Solder Bath Composition

Introduction

Solder bath elemental composition is important and should be maintained within recommended specifications. This helps to optimize wetting, reduce drossing, and to ensure high quality solder joint formation.

It is normal and expected for working solder baths to drift out of specification as they are used. The key elements within the solder alloy can become oxidized or form high melting mixtures and segregate as part of the solder dross. Various contaminate elements are introduced from printed circuit board assemblies (PCBAs). As solder bath elemental composition drifts farther away from nominal, the performance of the solder bath suffers.

It is recommended to regularly analyze the solder alloy composition. This is accompanied by making corrections to the solder bath. The frequency of analysis and correction depends upon how the solder bath is used, and how quickly it drifts out of specification.

Solder Analysis

Regular analysis and adjustment of working solder baths is important to maintain elemental composition and performance. Some fluxes can overcome and enhance solder baths which are performing less-than-optimally. Ideal performance is achieved by a solder bath within elemental specifications, coupled with fluxes tuned for the process and product being built.

The frequency of analysis and correction depends upon how the solder bath is used, and how quickly it drifts out of specification. IPC J-STD-001J states:

> Solder used… **shall be** analyzed, replaced or replenished at a frequency to ensure compliance with the limits specified in Table 3-1. If contamination exceeds the limits, intervals between the analyses, replacement or replenishment **shall be** shortened. The frequency of analysis should be determined based on historical data or monthly analyses. Records containing the results of all analyses and solder bath usage… **shall be** maintained for a minimum of one year for each process/system.

An excerpt from J-STD-001J Table 3-1 is in the Solder impurities section below.

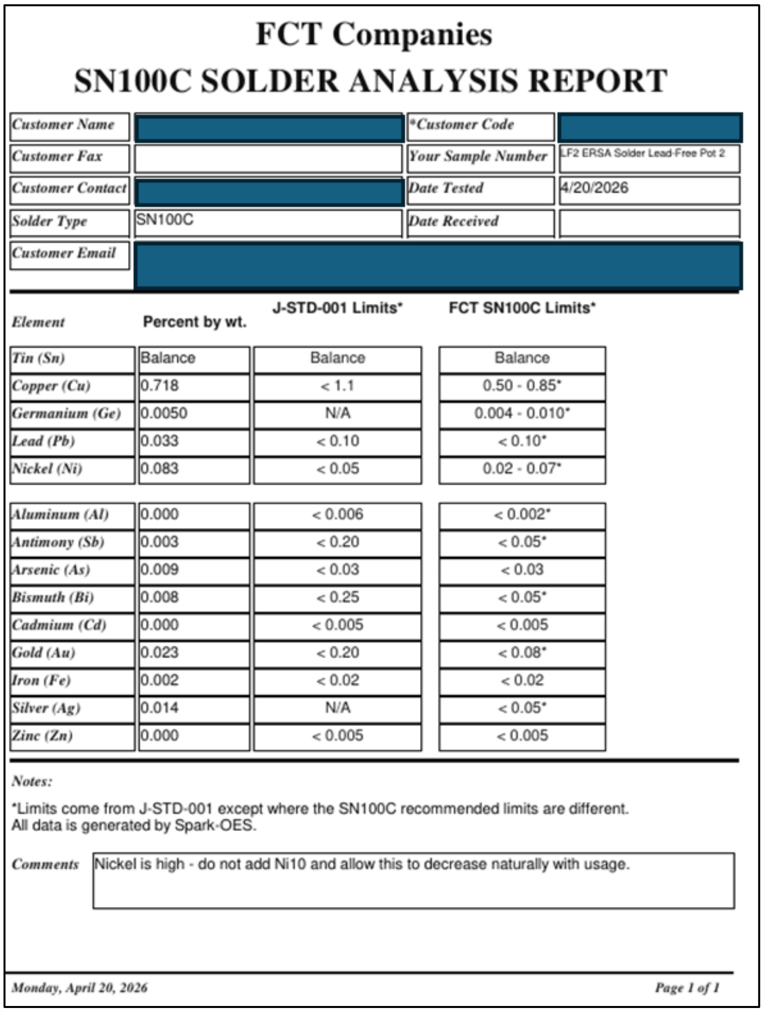
Solder sampling procedure

1. Turn on the wave / selective solder machine and allow the solder bath to warm up to operating temperature.
2. Turn on the pumps and recirculate the solder bath for ~5-10 min.
3. Remove the dross from the solder surface and dip out a sample with a sample scoop or ladle.
    a. The scoop or ladle should be made of a material that does not dissolve into the solder like stainless steel.
    b. Approximately 50-100 grams of solder is recommended.

4. Pour the solder sample into a mold or cup with a flat bottom surface. This mold or cup should take heat away and allow the sample to freeze quickly.
5. Label the sample with the solder alloy, date, and machine or solder pot description.
6. Send the solder sample to an analytical lab for analysis.

Solder elemental analysis report

Analytical laboratories provide a report of solder elemental composition similar to the example below.



FCT Companies
SN100C SOLDER ANALYSIS REPORT

Customer Name	[redacted]	**Customer Code*	[redacted]
Customer Fax		*Your Sample Number*	LF2 ERSA Solder Lead-Free Pot 2
Customer Contact	[redacted]	*Date Tested*	4/20/2026
Solder Type	SN100C	*Date Received*	
Customer Email	[redacted]		

Element	Percent by wt.	J-STD-001 Limits*	FCT SN100C Limits*
Tin (Sn)	Balance	Balance	Balance
Copper (Cu)	0.718	< 1.1	0.50 - 0.85*
Germanium (Ge)	0.0050	N/A	0.004 - 0.010*
Lead (Pb)	0.033	< 0.10	< 0.10*
Nickel (Ni)	0.083	< 0.05	0.02 - 0.07*
Aluminum (Al)	0.000	< 0.006	< 0.002*
Antimony (Sb)	0.003	< 0.20	< 0.05*
Arsenic (As)	0.009	< 0.03	< 0.03
Bismuth (Bi)	0.008	< 0.25	< 0.05*
Cadmium (Cd)	0.000	< 0.005	< 0.005
Gold (Au)	0.023	< 0.20	< 0.08*
Iron (Fe)	0.002	< 0.02	< 0.02
Silver (Ag)	0.014	N/A	< 0.05*
Zinc (Zn)	0.000	< 0.005	< 0.005

Notes:

*Limits come from J-STD-001 except where the SN100C recommended limits are different.
All data is generated by Spark-OES.

Comments Nickel is high - do not add Ni10 and allow this to decrease naturally with usage.

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The key elements that fall out of recommended specifications are noted in the comments. Corrections to adjust the solder bath are typically also written into the comments. This may involve removing dross, diluting the solder with fresh additives, or adding key elements.

After adjustments are made to the solder bath, it is best to analyze the solder bath again to confirm that the solder bath is within specifications. This is especially important if the adjustments were “extreme”, e.g. if any element was adjusted by more than roughly 20% of the concentration.

Solder Alloys and Key Elements

Some common solder alloys and their key elements are in the table below.

Solder Alloy	Key Element 1	Key Element 2	Key Element 3
Sn63/Pb37	Sn 63%	Pb 37%	
SN100C	Cu 0.65%	Ni 0.055%	Ge 0.005%
SAC305	Ag 3.0%	Cu 0.5%	
SAC0307	Ag 0.3%	Cu 0.7%	

It is important to maintain the concentration of key elements within their recommended specification ranges. This keeps the solder bath working optimally. When key elements drift too far from nominal, then melting ranges can expand causing the solder to be more “pasty” during melting and freezing. This can inhibit wetting and flow of the solder.

Maintenance of key elements in working solder baths can be done as follows. This is based upon elemental analysis of the solder bath, which can be done by most solder manufacturers and some testing labs.

Single key element is low

If a single element is low in concentration, then it can be added either as a pure element, or as a pre-diluted replenishment alloy. The addition should be made with the solder bath at operational temperature with pump recirculation. It takes time for some additives to dissolve and disperse throughout the solder bath.

For example, an 800 pound SAC305 bath has a target copper (Cu) content of 0.50% wt and a measured Cu content of 0.20% wt. The Cu is 0.30% low.

- Copper (Cu) metal (100% Cu) could be added directly to the solder bath. The calculation for the amount is below.
    - Cu metal to add (pounds) = (solder pot weight) x [(Nominal % - Actual %) x 0.01]
    - Cu metal to add (pounds) = (800) x [(0.50 – 0.20) x 0.01] = 2.4 pounds
    - It takes time to dissolve solid metals and some of this may be segregated into dross as it dissolves.
- A copper (Cu) concentrate dissolved in tin (Sn) could be added instead. For example, a Sn/20% Cu additive is used and the calculation for addition is below.
    - Sn/20% Cu to add (pounds) =
      (solder pot weight) x [(Nominal % - Actual %) x 0.01] x [100 / (% metal in additive)]
    - Sn/20% Cu to add (pounds) =
      (800) x [(0.50 – 0.20) x 0.01] x [100 / 20] = 12.0 pounds
    - Diluted metals dissolve rapidly and disperse more efficiently into working solder baths.

Multiple key elements are low

If multiple key elements are low in concentration, then the single element additions could be made for each element.

For example, a 500 pound SN100C bath has a copper (Cu) content of 0.10% and a nickel (Ni) content of 0.020% which are both low. The nominal values are 0.65% Cu and 0.055% Ni. Diluted metal additives are used which are Sn/20% Cu and Sn/10% Ni.

- Metal additive needed (pounds) = (solder pot weight) x [(Nominal % - Actual %) x 0.01] x [100 / (% metal in additive)]
- Sn/20% Cu needed (pounds) = (500) x [(0.65 – 0.10) x 0.01] x [100 / 20] = 13.8 pounds
- Sn/10% Ni needed (pounds) = (500) x [(0.055 – 0.020) x 0.01] x [100 / 10] = 1.8 pounds

After making additions, it is best to mix the pot at operating temperature for a time to dissolve the additives. Then analyze the solder bath again to verify the composition.

Single key element is high

If a single key element is high, then dilution is necessary to reduce the concentration of the high element. It is best to remove solder from the bath and replace it with the dilution alloy.

For example, a 600 pound SAC0307 solder pot has high copper (Cu) at 1.0% wt and the nominal Cu is 0.70%. An additive called SAC0300 (Sn/0.30% Ag/0.00% Cu) can be used to dilute the copper without diluting the silver (Ag). The calculation for dilution is shown below.

- Dilution alloy needed (pounds) = (solder pot weight) x [(Actual % - Nominal %) / (Actual %)]
- Dilution alloy needed (pounds) = (600) x [(1.0 – 0.7) / (1.0)] = 180 pounds
- Remove 180 pounds from the solder bath and add back 180 pounds of SAC0300 alloy.

In some cases, the key element may decrease over time naturally with use, and no negative soldering effects occur. For example, a SN100C solder bath has a nickel (Ni) content of 0.080% by weight and the nominal is 0.055%. Ni slowly becomes part of the dross and is removed over time when dross is removed. The recommended practice is to stop adding Ni rich alloys and to allow the Ni content to drop over time.

Multiple key elements are high

If multiple key elements are high, then it may be best to add pure tin (Sn) to the solder bath to dilute the high elements. It is best to dilute the element that is closest to the nominal and determine if the other elements fall into specification. This practice will make the least amount of correction to the solder bath. Further correction can be made if needed. It is recommended to remove solder from the bath and add back the dilution alloy.

For example, a 900 pound SAC305 solder bath has 3.80% silver (Ag) and 0.70% copper (Cu), and the nominal values are 3.00% Ag and 0.50% Cu. Ag is 21% high of nominal and Cu is 28% high of nominal. The element that is closest to nominal is Ag. Pure tin (Sn) can be used to dilute both back into range, and the calculation for dilution is shown below.

- Dilution alloy needed (pounds) = (solder pot weight) x [(Actual % - Nominal %) / (Actual %)]
- Dilution tin (Sn) needed for Ag reduction (pounds) = (900) x [(3.8 – 3.0) / (3.8)] = 189 pounds
- Remove 189 pounds from the solder bath and replace it with 189 pounds of pure Sn.
  - The new Ag content will be ~3.0%.
  - Calculation for new Cu content:
    [(solder pot weight - dilution add) / (solder pot weight)] x (Actual %)
  - Calculation for new Cu content: [(900 - 189) / (900)] x (0.70) = 0.55% Cu
  - This new Cu content is within the range for SAC305 alloy, so no further correction is needed.

Solder Impurities

Solder impurities may build up in working solder baths. These are introduced through PCBAs, soldering equipment and tools, and things that come into contact with the solder bath.

The elemental limits in the table below come from IPC J-STD-001 revision J Table 3-1. These limits are superseded by the key elements used to create solder alloys. For example, SAC305 has a target silver (Ag) content of 3.0% by weight, which exceeds the limit in the table below.

Element	IPC J-STD-001J Limits for SAC305 Pb-Free Alloy (% by wt)	Potential Effects when High Out of Specification
Copper (Cu)	1.10	Increased melting range. Bridging, webbing or spikes.
Gold (Au)	0.20	Embrittlement of the solder joint. Reduced wetting.
Cadmium (Cd)	0.005	Increased dross rate. Bridging, webbing or spikes.
Zinc (Zn)	0.005	Increased dross rate. Reduced wetting.
Aluminum (Al)	0.006	Increased dross rate. Reduced wetting.
Antimony (Sb)	0.20	Increased melting range.
Iron (Fe)	0.02	Formation of $FeSn_2$ needles. Increased dross rate.
Arsenic (As)	0.03	Reduced wetting.
Bismuth (Bi)	0.25	Lowered melting range. Increased dross rate.
Silver (Ag)	0.05	Reduced wetting.
Nickel (Ni)	0.10	Reduced wetting. Increased dross rate.
Lead (Pb)	0.10	No longer RoHS compliant.

When solder impurities exceed limits, then they can be reduced through removal of dross, or dilution of the solder bath with freshly made solder. A calculation for dilution of impurities is shown in the example below.

For example, a 50 pound SAC305 selective solder pot has high gold (Au) at 0.35% wt and the limit is 0.20% Au, but the target concentration is half of the limit or 0.10% Au. It is recommended to remove SAC305 from the solder bath and replace it with fresh SAC305 alloy. The calculation for dilution is shown below.

- Dilution alloy needed (pounds) = (solder pot weight) x [(Actual % - Nominal %) / (Actual %)]
- Dilution alloy needed (pounds) = (50) x [(0.35 – 0.10) / (0.35)] = 36 pounds

- Remove 36 pounds from the solder bath and add back 36 pounds of SAC305 alloy.
- With smaller selective soldering baths, it may be best to simply drain and replace the entire contents of the solder bath. In this example, that would require 50 pounds of SAC305.