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REGROUPEMENT DE L'INDUSTRIE ÉLECTRONIQUE

LE VIRAGE AU SANS PLOMB : UN INCONTOURNABLE !

Comité organisateur. Les membres du Comité exécutif du RIE assurent différentes responsabilités quant à l'organisation du Congrès R.I.E. Novembre 2004.

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ARTICLES SUR LE VIRAGE AU SANS PLOMB

MOT DU PRÉSIDENT

Chers ami(e)s et collègues,

Notre industrie se prépare à vivre un grand bouleversement, dont les effets sont mal connus mais dont l'impact sera beaucoup plus important que ce que vous pouvez envisager. Pensez au nombre de produits que vous fabriquez, vendez et développez présentement! Combien d'appareils possèdent un circuit imprimé, soudé au plomb ? Avez-vous réfléchi à la quantité de matières, pièces et composants, néfastes à l'environnement, qui dans moins d'un an ne pourront plus être utilisées pour le marché Européen et suivrons par le fait même le marché NORD-AMÉRICAIN ?

Imaginez le travail pour arriver à élaborer de nouveaux procédés complets de production, leurs contrôles, vos équipements de production! Quelles seront l'impact sur la qualité et la durabilité des produits que vous fabriquerez ? Quelle seront les problèmes d'implantation dans votre usine? Vos produits risquent de devoir être conçus et homologués à nouveau, selon un nouveau processus de fabrication. Bref, à terme, cela impliquera une réévaluation complète de toute votre gamme de produits et services.

Un incontournable, un virage à 90° qu'il ne faut pas manquer!

Le Regroupement de l'Industrie Électronique (Rie)

Réjean Dion,
Président www.Rie.ca

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MOT DE LA COORDONNATRICE

Le compte à rebours est déjà commencé.

C'est une question de survie ! Êtes vous prêts ?

0000553 jours

Dès, le 1er juillet 2006,

La soudure au plomb sera interdite dans plusieurs pays. Plusieurs substances dangereuses ne pourront plus être contenues dans les produits électroniques utilisés en Europe. Ces " cinq indésirables " sont : le plomb, le cadmium, le chrome hexavalent, le mercure et les produits ignifuges PBB et PBDE.

"La pollution au plomb est très dangereuse pour la santé puisqu'elle est directement liée à une détérioration du système nerveux.." - Pour l'instant, les normes s'appliquent essentiellement aux produits de consommation courante. Des études ont été menées sur la soudure sans plomb ainsi que d'autres composantes ont été approuvés comme remplacement. L'instauration de mesures ciblées sur l'ensemble des processus de fabrication interdira l'usage de plomb, et de certains autres produits dans les pays membres de l'union Européenne et ce, d'ici le 01 janvier 2006. Le Japon et certains pays Scandinaves adopteront également les même politiques. De plus, certains réactions circonspectes aux &Eacte;tat-Unis font en sorte que le plomb est devenu un important sujet d'inquiétude et de débat.

Ferez vous partis des survivants du bouleversement de l'industrie ?

La conversion au sans plomb, naturellement !

Cette nouvelle réalité entraîne de profondes mutations dans tout le processus de fabrication (élaboration, développement, approvisionnement, production, distribution), ainsi que dans les programmes de formation en électronique. De plus, tous les secteurs sous-jacents et parallèles sont concernés.

Instaurez la soudure sans plomb dès maintenant.
Le virage au sans plomb est un incontournable !

Coordonnatrice www.Rie.ca

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ARTICLE TECHNIQUE SUR LE VIRAGE DE LA SOUDURE AU SANS PLOMB

On The Forefront: June 2000
by Phil Zarrow

“Lead Free - Act, Don’t React???

“Good and bad, I define these terms. Quite clear, no doubt, somehow.???
Bob Dylan

From time to time, in SMT, there arise issues of widespread proportions, usually in the form of calamities. I call these “buzz issues??? and past ones have included cracked capacitors, the banning of freon, micro-cracking of ICs, etc. Of course, the current buzz issue is no-lead solder and material finishes. This is no small matter, but rather one of major proportions since it affects the entire industry. Unfortunately, it is generating a bit of mass-hysteria.

I discussed the basics of the matter in the August issue (“Lead Free - Don’t Fight a Fact, Deal With It???)1 and it seems to be the second part that we’re having trouble with. Everywhere I go within the industry, the question inevitably arises as to what I think about the upcoming potential ban on circuit boards containing lead solder and finishes (or something to that effect) and how will they ever be able to market their product in Europe if a non-leaded substitute is not found. The discussion usually goes on as to the plausibility of banning lead from circuit boards since our usage is so little compared to, say, auto batteries. Well, let’s take a look around here and ascertain the facts of the Lead-free “direction???.

The whole idea behind banning lead from circuit boards is the fear of the lead of discarded circuit boards leaching into the water table. Now, the electronics industry accounts for only 2% of lead usage so we do indeed wonder why they are picking on us. When was the last time you saw a discarded circuit board lying on the side of a road or in a stream? One tends to see a lot more old car batteries carelessly strewn about the landscape. Also, bear in mind that lead exists in nature naturally - it is not a manmade compound. Now assume, for a moment, that we now have a “lead-free??? circuit board discarded safely in the landfill. How about the tin - it won’t be too healthy when it leaches into the water supply. And is what about that gallium arsenide (GaAS) device on that board? I know, don’t give “them??? ideas. The WEEE proposal appears to seek to first “prevent??? the use of lead in products, if possible, but if that is not feasible, it pushes for recycling:

“Components containing substances listed below lead have to be removed from any end of life electrical or electronic equipment which is destined for landfilling, incineration, or recovery.???2

Doesn’t quite sound like an outright “ban??? on lead, however, certain political types have deemed anything with lead solder in it as un-removable and thus dangerous. Interestingly, the automotive industry has requested and is being considered for exemption and wants to be

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“On The Forefront???, Circuits Assembly, August 1999

2Proposal for a Directive on Waste From Electrical and Electronic Equipment???, Annex IV, 2nd Draft. This can be downloaded from the IPC “Legislation??? page at www.IPC.org. able to use lead in its products (as in batteries, perhaps?). Military electronics would also be exempted from the proposed lead ban. What, no ecologically correct weapons of mass destruction? There are some other interesting politics involved here and that seems to be the real nature of the directives. Though the date of the proposed ban keeps getting pushed back (it is now out to 2006), the possibility is very real. On the other hand, has anyone touched a real Eurodollar yet?

Logically if you can “get the lead out??? of the product, it theoretically could be disposed of legally. Of course, how exactly does one reclaim lead from a PCBA? As Ralph Woodgate mentioned3 one such method is a process that was developed and implemented in Germany that accomplishes this. Old PCBAs are ground up and the organics are removed leaving the metal(s) for recycling. No doubt there are other practical and economical methods that are also effective. One would reason (key word here being reason) would seem to satisfy the edicts of the EEC 75/422 Directive. Such removal would apparently be the responsibility of the original manufacturer. That manufacturer, in keeping with today’s outsourcing trend, could turn to a third-party firm to specifically handle reclamation, recycling and disposal of their product. Sounds like a potential new cottage industry could evolve from this.

In the meantime, the drive continues to find a suitable no-lead alloy for use in solder as well as component and PCB finishes. The National Electronics Manufacturing Initiative (NEMI) formed a Lead-Free Task Force to come up with a recommendation for a standard lead free solder alternative. These people are very serious - the member companies pay big bucks to belong to NEMI and finance this research. Unfortunately, the best they’ve been able to come up is Sn.5Ag3.9Cu0.6 for reflow and Sn99.3Cu0.7 for wave soldering. The problem here is a melting temperature of approximately 217 deg. C which means a full liquidus temperature of around 230 deg. C. Tell that to most component manufacturers and they respond with “no way??? (sometimes with an expletive inserted in the middle of the statement).

The recommendation for these alloys as “standard??? came from exhaustive and important research in which quite a number of alloys were researched and characterized in terms of their inter-reaction with other PCB materials, reliability aspects and relative cost. It should be noted that the NEMI task group recommended avoiding consideration of those alloys that were subject to patents, such as Castin (among several others) which is a quartenary alloy comprised of tin-silver-copper and antimony. There is supposedly concern about control of quartenary alloys but perhaps Castin and these other alloys might be just right for some applications and thus should be thoroughly characterized on its performance just as any other alloy should.

Let’s stop for a moment and ponder something. What is the “standard??? alloy of the industry right now? Answer…anyone…? Yes, you in the back. Sn63Pb37 ? Well, yes, a lot of people use it but it isn’t the “standard???. Quite a few of you use 2% silver, as well as Sn60Pb40, Sn42Bi58 and I even came across someone using that Castin stuff. The answer is that there is no “standard??? alloy and there never was. So why, all of a sudden, do we need a “standard??? alloy - no-lead or otherwise?

3“Letters to the Editor???, Circuits Assembly, February, 2000

Let’s get real. Just like most everything else in SMT, the choice of an alloy has been, and will be application driven. With the advent of the aforementioned Euro-legislation, the alloy and the disposal scheme should be driven by the application. Consider this practical scenario:

• Consumer electronic products, the type that are considered “throw-away consumables??? with relatively short lifespans, such as portable CD and tape players, televisions, radios, and even some automotive applications - the type of things that might actually wind up in a landfill 4 would likely benefit from being constructed with no-lead alloys. The recovery process might cost too much in light of margins and the user may not be “responsible??? enough to comply with such a program.

• Industrial and high-reliability applications, such as broadband and network control cards, computers, medical and military products, in fact most Class II and Class III, might still use lead bearing solder alloys and, accordingly, have reclamation programs as described. Since these products are more expensive, adding in another 5% or so for reclamation (if even that much) will not severely impact the overall cost of the product.

Of those products, in any reliability class, that want to go lead-free, there should be and are a number of options available to them - again with the application with its composition, life expectancy and operating environment driving the choice. Bismuth, when added in small percentages to tin-silver, reduces the melting point. While found to contribute to fillet lifting in through-hole joints, this seems to be the case with lead alloy finished circuit boards, as opposed to lead-free finish PCBs. It might also be ideal in surface mount joints, particularly in applications that are subjected to a high degree of thermal cycling.

I know of applications, including a large-frame computer motherboard, that were assembled with Sn42Bi58. They all operated at a relatively low, steady-state temperature and the alloy never presented reliability problems. Again, the material choice fit the application parameters.

Conductive epoxies are another alternative. Already in use in many applications, they do tend to be expensive - a silver-filled conductive epoxy is around 10 times the cost (per gram) as Sn63Pb37 solder paste. However, besides being no-lead, it is also no-clean and has some properties that make it ideal for some applications (and less than desirable for others). The idea of a single lead-free alloy that will globally adaptable by the industry is quixotic. Accept the fact that there is not a “one size fits all??? solution. Rather than try to derive a “standard alloy for the industry???, the NEMI task group should use its resources to continue its valuable work in characterizing all the alloys and materials available, including their limitations and inter-reactions with other materials, so that the manufacturer might choose the best solution for his application and situation, rather than be forced into conforming to a committee derived “standard???.

Recycling and reclamation should be a viable direction. Instead of developing and trashing a better class of waste products, as Ken Gilleo so aptly put it5, let’s recycle what we have.

This 4 Or on the side of the road in Texas or elsewhere is so basic and obvious, it has to even make sense to legislators, even if they are lawyers. Let’s not cower in the shadow of impractical and unnecessary legislation. Remember, we’re all in this together.

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On The Forefront: August, 1999
by Phil Zarrow

Lead-Free: Don’t Fight a Fact - Deal With It!

This month’s column is about the all-important subject of no-lead solder technology. No, purposely avoided titling it with the overused cutesy phrase of “getting the lead out???. I recognize that this magazine has a sophisticated readership that are quite tired of trite expressions. More important, our readers are pretty much aware of the consequences of potential legislation that would alter our favorite soldering alloy.

The tin-lead alloy has been around for about 3000 years, its discovery credited to the Egyptians.1 Of course we have been using it for electronic interconnection not quite as long but we have come to depend upon it. Regarding Sn63/Pb37, in terms of tensile strength, shear strength, conductivity, and of critical importance, melting point, it is the “hot set-up??? for most applications. Now, legislation is afoot in Europe as well as in North America and Japan, that will have the effect of eliminating lead from our industry. While we are only pikers in terms of lead usage accounting for less than 1% of the total amount of lead used industrially (compared to wet-cell batteries for example), there is overwhelming concern about lead from used PCB assemblies in landfills leaching into water supplies. In spite of strong opposition, in Europe the Waste from Electrical and Electronic Equipment EC draft document would effectively ban lead in electronic assemblies as of January 1, 2004. Several countries already make the manufacturer of products using lead, such as circuit boards, responsible for reclamation of this material before disposal of the boards. In Japan, the JEIDA2 and JIEP3 last year presented a leadfree roadmap and a number of Japanese electronic companies declared their own policies.

Manufacturers including Matsushita (Panasonic), NEC, Sony, Toshiba, and Hitachi are eliminating lead from some product lines (not all, though) with reduction of as much as 50% of 1997 levels by as early as the end of this year.

In the US, we had a brush with potential legislation a few years ago. Nothing came through but there will likely be renewed attention. A few companies, particularly the automotive and a few telecommunications firms, such as Motorola, have internal mandates. A number of industry organizations are lobbying against lead-free legislation including NEMA, EIA and the IPC.4 On the other hand, the National Center for Manufacturing Sciences (NCMS) as well as the National Institute of Standards and Technology and Lehigh University are leading efforts to find lead-free solutions.

You
1 Which shows that not quite everything we use in electronics originated at IBM or Bell Labs.
2 Japanese Electronic Industry Development Association
3 Japanese Institute of Electronics Packaging
4 The American spirit - don’t deal with a fact, fight it! Remember the US vs. Japan a few years ago regarding attitudes and efforts towards reduced fuel automotive consumption? better believe that the solder companies particularly Alpha Metals, AIM, Kester and
Indium are involved in heavy-duty R&D to come up with ideal lead-free alloys.

This is a tall order - to come up with a substitute for tin-lead, particularly Sn63/Pb37 and Sn62/Pb36/2Ag. Of primary concern in electronic assembly, is that the melting temperature be below 200 deg. C and thus the reflow (full liquidus) temperature must be below 230 deg. C and even that is an uncomfortable thermal excursion for many components. However, the alloy has to be economical. This puts a damper on alloys containing Indium and large portions of Bismuth. Indium is in limited supply and thus expensive. Bismuth, among other things, is a bi-product of mining for lead and if we stop mining lead, well, need we say more. The alloy should allow for acceptable wetting and there are some problems related to zinc here. Ideally, the alloy should be eutectic or, at the very least, have a small plasticus ("mushy???) zone, say less than 10 deg. C to avoid incurring fillet lift. It must have acceptable physical properties - strength, elongation, thermal fatigue, electrical and thermal conductivity, etc. to ensure relability of the solder joints. It must be compatible with other metallizations such as those used for PCB substrate finish and component lead terminations. It must be capable of consistent manufacturability which is one of the reasons conductive epoxies are not considered a drop-in, no-lead (and no-clean) solution. Also, we would prefer an alloy that can be supplied in paste, bar (for wave-solder) and wire (for hand-soldering/repair) and some alloys cannot fill all three niches. Last, but certainly not least, they must be low toxicity - the reason we are in pursuit of a lead-less alloy in the first place.

Alloy	Melting Range (deg.C)	Metal Cost / lb (US$)	Density at 25 deg.C (lbs/in3)	Metal Cost per in3 (US$)
Sn62/Pb37	183	2.37	0.318	0.75
Sn42/Bi58	139	3.44	0.316	1.09
Sn77.2/In20/Ag2.8	179-189	30.06	0.267	8.02
Sn91/Zn9	199	3.23	0.263	0.85
Sn91.8/Ag3.4/Bi4.8	208-215	6.24	0.272	1.70
Sn90/Bi7.5/Ag2/0.5Cu	186-212	5.09	0.273	1.39
Sn96.2/Ag2.5/Cu0.8/Sb0.5	213-219	5.48	0.267	1.46
Sn96.3/Ag3/Cu0.7	217-218	5.9	0.268	1.58
Sn95/Ag3.5/In1.5	218	8.15	0.268	2.18
Sn93.5/Ag3.5/Bi3	216-220	5.92	0.269	1.59
Sn96.5/Ag3.5	221	6.32	0.368	2.33
Sn99.3/Cu0.7	227	3.48	0.264	0.92
Sn95/Sb5	232-240	3.37	0.263	0.88

Table 1: The most commonly considered alloy alternatives (Source: Alpha Metals) So what are the leading contenders to the lead solder replacement dilemma? Table 1 lists a number of alloys that are under serious consideration. Reportedly Nortel has elected to use Tin-Copper to a certain extent, as is Matsushita who, along with Nokia and Toshiba will also be incorporating Tin-Silver-Copper alloy solder into much of their product line. All in all, the favored alloy at present, which appears to be the most promising for the industry is the Tin-Silver family with ternary alloys comprised of relatively low amounts of copper or bismuth.

Tin-Silver, such as Sn96.5/Ag3.5 is fairly familiar to the industry. Though the price is somewhat higher than good ol' Sn63/Pb37, the materials are abundant and the cost is still fair. On the other hand, though eutectic, it does have a high (221 deg. C) melting point meaning that the assembly will be exposed to temperatures as high as 240 deg. C during reflow if adequate wetting is to occur. Throwing in some Bismuth, as in Sn91.8/Sn3.4/Bi4.8 gives us a melting range of between 208 and 215 and the cost is similar. However, this alloy is fine for reflow but can present fillet lift problems during wave-soldering. This is the separation of the solder fillet from the circuit board land at the solder-to-Cu/Sn intermetallic layer. While the barrel of the through-hole joint appears to be intact, and there are no cracks in surface mount joints, the lift phenomenonoccurs at the annular ring during cooldown (to room temperature). The same has been observed of printed Tin-Silver-Bismuth paste on intrusive-reflowed joints Lift susceptibility tends to increase with thicker substrates, larger land sizes, and CTE mismatch.

Tin-Silver-Copper alloys, particularly Sn96.3/Ag3/Cu0.7, has a lower melting range than Tin-Silver (though slightly higher than Tin-Silver-Bismuth) and costs less than the two aforementioned alloys. The materials are widely available and the industry is gaining experience with it. For wave-soldering, an alloy of Sn99.3/Cu0.7 is being experimented with. With highly available materials, it is, at present, the lowest cost non-lead alloy. However, it has been observed that inerting the solder pot is required due to poorer wetting.

An alloy comprised of Sn96.2/Ag2.5/Cu0.8/Sb0.5, with the addition of the Antimony, works very well in both reflow (paste) and wave-solder applications. The cost becomes more reasonable as this alloy satisfies the quest for a common alloy that is compatible with both means of soldering.

Even with these promising solder alloys, we are not out of the woods yet. We are still dealing with melting and reflow temperatures that are well above the approximately 205- 210 deg C peak (full liquidus) of Sn63/Pb37. This means that, with ever-present gradients across the PCB assembly (depending upon the complexity of the assembly and the thermal transfer efficiency of the oven), there are going to be some components that will not be compatible with the inherent thermal excursions. These higher temperatures may also require, in many cases, inerting of the oven (with nitrogen) to stave off further oxidation during the reflow process. Indeed, some ovens in field may not even be capable of sustained operation at these slightly elevated temperatures. Inerting will likely also be the order of the day for wave-solder machines with pot temperatures in the vicinity of 500-520 deg F.5

5 Aren’t you glad you hung on to that AirCo and AirLiquide stock after all? It has been noted that PCBs with OSP coating undergo dramatically reduced wetting with almost all of the lead-free alternatives mentioned. No doubt these can and will be reformulated but in the interim, nickel-gold finishes work well. Some researchers have
found that voiding increases with a number of the alloys.

It appears apparent that lead-free is going to happen. Yes, it will cost more and yes there are problems to be resolved. However, it is very much like the CFC based solvent demise of the 1980’s - get with it or get out of the way. Remember, we’re all in this together.

Special thanks to Chris Bastecki at Alpha Metals, Jersey City, NJ.
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On The Forefront: June 2001
by Phil Zarrow

The Real Cost of Lead Free Soldering

“You give up something for everything you gain,
So pay for your ticket and don’t complain.???
Bob Dylan

Yet another article on Lead-Free Soldering. It’s not going to go away - too much is at stake here - ecologically, financially, emotionally, politically. There is a lot of information regarding the implications of lead-free - as well as mis-information and disinformation. Of course, this is typical of issues of this wide a scope and impact.

My associate, Jim Hall, and I are currently involved in a study regarding the real costs of “going lead-free???. Our objective is to look at the issue from the perspective of PCBA manufacturers and assess what the financial impact will be across the board.[1] Objectivity is the key word here - we are not getting involved in the politics of the issue. This is an examination of the costs of the lead-free approach to circuit board assembly.

As we all know, the whole idea behind banning lead from circuit boards is the fear of the lead of discarded circuit boards leaching into the water table. We are all also aware that the electronics industry accounts for less than 1% of lead usage.[2] Nevertheless, the move towards lead-free ponders on with pending legislation in Europe (WEEE and ITRI) and, more recently, Japan (JEDA).

This month’s column will examine particular aspect of the cost of lead-free. The impact on the cost of manufacturing lead-free solder material by the solder manufacturers will be discussed. Bear in mind that, while we are focusing on solder, the lead-free initiatives also affect circuit board finishes, component leads and internal component interconnections. As is the case with the issue in general, there is a lot more than meets the eye.

1 Pun intended.
2 I still contend that I see a lot more dead car batteries discarded improperly than circuit boards.

Product	Consumption (%)
Storage Batteries	80.91
Other Oxides: paint, glass and ceramic products, pigments, and chemicals	4.78
Ammunition	4.69
Sheet Lead	1.79
Cable Covering	1.40
Casting Metals	1.13
Brass and Bronze billets and ingots	0.72
Pipes, Traps, Other extruded products	0.72
Solder (non-electronic)	0.70
Electronic Solder	0.49
Miscellaneous	2.77

Table 1: Lead Consumption (Worldwide) by Product (Source: Advancing Microelectronics, September/October 1999 p. 29)

Materials

Of course the cost of materials will affect the cost of solder and, ultimately, the cost of the assembly. Most people tend to think that this is the only impact on solder cost that will be brought about by conversion to lead-free solder alloys. It isn’t but it is a major factor.

Lead is relatively inexpensive and, for the most part, none of the replacement metals are as economical. Accordingly, if we convert from a Tin-Lead alloy to a Tin-Silver-Copper as it appears the most favored direction is leading, silver as well as copper are more expensive than lead. While we may not be going from 37% lead to 37% silver but rather less than 5% silver, as Table 1 enumerates, the relative costs of tin, silver and copper do add up.

Element	Metal Cost per Pound (approx.)	Density at 25°C (Pounds per Cubic Inch)
Lead	$ 0.45	0.410
Zinc	$ 0.50	0.258

Copper $ 0.65 0.324
Antimony $ 0.80 0.239
Bismuth $ 3.40 0.354
Tin $ 3.50 0.264
Silver $ 84.20 0.379
Indium $125.00 0.264
Table 2: Cost of Metals (approximately) (Source: Wall Street Journal Metals Cost
February, 1999)
Material Density

Table 2 examines the resulting cost of some of the solder and finish alloys being considered. When we look at the price of the alloys by volume, we notice quite an difference in price from the baseline Sn63/Pb37 solder alloy. This brings up another very interesting aspect. Solder is not purchased on a basis of volume but rather by weight -
solder paste by kilograms, bar and wire solder by the pound. Looking at the Density column in Table 1, we observe (not to anyone's surprise) that the substitute metals are far less dense than lead. Table 2 shows the density of the particular alloys being considered.

The difference in density, for example, between Sn63/Pb37 and Sn96.3/Ag3/Cu0.7, the alloy currently most favored as the replacement for reflow soldering, is almost 20%.

Thus, if 1 kilogram of Sn63/Pb37 yields 1000 jars of solder paste, 0.8 kilograms of Sn96.3/Ag3/Cu0.7 will yield the same 1000 jars of solder paste. A solder pot on a wave solder machine that requires 800 lbs. of Sn63/Pb37 will now only require about 640 lb. of Sn96.3/Ag3/Cu0.7. However, in both cases, the cost to manufacture the soldering
material is the same, excluding the cost of metals, even though 20% less by weight will be made since the same amount of material by volume is being produced. Hence, the method of selling solder by weight aggravates the perceived increase of the actual cost.

Why is solder sold by weight? Likely some ancient tradition that has long becomeobsolete since we measure solder deposition and joints by volume. Here is an opportunity - a second chance, if you will, to do it right. Of course that will mean reeducating everyone, especially purchasing people. Industry conversion to lead-free is Herculean enough but that last aspect may be downright impossible.

Alloy Melting Range (deg. C)
Metal Cost / lb (US$)
Density at 25
deg.C (lbs/in3)
Metal Cost per in3 (US$)
Metal Cost per . Sn63/Pb37
Sn62/Pb37 183 2.37 0.318 0.75 0%
Sn42/Bi58 139 3.44 0.316 1.09 +45%
Sn77.2/In20/Ag2.8 179-189 30.06 0.267 8.02 +970%
Sn91/Zn9 199 3.23 0.263 0.85 +13%
Sn91.8/Ag3.4/Bi4.8 208-215 6.24 0.272 1.70 +125%
Sn90/Bi7.5/Ag2/0.5Cu 186-212 5.09 0.273 1.39 +85%
Sn96.2/Ag2.5/Cu0.8/Sb0.5 213-219 5.48 0.267 1.46 +95%
Sn96.3/Ag3/Cu0.7 217-218 5.9 0.268 1.58 +110%
Sn95/Ag3.5/In1.5 218 8.15 0.268 2.18 +190%
Sn93.5/Ag3.5/Bi3 216-220 5.92 0.269 1.59 +110%
Sn96.5/Ag3.5 221 6.32 0.368 2.33 +125%
Sn99.3/Cu0.7 227 3.48 0.264 0.92 +23%
Sn95/Sb5 232-240 3.37 0.263 0.88 +17%

Table 3: The most commonly considered alloy alternatives. (Source: Internal Research)

Manufacturing Processes

Currently, when solder is produced, metal ingots of each of the alloys are put into the solder manufacturer's solder pots in the proper ratio. For example, if the manufacturer wishes to produce bar solder of the alloy Sn60/Pb40, he fills the capacity of the pot with 60% tin ingots and 40% lead ingots. They are melted together and the bars we put into
the solder pots of our wave solder machines are formed from this. He can take that same alloy and extract wire for wire solder. If Sn63/Pb37 solder paste is to be made, he again puts into a solder pot 63% tin ingots and 37% lead ingots and the resulting solder is
atomized by a special process, usually using a series of sieves to derive the powder of the specified diameter (for example between 38 and 53 microns for Type 3 paste).

However, tertiary and quaternary alloys being considered will require far more accuracy and control of composition. Rather than simply adding the individual metals at the point of manufacturing (of the solder), the manufacturer will most likely have to add an
additional step of pre-composing the alloys.

Composing an alloy with 96.3% of one metal, 3% of another and 0.7% of a third element demands more precision than might be expected to be carried out at the pot. These metals will have to be combined under
tightly controlled conditions and that resulting alloy sent to the machine center where the solder will be manufactured. This extra step and handling results in additional cost of manufacturing.

Bear in mind not everyone is going to switch over to lead-free simultaneously and when they do, not necessarily to the same alloy. This puts a burden on the solder manufacturer to carry a far more extensive product line, albeit with diminishing volume on many
alloys. This adds a lot of in-process work including "sanitizing??? the solder pots and other equipment used in between runs of different alloys to maintain purity.

Finally, the higher liquidus point of all of the leading lead-free alloys will require significantly more energy to alloy and process. In some cases, this energy requirement may more than double due to the low volume of the individual alloys and the need to potentially melt the alloy more than once to make the final product due the aforementioned smaller production runs.

Patents
As discussed in an earlier column3, the National Electronics
Manufacturing Initiative's
(NEMI) lead-free solder roadmap was attempting to derive a "standard??? for a lead-free 3 Zarrow, Phil, "Lead-Free: Don't Fight a Fact - Deal With It!???, Circuits Assembly , August, 1999 alloy that was not subject to a patent. The motive was that an industry standard should not allow an individual to profit simply by virtue of intellectual property. Noble or not,
this turned out to be somewhat altruistic - such a path turned out to be a jaunt through a minefield. There are patents originating in North America and Japan. Virtually all of the best alloys in terms of soldering, manufacturing and reliability characteristics are covered by patents. All the key combinations of tin, silver, copper, bismuth and antimony are
spoken for, including SnAgCu.

The result is that we can most likely expect part of the cost of a lead-free solder alloy to be royalties to some person or entity. This will likely add somewhere between 2 - 8% to the cost of the alloy. Hey NEMI, thanks for trying.

It should be noted that, regardless of the extent of adaptation of lead-free solders and finishes, recycling and reclamation is still a very viable direction. Instead of developing and trashing a better and now more expensive class of waste products, let's recycle what we have. Remember, we're all in this together.

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Informations

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Congrès Rie,

Cet événement est organisé par le 'Regroupement de l'Industrie Électronique (Rie)', conjointement avec le Ministère du Développement Économique et Régional et de la Recherche (MDERR) et Développement Économique Canada (DEC). Ce congrès tournera autour de l' "Évaluation de l'impact de la nouvelle législation européenne RoHS's et WEEE's sur l'industrie électronique au Québec "

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