

## Newsletter No. 2 April 2005



### Editorial

Welcome to the second NZTE/Electronics South RoHS and WEEE news letter. In this issue I will be covering reliability issues with 3 articles that I have found on the net covering Tin Whiskers and the lesser known Tin Pest. I also have some clarification on NiCad batteries and RoHS.

It is heartening to see a good number of local companies well down the track to compliance. Most of the major companies have gone beyond first base where the question is asked “does this apply to us” and the ensuing exploration of scope and exemptions, which in a number of cases ends up in The Grey Area. Talking of The Grey Area – the EU have stated that they expect to release a RoHS scope clarification document mid 2005.

When this clarification document is released I will be holding a one day seminar in Christchurch to update industry on the changes. The major area of concern for clarification is the definition of “industrial scale tools”. The EU Technical Adaptation Committee (TAC) minutes from 2003/2004 indicated that they were considering that this would include most items that did not have a plug on the end and/or needed to be installed by a professional, however a more recent communication I have has indicated that this may only apply to power stations, oil refineries and such like. However it would be unrealistic for the TAC to make a ruling this close to the due compliance date and not allow some phased implementation method.

Well that’s enough rambling from the Editor for this issue. Many thanks to all who have

sent back supportive comments regarding this newsletter – your feedback is always gratefully received. I can be contacted on [rsommer@sommerconsulting.co.nz](mailto:rsommer@sommerconsulting.co.nz) if there is any specific topic that anyone wants covered please email me and I will do my best to cover it in the next issue.

Roland Sommer

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### Update on WEEE implementation

Since the last newsletter the EU have issued a statement on the implementation of WEEE.

The full document is available on the WEEE/Legislation and Progress page of [www.electronicssouth.com](http://www.electronicssouth.com) – RoHS and WEEE.

The main points are:  
RoHS

- No delay in RoHS - 1 July 2006 is still D-day

WEEE

- No delay in transposing WEEE into law, however the take back obligations are delayed until January 2006.
- No delay in requirements for marking of equipment
- No delay in requirement for calculation of historical waste for period January to Dec 2004
- Producers can register individually or their compliance schemes may handle this for them
- Further announcements of arrangements for registration and data reporting will be made in advance of the opening of registration this summer (UK Summer), however the government expects registration will be with the environment agencies (note the UK has separate agencies for England, Scotland, Wales and Ireland).

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- Confirmation on voluntary approach for visible fee

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**TAC Update**

The TAC met on 16 March and again voted to accept the 8 exemptions that it had previously voted in December to accept. None of these will affect NZ manufacturers. There was also discussion on the development in the medium to long term of non mandatory standards for compliance testing and supply chain reporting formats. These are likely to be based around the JEDEC and IPC 1752 standards outlined in the last newsletter. Considering the issues surrounding scope the meeting minutes were under-inspiring. The minutes can be found on the "legislation" page under the RoHS section of [www.electronicssouth.com](http://www.electronicssouth.com)

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**RoHS and Batteries**

Article 9 of the RoHS Directive states "This Directive should apply without prejudice to Community legislation on safety and health requirements and specific Community waste management legislation, in particular Council Directive 91/157/EEC of 18 March 1991 on batteries and accumulators containing certain dangerous substances"

This basically means that batteries are subject to the Batteries Directive and not to the RoHS Directive.

The following is an extract from an email from ERA Technology in the UK who are one of the main advisors to the UK Department of Trade and industry for RoHS and WEEE

*Batteries are clearly excluded from the scope of the RoHS directive. Although this is not stated in the directive or legislation,*

*except the French decree, this has been clearly stated as batteries are covered by the batteries directive.*

*The new battery directive has an exemption for industrial nickel cadmium batteries.*

Note however the WEEE directive states that batteries must be able to be removed from the equipment for separate treatment and it is inferred that any recycling documentation supplied should give instructions on how to remove the batteries.

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**Threat of Tin Whiskers Haunts Rush to Lead-Free**

By Rob Spiegel -- *Electronic News*, 3/17/2005

With the move to lead-free components upon the electronics industry, many companies are haunted with worry about tin whiskers produced by pure tin plating in solder.

The warnings are coming primarily from the engineering community -- particularly those in aerospace and military organizations. In the world of commercial electronics, there's less concern with tin whiskers and more concern with complying new environmental laws that ban lead and other hazardous materials.

Two very real fears have gripped the electronic industry. One is the fate Sony suffered when The Netherlands held back 1.3 million of its PlayStation game consoles in December 2001 because there was cadmium in its cables. The Netherlands government, which has strict laws against products with cadmium, was tipped by a Sony competitor. And two is the fate of the \$250 million Galaxy 4 communications satellite that shut down in its cold, empty space orbit. Engineers believe the cause

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was tin whiskers growing under the extreme pressures of space. When the whisker grows long enough, it can break off and create a short circuit.

Commercial electronics manufacturers are most fearful of Sony's fate -- losing sales in markets that enforce Restriction of Hazardous Materials (RoHS) standards. Military, aerospace and hi-rel manufacturers are most concerned about the fate of Galaxy 4 -- potential equipment failure due to pure tin soldering growing tin whiskers that break off and short out the product.

The RoHS, passed by the European Union in 2002, bans the sale of products containing lead and other hazardous materials and goes into effect on July 1, 2006. But in order to make that deadline, the electronics industry is moving now to products that use tin soldering, which doesn't contain the 2 percent or 3 percent lead that has proved over the last 50 years to dampen the whiskering phenomenon. RoHS applies to all electronic products, exempt those produced by the military and portions of the telecommunications industry.

No definitive explanation has been given for the whiskering, though it is known to be mitigated by the presence of some lead, gold, antimony or indium. Gold has been cited as the most successful additive besides lead in controlling whiskering, but it adds to the cost of the component and has not been used widely. For the most part, RoHS-compliant components use pure tin. Some in the components industry say that only electroplated tin will grow electrically conductive tin whiskers. Yet many engineers insist that any form of pure tin will grow whiskers.

Engineers have found that pure tin grows whiskers mostly in high-stress environments. "I have some parts that are pure tin and they are 12 to 15 years old, and there are no tin whiskers," said a Lockheed Martin engineer who was willing to speak with *Electronic News* anonymously. "Whisker growth

requires mechanical stress, a torque force, pressure on the metal itself."

The military has been exempted from RoHS regulations so they can avoid potential failure due to the use of pure tin. But the Lockheed Martin engineer points out that the military has increasingly turned to commercial-grade components for the cost savings, and those components will quickly shift to lead-free versions. He also noted that commercial jets and life-support medical equipment will be vulnerable to tin-whisker malfunctions because these products are not exempt from RoHS rules.

Over at component producer Actel Corp., executives note they will continue to produce commercial leaded components for customers in the military and telecommunications industries. "The military and aerospace do buy commercial products, but we will still offer components containing lead for exempt customers," Cindy Newell, Actel's tactical marketing manager, said.

Newell notes that Actel has switched much of its shipment to lead-free components and there has not been a rise in returns due to tin whiskering. "We've been shipping lead-free product for over a year and we have not had a customer come back and say we have an issue with whiskers," she said.

Meanwhile, the Lockheed Martin engineer contends that you often can't easily identify whiskering as the source of a failed product. The whisker often vaporizes when it shorts out a system, so when engineers open the product to see why it failed, there's no whisker apparent. He also noted that when a \$49 cell phone fails, there is typically not an investigation into the source of the failure and thus tin whiskering may be causing difficulties in commercial products without being identified as the culprit. Newell countered that Actel has not seen an increase in reported product failures for any reason since it started shipping lead-free components.

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At component producer Integrated Device Technology Inc. (IDT), executives acknowledge that pure tin can produce whiskers, but they insist the whiskers are harmless. "We do believe that given the right conditions, tin whiskers will grow," Anne Katz, IDT's VP of worldwide assembly and test operations, said. "What we disagree with is the likelihood of the product shorting out."

Katz said IDT tested lead-free versions of its components extensively and adopted a manufacturing process that produces lead-free parts that are unlikely to have whiskering problems. "We have developed a proprietary process that mitigates whisker growth. We spent thousands of hours testing our components. Some have spent over a years under stress, and there's no whisker growth."

Jerry Czerwonka, director of quality assurance for Avnet EM in the Americas, the components business at Phoenix-based Avnet Inc., noted that most of the worry over tin whiskers comes from engineers in the military and aerospace. "When you talk to the military and aerospace people, they say whiskers are very real, but when you talk to the commercial commodity folks, they say, 'Hey, it's no problem.'"

Czerwonka believes that the phenomenon of smacking a malfunctioning electronics product to make it work again is likely a tin whisker problem. You hit the product and the malfunction goes away because you've dislodged a whisker that was shorting out the system. "That's not a big deal if you have an inexpensive commercial product," Czerwonka said. "But let's say you have a satellite that cost billions. You can't get a Martian to thump it on its head and make it work again."

Like the Lockheed Martin engineer, Czerwonka believes that most vulnerable area for lead-free products comes from the commercial-grade components that are designed into military and aerospace

systems. "The military went to commercial best practices, and now the commercial products are going to lead-free components," he said, adding that the military can't simply redesign products to switch to leaded military-grade components. "When you're talking about a missile, you can't just redesign it."

Like Actel, some component suppliers say that's not a problem because they intend to continue producing components with lead content, as well as lead-free parts. But military engineers question how long suppliers will continue to produce leaded parts if the market shrinks to the small portion of the electronics market this is exempt from RoHS.

According to Ken O'Neill, Actel's director of military and aerospace product marketing, any phase out of leaded components would come under the company's normal phase-out procedures. "If we had a leaded product phase out, it would be under our usual 18 month cycle, so there would be plenty of warning."

**The 'Other' Tin Issue: Tin Pest**

*Advanced Packaging* April, 2005  
**Author(s)** : Leo M. Higgins III

Most IC packaging technologists are aware of this "other" issue, but this topic has never required serious consideration. The issue is the phase transition in experiences when cooled through 13°C. The result of this transition, called tin pest, is reported to cause historic tin objects to disintegrate into a dark, powdery material. This transition is not a rapid, spontaneous change, and may take years to initiate, but some in the electronics industry are beginning to ask questions about it. Some experts in the field of tin finishing have reported the inability to induce tin pest in pure tin deposits, so much remains to be learned.

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Normal, "white" Sn (beta phase) undergoes a crystal phase transition (polymorphic or allotropic transition) to brittle, alpha "gray" Sn, upon cooling below 13°C. The tendency for this transition to occur is enhanced by the presence of certain impurities, such as Al or Zn, in the Sn. Colder temperatures also accelerate the transition, reaching a maximum transition rate between -30° and -40°C. It also has been reported that the solution of appropriate levels (possibly only 0.1 to 0.5 mass %) of suitable metals, such as Sb or Bi, may inhibit the transition or drive the initiation temperature so low that it is not relevant, or where the low temperature itself may oppose the atomic reordering required in the transition. Another brittle phase transition occurs at 161°C, but it appears that the typically rapid cooling rate seen in electronic assembly avoids this transition - resulting in the formation of the ductile beta phase when solidified (See Table).

### Crystal Phases of Tin

Tin phase	Transition temp.	Tin density (g/cc)	Volume change
Alpha	13°C (beta to alpha)	5.75	+26%
Beta	Stable (Room temp. to typical elec. application environments)	7.28	----
Gamma	161°C (beta to gamma)	6.54	+10% (approx.)

The beta-to-alpha molar volume increase of 26% causes the disintegration of Sn objects. This "swelling" might not be a problem if the alpha tin retained the ductility of beta Sn. Alpha Sn, however, is brittle like neighboring members of the Periodic Table Group 14 (C, Si, Ge, Sn, and Pb). Alpha Sn shares other characteristics with its sister elements, Ge and Si. In the transition, metallic beta Sn converts to semiconductor alpha Sn, and the alpha Sn phase crystal structure is diamond cubic, just like silicon. The transition swelling causes high stress levels in the brittle alpha crystal lattice, resulting in its crumbling into a dark powder. White Sn is a unique metal that does not show the atomic ordering of common metals. Instead, the highly ordered

Sn tetrahedrals exhibit preferred directional bonding that is characteristic of covalently bonded non-metals.

Tin rods are known to "squeak" when bent, due to strain in the directionally bonded crystal structure. Most lead-free solders being considered for the electronics market consist of  $\geq 90$  mass % Sn. Sn-Cu and SAC solders possess an almost pure tin matrix phase, because of the low solubility of Ag and Cu in solid Sn. In 2001, Plumbridge, from The Open University in the U.K., reported that tin pest will occur in bulk Sn-0.5Cu solder bars held at -18°C for up to 2 years. At NEPCON 2004, Plumbridge and Rist showed that tin pest can occur in bulk Sn-3.8Ag-0.7Cu solder cylinders under the same conditions, although the severity appeared much reduced.

It remains to be demonstrated that tin pest may occur in lead-free electronics. Leadframe-based electronic components commonly were plated with Sn or Sn-dipped until approximately the mid-1970s, when the addition of lead to the tin-plating chemistry was mandated to mitigate tin whiskering.

In a recent, extensive, web-based literature search, no references were found recounting the failure of electronics from tin pest, although it is recognized that little or no assembly used lead-free solders, even with Sn-plated components. This may be due to the composition of the Sn finishes, thin Sn layers, base leadframe substrate effects, morphology of the Sn, Sn stress state, high purity of Sn, etc. These factors may be significant and cause effects that differ from those reported on the large bulk results in Plumbridge's work. Or, they may have nothing to do with the results on the test bars. Could the beta-to-alpha transition in the large bars be affected by unintended low-level impurities in the bulk metals, residual stresses from casting, surface contamination, surface morphology imposed by the mold, cooling rate gradients, etc.?

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Presently, there is no body of evidence declaring tin pest to be a clear concern. I believe the industry should not be complacent, and the issue should be addressed by open industry consoria efforts. At least one significant study appears to be underway at the University of Maryland (CALCE), with results due this year.



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### Long-Term Reliability of Pb-Free Electronics

(copied verbatim from Circuitnet)

Many electronics companies are in the process of converting from lead-based alloys to lead-free in electronics, both to comply with government legislations and to increase market share through product differentiation. Considering that lead-based electronics have been in use for over 40 years, the adoption of lead-free technology represents a dramatic change.

Key issues that are being addressed by academia and industry include lead-free solder alloy selection, characterization of lead-free solder alloy properties and behavior under various stress loading conditions, lead-free manufacturing, logistics and intellectual property issues, and lead-free assembly reliability assessment.

Although abundant data exist on the short-term reliability of lead-free solder joints (i.e. less than 5 years) under single loading conditions, long-term reliability is still unknown. Lead-free electronics are

expected to be deployed in many products that require greater than 5 years of reliability, often in environments exhibiting extremes in temperature, vibration and contaminants.

In order to assess the long-term reliability of lead-free electronics, a consortium of Universities and companies led by the CALCE Electronic Products and Systems Center at the University of Maryland has initiated the long-term lead-free reliability program. This program involves collaboration with Aero combined Environment Laboratory of China Aero-Polytechnology Establishment, Hong Kong University of Science and Technology, Wroclaw University of Technology in Poland and many companies engaged in telecommunication, industrial, aerospace, and oil exploration businesses.

The study involves the design, manufacture, test and analysis of PCB assemblies with the objective of obtaining critical information related to the long-term (5-15 years) reliability of lead-free assemblies. The test conditions include long-term high temperature and low temperature aging, vibration after aging treatment, long-term temperature cycling, and combined thermal-mechanical loading. The key results expected from this long-term reliability studies include:

- 1) Extent of the growth of intermetallics in the solder joints as a function of commercially available PCB pad finishes and component finishes
- 2) Assessment of any yet-unknown risks, such as tin pest of high tin solders joints after long-term exposure to low temperature
- 3) Impact of PCB degradation due to high temperature lead-free soldering in causing corrosion failures and degradation in insulation resistance between solder interconnects

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- 4) Vibration fatigue life and failure modes of lead-free solder joints with thicker intermetallics, and possibly with tin pest
- 5) Failure mechanisms, mode in solder joint failures in the combined temperature cycling + vibration tests
- 6) Long-term life of lead-free assembly in comparison with the eutectic tin-lead solder.

More information can be found at [www.calce.umd.edu](http://www.calce.umd.edu).

*Sanka Ganesan, Ji Wu, and Michael Pecht*

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**437 Days to go** by Ron Daniels editor of Circuitnet

As of today, April 19, 2005, the electronics industry in North America and across the globe has 437 days left to RoHS compliance. Sounds like a lot of time, doesn't it? Look at it this way – we have 14 months and 8 days or 1 year, 2 months and 8 days to comply (give or take a day and a few hours).

The acquisition of an assembly line takes an average of 13 months (unless production requirements dictate otherwise), including planning, research, equipment evaluation, purchase, intallation and integration – one month less that the RoHS compliance deadline and not as many headaches or as many elements to research.

Here's another way to look at it. According to the National Association of Real Estate Brokers, it takes 16 months, to purchase a house. That's counting the intial decision, shopping for a location, finding the right model, contracting, build and move in. The National average for cost of acquisition is around \$200,000 US – a lot less that it will probably cost to comply to RoHS.

I encourage you to start now if you haven't already begun your planning. There's a heck of a lot to do. The biggest and most complex job will be scouring your BOMs. You must assure that

your incoming materials will be RoHS compliant (hint – it's not only lead that's banned). If you have the luxury of dictating surface finishes for PCBs and components (not many of us will), start your research and testing. If not, start your research and testing of the multitude of choices available.

Take a look at your work instructions, are they compliant with IPC-A-610D? This new revision provides photos and acceptance criteria for lead-free soldering – get a copy. Are you preparing to train your operators for the changes?

Moving away from the paperwork needed to comply, let's talk about equipment. How's your reflow oven? Does it have the capabilities to provide the profile needed for the SAC and other lead-free alloys? How 'bout that pot in the wave solder machine? Is it stainless steel? If so, you're going to have to change it *and* the pump system.

Are you working with your x-ray and AOI equipment suppliers to determine the changes to your inspection algorithms and setup?

And finally, do you have the new lead-free process ready to go? This is one of the most important steps to compliance, but also the one that will take the least amount of time to complete. All the other elements to assure compliance will take far longer and are more complicated.

Get 'er done!

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