Test & Measurement Coalition

RoHS Directive Scope Review

Contribution to Öko-Institut study on RoHS current exemptions

1 April 2008

Introduction to T&M Coalition

The Test & Measurement Coalition represents an ad-hoc grouping of companies active in producing Category 9 type products. The Coalition includes six leading companies in the sector including Agilent Technologies, Anritsu, Fluke Corporation, Keithley Instruments, National Instruments, and Tektronix. We estimate the coalition membership represents roughly 60% of the global production of industrial Test and Measurement products and other Category 9 equipment including chemical analysers.

The Test & Measurement Coalition actively participated in the consultations organised by DG Environment and DG Enterprise regarding RoHS revisions. We have also submitted detailed information to ERA about the exemptions needed for our products. We are pleased now to contribute to the Öko-Institut consultation preparing the study on current RoHS exemptions.

Summary

Category 9 is currently not in the scope of RoHS. Bringing Category 9 into scope will require significant substitution and redesign of the large number of products due to extensive use of lead solder. Assuming that drop-in replacement, compliant components were available, which is not the case for many custom parts, compliance will require re-qualification of virtually all products after new designs are assembled with lead-free solder. Qualification testing alone will have a major impact on our industry and on our customers considering the large number of products we make, even without additional practical issues to solve.

The Coalition strongly emphasises the need to maintain the following exemptions when category 9 will be brought into the scope:

a) Exemption #1 - Mercury in compact fluorescent lamps not exceeding 5mg per lamp.
b) Exemption #5 - Lead in the glass of cathode ray tubes, electronic components and fluorescent tubes.

c) Exemption #6 - Lead as an alloying element in steel containing up to 0.35% lead by weight, aluminum containing up to 0.4% lead by weight and as a copper alloy containing up to 4% lead by weight.
d) Exemption #7
   - Lead in high melting temperature type solders (i.e. lead based alloys containing 85% by weight or more lead).
   - Lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signaling, transmission as well as network management for telecommunication.
   - Lead in electronic ceramic parts (e.g. piezo-electronic devices).
e) Exemption #8 Cadmium and its compounds in electrical contacts and cadmium plating except for applications banned under Directive 91/338/EEC (1) amending Directive 76/769/EEC (2)
f) Exemption # 9 a Deca BDE in polymeric applications
g) Exemption # 11 Lead used in compliant pin connector systems
h) Exemption #13 Lead and cadmium in optical and filter glass
i) Exemption #14 - Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80% and less than 85% by weight.
j) Exemption #15 - Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit Flip Chip packages.
k) Exemption #23 - Lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm or less with NiFe lead frames and lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm or less with copper lead frames.
l) Exemption #24 - Lead in solders for the soldering to machined through hole discoidial and planar array ceramic multilayer capacitors.
m) Pending Exemption: Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes

In addition, we assume no additional regulated materials are added to the EU RoHS Directive and that Maximum Concentration Values for existing RoHS substances are not reduced.

The reason for requesting the extension of the above mentioned exemptions is linked to the specific nature of our products, their design cycles and high reliability requirements:

- Redesign often presents significant technical challenges that take time to resolve – it can be 1-2 years before a new product can be released and 0.5-1 year for an enhancement. A significant amount of the time is required for environmental and safety testing of new designs.
- 15 - 20% of the components used in Test & Measurement products are custom designed for our instruments. As many of our members use around 100,000 different parts today this means redesign and testing of several thousand custom parts for each company.

- Where RoHS compliant components are available, they require extensive testing to verify their long-term reliability when used in Test & Measurements products.
- Test & Measurement products have a long product life (≈10 years on average) and frequent redesign is not common for the sector, further emphasizing the need for extended transition periods to achieve compliance with existing resources.
- Test & Measurement products are extremely complex and there are a limited number of highly qualified engineers available to work on redesign. This will divert significant resources from the development of new, innovative products.
- Material substitutes meeting our customers' reliability criteria are limited in some instances. For example a domestic household product with expected life of five years has more material options for anti-corrosion coating than a Test & Measurement product for outdoor use which customers expect to work reliably for ten years or more.
- Historically, material or component substitutions have been validated through a number of tests under extreme conditions. Testing programmes can last one or two years.
- Preliminary evaluation of several RoHS compliant substitutes in our critical applications has so far yielded less than satisfactory results.

Removal of these exemptions will result in premature withdrawal of the affected products from the EU market when professional Category 9 equipment is brought into the scope of RoHS as redesign will in most cases not be economically viable.

Forced obsolescence will have a significant impact on EU industries using Test & Measurement equipment such as communication, defence, research & development, aerospace, electronic manufactures, industries involved in design manufacturing validation and testing of electrical and electronic components and systems, network equipment manufacturers and network providers, pharmaceuticals, etc. Service, installation and maintenance in thousands of heavy to light industries depend on the availability and reliability of Category 9 equipment.

With early retirement, customers will lose access to tailor-made specialty products which provide unique solution for a unique set of customers. This will have a negative impact on the reliability of these customers' products. Proven safe products will not be available for service, installation and maintenance application in industrial venues.
Forced obsolescence will additionally have a major impact on companies who have invested in modular T&M systems, which can be continually upgraded and replaced.

Exemption 1: "Mercury in compact fluorescent lamps not exceeding 5 mg per lamp"

This exemption is currently in widespread use in the Test and Measurement sector to allow for the sale of products and systems incorporating LCD display technology. Due to the expectation for high reliability in Test and Measurement equipment, industrial display units are used. These display units generally incorporate one or two compact fluorescent lamps which do not exceed 5 mg mercury per lamp.

As downstream users of industrial display technology, test and measurement equipment producers are only able to incorporate the materials made available by display producers. At the current time, commercially viable industrial-grade LCD units using non-mercury LED backlighting are just starting to become available in some of the smaller i9isizes and form factors. It is expected that these substitutions will increase over the next three to five years, making available mercury-free displays for most if not all new designs.

It should be noted, however, that the Electromagnetic Compatibility performance of many Test and Measurement products is highly dependent on the particular display unit used. Should substitution in current designs be required, each replacement will require costly re-qualification of the product as a whole and potential scrap of any remaining stock of mercury-containing display units. This would not serve the goals of the Directive as units already on the market would be scrapped prematurely for a very minimal environmental return.

For further details, see our submission to ERA.

Exemption 5: "Lead in glass of cathode ray tubes, electronic components and fluorescent tubes"

We support the continuation of the exemption for lead in glass of electronic components as we are not aware of any alternatives for some components using these materials, e.g. surface-mount resistors, conformal coatings of semi-conductor dies, glass-bodied diodes, LCD frit seals and transformers. While many of these are common applications, some are very specialized. One custom use is in the glass capillary tube, composed of more than 20% Lead that helps deliver sample into a Mass Spectrometer (MS). The glass for this application needs to be electrically conductive to improve ion transfer into the MS. Non-leaded glass would not work for this application.

Due to the unique nature of these components, the removal of the exemptions listed above would drive design changes to the individual component and potentially design changes to the application where the component is utilized.

For more details see our submission to ERA.

Exemption 6: "Lead as an alloying element in steel containing up to 0,35% lead by weight, aluminium containing up to 0,4% by weight and as a copper alloy containing up to 4% lead by weight"

Both steel and aluminium which contain lead are used to create machined chassis parts. Steel with lead is also used to create fine-pitch screws. We support the conclusions of the ELV assessment that there is currently no substitute for lead in steel and aluminum.

Copper alloys containing lead are also used for their improved machinability. Currently leaded copper alloys are used extensively in custom parts for Test and Measurement products, such as probes, for fine tolerance, high-reliability contact points. These alloys are also used to machine precision cavities. Substitution materials, if available, would need to work under potential size constraints due to RF-domain impedance concerns. Materials being marketed as potential substitutes (e.g., Ecobrass) do not claim machinability on par with higher-lead copper alloys, which makes it likely they would promote faster machine wear and have lower manufacturability (slower machining) characteristics. We support maintaining the current exemption for lead up to 4% in copper alloys.

For more details see our submission to ERA.

Exemption 7: "(a) Lead in high melting temperature type solders (i.e. lead-based alloys containing 85% by weight or more lead), (b) lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signaling, transmission as well as network management for telecommunications, (c) lead in electronic ceramic parts (e.g., piezoelectronic devices)"

(a) The Test and Measurement industry supports at least a limited continuation of the exemption for lead in high-melting type solders due to the unique nature of the design cycles employed in the industry. It is typical practice in the industry to have custom ICs produced to meet those design criteria that cannot be achieved using off-the-shelf parts. Due to the low volumes and long product and design lifetimes typical of the test and measurement industry, custom ICs are frequently built in a single run that constitutes a lifetime supply of parts for both production and service applications. Older IC designs were built up in this fashion with high melting temperature type solders and these parts will be required to continue producing the products designed to incorporate them. Removal of the exemption will result in premature withdrawal of the affected products from the EU market when professional Category 9 equipment is brought into the scope of RoHS as redesign of the ICs to extend product life will in most cases not be economically viable. The material is also used for ceramic ball grid array (CBGA) applications where the stand-off must be maintain to control stress introduced by CTE mis-match. Potential RoHS-compliant replacements relying on technical breakthrough developments are 6 or more years away according to industry sources.

(b) Pb/In-based solders are used for soldering of high frequency connector pins to thick film gold traces in network management applications. Tests showed that tin-based solder are not suitable for this application due to the high gold dissolution rate, and there is no real replacement solder that would work in the common solder temperature range. Test and Measurement equipment manufacturers are also in some cases downstream users of servers and server storage arrays, as well as suppliers of equipment to the affected telecommunications network industry. The high reliability of a server platform or server array is an important criterion for their utility in test and measurement system designs. Though some years of lead-free solder reliability data have now been accumulated, it does not extend to the longer lifetimes needed in test and measurement applications. Until more data has been accumulated on the long-term reliability of lead-free solders in complex, “always-on” applications, we support a continuation of the exemption for lead in solders for servers, storage and storage array systems, network infrastructure equipment for switching, signaling, transmission as well as network management for telecommunications.

(c) This exemption is critical for the thick film technology that is central to the circuitry business. Suppliers of thick film pastes are just at the initial phase of introducing Pb-free compatible pastes, and in some cases, no suitable replacement material has been introduced.

Due to the unique nature of these components, the removal of the exemptions listed above would drive design changes to the individual component and potentially design changes to the application where the component is utilized.

For more details see our submission to ERA.

Exemption 8: “Cadmium and its compounds in electrical contacts and cadmium plating…”

There is no supplier for switches capable of currents above 10 Amps that does not use silver cadmium oxide contact plating material. AgCdO plating on switch contacts material prevents arcing leading to fire. This application requires the cadmium exemption to be maintained to meet safety standards.

For more details see our submission to ERA.

Exemption 9 a: “Deca BDE in polymeric applications (exemption until 2010)”

Deca BDE is used in some custom cables. Due to the unique nature of these components, the removal of the exemption would drive design changes to the individual component and potentially design changes to the application where the component is utilized. Alternative flame retardant additives exist, though frequently less risk assessment data is available for these alternatives. Based on the outcome of the EU risk assessment deca BDE does not meet the criteria for restriction under RoHS so its continued use should be allowed via exemption.

Exemption 11: "Lead used in compliant pin connector systems"

This exemption is needed for making compliant pin connectors using alloys containing lead. In one case we have found a single source producer that has not found a feasible substitute to-date.

Exemption 13: "Lead and cadmium in optical and filter glass"

Gas Chromatograph Detectors and lasers use leaded Optical Filter glass as the glass must not shift color or optical quality from -40 to +450 C with very low optical interference and absorption. Trials were made last year to use filter glass of 5 different possible base materials. In all instances, either the temperature expansion capacity, opacity, or color retention to maintain the ability to filter and measure light levels that are at the minimum optical transmission were not able to perform with the same ability of leaded glass. The low level analysis of hydrogen flame color to measure amounts of Nitrogen, Sulfur, and Phosphorus in chemical matrix for raw oil, natural gas, etc. is the main use for this detector. If the leaded optical glass exemption is removed, the measurable base level of sulfur in oil & gasoline will no longer be capable of being measured to the level specified by the EU. GCs and lasers need the leaded glass for optical filters exemption if the standards for these & other applications are not impacted in the future. Leaded optical filter glass cannot be replaced in all precision optical applications including laser head lenses and beam-splitting interferometers especially where high refractive index glass is required. In applications requiring lower index, non-leaded glass is feasible and has been introduced. These precision optical components are incorporated into equipment for nanotechnology, integrated circuit fabrication and positioning systems.

For more details see our submission to ERA.

Exemption 14: "Lead in solders consisting of more than two elements for the connection between the pins and the package of microprocessors with a lead content of more than 80% and less than 85% by weight.

Test & Measurement Coalition members are down-stream users of microprocessors. Our suppliers have indicated that suitable lead-free solder connections are not available.

For more details see our submission to ERA.

Exemption 15: “Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit Flip Chip packages”

The Test and Measurement industry supports continuation of the exemption for lead in solders to connect die to carrier due to the unique nature of the design cycles employed in the industry. It is typical practice in the industry to have custom ICs produced to meet those design criteria that cannot be achieved using off-the-shelf parts. Due to the low volumes and long product and design lifetimes typical of the test and measurement industry, custom ICs are frequently built in a single run that constitutes a lifetime supply of parts for both production and service applications. Older IC designs were built up in this fashion with lead-containing solders and these parts will be required to continue producing the products designed to incorporate them.

There are a number of flip-chip BGA packages that require the high temperature melting solder connections to prevent against re-reflow of the solder joints during Pb-free solder assembling processes. Flip chip technology allows the entire die surface to be covered with an array of bonding pads. There are currently no available substitute components for use in high reliability applications, and few, if any, alternative components or technologies available for other applications. Substitution of lead-free solders has been shown to create unacceptable early life failures due to electro migration or dielectric damage in high reliability applications.

Removal of the exemption will result in premature withdrawal of the affected products from the EU market when professional Category 9 equipment is brought into the scope of RoHS as redesign of the IC Flip Chips to extend product life will in most cases not be economically viable.

For more details see our submission to ERA.

Exemption 23: “Lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm or less with NiFe lead frames and lead in finishes of fine pitch components other than connectors with a pitch of 0.65 mm or less with copper lead frames.

Current research did not come up with a conclusion as to when a suitable replacement will be available. Until the mechanisms for whisker production are fully understood and can be reliably and generally mitigated over an extended product lifetime, we support the maintenance of an exemption for lead in the finishes in the listed fine-pitch components.

For more details see our submission to ERA.

Exemption 24 – "Lead in solders for the soldering to machined through hole discoidial and planar array ceramic multilayer capacitors"

Pb in solders for installation of discoidal through hole multilayer ceramic capacitors affects capacitive DC feeds used in the fabrication of custom hybrid microcircuit package assemblies. The high temp solder alloy contains > 85% Pb and at this juncture, there is no RoHS compliant high temperature solder alternative that meets high reliability standards. Lower temp solders are not appropriate due to incompatible solder hierarchy for hybrid microcircuit package assembly. Additionally, suppliers of EMI filters constructed using these capacitors have reported the use of InPb solders in order to achieve thermal matching with the ceramic material and avoid cracking. As downstream users of these parts we support the extension of this exemption for the use of lead.

For more details see our submission to ERA.

Exemption: "Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes" (Adopted October 07)

We need the exemption to be extended to cover seal frit for making assemblies for helium laser tubes. Unleaded glass frits have been tried but result in increased leakage of helium reducing the three year life of laser tubes using lead glass frit seals. As these tubes are replaced many times during the 20+ laser lifetime, the exemption could be withdrawn if the Commission defined "consumables" in respect of RoHS and provided binding ruling that laser tubes are consumables.

Test and Measurement Coalition

RoHS Scope Review of Category 8 and 9 Products

Contribution to ERA study

16 February 2006

Lead Shielding Dossier

1. **<u>Use of lead shielding for radiation protection</u>**

1.1. General

Lead is widely used in test and measurement instruments that are used in the presence of ionizing radiation (primarily x-rays and gamma rays) and in instruments that detect and measure ionizing radiation. In these instruments, lead is used to:

- Shield sensitive electronic components from the damaging effects of radiation.
- Shield radiation detectors from background radiation
- Collimate or limit a detector's field of view to prevent radiation from entering the detector from unwanted sources.
- Adjust a radiation detector's energy response by attenuating lower energy photons while allowing transmission of higher energy photons.
- Shield the user from radiation produced by the test and measurement equipment

1.2. Technical Characteristics

Lead is often used because of its excellent attenuation properties and its relatively low material cost and low processing (molding, machining, etc.) costs. In many applications, lead attenuates x-rays more efficiently than any other material commercially available. How well a shield absorbs radiation is a function of the material it is made of, its thickness and the type and energy of the radiation it is exposed to. Generally, as the energy of the radiation increases, the thickness of the shielding must increase or a material with a higher attenuation coefficient must be used. Standards indicating minimum thickness of lead include NCRP Report 102, Appendix B, IEC 60601-1-3, Clause 29.207 and Radiological Health Handbook, Section III

1.3. Trends

There are no current trends within the test and measurement industry to replace lead shielding of x-ray radiation with alternative materials.

2. <u>Substitution of Lead</u>

2.1. Substitutes for Lead

Tungsten is a common alternative to lead. It has slightly lower attenuation properties, is significantly more expensive than lead, and is costlier to process than lead (it is very hard and difficult to machine). Tungsten loaded polymers are available, but have lower attenuation properties than solid tungsten since they are a mixture of tungsten powder and polymer. These polymers can be injection molded, but the tungsten loading causes significant wear on tooling, reducing its useful life by half.

Steel may be used instead of lead, but its lower attenuation properties are a drawback, as more material is needed to make up for the reduced attenuation. At x-ray energies below 75 kVp, 3mm of steel is needed to provide the same attenuation as 0.5mm of lead. (The Swedish Radiation Protection Institute’s Regulations on Radiation Shielding of X-ray Installations for Veterinary Diagnostics)

Concrete offers less attenuation than tungsten or steel, but offers low cost when space is available. At x-ray energies of 100 kVp, approximately 80mm of concrete is needed to provide the same attenuation as 1mm of lead. (Radiological Health Handbook, revised edition January 1970)

Materials with greater attenuation properties exist but many are radioactive and are not suitable for use in shielding.

2.2. Selection and Testing of Substitutes

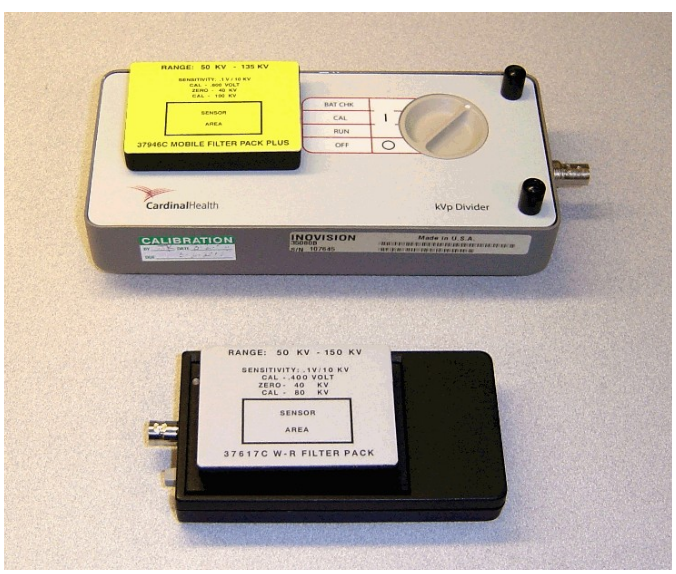
2.2.1. When lead is used to provide shielding, alternative materials must be identified and shields or collimators redesigned to make them larger (due to reduced attenuation) and tested. The redesigned shielding may cause other related components to be redesigned and tested. In some cases, the complete system may need to be redesigned to accommodate the needs of the new shielding material. In any case, radiation testing to ensure that the shielding remains effective must be performed. Additional testing may also be required to ensure that the substitute shielding meets the product’s qualification requirements.

2.2.2. Selection of alternate materials to replace lead foils used to adjust a radiation detector's energy response involves identification and selection of viable alternates and rigorous radiation testing to ensure that the detector meets its specified energy response.

2.2.3. Where a test and measurement instrument relies on the attenuation properties of lead and/or other materials as a basic operating principle, the attenuation/transmission properties of lead and/or the combined effect of all filter materials must be taken into account. The process of finding viable alternatives to lead filters requires a great deal of research, modeling and radiation testing.

2.3. Impact of Substitution

2.3.1. Many of the test and measurement instruments that are used to measure ionizing radiation rely on the attenuation properties of lead and other materials as a basic operating principle. For example, non-invasive kVp meters or voltage dividers, such as the Fluke Biomedical Model 35080B and 35080M rely on the attenuation properties of lead and other materials for their basic operation (Ref. U.S. Patents 4,843,619 & 4,916,727). These products are used in hospitals and imaging centers to perform quality assurance measurements on x-ray machines. The process of finding alternatives to lead filters in this case is much more difficult because the instrument's response is not based on the attenuation/transmission properties of only lead but on the combined effect of all of its filter materials. As a result, not only the lead filter material would change, all of the other filters would need to change too because of the interaction of the attenuation/transmission properties of the substitute materials with the other filter materials. An average redesign cost of €300K-500K per product is expected.



Fluke Biomedical Non-Invasive kVp Dividers

2.3.2. Lead foils are also used to adjust a radiation detector's energy response when used in radiation survey meters (below) and other applications. Alternative materials must be identified and rigorously tested to ensure that the detector meets its specified energy response in order to provide an accurate measure of the radiation detected. These instruments are used in medical, nuclear power, and homeland security applications. To assess of the safety of the radiation environment lead foil is commonly wrapped around Geiger-Mueller detectors to provide energy compensation by flattening the detector's energy response. The alternative material cost in this case may not be significant, but an average redesign cost of €100K-200K per product is expected.

Victoreen® Advanced Survey Meter

2.3.3. Where lead shields or collimators are used, alternative materials must be identified and shields or collimators redesigned to make them larger (due to reduced attenuation) and to support the manufacturing methods suitable for the new material. The increase in size may cause other related components to be redesigned. For example, the Fluke Biomedical Model 35080M, Non-Invasive Voltage Divider, employs two lead shields to both shield its detectors from stray radiation and to collimate its field of view to only the x-rays passing through a set of filters (attenuators). Replacing the existing lead shields with tungsten shields adds approximately €800 to the cost of the unit; a 75% cost increase. This cost increase can be expected for all non-invasive kVp meters in the market place today. An average redesign cost of €100K-200K per product is expected.

2.3.4. In large systems, such as x-ray testers used in manufacturing test of assembled printed circuit boards (below), where lead may be replaced with concrete, €200K is the estimated additional cost of hardware for development (concrete is a new material in electronics). An additional cost of €400K is also needed to develop robotic arm placement of boards under test. For a design based on concrete shielding the operator can no longer stretch over 10-20 meters of concrete to place the PCB under test in the centre test area. Certification costs of €200K are expected because special safety interlocks and test rules the apply to equipment emitting radiation. A total redesign cost of €800K per system is expected. Transportation costs, both from contract manufacturer of pre-shaped concrete blocks (the lead shielding of the model shown comprise 52 separate lead block sub-assemblies) to the producer of the x-ray test systems and from the producer to customer would increase. The cost of WEEE processing due to increased weight of concrete compared to lead would also increase. WEEE costs typically range from €45-80 /kg of product. X-ray testers are used in manufacturing test of assembled printed circuit boards, and are the only way of detecting internal voids, marginal joints or insufficient solder in solder joins. Due to the need for stability of product for clear x-ray pictures and the shielding itself, the products are heavy with up to 1 ton of lead shielding.

Agilent Medalist 5DX X-Ray Tester

2.3.5. Where test and measurement instruments that measure ionizing radiation are installed in monitoring and control or safety related applications, such as nuclear power plants, qualification of new products is required. For example, the radiation monitors (below) in nuclear power facilities provide assurance that radiation levels do not exceed maximum permissible levels as set forth in the United States Nuclear Regulatory Commission (USNRC) radiation protection standards. Products of this class are typically qualified to seismic, corrosive atmosphere, EMI/RFI, and radiation tolerance standards. An average redesign and qualification cost of €300K-500K per product is expected.

Victoreen® Off-Line Gaseous Effluent Monitor and Wide Range Ion Chamber Area Monitor

3. Requests/recommendations

3.1. Exemptions

An exemption is needed for lead shielding for radiation protection in test and measurement equipment. The applications include:

- Shielding electronic components from the damaging effects of radiation.
- Shielding, collimation, and energy compensation for radiation detectors.
- Shielding for users of test and measurement equipment that produces ionizing radiation

Tungsten and steel substitutes are available for some shielding applications of lead, however standards for thickness of material have to be developed covering the energy levels of radiation used in test and measurement. Concrete is technically feasible and widely accepted with appropriate thickness requirements in standards. However the impacts of using concrete are: increased weight and volume of products impacting energy required for transportation, and safety of handling during manufacture, transport and installation.

We note that lead is exempt in RoHS in CRTs where the lead in glass provides protection to users from low levels of x-ray radiation energy in the CRT tube. We believe this precedent for lead shielding must be taken into consideration. Furthermore, as the majority of our applications involve much higher energy levels the radiation laws for high energy X-ray equipment regarding safety of installation and use must be considered by the Commission. To this end the Commission must establish agreement with local competent authorities in each member state regarding use of lead substitutes for high energy X-ray equipment – standards for thickness of material and impacts on local radiation safety laws and user licensing have to be considered before industry can truly assess impacts of a viable substitute for lead in radiation shielding for protection.

In summary we are requesting one additional exemption for lead shielding radiation applications in test and measurement equipment.

3.2. Phase-in period

If the exemption is not granted we estimate a transition phase-in period of ten years from the entry into force of the revised RoHS Directive would be required to re-design products currently using lead shielding for radiation protection. Phase-in can only start following prior amendments to standards and regulations outside RoHS that currently apply to high energy X-ray equipment. In our opinion substituting lead with concrete as not viable for safety and environmental reasons outlined above.

Test and Measurement Coalition

RoHS Scope Review of Category 8 and 9 Products

Contribution to ERA study

27 January 2006

Cadmium Dossier

1. <u>Use of cadmium in test and measurement equipment</u>

1.1 General
Several uses of cadmium and its compounds are known in electrical and optical equipment however usage has been reduced considerably on safety and environmental grounds wherever cost-effective substitutes have been found in applications of cadmium:

- As an anti-corrosive agent where it forms a sacrificial coating against the elements and as plating to protect connectors and metallic fixings in salt spray conditions
- As an anti-binding agent in switch contacts
- As a yellow pigment in paints and stabilizer in plastics
- In rechargeable batteries (excluded from the RoHS Directive)
- In optical filter glass and x-ray filters
- As an alloy constituent for low temperature solder
- In alloys with other special features
- In sensors:
  Photovoltaic cells, based on thin-films of either cadmium telluride (CdTe) or cadmium sulphide (CdS), Cadmium sulphide photoconductive cells, Cadmium mercury telluride is an important semiconductor for infra-red imaging, while cadmium sulphide, cadmium tungstate, cadmium borate and cadmium silicate, are essential in the preparation of light-emitting phosphors that are activated by electron beams

Cadmium usage in our sector has been greatly reduced in the last decade. Excluding sensors, it is in limited use in high current switch contacts, plating, x-ray filters and optical glass. The actual amount in use is very small compared to the other RoHS metals.

1.2 Technical characteristics

1.2.1 Where products are used in harsh outdoor environments, zinc cadmium plating provides good anti-corrosion over steels especially in seawater. Salt spray corrosion testing is done to military or AMS 2473 standards for 500 hours duration under salt spray test conditions.

1.2.2 Cadmium oxide provides an abrasive surface on mechanical switch contacts and this property keeps electrical contact resistance low. If contact resistance increases over life then additional heat (proportional to resistance x current^2) is generated with increased risk of fire and reduced switch life. Cadmium plating has also been used on pins of plugs and sockets for its abrasive cleaning property.

1.2.3 Cadmium in pigments provides exceptionally strong yellows. Based on this property it is preferred for use in safety applications such as the radiation symbol

1.2.4 Lead is the most common stabilization additive in polymers followed by cadmium. As with UV light, heat tends to oxidize polymers. Without stabilizers to mitigate oxidation plastics develop symptoms of embrittlement, melt flow instability, loss of tensile properties and discolouration. Vulnerable polymers requiring most stabilization are PVC, chlorinated polyethylene and PVC/ABS blends.

1.2.5 Several Red and Orange coloured filter glasses can only be made with the inclusion of cadmium compounds.

1.2.6 X-ray filters are used to non-invasively measure the kilo-voltage applied to x-ray tubes used in hospitals, commonly mammography equipment where accuracy of x-ray levels is critical to patient safety. Cadmium filters are used in this application because they exhibit a step attenuation characteristic at 26.7 kV, within the band of energies applicable to mammography.

1.2.7 Cadmium alloyed with silver, zinc and/or tin makes excellent solders with a tensile strength two to three times greater than most common solders for joining copper interconnections. Zinc-cadmium alloys are useful for soldering aluminium whilst cadmium-zinc-tin alloys are used for soldering magnesium. Cadmium alloyed with tin and bismuth enables low temperature melting solders.

1.2.8 Cadmium alloys are used for their mechanical strength and high temperature properties such as bearings (cadmium-tin alloys), radiators (cadmium-copper alloys), precious metal alloys for jewellery for improved hardness, and cables subject to stress (cadmium-lead alloys)

Further details can be found at http://www.cadmium.org/app_allo.html and at http://www.specialchem4polymers.com/index.aspx

1.3 Trends

1.3.1 Since the introduction of 91-338-EEC many suppliers to our industry have eliminated use of cadmium plating in anti-corrosion applications.

One member company surveyed its suppliers of switches and connectors in 2003 to determine where if any cadmium is still in use:
Connector suppliers reported that cadmium plating in their products is now restricted

to military connectors.
Switch and relay manufactures continue to use cadmium oxide for high current power switches to prevent significant contact resistance developing. We note that cadmium in switches is exempted under 91-338-EEC [Section 3.3. - electrical contacts in any sector of use, on account of the reliability required of the apparatus on which they are installed.] which is the basis of exemption 8 in the RoHS Annex.

1.3.2 Cadmium has been restricted by coalition companies to varying degrees and is tolerated for a few specific applications in new products. One member company for example allows cadmium in optical glass and switch contacts, and restricts use to 50 parts per million in anti-corrosion coatings, plastic stabilizers, paints, dyes, and pigments (except safety warning signs).

1.3.3 The quantity of cadmium and associated product types shipped to EU customers by member companies annually is given in the annex of our sector description. Data provided in annex should be amended as we can now identify the amount of cadmium in x-ray filters shipped annually to the EU is approximately 10 grams.

2. Substitutes for Cadmium

Available substitutes

Successfully implemented alternatives for cadmium plating include:

- Tin and tin alloys,
- Zinc-alloy plate,
- Aluminium coatings applied by ion vapor deposition (IVD), and
- Electro-less nickel plating

In addition, some suppliers are implementing zinc cobalt giving a drab olive appearance as a less costly alternative.
To date the primary problems with cadmium plating substitutes have been:

- Finish quality including brightness; and
- Higher cost.

None of the available plating substitutes are currently restricted by regulation.

Alternative materials to cadmium oxide in contacts are silver zinc oxide and silver tin indium oxide. Available switches using them have been specified for lower current capacity and also have relatively short lifetime of $< 10^6$ operations.

Our sector has no requirement for strong yellow pigments except for safety labels. All eco friendly yellow pigments including bismuth vanadate start out as paler strength yellow compared to cadmium pigments. Various other organic substances are added to increase the depth of yellow to match the required colour index. The auto industry has found solutions from their suppliers for the deep bright yellow paints like "JCB yellow" based on bismuth vanadate with added organics. Details can be found at http://www.cibasc.com/coatings_all.pdf?wobj=37475#page=3
Note yellow pigments have existed for centuries based on iron bearing yellow ochre but final colour is very temperature sensitive.

Cadmium-based stabilizers are being phased out. To achieve the same effect, however, the replacements have to be complicated mixtures of salts. Organotin and calcium/zinc systems are favoured at present. In general, alternatives based on calcium and zinc are less effective, but are cheaper than those based on aluminium or magnesium. Water absorption can be a problem with systems not using heavy metals. More information can be found by searching for cadmium at http://www.specialchem4polymers.com/index.aspx

No RoHS compliant substitutes have been identified for cadmium in glass for red and orange filters. The actual quantity of cadmium used in these filters varies with the refractive index to achieve the frequencies of filtering and is very small. While our members have a small number of optical products using filters containing cadmium, our best estimate is that the quantity of cadmium in the glass shipped annually in the EU is less than one gram.

X-ray filters are designed using two materials (lead and cadmium) in a filter pack to provide the step attenuation characteristic. To find a substitute for cadmium would require two substitute materials that together provide an attenuation step in the range of x-ray energies of the mammography application. An indium or silver filters can provide a step characteristic for measurement purposes but are not optimal for the band of energies applicable to mammography.

Aluminium parts in our products are machined castings with no sub-parts joined by welds and we do not incorporate magnesium parts requiring welding. We have not investigated the performance of cadmium free solder / brazing alloys for joining aluminium or magnesium.

We are not aware of substitutes for cadmium based sensors listed in section 1 and they are not incorporated inside our products.

Selection and testing of substitutes

Choice of substitute depends on the base metal being coated, quality of finish, cost and performance. Member companies have already substituted custom parts with plating finishes that meet their requirements as well as reduced risk to the environment and human safety. The majority of plated off-the-shelf parts in our current range of products today use nickel or zinc substitutes on low carbon steel or tin plating on high carbon stainless steel.

When selecting switches, cadmium contact types are restricted to high current applications in power circuits on the grounds of safety as previously described. They are used in large instruments and systems for switching power currents – see Annex 1 of our Sector Description.

3. Impact of substitution

3.1. Assuming no change to the current RoHS exemptions for cadmium, costs to transition our members' products will be relatively small for cadmium except for one company manufacturing equipment containing x-ray filters for hospitals; there may be instances of cadmium in custom parts and instances of cadmium being used for unusual applications. In the course of supplier verification of cadmium content by one member company, cadmium has been found in some network passive (multi-pack) resistors. The supplier has not identified the reasons for intentional use of cadmium but intends to have compliant versions available by mid 2006. Another reference to unusually high amounts of cadmium impurity in zinc above RoHS cadmium maximum concentrations can be found in Directive 91/338/EC

3.2. Redesign costs for the x-ray filter application are estimated to be a minimum of 500 k euros if a substitute pair of materials can be found providing suitable filter characteristics in the required band of x-ray energies.

3.3. There are no additional financial costs perceived in substitution in terms of part cost or transport of compliant parts. This position would change in future if current cadmium exemptions were removed.

3.4. WEEE provides a closed loop in terms for risk management and recycling of cadmium compounds ensuring they should no longer enter the environment. Note the quantity of cadmium in nickel cadmium batteries is far greater (around 20% of battery weight) than cadmium in plating and switch contacts.

3.5. All available substitute substances have less environmental impact for equivalent volume. See section 2 and references.

Clearly there will be impacts on producers in order to carry out due-diligence surveys on suppliers of all potentially affected parts with a view to obtaining compliance declarations. The cost will be amortised to the extent that each part declaration will include compliance data information (absence, etc.) for all RoHS substances in each part. We believe our current products are generally compliant with RoHS cadmium restrictions but cannot guarantee compliance until due-diligence survey results have been analysed.

4. Requests/recommendations

4.1. Exemptions

The existing RoHS exemptions for cadmium in glass, plating, switch contacts and safety signs are well positioned to support our industry moves to reduce hazardous substances in products without compromising reliability. However an exemption is required for x-ray measurement filers because no technically feasible substitute has been found and the safety of patients in hospitals would otherwise be compromised. As tested substitutes are available for remaining applications of cadmium and cadmium alloys in our companies' products, no other exemptions are required for our continued use of cadmium. For most producers the impact of coming in scope of RoHS will be to check with suppliers that cadmium and its compounds are absent or exempt and, where still in use, obtain substitute compliant parts. Custom parts represent the largest potential difficulty for substitution.

In summary we are requesting one additional exemption for cadmium in hospital x-ray applications that is necessary to ensure patient safety. Additional exemptions may be requested by manufacturers of cadmium-based sensors or other companies in our sector who are not Coalition members.

4.2. Phase-in period

Assuming an exemption for x-ray filters is granted, we estimate a transition phase-in period of three years from the entry into force of the revised RoHS Directive, is needed to conduct surveys with suppliers and update products where necessary to ensure compliance on the grounds that this activity will be done in parallel for all substances restricted in the directive. This period could be reduced if the scope focus were limited to cadmium since the number of parts at risk is a fraction of the average 100,000 parts used by each member company.