



LEAD-FREE ALLOYS - THE WAY FORWARD

Due to impending EC legislation proposing the phase-out of lead solder in electronics SOLDERTEC at ITRI is constantly requested to make recommendations on choice of lead-free solder alloys. In order to clarify the situation SOLDERTEC is now recommending that alloys within a certain composition range of the Sn-Ag-Cu ternary alloy system should be accepted as a general replacement for Sn-Pb. This alloy type has been chosen as it appears to be suitable for surface-mount, wave and hand soldering and for use in a variety of product types. It can be used as a multi-purpose lead-free solder.

There now appears to be general agreement, certainly within UK industry, on the acceptability of Sn-Ag-Cu as a replacement for Sn-Pb. The SOLDERTEC recommendation of this alloy system is supported by the UK trade organisation PCIF (Printed Circuit Interconnection Federation), and UK solder suppliers; Alpha, Heraeus, Indium Corporation, Kester, Multicore and Senju.

Alloys within the composition range of **Sn-[3.4-4.1]Ag-[0.45-0.9]Cu** are recommended. This includes the 4 most commonly available solders; Sn-4Ag-0.5Cu, Sn-3.8Ag-0.7Cu, Sn-3.6Ag-0.5Cu and Sn-3.5Ag-0.7Cu. Although the properties of all these alloys are expected to be similar the current preference is for those with the slightly higher silver content. The Sn-Ag-Cu-Sb alloy also appears to provide a good balance of properties.

This recommendation does not preclude the use of other alloys such as Sn-Cu, Sn-Ag, Sn-Ag-Cu-Sb, Sn-Ag-Bi and Sn-Zn-Bi and it is anticipated that users able to make informed choices on the differences between these alloys will prefer to use one or more for specific purposes. For instance, the comparatively low price of Sn-Cu may lead to significant use in wave soldering, and, as the Sn-Bi-Ag alloy offers the opportunity for lower process temperature it may gain acceptance in certain surface mount applications.


This statement is based on knowledge of alloy properties gained to-date. Future work will allow better definition of an exact single composition and also applications where use of other alloys may give additional benefits.

It should be noted that certain lead-free solder compositions are subject to patent/licence restrictions in some areas but solder suppliers should be aware of, and be able to provide information on this issue.

A permitted residual lead content in 'lead-free' solders has yet to be defined. The US EPA defines lead-free plumbing solders as those containing less than 0.2%Pb although this may be reduced to 0.1% in the future. It is this level of impurity limit that may also be expected in 'lead-free' solders for electronics.

SOLDERTEC at ITRI
LEAD-FREE SOLDER COMPARISON

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	Sn-3.5Ag	Sn-Ag-Cu	Sn-Ag-Cu-Sb	Sn-0.7Cu	Sn-Bi-Ag	Sn-Zn-Bi
Melting/process temperature	5	3.5	3.5	6	2	1
Fillet lifting resistance (1)	2.5	2.5	2.5	2.5	5.5	5.5
Solderability (2)	4	2	3	5	1	*10
Processability (3)	3	1.5	1.5	5	4	*10
Reliability (4)	3	1.5	1.5	4	5	6
Recyclability (5)	2.5	2.5	2.5	2.5	5	6
Cost (6)	4.5	4.5	4.5	1.5	4.5	1.5
Alloy availability (7)	1.5	3	4	1.5	5	6
TOTAL SCORE	26	21	23	28	32	46
AVERAGE SCORE	3.3	2.6	2.9	3.5	4.0	5.6

Proposed range Typical composition

3.4-4.1 %Ag 2.5Ag
plus 0.8Cu
0.45-0.9 %Cu 0.5Sb

NOTES:

- 1) Bi alloys most prone to fillet lift, and most problems with Pb contamination
- 2) Zn alloy oxidation, requires very strong flux
- 3) SnAgCu(Sb) and SnBiAg advantage of lower temperature but with SnBiAg must consider fillet lifting
- 4) **On average only**; different test/service conditions can give different ranking
- 5) Zn and Bi increase problems/cost; some pros and cons for all other alloys
- 6) Approximate relative cost; dependant on Ag content; more effect on bar than paste
- 7) SnAgCu some patents; SnAgCuSb patented and licenced; SnBiAg and SnZnBi various patents

1 GOOD → 6 POOR → *10 BAD

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