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Agilent Technologies Responses to Exemption Request No. 18

"Lead used in compliant pin connector systems for use in monitoring and control instruments (Category 9)"

Dear Ms. Zangl,

Please find attached below the stakeholder contribution from Agilent Technologies answering your questionnaire for Exemption Request No.18

Agilent Technologies supports this request, underpinned by the technical contributions from University of Maryland, Center for Advanced Lifecycle Engineering (CALCE) and Purdue University, Materials Engineering.

Please don't hesitate to contact me directly should any further clarifications be required.

Sincerely,

Julie Silk,
Environmental Compliance Technical Program Manager

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"Lead used in compliant pin connector systems for use in monitoring and control instruments (Category 9)"

1. **Please state whether you either support the applicant's request or whether you would like to provide argumentation against the applicant's request. In both cases please provide detailed technical argumentation / evidence in line with the criteria in Art. 5 (1) (a) to support your statement.**

Agilent Technologies supports this request, with agreement and contribution to the technical argumentation from Michael Osterman, PhD, of University of Maryland, Center for Advanced Lifecycle Engineering (CALCE) and Carol Handwerker, PhD, of Purdue University, Materials Engineering. The concerns with insertion and retention forces have been resolved with careful selection of printed circuit board (PCB) finishes and appropriate PCB thickness. For monitoring and control instruments, where long life is important, the risk of tin (Sn) whiskers from Sn-plating is of great concern. There is much about tin whisker formation that is still not known. We do know that compression of the Sn contributes to tin whisker growth, and that compliant pin connectors necessarily compress the plating as they are inserted into holes in the printed circuit board.

The connector industry has already started to replace some tin-lead (SnPb) pin plating with pure Sn plating. Qualifications still show both success and failure of tin-plated pins, with tests performed at a reputable OEM as recently as January 2012 showing significant tin whisker formation. These whiskers formed on both eye-of-needle and action-pin type compliant pins. The whiskers were not specific to a lot, manufacturer or pin type. Whiskers formed in 1000 hours at ambient conditions, with a similar time-frame for samples at 85°C and 85%RH. Pictures of field failures that motivated the testing are shown in Figure 1.

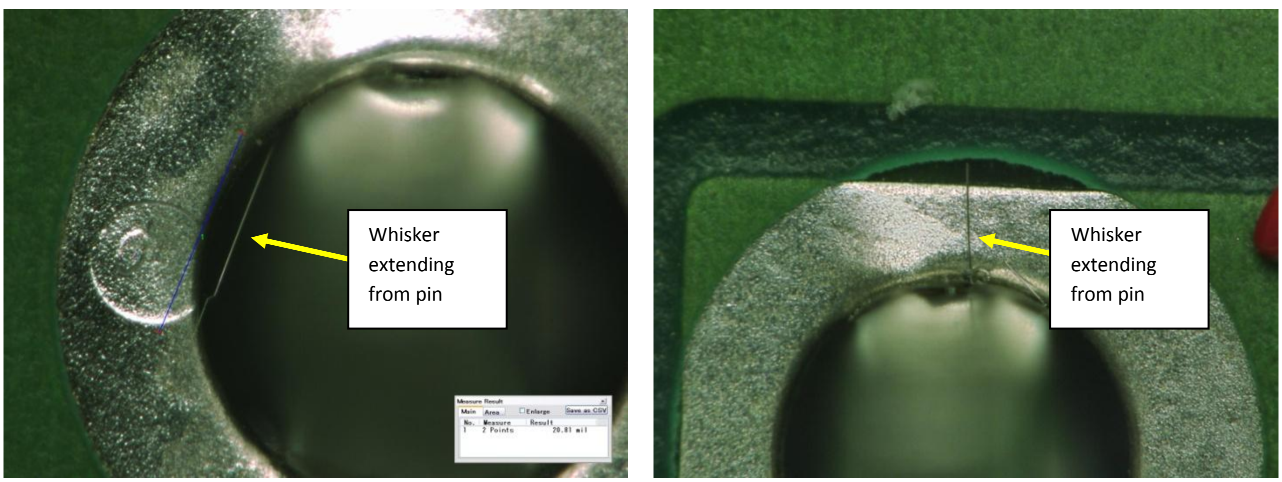

Figure 1. Examples of tin whiskers growing from compliant pin connector pins with Sn over Ni plating. Assembled April 2010, failed July 2011, photographed October 2011

Tin whisker formation has been observed to occur when compressive stresses are applied to tin finished surfaces. Crystal filaments of tin erupt from areas adjacent to the stressed region. The formation of tin whiskers is considered a stress relief mechanism. The whiskers formed by these filaments of tin, even though very thin, can be long and robust and can short out electronic circuitry. Recent failures of Toyota accelerator petal assemblies which have been positively linked to tin whisker formation demonstrate the threat posed by the use of tin finish [Sood et al and Leidecker] . The compressive stress in tin can occur in many ways. With compliant pin systems, the pin necessarily compresses as it is pressed into the barrel of a hole in the printed circuit board. The plating in both pin and PCB are compressed. The effect on the PCB side can be minimized by careful plating selection. When the pin is tin-plated and has no Pb content to mitigate the formation of whiskers, there is a risk of reliability failures. Alternative platings to Sn have not been demonstrated to be viable yet, such as gold which has higher insertion force and lower retention force.

Studies of whisker formation indicate several potential drivers for whisker growth on tin and tin based lead free surface finishes. Whisker growth drivers include substrate to tin interfacial intermetallics, surface oxidation, surface corrosion, and compressive surface loads. With regard to contact surfaces, Shibutani et al have shown that the creep behavior of the lead-free tin film plays a role in whiskers formed by mechanical compressive surface loads. Panashchenko and Osterman found that extensive whisker growth can occur after extended periods with no observable growth when stress state in the ambient environment changes. Panashchenko found in a review of multiple test conditions, no discernible acceleration factor. Since current test methods do not provide consistent results and no acceleration models or test methods have been demonstrated for long term estimation of whisker growth, the use of lead-free tin finish on compliant pins can present a significant reliability risk. Depending on the application, the risk could escalate to a safety issue. Recent studies at CALCE have indicated that metal vapor arc formation due to tin whiskers could occur in applications with less than 50 volts in ambient conditions. The growth of whiskers has been found to be highly variable with a lognormal distribution fitting populations of whisker lengths [Fang et al]. As such, when whisker growth occurs, a small subset of long whiskers are possible, which presents non-zero risk of failure when using tin whisker-prone plating types.

References:

- C.Gensch, S. Zangl, R. Gross, A. Weber, O. Deubzer, Adaptation to scientific and technical progress under Directive 2002/95/EC Final Report, Öko-Institut, Fraunhofer, 20 February 2009
- T. Shibutani, Q. Yu, M. Shiratori, M. Pecht, Pressure-induced Tin Whisker Formation, Microelectronics Reliability, Vol. 48, pp. 1033-1039, 2008
- Lyudmyla Panashchenko and Michael Osterman, Examination of Nickel Underlayer as a Tin Whisker Mitigator , Electronic Component and Technology Conference, May 2009.
- Lyudmyla Panashchenko, Evaluation of Environmental Tests for Tin Whisker Assessment, University of Maryland, College Park, MD
- T. Fang, M. Osterman, S. Mathew, and M. Pecht, Tin Whisker Risk Assessment, Circuit World, Vol. 32, No. 3, pp 25-29, May. 2006.
- G. Chou, R. Hilty, Toward Lead-Free Compliant Pin Connectors, SMTA International conference proceedings, September 2005

2. The applicant asks for an extension of the exemption until 2021. Do you agree with this expiry date, or would an earlier expiry be feasible in case the exemption is justified?

The evidence above needs to be reviewed by the compliant pin connector industry to evaluate further alternative RoHS compliant termination finishes that meet the long-term reliability needs of the electronics industry. As this work has still to be initiated, it will take an indeterminate time at this point to develop and make available more reliable alternative compliant pin connector components. This should be reviewed in line with the Exemption durations specified in the RoHS Recast.

3. Do you consider any other aspects or details to be of importance, which have not yet been taken into account?

One of the preferred mitigations for Tin whisker growth in termination finishes for lead-free solder applications is Tin over Nickel under plating. This has been successful where there are no further compressive stresses either during or following the solder process. By their very nature, compliant pin connectors are subject to compression stresses during assembly into a PCA. The evidence above illustrates the state of the art for lead-free compliant pin connectors cannot be considered immune from Tin Whisker growth. Consequently, the long-term reliability of these components is not assured.

Julie Silk, Environmental Compliance Technical Program Manager

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