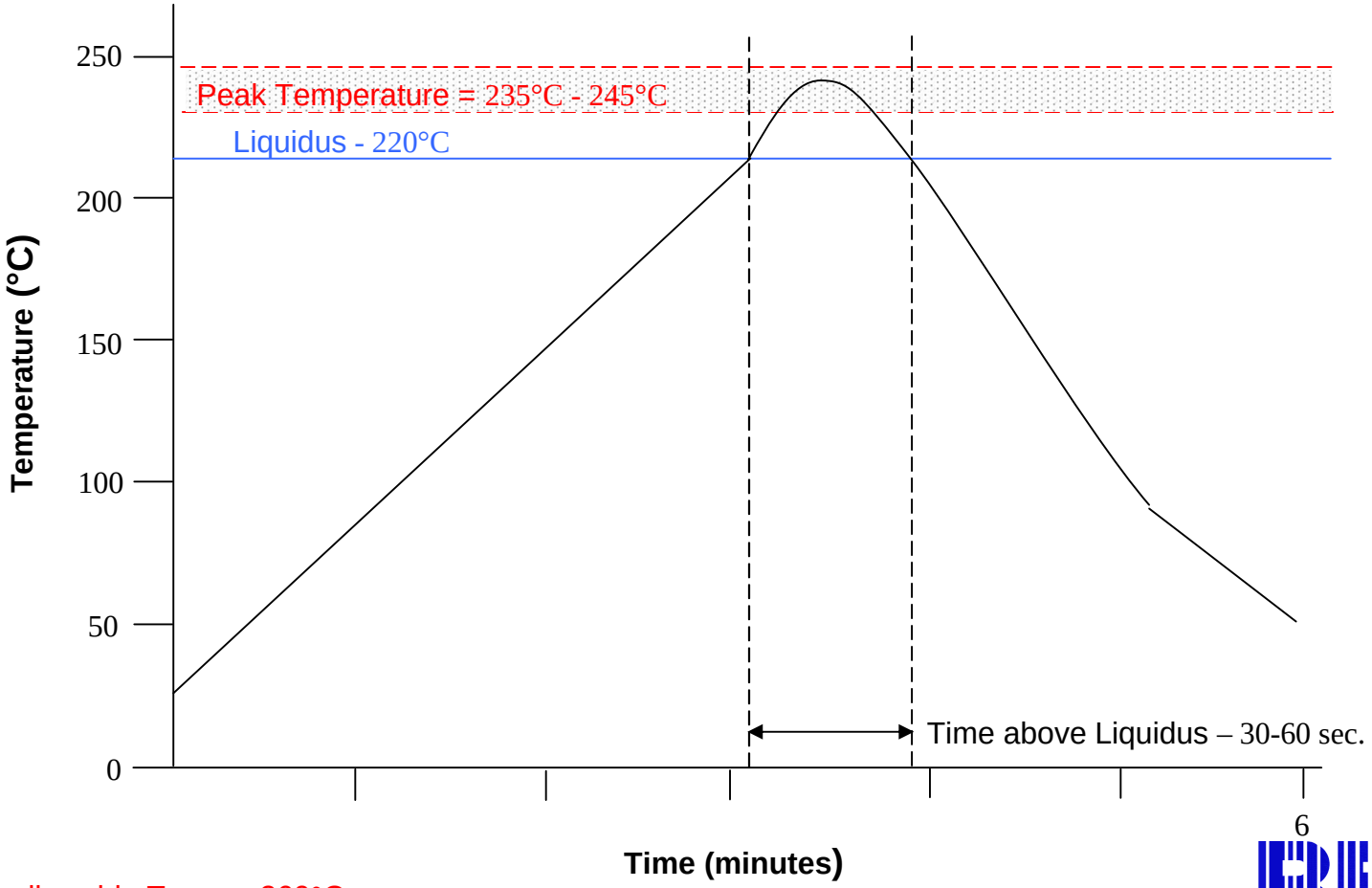
Typical SAC Solder Reflow Profile



Maximum allowable Temp = 260°C

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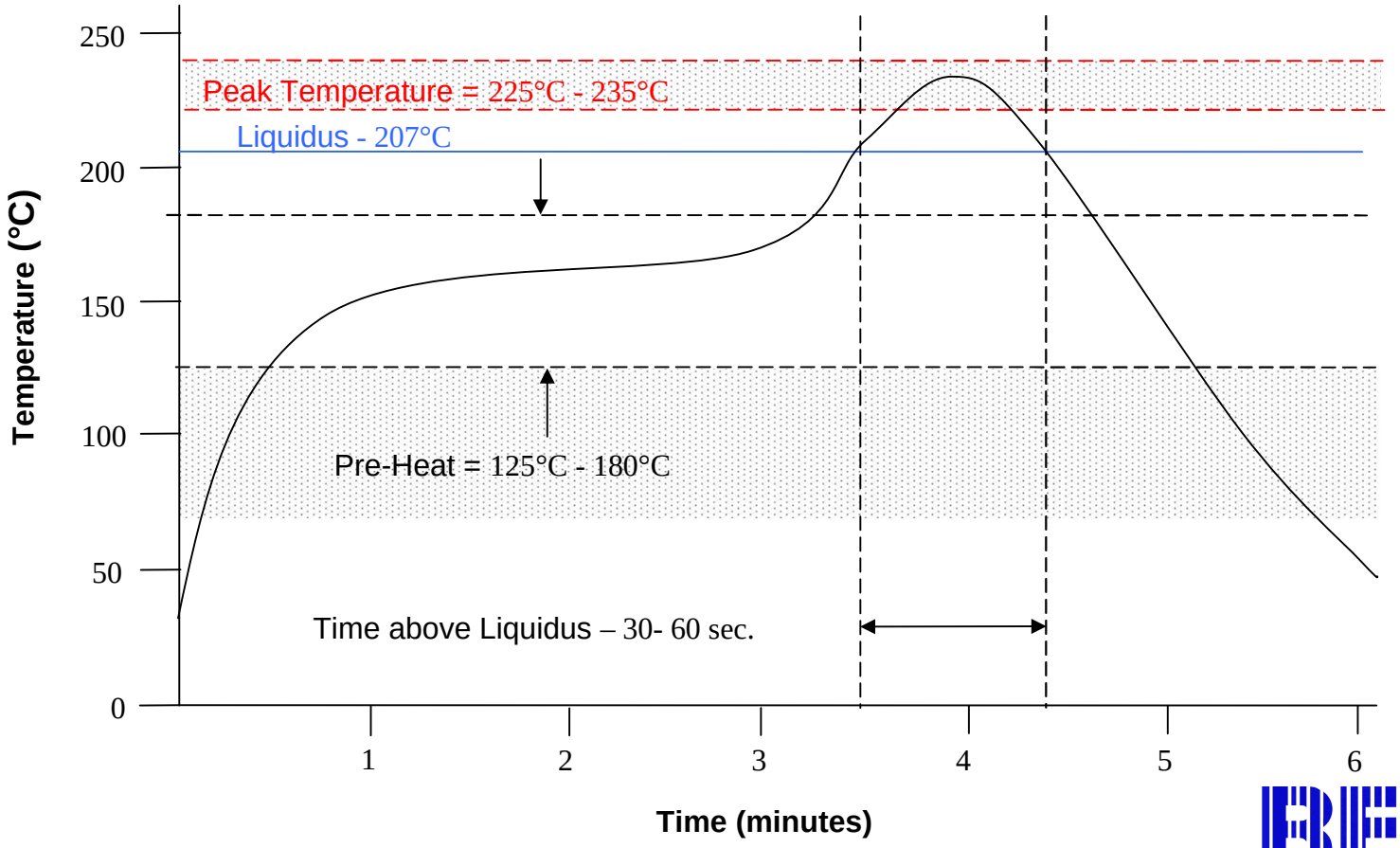
"Enhanced" SAC Solder

- *We got our best results using "Enhanced" SAC solder*
  - Approximate composition = 88.5%Sn/4%Ag/0.5%Cu/7%In
  - Liquidus (melting point) = 207^0C
  - Solidus (freezing point) = 201^0C
  - 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



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Fluxes and Cleaning

- *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.

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Customer Required Tests/Results

- *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.

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Additional Test Results

- *Solder joint reliability*
  - Devices soldered to PWB (surface finish of Pb-Free HASL) and then temperature cycled at -55^{0}C to +125^{0}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

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Summary

- 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