Reflow Soldering

1. Introduction

The following application note is intended to describe the best methods for soldering sensors manufactured by Merit Sensor using automated equipment. All profiles should be evaluated and tested for the best performance.

More and more companies are moving away from the use of conventional tin-lead (Sn/Pb) solder in circuit board manufacturing because of concerns over the safety of lead and new regulations prohibiting its use, such as the Restriction on Hazardous Substances (RoHS) Directive in Europe. The RoHS Directive bans the European sale of new electrical and electronic equipment containing more than the specified levels of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants.

All pressure sensors from Merit Sensor are RoHS compliant and are mounted on ceramic substrates. The lead-free solder pads are plated with AgPt to ensure a good solder joint for most PCB connections.

Soldering of Merit Sensor parts can be done using either Pb-containing or Pb-free solder processes. This application note is intended to assist end users with soldering Merit Sensor parts using either Pb-free solder or Pb-containing solder.

In order to meet the RoHS directive, products should be soldered with Pb-free solder.

2. Soldering with Pb-free solder

Since Merit Sensor's pressure sensors are fabricated on ceramic, it is import to choose the Pb-free solder that is compatible with the solder pads. Merit Sensor suggests using solder alloys with SnAgCu that have a melting point of 217-221°C. Table 1 below shows the Pb-free solder alloys in the SnAgCu family.

Metal	Mix Ratio
Sn (tin)	95.5 – 96.5%
Ag (silver)	3.0 – 4.0%
Cu (copper)	0.5 – 0.7%

Table 1: Pb-free solder alloys of the SnAgCu family

Please note that the surface of Pb-free solder alloys can look substantially different when compared to Pb-containing solder (See Figure 1). A Pb-free solder joint will have a dull, or matte, finish, when compared to a Pb-containing solder joint because when Pb-free alloys start to cool, the surface of the solder joint will become rough. This is due to an increased volume contraction of the Pb-free alloys. The Pb-free solder joints are usually smaller than Pb-containing solder joints but should have no impact on the reliability since these characteristics are only cosmetic.

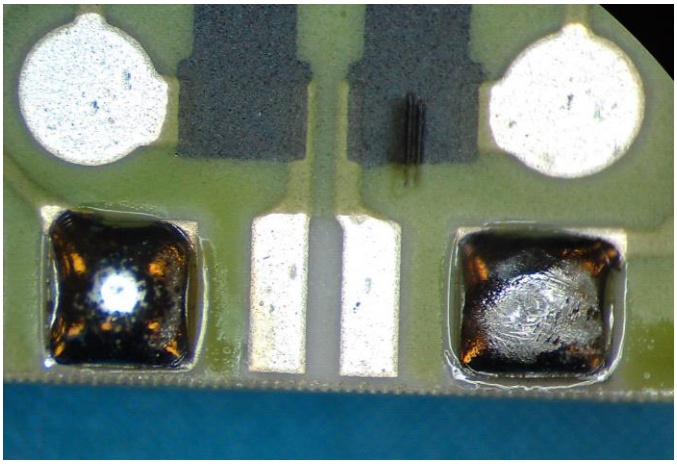

Figure 1: Examples of a Pb-containing solder joint (left) and a typical finished surface of a Pb-free solder joint (right)

A reflow soldering profile for Pb-free soldering requires a higher melting point when compared to Pb-containing solders. The process time for Pb-free solder is shorter than Pb-containing solder, so it is important that the temperature differences on the board be minimized. For this reason, Merit Sensor does not recommend IR Reflow systems for Pb-free soldering. To ensure a successful Pb-free reflow soldering, Merit Sensor recommends using forced convection reflow systems.

Merit Sensor's pressure sensors can be soldered with profiles based on the standard IPC/JEDEC J-STD-020C (January 2004). It is important to evaluate each process in order to find the best temperature profile. The best temperature profile will be defined by the board and the solder paste used. The suggested profile according to IPC/JEDEC J-STD-020C can be seen in Table 2 and Figure 2 below.

Profile Feature Pb-Free Assembly (IPC/JEDEC J-STD-020 Revision C)	**Package thickness ≥ 2.5 mm or Package volume ≥ 350 mm^3**	**Package thickness ≥ 2.5 mm or Package volume < 350 mm^3**
Average ramp-up rate (Tsmax to Tp)	3°C/second max.	
Preheat – temperature Min (Tsmin) – temperature Max (Tsmax) – time (min to max) (ts)	150°C 200°C 60-120 seconds	
Time maintained above – temperature (TL) – time (tL)	217°C 60-150 seconds	
Peak temperature (Tp)	245 +0/-5°C	250 +0/-5°C
Time within 5°C of actual peak temperature (tp)	20-40 seconds	
Ramp down rate	6°C/second max.	
Time 25°C to peak temperature	8 minutes max.	

Table 2: Pb-free classification reflow profile according to IPC/JEDEC J-STD-020C

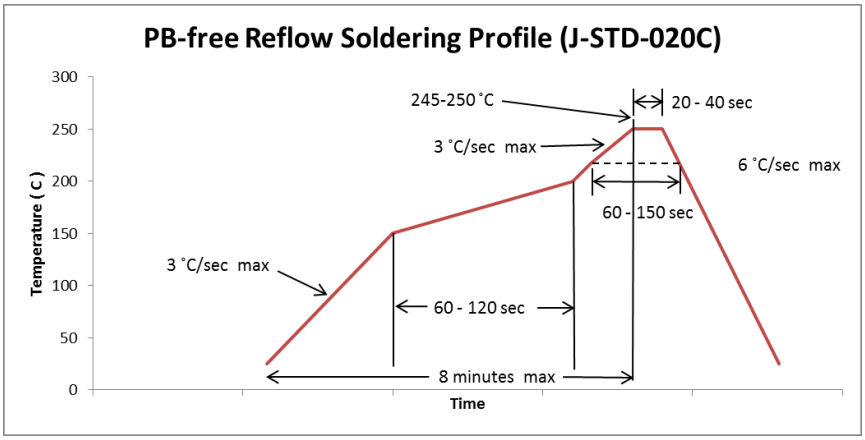

Figure 2: Pb-free Classification reflow profile according to IPC/JEDEC J-STD-020C

Use of nitrogen – Due to the increased temperature and oxidation of Pb-free solder, it may be necessary to work in nitrogen if air leads to unsatisfactory solder joints. Most Pb-free solder pastes however, can be used in air. Nitrogen may be used if the solder joints do not have sufficient wetting.

Hand soldering – Merit Sensor does not recommend hand soldering. Pb-free soldering requires an excess amount of energy compared to Pb-containing solder alloys. The heat transfer to the solder joint is very critical and should not be attempted with a soldering iron.

If a soldering iron is used, it is important to remember that Pb-free requires a fast heat transfer to achieve a successful solder joint. It may require a longer solder time and/or an increase in tip temperature to of 360-390°C. It is highly recommended to use solder stations of at least 80 watts of power. Pre-heating can be used to reduce the amount of heat imposed on surrounding components during hand soldering, as is done with reflow soldering.

3. Soldering pressure sensors with Pb-containing solder

If Pb-containing solder is used, then it is important not to exceed temperatures of 225°C for 30 seconds. Merit pressure sensors should be soldered with “no-clean” type solder paste which contains 62%Sn36%Pb2%Ag and has a melting point of 179°C. This solder paste contains 2%Ag and significantly reduces silver migration from the AgPt pad into the solder paste. We recommend that you do not use 63%Sn37%Pb solder paste. See Table 3 and Figure 3 for proper reflow profile for SnPb solder.

Profile Feature Sn-Pb Eutectic Soldering (IPC/JEDEC J-STD-020 Revision C)	Package thickness ≥ 2.5 mm or Package volume ≥ 350 mm^3	Package thickness ≥ 2.5 mm or Package volume < 350 mm^3
Average ramp-up rate (Tsmax to Tp)	3°C/second max.	
Preheat – temperature Min (Tsmin) – temperature Max (Tsmax) – time (min to max) (ts)	100°C 150°C 60-120 seconds	
Time maintained above – temperature (TL) – time (tL)	183°C 60-150 seconds	
Peak temperature (Tp)	225 +0/-5°C	
Time within 5°C of actual peak temperature (tp)	10-30 seconds	
Ramp down rate	6°C/second max.	
Time 25°C to peak temperature	6 minutes max.	

Table 3: SnPb classification reflow profile according to IPC/JEDEC J-STD-020C

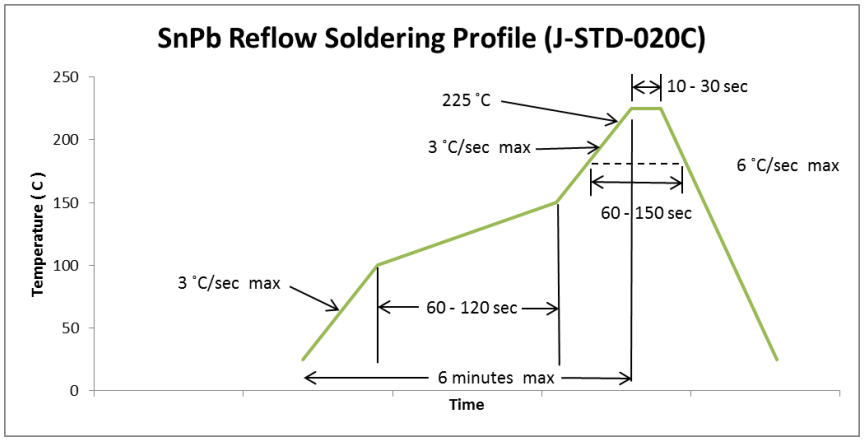

Figure 3: SnPb Classification reflow profile according to IPC/JEDEC J-STD-020C

If the reflow process if followed accurately, then the solder joint should cover the entire solder pad of the ceramic PCB (See Figure 4 - left). Soldering by hand, in most cases, will result in overheating of the device due to the high thermal conductivity of the ceramic. Too low of a temperature will result in incomplete soldering, resulting in a weak connection to the PCB as can be seen in Figure 4 (middle & right). The middle solder joint is an example of a sufficient solder. However, that solder failed to wet out and cover the entire pad. The joint on the right was exposed to insufficient solder and low heat, resulting in both poor pad coverage and a weak joint as the solder balled up. It is recommended to attach a thermocouple to the sensor to optimize the solder profile and make sure none of the maximum temperatures are exceeded.

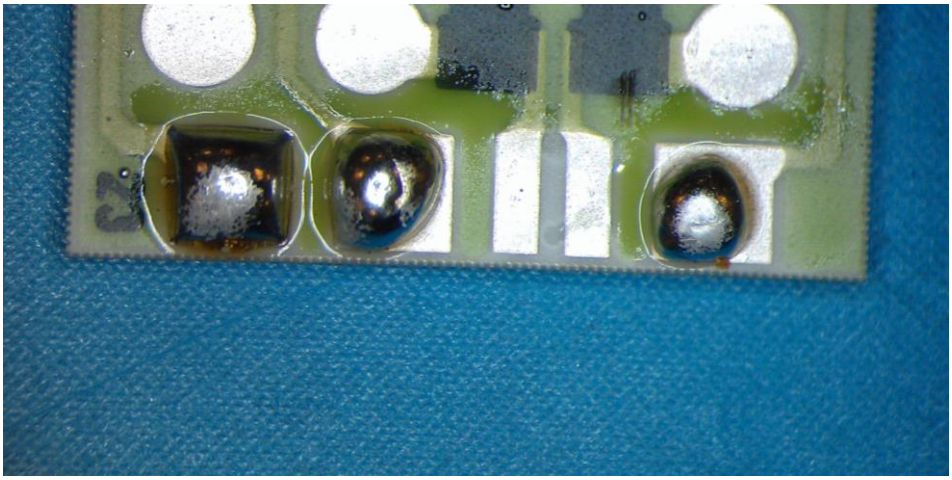

Figure 4: Example of good solder joint (left) and bad solder joints (middle & right).

4. Stress normalization delay for calibration

For best results prior to calibration, Merit Sensor recommends that any surface mount pressure sensor be allowed to rest at room temperature for least 48 hours prior to calibration. The stress caused by reflow soldering will usually normalize within this period and help improve the calibration of the product.

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