REACH impact for aerospace connectors

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- ROBIN MONTPELLAZ, Amphenol Socapex

On behalf of Connector Manufacturers Group (CMG)
SUMMARY

• CMG introduction & Goals
• Main constraints for connectors
• Authorization Dossier: status & lessons learned
• Challenge for tomorrow: Cd Substitution
• Main results on alternate solutions
• Conclusion and perspectives
• Q&A session
\textbf{CMG Introduction}

\textbf{CMG} = \textbf{C}onnect\textbf{r} \textbf{M}anufacturers \textbf{G}roup

\textbf{Why CMG ?}

• CMG is concerned by substance-restriction for the plating of our connectors.
• Mainly military and aeronautics connectors are concerned.
• Specific performances of the corresponding connectors (harsh environment).
• The use of hexavalent chromium compounds is not longer authorized in EU since \textbf{September 21, 2017} sunset date
• No alternative having the same properties as current plating, and being fully intermateable with current plating has been qualified before the sunset date.

\textbf{CMG Members} : Created on December 2014 by 6 manufacturers

\textbf{Amphenol, ITT Cannon, Radiall, Smith Connectors, Souriau, TE Connectivity}

All of them are \textbf{ACSIEL} members, a french syndicate dedicated to electrical components
Goals

Share a common understanding of REACH compliance impact on our supply chain

Involve connector manufacturers and their strategic customers in a common management process of REACH risks

CMG members representing 6 manufacturing sites with plating activities in Europe worked together in order to obtain authorization for Cr6+ compounds use after sunset date of 21st September 2017
Where is Cr6+ used in process?

**CONTACT**
- Etching process

**CONNECTOR SHELL**
- Passivation of metallic layers
- Chemical conversion on aluminum
- Etching on composite
- Passivation on S/S

**SUBSTANCES**
- Chromium trioxide
- Potassium dichromate
- Sodium dichromate
CMG Application for Authorisation

• **Substances:**
  - Chromium trioxide, Potassium dichromate, Sodium dichromate, Acids generated from chromium trioxide and their oligomers

• **Uses:**
  - **Use 1 = Passivation of Cadmium**
    Achieve a higher level of performance than the requirements of International standards as well as to withstand harsh environments and high safety applications.

  - **Use 2 = Other passivation – ZnNi, stainless steel, …**
    Meet the requirements of international standards and special requirements of industries subject to harsh environments

  - **Use 3 = Etching of composite connectors.**
    Ensure adhesive deposit to meet the requirements of international standards.
Authorization dossier

- Notification to ECHA
- Draft of the dossier
- Pre-Submission information Sessions
- Submission of the file to ECHA (European Chemicals Agency)
- Public Consultation
- Opinion of ECHA experts
- Positive Decision of the EU Commission

Timeline:
- 2014: July
- 2015: Feb., Apr. to June
- 2016: Dec.
- 2018: June

SUNSET DATE: June 2018
Duration of time extension

Authorization to use this substances was granted the 22\textsuperscript{nd} of June, 2018

<table>
<thead>
<tr>
<th>USE</th>
<th>Request from CMG</th>
<th>Time extension granted (from sunset date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passivation of Cd</td>
<td>12 years</td>
<td>12 years</td>
</tr>
<tr>
<td>Other passivations</td>
<td>7 years</td>
<td>7 years</td>
</tr>
<tr>
<td>Etching</td>
<td>4 years</td>
<td>4 years</td>
</tr>
</tbody>
</table>

Lessons learned

- Regional European Regulation but with potential impact:
  - on worldwide distribution of connectors if parts are produced in EU
  - on the global supply chain including suppliers/subcontractors (ex: rationalisation of chemical baths)

- Regulation is continuously moving and list of substances that could be banned in the future is updated every 6 months: CADMIUM and LEAD are now potential candidates

- Survey is key and all CMG companies are working in close partnership on that topic

- Even if authorization is granted, work is not yet finished!
  - Risk Management measures (RMM) and the Operating Conditions (OC) described in the authorisation file or in the EU Commission decision must be applied
  - Be proactive on substitutions to prepare the next step
**Challenge for tomorrow: Cd Substitution**

### Technical requirements (MIL DTL 38999 SIII CLASS W)

<table>
<thead>
<tr>
<th>Standard requirements</th>
<th>Extra performances targeted</th>
<th>Requirements for manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Comply with REACH regulation</strong></td>
<td>Degradation substances that may occur after long term use shall not be SVHC</td>
<td><strong>Mandatory</strong></td>
</tr>
<tr>
<td><strong>Backward compatible with cadmium</strong></td>
<td><strong>Compatible with legacy platings</strong> (panel, braid, ancillary parts, accessories…)</td>
<td>- Compatible with standard aluminum alloys</td>
</tr>
</tbody>
</table>
| Electrical performances complying to \(2.5 \text{ to } 5 \text{ mΩ}\)/lighting strikes/EMI | **1000hrs** targeted in order:  
- To be compatible with marine application  
- To be aligned on backshell standards | - Capable and monitorable process |
| Salt spray resistance 500hrs | **« Self healing »** properties, resistance to scratches | - Compatible with additional process steps (bonding, marking,…) |
| Correct adhesion of coating/plating after mechanical tests (vibration), thermal aging, … | | - No risk for human health during either manufacturing or implementation on system |
| Mechanical durability 500 mating/unmating cycles | | - Best ratio cost/efficiency |
| Operating temperature range \(-65/+175°C\) | | **Nice to have** |
| Cosmetic aspect: dark and non reflective | Cosmetic aspect shall not be affected after either aging or salt spray test | - Solution could be repaired/washed on ground |
| | | - Overall Thickness compatible with usual legacy cadmium platings (12-25µm) |
Shell to shell bonding resistance test method

- Test method according to EIA364-83
  - measure the potential drop of the mated connector from a point on the rear accessory thread of the plug to a point adjacent to the mounting holes (at the flange) on the receptacle
  - The applied potential is 1.5 volts D.C maximum and the current limited to 1.0 ±0.1 ampere
  - Probes with spherical ends of 1.27 mm (0.05 inch) minimum radius are used to make the voltage measurements
Black Nickel w/o Cr6+ (No standard)

<table>
<thead>
<tr>
<th>Salt spray</th>
<th>Electrical bonding</th>
<th>Aspect</th>
<th>Backward compatibility</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>No bleaching of</td>
<td>Pass (&lt;5mΩ after salt</td>
<td>Dark aspect</td>
<td>Compatibility to be assessed</td>
<td>Proprietary process</td>
</tr>
<tr>
<td>plating after 500hrs dynamic salt spray</td>
<td>salt spray</td>
<td>No bleaching after salt spray</td>
<td></td>
<td>Self healing / scratch resistance of the finish to be assessed</td>
</tr>
<tr>
<td>Base material can be exposed in few areas</td>
<td>Base material can be exposed in few areas after salt spray</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pros**
- Fulfill the standard requirements
- No bleaching
- Dark aspect

**Cons**
- Corrosion resistance less efficient compared to cadmium
- Base material can be exposed in few area after salt spray
- Electrical bonding less efficient compared to cadmium
# Main results on alternate solutions

## Ni PTFE w/o Cr6+ (class T standard)

<table>
<thead>
<tr>
<th>Salt spray</th>
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<tbody>
<tr>
<td>Good behavior during 1000h static salt spray.</td>
<td>Pass (&lt;5mΩ after salt spray)</td>
<td>Initial aspect grey and reflective</td>
<td>Issue of galvanic couple with cadmium on tested configuration</td>
<td>Very low friction coefficient induce several issues</td>
</tr>
</tbody>
</table>

| | | | | Self healing / scratch resistance of the finish to be assessed |

### Pros
- Fulfill the standard requirements
- Good corrosion resistance
- Good conductivity

### Cons
- Reflective and non dark aspect
- No backward compatibility
- Low friction coefficient
**SnZn w/o Cr6+ (no standard)**

<table>
<thead>
<tr>
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<th>Backward compatibility</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleaching of SnZn plating after 500hrs salt spray</td>
<td>Pass (&lt;5mΩ after salt spray).</td>
<td>Initial aspect grey and reflective</td>
<td>Theoretically compatible with cadmium</td>
<td>Self healing / scratch resistance of the finish to be assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Initial aspect grey and reflective</td>
<td>Bleaching of parts starts at approx. 196hours</td>
<td>Actual compatibility to be assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low ductibility of the plating to be assessed</td>
</tr>
</tbody>
</table>

**Pros**
- Fulfill the standard requirements
- Good electrical performances (despite white oxyde on surface)

**Cons**
- Reflective and non dark aspect
- Corrosion resistance less efficient compared to Cadmium
- Whitish aspect after salt spray
Main results on alternate solutions

SnNi w/o Cr6+(no standard)

<table>
<thead>
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<tbody>
<tr>
<td>No bleaching after 500hrs salt spray</td>
<td>Pass (&lt;5mΩ after salt spray)</td>
<td>Initial aspect grey and reflective</td>
<td>Theoretically not compatible with cadmium</td>
<td>Self healing / scratch resistance of the finish to be assessed</td>
</tr>
<tr>
<td>Light change of aspect</td>
<td></td>
<td>Darker aspect after salt spray</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pros
- Fulfill the standard requirements
- Good corrosion resistance

Cons
- Reflective and non dark initial aspect
- No backward compatibility
## Main results on alternate solutions

### Black ZnNi w/o Cr6+ (class Z standard)

<table>
<thead>
<tr>
<th>Salt spray</th>
<th>Electrical bonding</th>
<th>Aspect</th>
<th>Backward compatibility</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good behavior during dynamic salt spray</td>
<td><strong>Pass</strong> (&lt;5mΩ after salt spray)</td>
<td><strong>Initial aspect</strong> dark and non reflective</td>
<td><strong>Compatible with cadmium</strong></td>
<td><strong>Self healing / scratch resistance</strong> of the finish to be assessed</td>
</tr>
<tr>
<td>Bleaching of parts starts at approx. 196 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pros
- Fulfill the standard requirements of Z class
- Initial dark aspect
- Backward compatibility (already used and qualified in its hexavalent chromium version)

### Cons
- Corrosion resistance & electrical bounding less efficient compared to cadmium
- Whitish aspect after salt spray

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![Initial](image1.png)
![After dynamic salt spray](image2.png)
# Grey ZnNi w/o Cr6+(no standard)

## Main results on alternate solutions

<table>
<thead>
<tr>
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<th>Backward compatibility</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleaching of ZnNi plating after 500hrs</td>
<td>Pass (&lt;5mΩ after salt spray)</td>
<td>Initial aspect matte grey and non reflective</td>
<td>Compatible with cadmium</td>
<td>Chemistries sensitive to temperature variations</td>
</tr>
</tbody>
</table>

**Pros**
- Fulfill the standard requirements
- Non reflective and matte aspect
- Good electrical performances

**Cons**
- Non dark aspect
- Corrosion resistance less efficient compared to Cadmium
- Whitish aspect after salt spray

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Initial aspect | After salt spray
## ZnNi Blue Generation w/o Cr6+ (VG standard)

### Main results on alternate solutions

<table>
<thead>
<tr>
<th>Salt spray</th>
<th>Electrical bonding</th>
<th>Aspect</th>
<th>Backward compatibility</th>
<th>Other comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleaching of ZnNi plating after 500hrs salt spray</td>
<td>Pass initial (&lt;5mΩ before salt spray) Fail (&lt;10mΩ after salt spray) (VG standard criteria)</td>
<td>Initial aspect blue / grey reflective Bleaching of parts after salt spray</td>
<td>Good results with Cadmium on actual applications</td>
<td>Color variations</td>
</tr>
</tbody>
</table>

**Pros**
- Fulfill static salt spray requirements
- Pass shielding performance according to VG

**Cons**
- Low electrical performances after salt spray
- Reflective and non dark aspect
## Results summary

### Results

<table>
<thead>
<tr>
<th>Plating</th>
<th>Salt Spray 500hrs</th>
<th>Salt Spray 1000hrs</th>
<th>Elec. Bonding</th>
<th>Aspect (before &amp; after NSS)</th>
<th>Backward compatibility</th>
<th>Cost compared to Cad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black nickel w/o Cr6+</td>
<td>Green</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Green</td>
<td>=</td>
</tr>
<tr>
<td>Ni PTFE w/o Cr6+</td>
<td>Green</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>++</td>
</tr>
<tr>
<td>SnZn w/o Cr6+</td>
<td>Green</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>=</td>
</tr>
<tr>
<td>SnNi w/o Cr6+</td>
<td>Green</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>=</td>
</tr>
<tr>
<td>Black ZnNi w/o Cr6+</td>
<td>Red</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>=</td>
</tr>
<tr>
<td>Grey ZnNi w/o Cr6+</td>
<td>Red</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>=</td>
</tr>
<tr>
<td>ZnNi BlueGen w/o Cr6+</td>
<td>Red</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>=</td>
</tr>
</tbody>
</table>

- **All manufacturers comply with requirement**
- **To be discussed - standard needs clarification**
- **No manufacturer complies with requirement yet**
Conclusion & Perspectives

At this time, no one-to-one substitute to cadmium has been found

CMG * has engaged collaborative research work and explores alternate innovative breakthrough technologies (Cad STAR project)

Cad STAR members:
- Souriau
- TE
- Amphenol
- Radiall

In any case standardization work remains necessary between OEM and manufacturers to align all requirements so as to be representative of real usage
Conclusion & Perspectives

**CONVENTIONAL PLATINGS**
- new zinc Alloys considered as the best candidate
- Pulsed current technology
- Multi-layer coating

**BREAKTHROUGH TECHNOLOGIES**
- based on functionalization of conductive elements (solgel, PVD coating, paintings...)
- Promising results from studies and first tests achieved on mock up
- Long term solution, y. 2025 (tbc) for industrialization

**State of the art and selection of suppliers (CMG lead)**

**Evaluation tests with selected suppliers (CMG lead)**

**RESEARCH WORK (collaborative works including OEM)**

- TRL 4
- Qualification & Industrialization
- Standardization

**PhD works (CMG lead)**

**RESEARCH WORK (collaborative works including OEM)**

- TRL 2-3
- Qualification & Industrialization
- Standardization


August 2018
THANK YOU

QUESTIONS ?