Introduction to the request for exemptions to apply to category 9

Exemption for ": Lead used in compliant pin connector systems for use in industrial monitoring and control instruments (only sub-category 9 industrial)" exemption to expire in 2024

Background

There is widespread use of lead within compliant pin connector systems within industrial and professional monitoring and control instruments, including many custom parts. The long-term reliability of all alternatives to C-press compliant pin connector systems ***had until 2012 not been evaluated for our applications***. In this year we had external and independent research done into the compliant pin connector substitutes which yielded alarming results in speeded aging tests. Products with nickel plated boards – meant to inhibit tin whisker growth – showed unacceptable and dangerous whiskers within an estimated 2 year span. The results of this test are too alarming to ignore for our sector as the measurement and control instruments in question often manage system critical applications such as ground control radar and the like.

The known alternatives are rather new it has not yet been possible to put them through environment aging tests to ascertain long term reliability in our applications. Unlike other types of equipment the pin connector systems are part of the core of the instrument and need to last the lifetime of the product. Many applications in different sectors like the automotive or card based machines are more easily fixed by merely scheduling the replacement after an x number of years of the card with the pin compliant connector. This is not the case for category 9 industrial. Any forced change to follow the revised exemption requirements would require significant data collection from the supply chain, product review, redesign and requalification.

The Test & Measurement sector

The Test & Measurement coalition represents over half of the world's industrial / professional test and measurement equipment manufacturers, including Agilent, Anritsu, Fluke, Keithley, National Instruments and Tektronix. The coalition members specialize in high end, very complex test and measurement instruments, classified under RoHS as industrial monitoring and control instruments, which are designed for exclusively industrial or professional use. The complex, advanced technology of the components present in this sector's product renders the transitioning to new RoHS compliant parts more difficult than for other companies in the electronics market as outlined below and confirmed by numerous parliament sectioned RoHS consultants:

1) The coalition members' products are used to design and build cutting edge technological equipment and are themselves therefore one step more advanced and complex than any product developed or manufactured utilizing our Industrial monitoring and Control instruments. This places extraordinary constraints as regards to reliability, performance and quality, quite unlike consumer equipment;
2) Unlike most commonly available electronics, approximately 15-20% of all parts used in instruments manufactured by the Coalition members are custom made. Redesign is therefore both specific and does not benefit from any efficiencies of scale such as manufacturers of mass-produced parts enjoy;
3) As measurement equipment, many of the coalition member's products need to undergo formal third-party qualification and / or certification. This process is lengthy and bureaucratic and requires additional review upon any material change to the instrument;
4) Test & Measurement equipment have an average life span of 10 years with some products sold with guarantees to operate correctly for as long as 30 years;
5) Test & Measurement equipment, because of its longevity and complexity, goes through less frequent and slower redesign cycles than typical consumer electronics. Normally a full redesign isn't done for a minimum of 3 years, and 7 year redesign intervals are not unusual. Once undertaken, the time required to redesign and fully requalify a product can take two to three years. For a more limited enhancement of a product a year is not unusual. A ground-up development and design of a completely new product can take even longer, on the order of 3 - 5 years. The Coalition member's companies have specialized resources in place to deal with such cycles under normal conditions but would not be able to undertake unplanned rapid redesigns of existing equipment driven by unexpected exemption withdrawals;
6) Unlike other sectors, Coalition members produce a huge quantity of different kinds of products in rather low volumes (sometimes as few as one instrument sold a year). The extremely high technical level at which these instruments are manufactured and the limited pool of specialized engineers compared to the number of products results in further slowing the redesign cycles. By way of example – Agilent, the largest manufacturer produces approximately 27,000 different types of instruments compared for example to Nokia, a well-known consumer goods manufacturer, who has no more than 30[1] different product subject to REACH but ten times the number of engineers. The seeming slowness in transitioning by industrial category 9 is therefore not due to a lack of effort or willingness but simply by the

[1] From Nokia's corporate website: http://investors.nokia.com/phoenix.zhtml?c=107224&p=irol-productPortfolio

sheer scale and limited human, technical and financial resources available to make the transition;

7) Test and Measurement product complexity is reflected in part count, which can be several thousands of components in a single instrument. This adds to the burden of developing appropriate materials compliance systems that provide reconcilable proof of compliance. Furthermore, many parts have multiple suppliers to assure production. This multiplies the number of suppliers' declarations required;

Socio-economic effects if exemptions are not granted

The loss of expected exemptions has four key socio-economic impacts to the Measurement and Control industry due to rework of previously completed activities:

1. Compliance IT Systems for data storage and product-level compliance analysis must be reviewed and potentially reconfigured to account for unexpected exemption withdrawals.

2. Renewal of Supplier's declarations for any part relying on an expired exemption where there is no clear mapping or equivalent in the new exemption structure.

3. Products developed and released to the market which were expected to meet the RoHS Substance Restrictions will have to be re-evaluated after new part compliance data has been obtained.

4. Exemption 18a concerns a very limited amount of lead used in specific high pin intensity arrays. The environmental cost associated with their continued use is truly minimal compared to the risk associated with the introduction of untested and possibly unreliable compliant pin connectors with lead free solutions. By analogy to the REACH model for socio economic monetization of health/environment it is possible to monetize the cost of the maintenance of the exemption for example for ground radar:

    a. There are ca. 5 million flight movements in Europe each year;

    b. Lets presume the chance that a fault develops due to a whisker is 1:100,000;

    c. Lets presume further more that the chance the fault causes a fatal error is likewise 1:100,000

    d. Lets presume each such fatal fault might cause 150 fatalities;

e. The cost of a fatality – based on European Commission norms – is ca. €1 million euros.

   This means that the cost would be ca. € 50,000 based merely on the direct costs attributable to individuals that are deceased. Even though this is a small amount for sure the potential environmental cost for exposure to a few grams of lead from the extremely rare piece of equipment that is not recycled cannot exceed this. It is therefore a socio-economically unsound decision to withdraw this exemption until full certainty has been obtained regarding the reliability of the lead free alternatives.

5. Given that the products have very long lifetimes and are generally 100% recycled they comprise only a tiny part of the total waste stream, the environmental benefits that might be obtained are minimal whereas the economic and social effects of product withdrawal and the lack of access to T&M equipment for EU industries would be tremendous.

These impacts cannot be resolved simply by adding more engineering effort. All five aspects would take away existing resources from planned new product development activities. This effectively penalizes manufacturers who invested resources in developing RoHS compliant products in parallel to the regulations development to bring them into scope.

Rationale for exemption 18a

1) The unique applications in our sector are:
   a. Instruments are portable and have to survive use and transportation over a typical life of 10 years;
   b. Products are specified to operate over a wide range of temperature and vibration environments (unlike ITE equipment);
   c. Multi-pin data interfaces operating with very high speed data rates;
   d. Compliant-pin connectors allow the maximum connectivity per unit area on a printed circuit board, meeting the needs of improved signal density and integrity;
   e. The long-term reliability of the compliant-pin connector to printed circuit board joint is a fundamental requirement: they are required to last the lifetime of the Instrument;

f. Compliant-pin connectors are not reworked or replaced in Instruments due to reliability issues with the subsequent compliant-pin to PCB joint;

g. It is not possible to solder alternative connectors reliably due to the pin density and subsequent heat-sinking thermal properties of the PCA.

2) The primary products that utilize this connection methodology include:

a. High speed digitizers

b. RF & uWave signal sources

c. Wireless test equipment

As originally submitted, the long-term reliability of lead-free alternatives remains in question. Studies since the "substitution of lead in pin compliant connectors was found to be scientifically and technically practicable" continue to raise questions regarding the reliability of the substitute, particularly in relation to high-reliability, long-life products such as Industrial Monitoring and Control Instruments.

> "From these findings, tin finished press fit connectors should certainly be considered a failure risk. Literature does show that the addition of as little as 3 percent lead significantly mitigates the risk of long tin whisker formation that has been associated with electronic system failures."

Michael Osterman, Ph.D.
CALCE Operations Director
October 26, 2012.

Consequently, the reliability of substitutes is *not ensured* for products within cat 9 industrial sector, which is due cause for an extension to be granted while further investigations are undertaken.

3) The research by Calce and iNEMI show unacceptable reliability issues possibly connected with the compression force exerted in the connectors in the application.

Given the above, considerable life-time buys of tin-lead compliant pin connectors have been made to assure continued supply of these components for our applications. These last time buys are kept in moisture proof bags together with a desiccant. There

remain a number of these connectors available on the market today. While many suppliers are transitioning to lead-free alternatives, the continued availability of leaded compliant pin connector systems depends on an appropriate exemption continuing to be available under the RoHS Directive.

4) Investigations into the long-term reliability of lead-free compliant-pin connectors in our instruments are only being initiated now;
5) Once the long term reliability has been established (something we can only hope for at this time) – a process that takes 3 years minimum due to the need for speeded aging tests – we can look at installing the new compliant connectors into the systems and testing after that, this is too close to the 2017 deadline in the best of cases.
6) It has been argued that the exemption as requested is too broadly worded, an alternative wording that would not materially cause harm to the cat 9 sector would be: Lead used in other than C-press compliant pin connector systems for Industrial Monitoring and Control Instruments, exemption to expire in 2024. This wording would cover the needs of the coalition as well as the wording applied for above.
7) The amount of lead involved is minimal. Typically 50mg of lead are used per compliant pin connector of 100 pins. Sales in the EU are about 8300 devices (world-wide 36,000). This means there would be 450 grams of lead put on the EU market and 1.8 kg globally.
8) It has been suggested that there is still sufficient time before July 2017 for unproblematic technologies to be developed however this bypasses the limitations that apply to the T&M sector:

The following aspects need to be considered, evaluated, and proven before completing substitution of parts within our products. It is not possible to “simply” substitute components from a purchasing perspective and have this change roll through the value chain into each product. This extends beyond a simple form, fit, and function evaluation. These reassessment and redesign activities can take weeks to many months to complete, particularly where PCA changes are involved. Where there is a high business impact (resource and cost) product withdrawal from the market is a distinct possibility where there is a limited return on the investment forecast.

- Availability of substitute RoHS-compliant components:
    - Identification of alternative parts available from existing suppliers, or
    - Identification of alternative parts from a new supplier
        - Supplier assessment
        - Supplier acceptance and set-up
        - Supplier management
- Product Complexity – product changes need to be considered from five key perspectives:
    - Impact on published specifications
    - Impact on reliability
    - Impact on regulatory compliance (Safety, EMC, as well as Environment)
        - Manufacturer's ability to self certify
        - Engagement with third-party certification bodies
    - Impact on customer acceptance/approvals
    - Impact on business performance
        - Cost of scrapping old material
            - Especially important if "Life Time Buy" (LTB) had been made for material - potentially many €k impact
        - Cost of re-design
        - Cost of re-work
        - Benefit of continued market access

Changes for specific components need to consider the following attributes. This evaluation tends to be product-specific although results for one product can be leveraged ***for other applications only where*** the component is found to have direct form, fit, and function equivalence.

- Technical Equivalence – tight tolerance of key specifications are required to allow Cat 9 equipment to continue to meet published specifications
    - Electrical Performance
    - Optical Performance (if applicable)

  - Range of operating and storage temperatures
  - Tolerance to physical shock and vibration
  - Specification for operating altitude
  - Specification for operating and storage humidity
  - Availability of appropriate third-party safety certifications (if safety critical)
  - MTBF
- Physical Equivalence – physical size and pin layout must be equivalent to allow drop-in replacement for a specific component. Where this is not possible, the following two considerations also need to be taken into account:
  - PCA complexity – the vast majority of printed circuit assemblies are highly complex with 8~16 layers widely utilized. Any change in the printed circuit board to accommodate a revised component footprint or layout is non-trivial from a layout perspective. Any change in PCA requires a full re-qualification of the product
  - Instrument layout – Any change in physical size of a component also needs to consider the available space around the component. In addition to the obvious issue of physically fitting in the available space, the following impacts need to be considered:
    - Product safety creapage and clearance distances;
    - Impact on airflow through the product and the resulting impact on cooling, and corresponding long-term reliability.

Once changes have been designed, the following sequence of evaluations is required before the product change can be introduced into the market:

- Compliance with published specifications. The Test and Measurement sector produces highly complex, multi-function products. Re-creating NPI-Qualification test systems that exercise and measure the product's parameters is a highly skilled body of work. It should be noted that simply reusing or re-applying production test and calibration systems is not an option as these test a limited set of the product's parameters.
  - Even apparently simple substitutions need to have the relevant parameters associated to the circuit changes proven to meet published specifications.

  - Testing per product – can range from weeks to months depending of complexity of product and scope of changes.
- Assure Reliability is not impacted. – Run through an environmental test suite for weeks to months depending on product complexity
- Long-term reliability of a specific application – life testing: months if accelerated testing to years for critical applications where acceleration is not possible.
- Regulatory compliance evaluations
  - EMC – weeks
  - Safety evaluation – weeks
  - Third-party certifications – weeks to months depending on Agency used.

The sector also uses unique applications of the technology that are not in use with other sectors and therefore are not researched as they were for other sectors such as automotive. The unique applications in cat 9 industrial sector are:

- Instruments are portable and have to survive use and transportation over a typical life of 10 years (see remark on stress involved in portable instruments above)
- Products are specified to operate over a wide range of temperature and vibration environments (unlike ITE equipment)
- Multi-pin data interfaces operating with very high speed data rates (can be >THz);
- Compliant-pin connectors allow the maximum connectivity per unit area on a printed circuit board, meeting the needs of improved signal density and integrity
- The long-term reliability of the compliant-pin connector to printed circuit board joint is a fundamental requirement: they are required to last the lifetime of the Instrument
- Compliant-pin connectors are not reworked or replaced in Instruments due to reliability issues with the subsequent compliant-pin to PCB joint

- It is not possible to solder alternative connectors reliably due to the pin density and subsequent heat-sinking thermal properties of the PCA (Printed circuit assembly)

As OEKO agree, lead-free compliant-pin connector systems are not immune from tin-whiskers. The fit and forget use of the connectors coupled with long lifetime and use-model of the products can introduce the stresses that could initiate tin-whisker growth far more readily than with leaded variants.