Test and Measurement Coalition

RoHS Scope Review of Category 8 and 9 Products

Cadmium Dossier

1. Use of cadmium in test and measurement equipment

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.