AN233

Solder Reflow Recommendation

Introduction

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The electronic manufacturing industry is moving towards lead-free, environmentally safe assembly processes. Factors that should be considered when switching to lead-free soldering materials include:

- Circuit board thickness
- Fabrication complexity
- Surface finish
- Assembly process compatibility

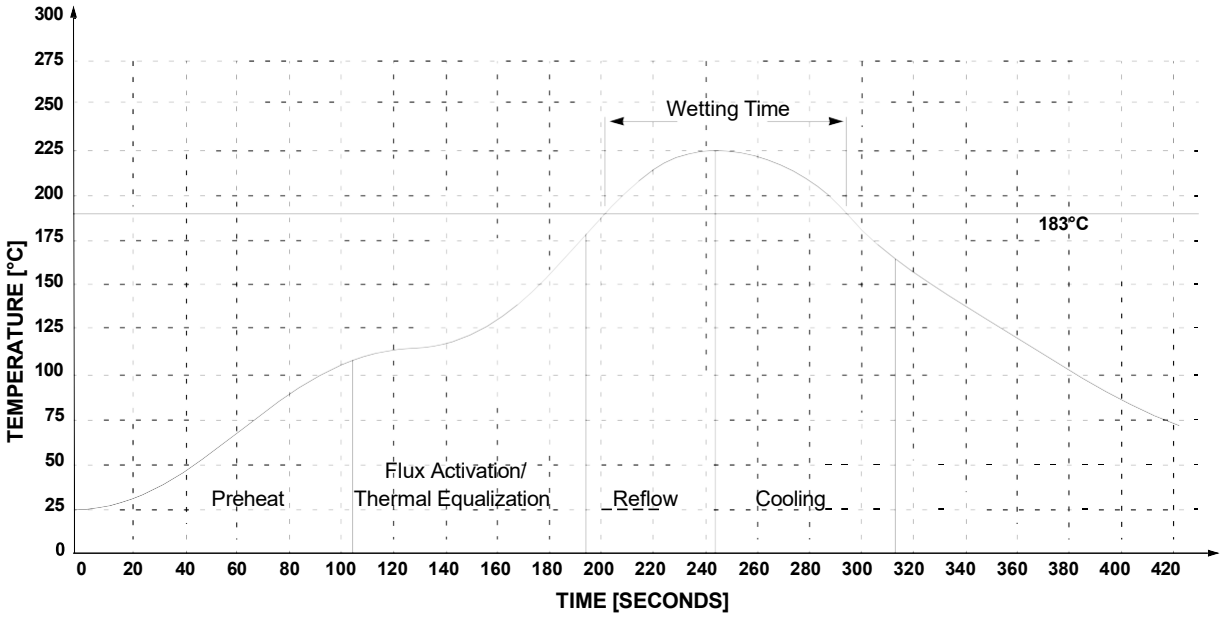
This application note focuses on solder reflow recommendations for packages with Matte Tin and Tin/Lead finishes.

1. Basics of the Reflow Process

Lead-free soldering techniques have been available for some years. However, they do not always meet the same physical criteria for attachments as alloys containing lead. In the past, the most common alloy for joining electronic components was the mixture of 63% tin and 37% lead. This composition of tin and lead provided excellent bonding strength as well as enough elasticity to withstand the thermal stresses in the product's operating environment. As electronic manufacturers move away from this longtime standard PbSn alloy toward Pb-free solder alloys such as tin-silver-copper (Sn-Ag-Cu), melting and eutectic temperatures also change, requiring modification to the solder reflow profile.

As a starting point for a review of the basics of the reflow process, a typical thermal reflow profile is shown in Figure 1-1. The process typically undergoes five distinct transitions, as seen in the diagram.

Figure 1-1. Sn/Pb Typical Reflow Profile



The five transition periods for the typical reflow process are:

1. **Preheat** – Brings the assembly from 25°C to 100-150°C and evaporates solvents from the solder paste.
2. **Flux Activation** – Dried solder paste is heated to a temperature in which the flux will react with the oxide and contaminants on the surfaces to be joined.
3. **Thermal Equalization** – Achieves temperature equalization approximately 25-50°C below the reflow temperature. Actual time and temperature will depend on the mass and materials used.
4. **Reflow** – In this stage, the assembly is brought to the temperature sufficient to produce reflow of the solder. Note the "wetting time" is shown as the time the solder is in a liquid state around 183°C on the curve.
5. **Cool Down** – This is the final stage in the process where gradual cooling should be used. Slower cool down produces a finer grain structure in the solder joint, which will yield a more fatigue-resistant solder joint.

Figure 1-2. JEDEC Reflow Profiles for Sn-Pb and Pb-Free Assemblies

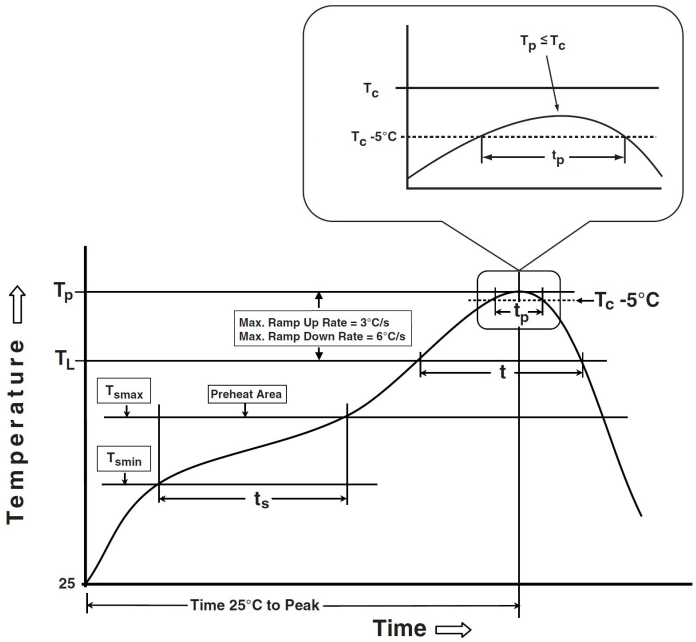


Table 1-1. JEDEC Classification Profiles

Profile Feature	Eutectic Assembly (SnPb)	Pb-Free Assembly (SAC Alloys)
Preheat Soak Temperature Min (Ts_{min})	100°C	150°C
Preheat Soak Temperature Max (Ts_{max})	150°C	200°C
Preheat Soak Time from Ts_{min} to Ts_{max} (ts)	60-120 seconds	60-120 seconds
Ramp-up Rate (T_L to T_P)	3°C /second max.	3°C /second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.
Liquidus Temperature (T_L)	183°C	217°C
Time Maintained above Liquidus Temperature (t_L)	60-150 seconds	60-150 seconds
Peak Package Body Temperature (T_P)	T_P shall not exceed T_C in Table 1-3	T_P shall not exceed T_C in Table 1-2
Time (t_P) Within 5°C of the Specified (T_C)	20 seconds	30 seconds
Ramp-down Rate (T_P to T_L)	6°C/second max.	6°C/second max.

Table 1-2. Pb-free (SAC Alloys) Process – Classification Temperatures (Tc)

Package Thickness	Volume < 350 mm^3	Volume 350–2000 mm^3	Volume > 2000 mm^3
< 1.6 mm	260°C	260°C	260°C
1.6 mm–2.5 mm	260°C	250°C	245°C
> 2.5 mm	250°C	245°C	245°C

Table 1-3. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume < 350 mm^3	Volume ≥ 350 mm^3
< 2.5 mm	235°C	220°C
≥ 2.5 mm	220°C	220°C

For reference, reflow conditions in Figure 1-2 and Table 1-1, Table 1-2, and Table 1-3 are based on IPC/JEDEC J-STD- 020F.

2. Solder Reflow Recommendations

Figure 2-1 (for reference only) shows the recommended profiles for Pb-free devices based on JEDEC Reflow Profile. These devices are plated with matte Tin (Pure Sn) and contain no lead. They can be used in standard tin-lead (SnPb) applications, using a profile that is equal to or above the lower line in the plot, or in Pb-free solder such as Tin-Silver-Copper (Sn-Ag-Cu) with profiles up to and including the upper line on the plot. The maximum peak package body temperature (Tp) depends on package thickness and volume. See Table 1-1 and Table 1-2 for the recommended reflow values.

Figure 2-2 (for reference only) shows the recommended profiles for standard devices with 63%/37% tin-lead (Sn-Pb) solder finish based on JEDEC Reflow Profile. The reflow profile for these devices can be anywhere between the upper and lower curves shown in Figure 2-2. Please note that the peak temperature is lower than that of the Pb-free devices. The maximum peak package body temperature (Tp) depends on package thickness and volume. See Table 1-1 and Table 1-3 for the recommended reflow values.

Figure 2-1. Reflow Profile Recommendation (Pb-Free)

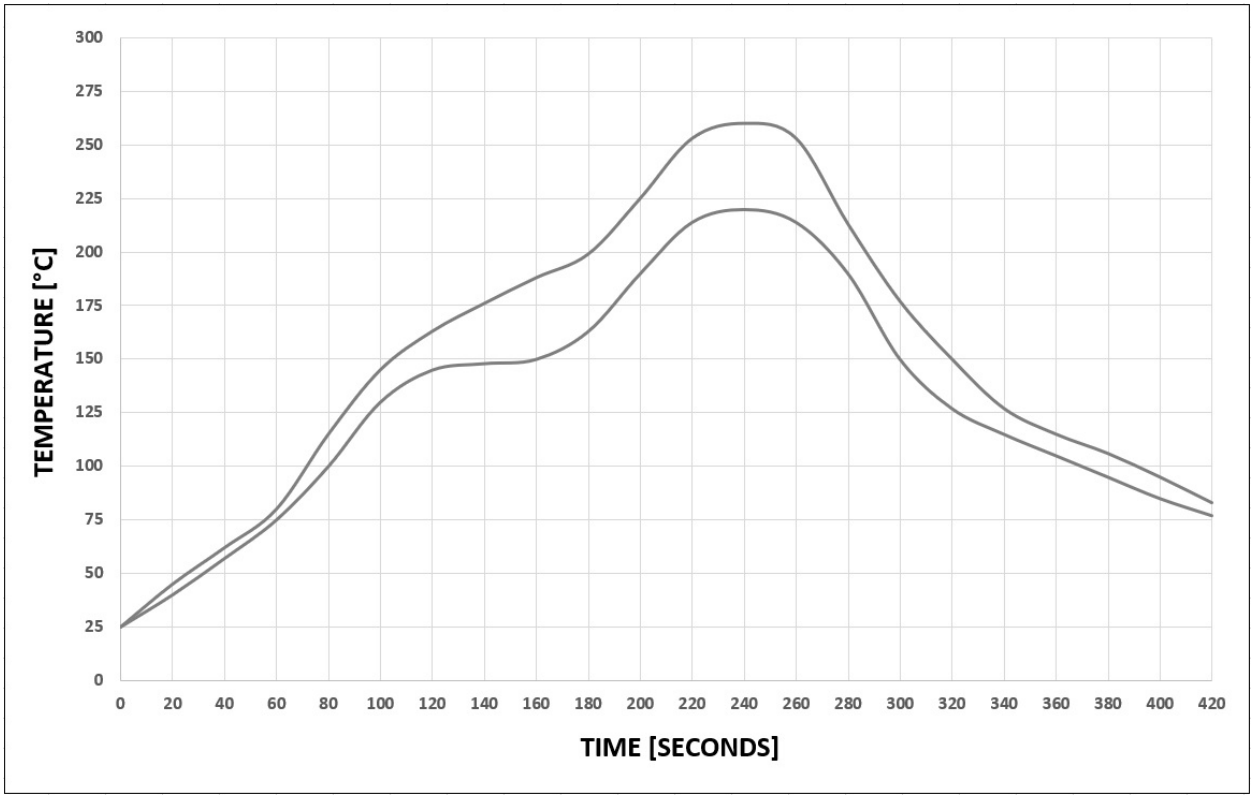
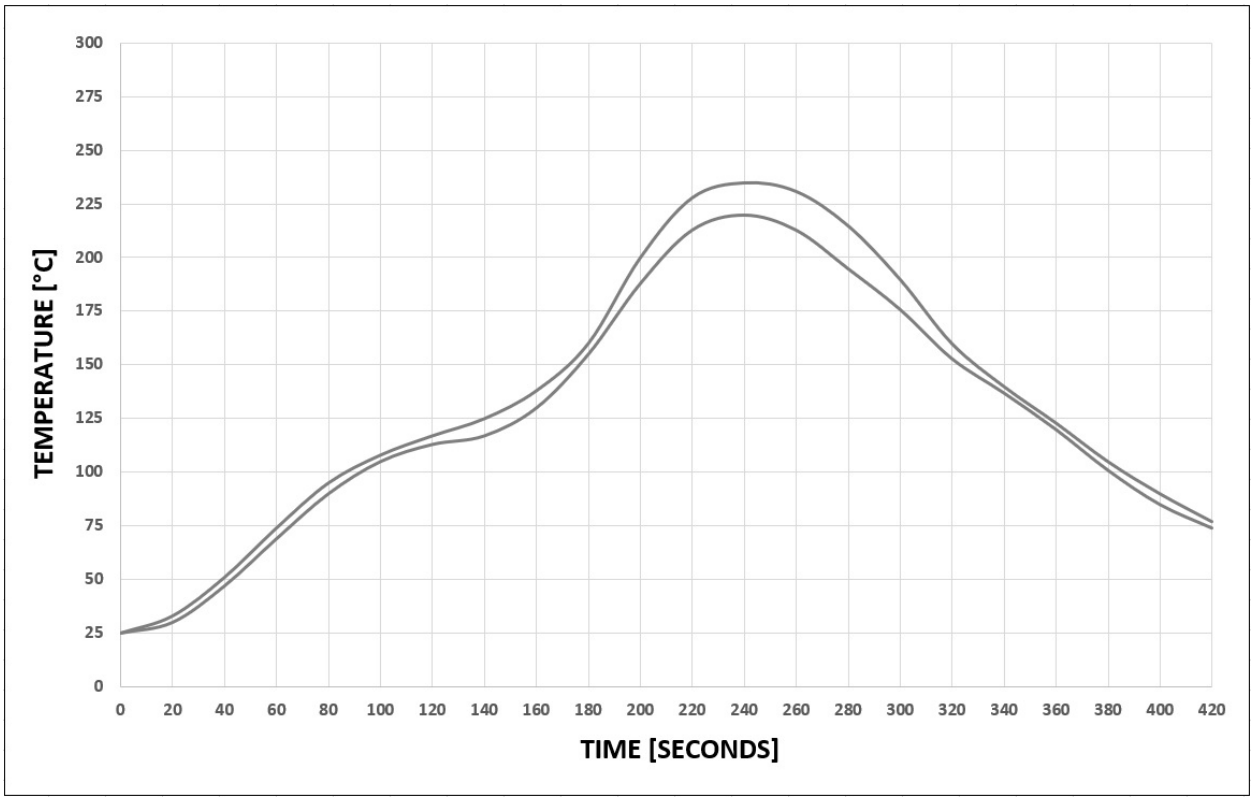


Figure 2-2. Reflow Profile Recommendation (Sn/Pb)



3. Conclusions

Many new lead-free alloy compositions are being released. When testing the alternative solder compositions the user must consider several issues:

- Is the material selected going to be compatible with the plating on the component leads or the finish specified on the circuit board?
- Will the material chosen compromise product performance, reliability or manufacturability?
- What is the residual effect of the higher temperature required for soldering lead-free alloys on the semiconductor packages, the passive components, and the board itself?

This application note addresses the use of Matte Tin andTin/Lead finishes, and recommends staying within the limits shown in Figure 2-1 and Figure 2-2. However, factors such as circuit board thickness, size, package type, and reflow equipment may affect the total profile time.

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ISBN: 978-1-6683-2872-9

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