How the US and Worldwide Regulatory Environment Affects Defense Sales and Sustainment - from Problem to Opportunity

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Summary

- Environmental regulations
  - US regs – effects on defense manufacturing, sustainment
  - REACH and other overseas regs – indirect effects on defense manufacturing, sustainment; direct effects on deployed assets

- Effects on current materials and processes, and on alternatives
  - Loss of alternatives
  - Development of better alternatives

- Way forward
  - Better science understanding
  - Faster, more rational development and testing, design and qualification
  - International collaboration
  - Alternatives that work better than originals
Why do aerospace and defense worry so much about corrosion?
Elements and simple compounds on various hazmat lists

To fight corrosion you need the right weapons
Effects on current materials and processes – e.g. chromates

- Chromate conversion, passivation
  - Al, Mg, anodize, Cd, Zn, ZnNi – aircraft, vehicles
  - Electrical connectors, fasteners

- Chromate wash primer
  - Vehicles – Army, USMC

- Chromate primers, sealants
  - Aircraft painting, wet-install fasteners
  - Aircraft fuel tanks

- Chromic acid anodizing, anodize sealing

- Hard chrome plating
  - Wear resistance, rebuild

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Regulations affecting chromates – US

**Defense regs**
- OSD-ATL Memo, Apr 8, 2009, Minimizing the Use of Hexavalent Chromium
- DFARS, FR 75, 25569, May 5, 2011, Minimizing the Use of Materials Containing Hexavalent Chromium

**OSHA - Feb 28, 2006, Occupational Exposure to Hexavalent Chromium**
- 8 hr TWA Cr$^{6+}$ reduced from 52 to 5µg/m$^3$
- Requires careful control, housekeeping, showers, etc

**EPA – Stack emissions to be halved to 6-15 µg/dcsdm**
- PFOS eliminated

**DFARS affects OEM coatings >0.1%Cr$^{6+}$**
- Primers, SermeTels, sealants
- Conversion coatings exempt
- Memo affects all uses of Cr$^{6+}$ in all DoD depots, operations

**Harder to meet standard – engineering controls**
- Reconfiguration of plating, anodizing, sanding, painting operations – high capital cost, lower efficiency
- Same with Cd

**Better engineering controls needed**
- More citations, fines

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Regulations affecting chromates – Europe

**RoHS**
- $\text{Cr}^{6+} < 0.1\text{wt}\%$ in any coating
- Aerospace, defense exempt

**REACH**
- Registration – cannot use if not registered for that use
- Authorization – cannot use unless authorized for that use; limited duration
- Restriction – certain uses not permitted
- NO AERO/DEFENSE EXEMPTION
  - Can exist, but limited and not all countries

- **Affects electronics**
- **Little other aero/defense impact**
- **Recast has not changed this**

- **Affects everything**
- Loss of chemicals from market
- More difficult sustainment in EU
- Constant change, hard to predict

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<tr>
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This is just the latest batch
Approximate timeline

If your processes are not in the list of Authorized uses by the Application dates you can no longer do them or have them done in the EU after the sunset dates, except on-base with US citizens.

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Chromates

- Chromic acid (Alodine 1200) and Na dichromate (Alodine 1600) are primary conversion coatings for aircraft skins, Al components
  - Corrosion control, repaint, touch-up
- Chromic acid used for
  - Hard chrome plating - rebuild, wear resistance
  - Chromic acid anodizing – corrosion resistance and paint adhesion on Al
- Primary aircraft sustainment chemicals
So what happens if \( \text{Na}_2\text{Cr}_2\text{O}_7, \text{CrO}_3 \) etc. go into Annex XIV?

- **Consortium set up** to pursue Authorization for \( \text{CrO}_3 \)
  - \$2 million and no certainty
  - \$50,000 to get authorization if not from vendor

- **Will they be authorized?**
  - Probably, as essential for EU aero industry (Al and Mg conversion, chrome plating, probably CAA, sealing and passivation)
  - But Authorization is time-limited (X yrs??)
  - Any user must derive authorization from vendor or other authorization holder, or have own

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**Will there be Authorization Consortia for the other chromates?** Je n’ai pas aucune idée

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What about other materials?

Cd

- Cd also covered under RoHS (<0.01wt%)
- Cd salts also SVHCs under REACH
  - Will be authorizable sooner or later
- Cd already restricted for most EU vehicles
- OSHA enforcing similar housekeeping issues for Cd as for Cr$^{6+}$
- Navy requires Cd-free for new Ohio class replacement submarine
What else is on the REACH hit list?

- Boric acid
- Almost all Ni salts
- Pb salts
- Cd and Cd salts
- Co salts
- Phthalates (plastics)
- Flame retardants
- Large numbers of organics
- Arsenic salts
- Refractory fibers

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**Notice what was also submitted in the same group – some of the most important alternatives to chromates:**

- Co salts – nanophase Co-P, Co-P SiC/Cr$_3$C$_2$ composite electroplating
- Most trivalent passivates for ZnNi contain Co salt (nitrate) inhibitor

**Note:** TCP uses zirconate inhibitor
The story so far

- All our primary coatings and treatments are becoming harder to do
- Risk of regulation, deselection by customers
- Loss of chemicals from the market
- Even alternatives are in the same boat
  - As soon as we qualify an alternative it is likely to be next against the wall
  - Especially since most inhibitors must be chemically active by definition
So, what do we do about it...??

- Better anticipation
  - Will Martin presentation REACH session Session 3

- Better understanding of the science
  - We can develop alternatives better if we know why they work
  - We can often develop alternatives better than the original materials

- Faster, more rational:
  - Materials development, testing, qualification
  - System design
The drive for better science

- In general everything has been used because it works
- To find good replacements need to know why things work in the first place – what does your replacement really need to do?
- Often find that alternatives work in completely different ways
  - So we have to find out, e.g. why different types of inhibitors work in general
SERDP is funding several projects to evaluate different inhibitors and to understand how they function

- Understanding chromate inhibitor function
- Understanding non-chromate inhibitor function
- Rare earth inhibitors
- Conductive polymers

Why they work so well is also why don’t work well for electrical connectors
We always worry that nothing can equal performance of current materials

- Esp Cr\(^{6+}\), Cd other corrosion coatings

These coatings originally used, not because they are the best possible but because they were the best we had at the time

- Consequently all our specs and tests and performance requirements are not really designed to meet needs but are built around those coatings

- Often we do not understand why we have a particular requirement – it is just what the current system does

- Any alternative must work “as well as or better than” the current material

- We have no good way or modeling, testing, understanding what we actually need
One of first materials replaced was hard chrome

HVOF clearly much better wear and usually better corrosion resistance

- But had to work out surface finish to prevent seal destruction
- Can spall at high stress – beginning to be solved
- Cannot coat most IDs

So “better than or equal” depends on what is most important to the application

HVOF now used on all new landing gear design because it performs better
Development of better alternatives - Cd

- Low Hydrogen Embrittlement Zn(14-16)Ni now being implemented at Hill AFB
  - LHE version of automotive ZnNi
  - ZnNi+Cr³⁺ better than Cd+Cr⁶⁺ in most respects
  - Looks like it could replace most Cd, including fasteners (next talk)
  - So far not on electrical components (except Cr⁶⁺)

- Big problem now is lack of plating shops to supply it
  - Just a month back one OEM reverted new design to Cd for lack of ZnNi plating vendors
Development of better alternatives — chromates

In aerospace and defense we use chromates for all aircraft finishes

- Steel
  - Zn or Cd
  - Chromate passivate
  - Chromate Primer
  - Topcoat

- Al
  - Chromate pretreat
  - Chromate Primer
  - Chromate sealer
  - Anodize (SAA, CAA adhesion)
  - Topcoat

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Development of better alternatives – chromates

- Chromates particularly difficult to replace as they are so easy to use and work so well
  - Replacement of chromate conversion on OML driven at Boeing by inadequate performance – rivet rash
  - Boeing developed sol-gel adhesion promoter
    - Now licensed to Henkel, AC Tech/3M, Socomor
  - Several new non-Cr primers on market that work better in tests than chromated primer
    - See Session 7, for example
  - Also powdercoat, e-coat

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Toward a non-Cr finish

- We can use chromate conversion and non-Cr primer or non-chrome conversion and chromate primer.
- So far no non-Cr finish in production is as good as chromate.
  - But we are seeing non-Cr systems in flight test that might be as good (Session 13).
- Typical approach is to use first on low-risk areas (easily monitored areas such as OML) and apply to successively more critical and harder-to-monitor areas, ending with inaccessible internal airframe areas and fuel tanks when confident enough.
Way forward

- Rapid development and adoption
- Be aware of what is coming down pike (NASF, Session 3)
- International cooperation (Monday sessions)
  - To develop and use common technologies
  - To fight irrational and damaging philosophies and restrictions
- Better outreach to society
  - So people understand why they need industry and what it takes for industry to function
Rapid development and adoption

- It has typically taken ~20 yrs to get a new coating or material accepted
  - 1995 HCAT started – HVOF for landing gear
  - 2006 HVOF used for all new landing gear
  - 2012 HVOF specified for most new USAF gear
    - Hard chrome still being used for most legacy system repair
    - So HVOF will come in only as old gear are condemned and replaced, and finally be HVOF coated in repair
Rapid development and adoption

- Increasing use of computational methods
  - Materials design (established)
    - Alloy design in months instead of years
    - Not yet much used for coatings
  - Corrosion prediction (starting, Session 6)
    - In place of rule-of-thumb design
  - Computational plating design (in use, Session 11)
    - Anodes, fluid flow, thickness, chemistry
- Rapid testing/qualification in development, NAVAIR, SWRI, AFRL (ESTCP)
  - Corrosion testing more closely reflecting reality
  - Corrosion tests in weeks instead of years
Increased international collaboration

- NASF Coatings Roundtable
- Automotive on heels of ELV, RoHS
- Electronic on heels of RoHS non-Pb solder
- Aerospace Industries Assoc (AIA) working with AeroSpace and Defence (ASD) in EU
- International Aerospace Environmental Group (IAEG)
- SERDP/ESTCP funds US and non-US work
- Worldwide technology diffusion
In summary, while the environmental drivers are a big problem, they are also an opportunity for us to develop better solutions

- Learn why solutions work, and use that knowledge to make them better
- New predictive methods for faster and more certain development, testing, qualification, production of new solutions
- Collaborate worldwide to get the best options into specifications and production