

**United Space Alliance, LLC  
Materials & Process  
Engineering**

**Chrome - Free Aluminum  
Coating System**

**John H. Bailey and Jeffrey D. Gugel  
May 12, 2010**



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# **Government Agency Policy on Hexavalent Chromium**

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- **OSHA has identified hexavalent chromium as a cause of serious, acute, and chronic exposure hazards for personnel**
- **EPA restrictions on airborne and liquid release of chromium containing compounds**
- **The Under Secretary of Defense issued a Memorandum in November 2008 entitled “Minimizing the Use of Hexavalent Chromium”, which directed DoD Military Departments to:**
  - “Approve use of alternatives where they can perform adequately for the intended application and operating environment”
  - “Update all relevant technical documents and specifications to authorize use of the qualified alternatives and therefore eliminate the use of materials containing Cr<sup>+6</sup>”

## ***Aerospace Aluminum Alloys***

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- **Aerospace aluminum alloys used in missiles and aircraft are typically wrought products of the 2xxx, 7xxx, and 6xxx series, in various precipitation hardened tempers**
- **These grades of aluminum are chosen for their light weight and high strengths, but require supplemental corrosion protection methods to maximize the service life**
- **Aerospace aluminum alloys have traditionally used hexavalent chromium compounds (Cr<sup>+6</sup>) to mitigate corrosion**
  - These compounds have been the preferred protection method for aerospace aluminum alloys
  - These compounds have been used for over 50 years

## ***Coating History at United Space Alliance***

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- **Solid Rocket Booster (SRB) structural hardware is constructed primarily of 2219-T87**
- **From the beginning of the Space Shuttle Program through the mid-1990's, the SRB hardware was coated with chromate - containing Alodine® 1201™ pretreatment, and AKZO epoxy topcoats which contained lead and chromates**
- **To achieve the maximum levels of corrosion protection, all aluminum alloys used for SRB hardware have utilized a 3-part system comprised of:**
  - Conversion Pretreatment
  - Primer
  - Topcoat

## **Coating History at United Space Alliance**

- **During the mid-1990's the SRB coating systems for aluminum alloys were changed to:**
  - Alodine® 1201™ hexavalent chrome conversion pretreatment
  - Deft chromated water-borne epoxy primer (lead - free)
  - Deft urethane topcoat (lead - free)
  
- **In 1999, USA began an extensive test program to qualify chrome - free pretreatment and coating systems**
  - 40 systems were evaluated
  - Alodine® 5200™ and 5700™ pretreatment, in combination with chrome - free primer and topcoat, proved to provide the best corrosion protection
    - **Performance criteria included**
      - Adhesion
      - Corrosion Resistance (Oceanfront Atmosphere, Seawater Immersion, Salt Fog, Electrochemical Impedance Spectroscopy)
      - Service Environment and Service Life
      - Future Processing (Touch-Up, Repair, Recoat)
      - Compatibility with Thermal Protection Coatings

## **Chrome - Free Replacement Testing**

- **The Alodine® Deft Replacement project consisted of three phases**
  - Down selection
  - Qualification
  - Implementation
- **Down selection consisted of:**
  - 40 suppliers evaluated
  - Phase I Testing - Six pretreatments and six coating systems
  - Phase II Testing - Three pretreatments and three coating systems were chosen for qualification
- **Qualification testing consisted of over 4,000 tests:**
  - All coating candidates were tested with each pretreatment candidate and the corresponding baseline
  - Testing was halted for candidates that were found to be unsatisfactory
  - Processability (Personnel Considerations, Repeatability)

# **Chrome - Free Replacement Implementation**

- **Implementation consisted of:**
  - Validation on Flight Structures (process validation - not flown)
    - No processing anomalies
    - Meeting acceptance requirements
  - Processing engineering change paper to incorporate change into engineering drawings and procedures
  - Verification on flight structures (flown)
  - Life Cycle Monitoring
    - Surface mapping for pits and general corrosion
    - Continuing to gather performance data

## **Chrome - Free Processing**

- **After this extensive three year evaluation, USA converted to chromate - free pretreatment and primer in 2002 for processing SRB hardware for the Space Shuttle Program**
- **USA's testing showed that moving away from Cr<sup>+6</sup>, while meeting baseline corrosion protection performance requirements**
  - Requires a system, as opposed to individual components
  - Maximum corrosion protection requires pretreatment, primer, and topcoat
- **SRB hardware has been flying for the past 7 years using chrome - free systems, with no deleterious effects**

## **Chrome - Free Processing (cont.)**

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- **The chrome - free pretreatment and primer / topcoat systems are being targeted for use on future manned space flight vehicles**
- **As a result of USA's proactive approach to finding an environmentally friendly solution to mitigate the hexavalent chrome issue on SRB hardware**
  - USA has become a recognized leader within the aerospace community in the removal of Cr<sup>+6</sup> from coating waste streams
  - USA is the only aerospace company at Kennedy Space Center to be using chrome - free conversion pretreatment and primer for flight hardware

## **Chrome - Free Coating System**

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- **Current Coating System Used on SRB Hardware**
  - **Chromate - Free Pretreatment System**
    - Chosen through testing as the primary conversion pretreatment on SRB aluminum hardware due to:
      - Chromate - free
      - Can be disposed of as non-hazardous waste
    - Alodine® 5200™ (immersion tank application) and Alodine® 5700™ (brush and spray application)
    - Operational personnel prefer this system due to ease of application and reduced exposure to hazardous material

## **Chrome - Free Coating System (cont.)**

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- **Current Coating System Used on SRB Hardware**
  - **Chromate - Free Primer and Topcoat System**
    - Chrome - free primer and topcoat were chosen through testing as the primary coating system for aluminum SRB hardware due to
      - Ease of mixing
      - Non-hazardous disposal
      - Ease of application (8 hour pot life for both primer and topcoat)
    - Operational personnel prefer this system due to reduced exposure to hazardous wastes and extended working life

## ***Acreage Coverage of SRB Components***

- **SRB Aft Skirt coated with Alodine® 5700™ and chrome - free primer / topcoat protective finish**



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## ***Acreage Coverage of SRB Components***

- **SRB forward structures coated with Alodine® 5700™ and chrome - free primer / topcoat protective finish**



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## ***Benefits of Chrome - Free Coatings***

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- **Benefits of Chromate - Free Pretreatment Systems**
  - Conforms to EPA and OSHA guidelines concerning hexavalent chromium
  - Supports the new DoD directive concerning the reduction of hexavalent chrome
  - Reduces in-process costs due to handling / safety issues
  - Reduces disposal costs
  - Meets or exceeds corrosion protection (as a system) compared to hexavalent chromium systems
  
- **Benefits of Chromate - Free Primer Systems**
  - Removes chrome compounds from processing stream
  - Meets or exceeds performance, repeatability, and adhesion as compared to chromate baseline coating systems
  - Provides corrosion protection foundation for polyurethane topcoats

## ***Why is USA's Chrome - Free Coating System a Good Solution?***

- **Eliminates chromates from waste processing streams**
- **Reduces worker exposure to hazardous materials**
- **Pretreatment satisfies baseline adhesion properties for primers and adhesives**
- **Pretreatment with paint systems satisfies corrosion resistance baseline requirements**
- **Pretreatment has an extended window for primer application**
- **Pretreatment is compatible with all SRB coating systems**
- **Pretreatment may be applied to all aluminum surfaces**

## ***Next Generation of Pretreatments***

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- **After 7 years of chrome-free processing, USA is evaluating new chrome - free coatings for aerospace use**
- **Electrodeposited Inorganic Titanium Oxides show promise as the next generation of chromate - free pretreatment**
  - This product is deposited by cool plasma
  - Deposit applied to aluminum and titanium alloys, and aluminized iron-base substrates
  - Corrosion resistant
  - Provides substrate corrosion protection
  - Wear resistant
  - High heat resistance
  - Chemical resistance
  - Coating thickness of several microns
  - Foundation for topcoats, adhesives, or thermal protection systems
  - May eliminate the need for organic topcoats