Aerospace and Defense Industry Collaborative Research

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Presentation Agenda

- Alternatives assessment
- Collaborative research approach
- Application of approach to the use of hexavalent chromium in the defense/aerospace industry

What is Alternatives Assessment?

A process for identifying and comparing potential chemical, material, product, or other alternatives that can be used as substitutes to replace chemicals of high concern.

Goals

- Reduce risk by reducing hazard
- Move from problems to solutions
- Avoid regrettable substitutions
- Encourage transparency, common language, and documentation to communicate among stakeholders

Alternatives Assessment

EHS	Cost/ Financial	Technical/ Performance
Is it safer?	Is it affordable?	Will it work?
• Flammability? • Human toxicity? • Animal toxicity? • Ozone depletion? • Persistence? • Bioacummulative? • Etc.	• Materials? • Regulatory compliance? • Insurance? • Training? • Equipment? • Utilities/energy? • Etc.	• Process changes? • Equipment changes? • Material compatibility? • Product quality? • Produce longevity? • Customer specifications? • Etc.

Conditions for Industry Collaboration

1. Use of a toxic chemical(s) of concern is pervasive in an industry sector
2. Toxic chemical is not used for competitive advantage (pre-competitive)
3. Strong market and/or regulatory drivers to reduce the use of the toxic chemical
4. Significant research required to switch to the use of safer alternatives
5. Time and cost intensive for companies to individually conduct research
6. Independent third party available to manage and coordinate the effort
7. Voluntary participation by government, academic, and industry collaborators
8. Participants provide either in-kind contributions (production equipment, technical expertise, materials, supplies, testing, etc.) or direct funding
9. Intent of participants is to adopt the safer alternative solutions identified
10. All results made public so that other companies can adopt solutions identified

Hex Chrome: Driver for Change

- Defense Federal Acquisition Regulation Supplement (DFARS) , May 2011
- No Department of Defense contract may include a specification or standard that results in a deliverable containing more than 0.1% hexavalent chromium or requires use or removal during subsequent phases of the deliverable, unless an exception or approval applies.
- Several exceptions include <u>conversion coatings</u>; hard chrome plating; chromic acid anodizing; most chromate metallic ceramics; and chromate washes, etches, pickling, etc.

Contributors to Phases I & II Research Efforts

Government

Aviation & Missile Command Safety Office

U.S. AIR FORCE

NAVAIR Naval Air Systems Command

NASA

OTA Office of Technical Assistance & Technology

Industry

Academia

UMASS LOWELL

TURI Toxics Use Reduction Institute UMASS LOWELL

LOCKHEED MARTIN

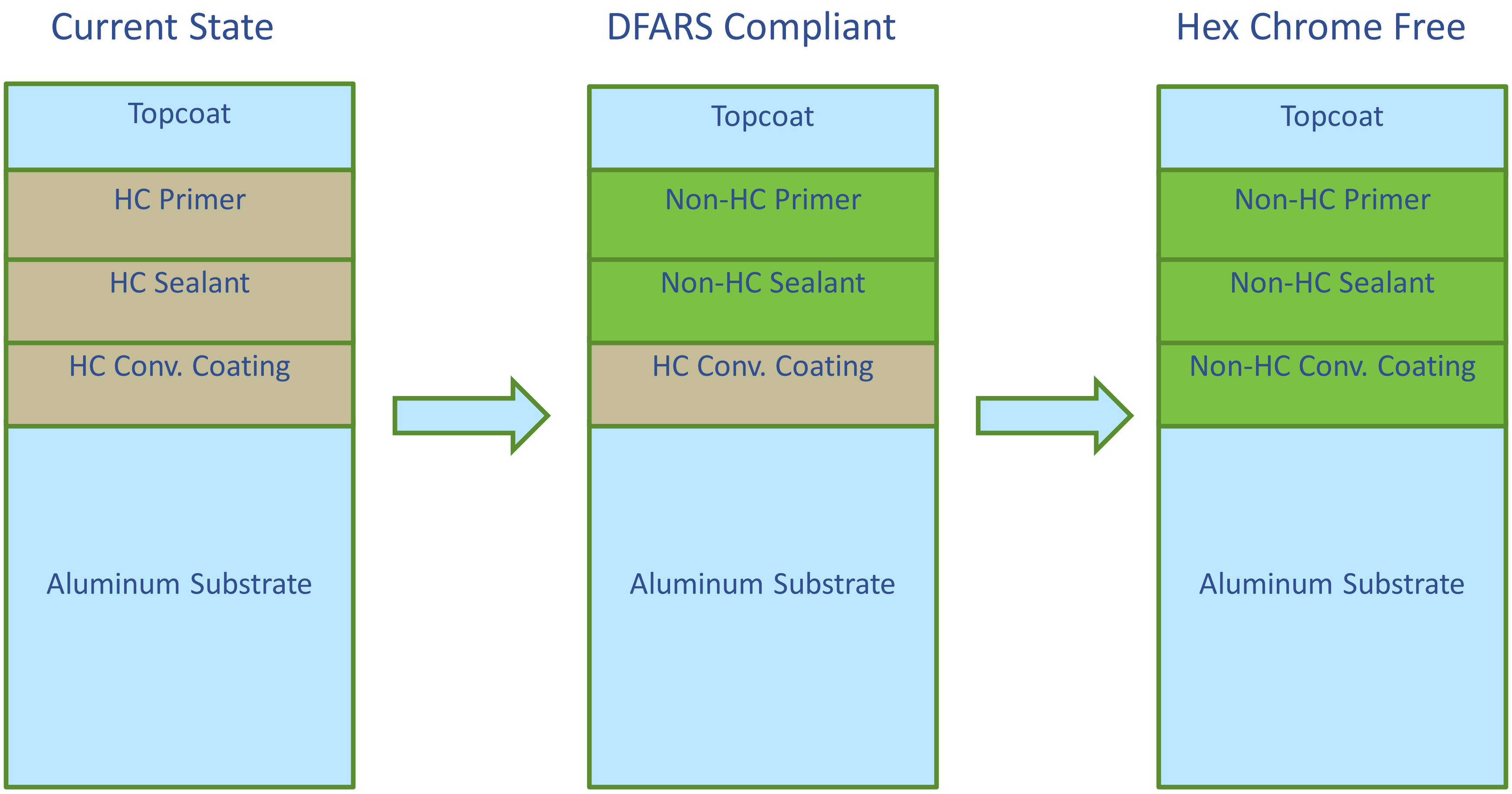
BOMBARDIER

NORTHROP GRUMMAN

METALAST International, Inc.

Raytheon

TUR of Hexavalent Chromium (HC)



Phase I Research Project Objectives

- Evaluate alternatives to metal finishing applications in the aerospace/defense industry that use hexavalent chromium sealants, primers, and conversion coatings.

- Conduct technical performance testing to evaluate the corrosion resistance for different types of sealant applications.

- The research results should provide screening level data to influence the company decisions regarding how to proceed with DFARs compliance: 1) pursue qualification level testing, or 2) support a request for a DFARs exemption.

- Develop a working relationship with research participants as a basis for continued collaborative research.

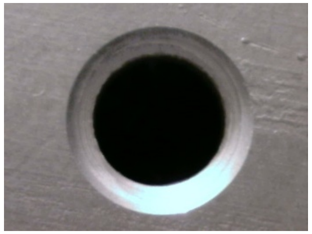
Sealant Applications

1. Sealant applied to the threads of a fastener (wet installation)

2. Sealant applied to the ends of a fastener

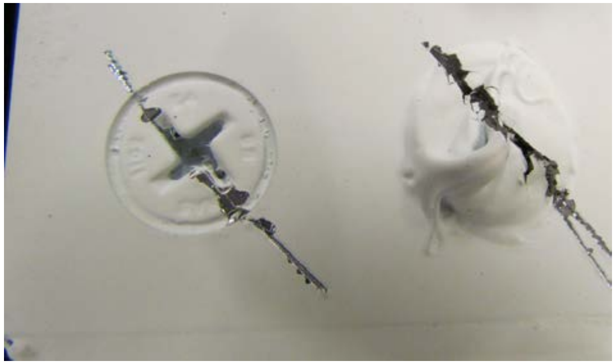
3. Sealant applied to butt joint (for example a ¼ inch gap between materials)

4. Sealant applied to faying surfaces (the surfaces of materials in contact with each other and joined together)



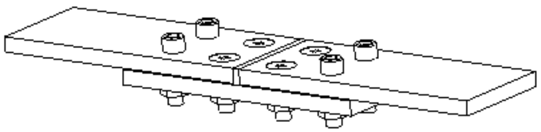
Test Vehicle Design Considerations

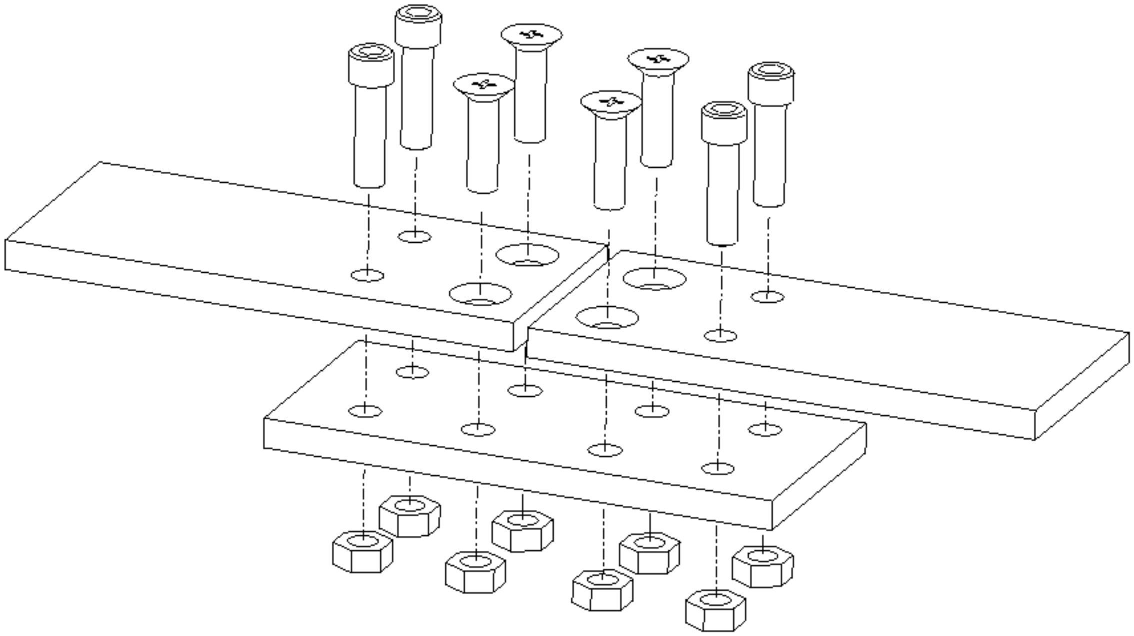
- Platform for evaluating the technical performance (corrosion resistance) of sealants, conversion coatings, and primers for different sealant applications
- Introduce galvanic differential between different metals
- No complex or costly fabrication requirements
- Ability to introduce damage to test vehicles to simulate a challenging operating environment



Phase I Test Vehicle

Aluminum plates:
2” x 4.5” x 0.25”
(alloys 6061 and
7075)

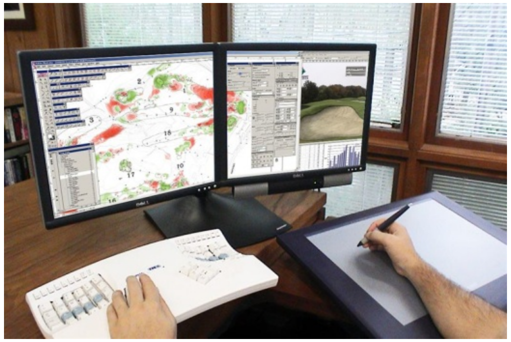




8 stainless steel fasteners (4 with 100 degree countersunk heads, and 4 with socket heads)

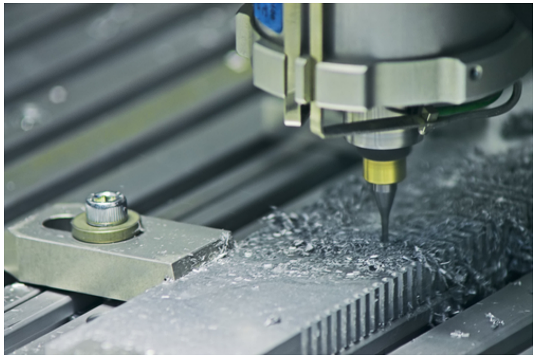
Research Process

Test plan development
All participants



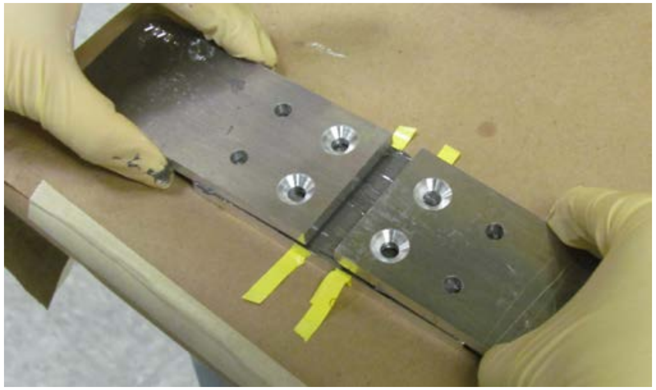
Test vehicle CAD design
Raytheon

Stress Analysis
Northrop Grumman



Aluminum plate machining
UMass Lowell – Phase I
NASA – Phase II

Research Process



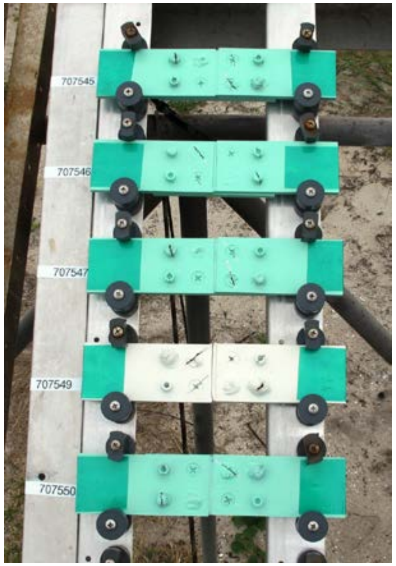
Conversion Coating (HCF)
Metalast

Conversion Coating (HC)
Northrop Grumman

Test Vehicle Assembly, Painting, Priming, & Scribing
Raytheon

Test Vehicle Thermal & Mechanical Preconditioning
NAVAIR

Research Process



Accelerated Corrosion Test (6weeks), Inspection, and Analysis
Lockheed Martin

Long-term Corrosion Test (one year)
NASA

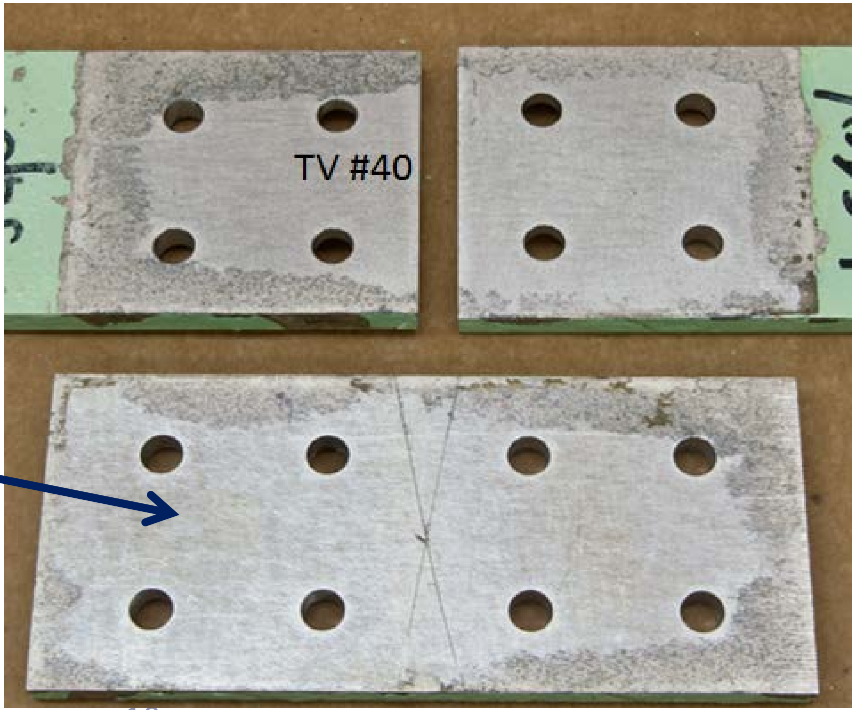
Statistical Analysis & Write Paper
TURI

Phase I Results

Corrosion analysis after exposure in salt fog chamber.

Countersunk holes

Faying Surface



Phase I Results

Metal Finishing Magazine

May/June 2013 Edition

TECHNICALLY speaking

BY GREGORY MOROSE, TURI, UMASS LOWELL; DAYNA LAMB AND DAVE PINSKY, RAYTHEON; KENT DEFRANCO AND ZACHARY POWELL, LOCKHEED MARTIN; AND ALP MANAVBASI, METALAST

Evaluation for Alternatives to Hexavalent Chromium Sealants

Polysulfide sealants containing soluble hexavalent chromium compounds are currently being used in a variety of applications in aerospace/defense manufacturing. The applications mostly involve the filling of gaps and recesses to prevent water intrusion and collection in an attempt to prevent corrosion of the base metal. These sealants are most commonly used on aluminum assemblies and are often over coated with a variety of common coating systems with hexavalent chromium-based corrosion inhibitors. Hexavalent chromium compounds are of concern because they are carcinogens, mutagens, developmental toxicants, and have high acute toxicity. Workplace exposure to hexavalent chromium may cause health impacts, such as lung cancer and respiratory tract damage in workers who breathe airborne hexavalent chromium, and skin damage from dermal exposure (OSHA, 2009).

Regulatory and market drivers are motivating a global effort in the aerospace/defense industry to replace hexavalent chromium-containing materials with hexavalent chromium-free alternatives for various applications. For example, the Occupational Safety and Health Administration (OSHA) implemented new Hexavalent Chromium Standards for general industry in 2006 (29 CFR 1910.1026) where the average worker exposure to hexavalent chromium over the course of an 8-hour work shift was reduced to 5 ug/m3 (OSHA, 2009). The Defense Federal Acquisition Regulation Supplement (DFARS) was issued on May 5, 2011 (76 FR 22569), "Minimizing the Use of Materials Containing Hexavalent Chromium." It states that no Department of Defense contract (for programs prior to Milestone A) may include a specification or standard that results in a deliverable containing more than 0.1% hexavalent chromium in any homogeneous material ***where acceptable substitutes are available***, or requires use or removal during subsequent phases of the deliverable, unless an exception or approval applies. There are several exceptions to the DFARS rule, such as conversion coatings and hard chrome plating (DFARS 2011). However, the DFARS rule applies to sealant and primer applications that contain hexavalent chromium.

Despite the known hazards and restrictions, hexavalent chromium materials continue to be used in the aerospace/defense industry, due to technical performance and economic challenges of transitioning to hexavalent chromium-free alternatives. The principal technical performance challenge is that the long-term, corrosion-inhibiting properties of the hexavalent chromium-free alternatives are not

VENDOR	VENDOR PN	SPECIFICATION	CHEMISTRY	CORROSION INHIBITOR
PPG Aerospace	PS-870	MIL-PRF-81733D Type II Class 1 Grade A	Polysulfide	Hexavalent chromium
3M	AC-735	MIL-PRF-81733D Type II Class 1 Grade B and AMS 3265 Class B	Polysulfide	Zinc phosphate
PPG Aerospace	PR-1775	AMS 3265 Class B	Polysulfide	Ammonium phosphite
PPG Aerospace	PR-2001	AMS 3277 Type II, Class B	Polythioether	None

Table 1: Sealants Included in the Design of Experiments

VENDOR	MODEL	PRIMER/ TOPCOAT	SPECIFICATION	HEXAVALENT CHROMIUM CONTAINING
Akzo Nobel Aerospace Coatings	10P20-13 High solids epoxy primer + EC-213 HS epoxy primer cure solution	Primer	MIL SPEC PRF 23377, Type 1, Class C	Yes
Deft Inc.	44GN098 1GK base and catalyst	Primer	MIL SPEC PRF 85582, Type 1, Class N	No
PRC-Desoto of PPG Aerospace	CA8211, 8211F37886MPY22K	Topcoat	MIL SPEC PRF 85285, Type 1	No

Table 2: Primers and Topcoat Included in the Design of Experiments

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Sealant Research Overview

Research Phase	Timeframe	Purpose	Materials Evaluated
Phase I	2012	Screening level information for sealant performance	4 sealants 2 conversion coatings 2 aluminum alloys 2 primers 2 fastener types With & without topcoat
Phase II	2013	• DFARs compliance for sealants • Sealant removal evaluation with safer materials	6 sealants Single conv. coating, alum. alloy, primer, and fastener type Sealant removers (TBD)
Phase III	2014	Totally hex chrome free stack-up: conversion coating, sealant, primer, & topcoat	To be determined

Sealant Selection

Vendor	Vendor PN	Specification	Purpose	Corrosion Inhibitor
PPG Aerospace	PS-870	MIL-PRF-81733D Type II Class 1 Grade A	Baseline	Hexavalent chromium
3M	AC-735	MIL-PRF-81733D Type II Class 1 Grade B and AMS 3265 Class B	Alternative Sealant	Zinc phosphate
PPG Aerospace	PR-1775	AMS 3265 Class B	Alternative Sealant	Phosphite salt
PPG Aerospace	RW-6040-71	Not yet qualified	Alternative Sealant	Phosphite salt
Flame Master	CS 5500N CI	Not yet qualified	Alternative Sealant	Not listed
PPG Aerospace	PR-1440	AMS-S-8802 Class B	Negative Control	None

Summary

- The collaborative research approach has been a cost effective way to share resources to evaluate the technical performance of safer materials.
- Phase II results should be available in January 2014.
- Let me know if you are interested in participating in this sealant evaluation effort.
- Let me know if you have any ideas for starting a collaborative approach for evaluating other chemicals of concern (e.g. cadmium plated connectors).

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