Hexavalent chrome issues and options

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Topics

- Usage of Cr\(^{6+}\) in DoD
- Cr\(^{6+}\) as a shelf life issue
- Regulatory issues
- Alternatives in development, qualification, use
- Information resources
Usage
Cr6+ usage in DoD

Cr6+ (CrVI, hexavalent chrome, chromate) is our primary corrosion control material
Makes coating systems self-healing

**Cr6+-containing coatings**
- Chromate conversion coatings
- Chromate sealers
- Chromated primers
- Chromate washes
- Chromated metallic-ceramics

**Cr6+ processes, non-Cr6+ coatings**
- Hard chrome plating
- Chromic acid anodizing
- Chromic acid passivation

Cr6+-containing coatings are a problem for sustainment (repaint, touch-up, corrosion control)
Cr6+ processes are only a problem for OEM and depot

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Typical coating stackups

- Steel
  - Cd plate
  - Chromate conversion coat
  - Chromated primer
  - High VOC topcoat

- Aluminum alloy
  - Anodize (or not)
  - Chromate conversion coat
  - Chromated primer
  - High VOC topcoat
Cr⁶⁺ makes production and sustainment difficult

A problem to put on:
Aircraft repainting:
25µg m⁻³ allowed in paint hanger
5µg m⁻³ for operator

A problem to take off:
Maintainer releases Cd and Cr⁶⁺ dust

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Cr\textsuperscript{6+} as shelf life issue

- Items must survive storage
  - Munitions, spares
  - Without Cr\textsuperscript{6+} corrosion coating damage will not heal and corrosion and SCC can occur
- UAVs must operate right out of the box

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ESOH
Regulatory issues

- OSHA Cr⁶⁺ PEL 5μg m⁻³
- RoHS
  - Cr⁶⁺ < 0.1at%
  - Military and aerospace exempt
- Upcoming US RoHS?
  - HR 2420, no defense, aerospace exemption yet
- REACH (no Defense Exemption as of now, except in UK)
  - Sodium Dichromate is now a candidate substance for Annex XIV (for authorization)
  - But not a priority substance because easy to get around
  - ECHA hints that may include all chromates in next few years
  - Issue for sustainment of our systems in Europe
- REACH and RoHS issues for foreign sales
April 8 ‘09 OSD issued memo restricting Cr\textsuperscript{6+} use, unless no cost-effective alternatives with satisfactory performance

Requires Program Executive Officer (PEO) and Corrosion Control and Prevention Executive (CCPE) to certify if no acceptable alternative

Effect will be to force adoption of Cr\textsuperscript{6+}-free coatings and production methods
Alternatives under development, qualification, implemented
### Cr\(^{6+}\)-free coatings

<table>
<thead>
<tr>
<th>Material</th>
<th>Status of alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromate conversion coating</td>
<td>Trivalent chrome and non-Cr commercially available. Not yet as good as Cr(^{6+}). Used on cars, Boeing 777, various military systems, USAF T.O. 1-1-8 Prekote</td>
</tr>
<tr>
<td>Chromate primers</td>
<td>Non-Cr primers commercially available. Used on F-35, AH-64 Apache. Performance good on Cr(^{6+}) conversion coating. Moving toward total non-Cr(^{6+})</td>
</tr>
<tr>
<td>Chromate finish system</td>
<td>Low temperature powder coat and UV curable finishes in validation to replace primer/topcoat for aircraft and vehicles. No Cr(^{6+}), low VOC. In development</td>
</tr>
<tr>
<td>Chromate conversion of Mg</td>
<td>Tagnite now used on EFV gearbox, some helicopter components. Performance much better than Cr(^{6+}) conversion and anodize. Limited DoD use. Keronite available</td>
</tr>
<tr>
<td>Metallic-ceramics</td>
<td>Low-Cr and non-Cr available commercially. Performance uncertain</td>
</tr>
<tr>
<td>Chromate washes</td>
<td>Direct-to-metal used for MRAP. Poor performance</td>
</tr>
</tbody>
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### Cr⁶⁺-free processes

<table>
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<tbody>
<tr>
<td>Hard chrome plating</td>
<td>HVOF on F-35 landing gear, all new commercial and military landing gear. Being implemented for overhaul at OO-ALC. Electroplates such as nCo-P in validation</td>
</tr>
<tr>
<td>Chromic acid anodize</td>
<td>TFSAA approved by NAVAIR, BSAA by Boeing</td>
</tr>
</tbody>
</table>
How well do alternatives work?

- In general finish systems not quite as good as chromate
  - But getting a lot better
  - Total Cr\(^{6+}\)-free finish systems not there yet, but probably will be as good a Cr\(^{6+}\) in <5yrs
  - Total Cr\(^{6+}\)-free finish systems can work today on low-risk parts
- Tend to be harder to do, easier to mess up
  - Much more sensitive to process conditions
  - Requires better QC, inspection
- HVOF much better than hard chrome
- Tagnite much better than HAE, Dow 17 etc for Mg
- Cr\(^{6+}\) sealing + Deft non-Cr primer better than standard chromated system on F-35
- Deft has new total Cr-free finish. Still under test

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What does the future hold?

- Move toward chrome-free primer and non-chromate conversion over 5-10 years
  - Immediately for new weapons systems
- Move toward Cr\textsuperscript{6+}-free UV cure finishes for aircraft and vehicles next 5 years or so
  - Much faster turnaround, eliminates primer
- HVOF in place of hard chrome on all new system landing gear, many hydraulics and some legacy systems
  - HVOF for repair on most legacy landing gear and some hydraulics

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ASETSDefense sources of information

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ASETSDefense
http://www.asetdefense.org

Quick information on alternatives
ASETSDefense workshop agendas, briefings, summaries (HCAT meetings coming soon)

Database
Team Work Spaces
Tools to be added
Chromate Conversion Alternatives

Current Usage
Chromate conversion coatings and chromated sealers are used to create a self-healing conversion coating on Al and Mg alloys that is resistant to corrosion. They are also used for sealing electroplated and anodized coatings. These treatments are typically used prior to painting and finishing, since they generally improve adhesion of paints and sealants.

<table>
<thead>
<tr>
<th>Typical Applications</th>
<th>Typical Chromate Conversion Coatings</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Aircraft skins</td>
<td>• Conversion and sealing coatings for Al (e.g., Alodine, Indite, etc.)</td>
<td>• MIL-DTL-81706</td>
</tr>
<tr>
<td>• AI frames for aircraft and vehicles</td>
<td>• Conversion and sealing coatings for Mg (e.g., Dow 7, 17, 19, HAE anodize)</td>
<td>• MIL-C-8541</td>
</tr>
<tr>
<td>• Mg gearboxes</td>
<td></td>
<td>• MIL-M-45202</td>
</tr>
<tr>
<td>• Corrosion-resistant coatings (Cd, Al, ZnNi, etc.)</td>
<td></td>
<td>• AMS 1171</td>
</tr>
<tr>
<td>• Anodize sealing</td>
<td></td>
<td>• TO 1-1-8</td>
</tr>
<tr>
<td>• Fasteners and electrical connectors (Zn or Cd plated)</td>
<td></td>
<td>• MIL-A-8625</td>
</tr>
<tr>
<td>• Wash primer for steels, armor</td>
<td></td>
<td>• MIL-C-3171</td>
</tr>
</tbody>
</table>

ESOH Issues
Cr⁶⁺ (CrVI, hexavalent chromium) is a known carcinogen that is strongly regulated under

- EPA Clean Air Act rules
- OSHA Occupational Exposure to Hexavalent Chromium (Cr⁶⁺ PEL is currently 5µg/m³)
- European rules (RoHS, WEEE, ELV)

Exposure
Personnel may be exposed during manufacture, depot overhaul, repaint, and operational level touch-up and repair.
Database – Simple search

**Main Menu**
- Home
- Surface Engineering Database
- Clean Alternative Information
- ASETSDefense Workshops
- DoD Policies
- Team Work Spaces
- Tools
- Assistance
- Links
- Contact ASETSDefense

**Simple Search:** Choose options by drop-down arrows in boxes, and click Search.

**Detail Search:** Click Search button to activate. Choose options in search boxes.

**Alternative To:** All
**Document Category:** All
**Generic Systems:** All
**Applications:** All

**Search:**
- Cadmium plate
- Chromic acid anodize
- Al and Mg alloys
- Composites
- Electrical
- Engines
- Fasteners
- Hydraulic systems
- Skins, structures
- Steels
- Wheels, tracks

**Designed to answer question “What alternative to hard chrome (etc) is available (authorized, implemented, spec’d) for my type of system and application?”**

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Search for specific materials, systems, tests, people, organizations

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JOINT TEST PREVIEW

Validation of HVOF Thermal Sprayed Hard Chrome Alternatives for Replacement of Hard Chrome on Hydraulic/Power System Components (August 2012)

Test program: August 2012
Prepared by: August 2012
Hard Chrome Alternatives

Engineering data

- Specimens removed at 10% cyclic life and subsequently discontinued due to indicated N1 failure.
ASETSDefense ’09: Sustainable Surface Engineering for Aerospace and Defense

Denver, August 31 - September 3, 2009

- Aircraft, ships, vehicles
- Alternatives to chromate primers, sealers, conversion coats, low VOC paint systems, hard chrome, Cd plate
- Stackups, hydraulics, fasteners, electrical connectors

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