IPC SOLDER PRODUCTS VALUE COUNCIL

ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

COST OF LEAD FREE SOLDER MATERIALS

A RESEARCH REPORT BY THE IPC SOLDER PRODUCTS VALUE COUNCIL

MAY, 2006

TABLE OF CONTENTS

COST OF LEAD FREE SOLDER MATERIALS

European implementation of the Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances RoHS) directives coupled with the adoption of lead free soldering by Japan's electronics industry have created unavoidable costs for the global electronics industry.

Here are examples of some costs associated with the implementation of lead free soldering.

ONE TIME:

- Investment in new equipment
- Changing bill of materials
- WEEE and RoHS licensing and compliances charges
- Scrapping old lead containing stock and inventory
- Revised packaging requirements
- Possible product re-design

ONGOING:

- End of life recycling costs
- Cost of product traceability
- Increased energy consumption
- Cost of raw materials

There is a wide range of costs associated with lead free implementation and their costs impact the entire electronics industry supply chain. It is not the intent of this paper to detail all these costs. Rather, this paper will attempt to create a cost comparison of soldering materials used in the transition from tin/lead to lead free soldering.

COST OF METALS

One of the first examples of the higher cost for lead free soldering is the higher cost of metals used in the lead free solder alloy. The following chart lists the market price of tin/lead and the most commonly used lead free solder – a tin, silver, and copper based alloy.

METALS PRICES AS OF MAY 10, 2006		US$/ METRIC TONNE
METAL ELEMENT COST OF METALS	Tin	$9,390
	Lead	$1,283
	Copper	$8,149
	Silver	$468,800
ALLOY COST OF METALS	63Tin 37Lead	$ 6,390
	"SAC305" (96.5Sn3Cu0.5Ag)	$23,170

} 263% COST OF METALS INCREASE

The above values of the constituent metals are based solely on market prices and do not include brokerage or financing charges which must be paid by solder product manufacturers. These additional charges will vary from producer to producer, depending on their bullion purchasing agreements.

As you can see, using the market prices alone, there is a 263% increase in base metal cost between the most popular lead free alloy SAC305 (96.5Sn3Cu0.5Ag) compared to the standard tin/lead (Sn63% Pb37%) alloy.

It should be noted that the market prices for these metals do fluctuate in accordance with published markets. In recent months, the price of all metals has risen dramatically. This is especially true for the price of silver which has almost doubled in value over a short period of time. Currently the cost of silver in the popular lead free alloys accounts for the largest share of the total raw metals cost and directly makes the differential in cost compared to Sn63/Pb37 even larger.

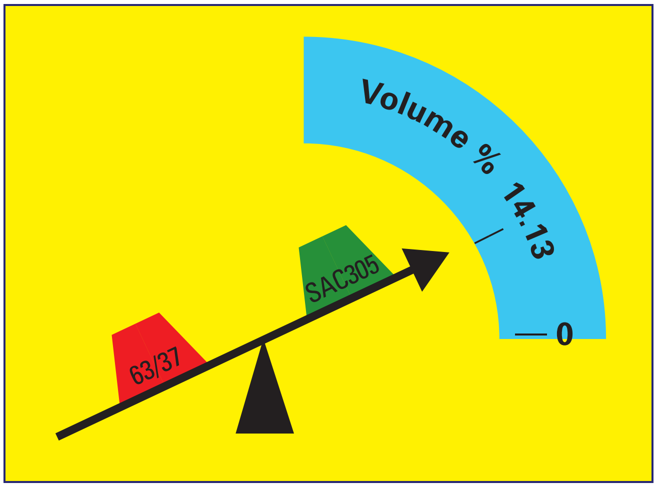
The RoHS requirement is very stringent and the allowable lead content is 200 parts per million. Many material sources do not meet the specification and, as a result, the price of higher purity raw material sources is greater. IPC-J-STD-006 is tightening the requirements on minor constituents in alloys, which is also changing the purity of raw materials used in the formulation of lead free solder.

ALLOY DENSITY

In all available lead free alloys, tin is used instead of lead which along with the other minor elements of lead free alloys, has the effect of replacing a very dense metal (lead) with others of much lower density. Using the two most popular alloys, the resultant effect in density change is tabulated below.

ALLOY	DENSITY
63Tin 37Lead	8.4
SAC305 (96.5Sn3Cu0.5Ag)	7.36

DENSITY / VOLUME



The illustration above shows that the SAC305 alloy has a density which is 87.62% of the tin lead alloy (Sn63% Pb37). This equates to an equal weight of SAC305 solder but a volume increase of 14.13% over the tin lead equivalent.

Traditionally, solder products have been sold by units of weight, and it will be the same with lead free solder products. Consumption of these products, due to the various processes in electronics assembly, is based on volume. A volume of solder paste deposited on a PCB will remain the same for tin lead as it will for lead free solder.

A certain volume of solder, as an example, is required to form the fillet on a quad flat pack (QFP) device or to fill the barrel of a hole in the printed circuit board (PCB). When transitioning to lead free soldering, this volume remains the same, but the mass of each solder joint will be significantly different. Also, the volume of a solder bath filled with lead free material will require approximately 14.1% less material by weight when compared to tin lead material. The industry will be helped by a reduction in consumption of materials and the cost may also be reduced. However, other factors must still be considered in this analysis.

The manufacturing process for solder products is also driven by volume. While the analysis of an alloy recipe is dictated by weight, the actual process of making solder into a usable product is determined by volume. Manufacturing costs and energy costs will all increase due to higher melting temperatures and furthermore it is necessary for the manufacturer, for example, to produce more solder powder and flux medium to obtain the equivalent batch weight of solder paste product.

PATENT COSTS

The majority of key compositions of lead free alloys that have performed well in manufacturing and with good reliability have North American and Japanese patents. Since these patents cover the use of lead free alloys based on tin, silver, copper, bismuth and antimony, the solder manufacturers have little or no option but to pay the patent royalties on behalf of the original equipment manufacturer or the electronics manufacturing services company.

The solder product manufacturer, depending on the country using the product, the customer's marketplace and the alloy used, must pay royalties of 4% to 8% of the final selling price of the product. It is almost impossible for the patent holder to regulate and recoup these royalties from the solder joint manufacturer for electronic and electrical equipment.

SOLDER BAR AND INGOT

Solder product in its most basic form consists of melting the constituent parts of the alloy recipe and "running it" to moulds to form the desired bar or ingot shape required by the customer. The density difference between lead free and lead containing alloys directly impacts the number of additional bars or ingots cast or extruded in relation to an equivalent batch weight of tin lead solders.

It has been noted that energy costs will also increase. Higher energy costs are due to the difference in liquidus temperatures of lead free alloys and the higher blending pot temperatures required to formulate alloys. Producers are also investing in casting or extruding lead free alloys in differing shapes. These new shapes provide a visual difference for the user that hopefully eliminates the accidental substitution of a lead free solder with a tin/lead solder in the wave soldering process. To avoid contamination of lead, some manufacturers have invested in dedicated melting pots and equipment solely for the production of lead free product.

In all applications where the user must use an existing lead containing solder pot or wave bath, it must be remembered that the corresponding weight of the lead free alloy required to fill the pot is 14.1% less. Additional costs to consider with lead free solder products are the monitoring and control of lead contamination in the manufacturing processes.

CORED SOLDER WIRES

Cored solder wires have a far more complex manufacturing process and involve:

- The formulation of flux for the core,
- Billet casting of the alloy
- Extrusion of the cored wire product at large diameter,
- Drawing the wire to the customer's desired diameter and
- Spooling of the wire onto reels or bobbins.

The cost of manufacturing increases because of the increased wire length necessary for the final product to be sold by weight.

Wire drawing of lead free products is more problematic due to the increased hardness of the lead free alloys and therefore often involves smaller increments of diameter reduction in the process. This diameter reduction increases the number of drawing steps which subsequently increases manufacturing times and costs. The alloy (metal) costs, as a result, have a smaller impact on the final price than the manufacturing costs.

Keep in mind, too, that a consumption reduction will be realized by the user as solder joints made from cored wire are volume limited and that each spool of wire at any particular diameter will have an extra 14.1% length of wire per unit weight.

SOLDER PASTES

Solder pastes, in their formulation and precision manufacturing techniques, are probably one of the most complex solder products. .Generally, the processes consist of:

- Powder manufacture which involves some form of particle making system combined with
- Sieving operations to achieve the desired or required particle sizes
- Flux medium blending
- Paste blending
- Packaging.

It is within this manufacturing process that solder manufacturers have invested the most in creating a lead free only facility to avoid contamination of lead free solder. In addition, each of these processes in lead free solder paste production is formulated by weight but controlled and costed by volume. Once more, the direct density difference of the alloys impacts each stage of the process with a 14.1 % additional cost in every costing element per unit weight.

These costs even apply to the chemical flux medium element, since it is formulated by weight and is finally mixed with the metal powders on a weight basis. It will, however, produce a final product greater in volume to its tin lead counterpart. For example, in a 500 gram jar of lead free solder paste, there is 14.1% more solder paste by volume compared to a tin/lead solder paste.

Flux mediums suitable for tin/lead processes are ineffective in the harsher environments of lead free soldering. This fact has necessitated the use of more thermally stable resins and activator packages which are typically more expensive compared to those used in tin lead formulated pastes.

Quality assurance also plays a major role in the manufacturing of solder pastes and has a much higher cost element to the final paste product compared to other solder products.

Once again, the industry has tried to identify lead free paste products by special package labelling in order to eliminate errors.

Of the three solder product groups we've analyzed in this article, it is fair to say that alloy costs will have the **least impact** on the final product cost for lead free solder pastes. Conversely, additional manufacturing costs have the greatest impact on the cost of the lead free solder paste.

ROHS COMPLIANCE

The European Directives are the main drivers for replacing lead in the solder alloys and hence, electronic products. The Directives too have added new costs in the manufacture of lead free solder products. Here are examples of some of the additional costs:

- Additional certification and compliance notifications
- Labelling
- Product identity
- Quality assurance in terms of lead contamination in manufacturing and lead impurity in finished solder products

CONCLUSIONS

1 It is extremely difficult to derive a direct comparison between the costs of a tin lead solder product and the same lead free product. As you have read, there are many cost associated with the production of lead free solder – manufacturing, patent, and administrative costs, to name a few. Therefore, it is not advisable to set target pricing of lead free solder benchmarked by the tin lead equivalent product.

2 As the cost of manufacturing solder products increases and the cost of the lead free metals increases, the manufacturer's required working capital climbs even higher. Solder manufacturers may have to borrow more money to finance their business.

3 Considerable research and development programs were conducted and funded by solder manufacturers to develop lead free solder products. These programs were supported by tin lead manufacturing and sales. Further research and development into new solder products will need to be funded by lead free margins.

4 A better understanding of the integral parts involved in supplying lead free solders has to be realized by users, and not by a direct comparison of lead free to lead containing alloys. Many factors must be considered including consumption reduction and a per board cost increase. An increase of paste prices, for example, does not mean that the cost per board increases by the same percentage. In fact, depending upon the quantity of paste used per board, the impact should be extremely minimal. It is estimated that lead free solder paste will increase the cost of an average computer product by 0.05%.

5 The really dramatic costs of implementing the WEEE and RoHS directives come from sources other than solder products.

6 It is expected that tin lead solder use will fall dramatically with the ever growing implementation of lead free soldering. It is likely that prices will rise dramatically for what may be considered "marginal products" using tin lead solder, thus diminishing any perceived advantage of reduced lead based solder costs for those who have an exemption to the directives.