



A Strategy for Reduction of Hexavalent Chromium and Cadmium at Corpus Christi Army Depot (CCAD)

Mark Feathers

U.S. Army Aviation and Missile Command

SERDP • ESTCP
SYMPOSIUM
2018 | Enhancing DoD's Mission Effectiveness

Overview

- RDECOM Environmental Technology Acquisition Program (ETAP); Environmental Quality Technology (EQT) Pollution Prevention (P2) Program
- Sustainability risk
- Programmatic strategy/Implementation Planning
- Status of TMR projects (projects in lab, Demo or planning phase)
- Challenges
- Summary



Toxic Metal Reduction (TMR) Program Background

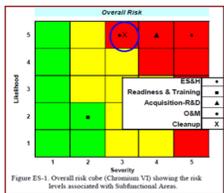
- TMR is funded by the Army ETAP program and managed by RDECOM
 - Funded by Army Equipping and Installation PEGs
- Addresses Army Environmental Quality Technology Pollution Prevention (EQT P2) Program requirement PP-2-02-06, “Toxic Metal Reduction in Surface Finishing of Army Weapon Systems” validated by ACSIM in 2018 ”
- Implements “Technology Transition Agreement for Hexavalent Chromium Free Surface Treatment Technologies for the Corpus Christi Army Depot (CCAD) Plating Shop”
 - Signed by AMCOM CoS, CCAD Deputy Commander, PEO CoS, RDECOM and AED-AEM
 - Coordinating with PM FVL (Future Vertical Lift) for endorsement
- Objective is to eliminate the use of Cr6+ and cadmium in the Plating Shop to reduce risk to people and processes
 - 13 projects in different phases

27 Million dollars has been invested or leveraged by the Army for TMR projects that have a direct benefit to the CCAD Plating Shop



Sustainability Risk

- **Obsolescence**
 - Regulatory pressure (OSHA, ACGIH or EPA)
 - Toxic Substances Control Act (TSCA) precautionary principle or OSHA/ACGIH lowers the exposure limit to unsustainable levels
 - Competitive global environment is moving away from Cr6+ products
- **Cr6+ is very prevalent in the CCAD Plating Shop**
 - Cr6+ found in 18% of active tanks in the plating shop
 - Critical processes: anodizing, sealing, conversion coating, plating and passivation
 - 400+ unique parts receive Cr6+ surface treatments
- Takes 5-10 years to implement a new alternative process
- Bottom Line: obsolescence + prevalence + duration to implement = high risk
- The Toxic Metal Reduction (TMR) program is designed to mitigate the Cr6+ sustainability issues and is relevant to legacy and Futures platforms



USD(ALT)
Memo
"Minimizing
the Use of
Hexavalent
Chromium"



4



**TMR
Program**

DISTRIBUTION A. Approved for public release: distribution unlimited.



Programmatic Strategy

- Define the problem
- Identify the technology gaps
- Stakeholder buy in (Technology Transition Agreement)
- Coordinate Test/Demonstration Plans
- Toxicology assessments
- Establish an IPT



Implementation Planning

- Understand your implementation requirements up front
 - Is IH on board?
 - Blanket approvals or part by part?
 - Additional requirements for CSI?
 - Is Engineering willing and funded to generate Maintenance Engineering Orders (MEOs) to implement the change?
 - What are the impacts to the wastewater treatment processes and have they been mitigated?
 - Training required?
 - Will demo provide full rate production capability or will additional upgrades be required?



Cr6+-Free Aluminum Anodizing (TMR 15-01)



Project Description

- AMCOM and ARL are executing a project to qualify Tartaric Sulfuric Acid Anodizing (TSAA) as an alternative to traditional Chromic Acid Anodizing (CAA)
- The TSAA process has been optimized by Sikorsky under a previous contract and will be tested by ARL against a battery of materials and performance criteria generated by AMRDEC AEF
- Replaces dichromate seal with Trivalent Chrome Pretreatment (TCP)



UH-60 Receives a MIL-A-8625F, Type I Anodized Coating on Rear Landing Gear Parts (e.g. spacer, knob, band, retainer)

Progress Report

- AMZ contract with ARL is in place and will validate optimized process and perform AED required testing
- Stripping of TSAA is being performed on a different project (TMR 13-03, ARL)
- TFSAA data being evaluated against AED test requirements

Schedule

- Demonstration: 1Q-FY20 thru 4Q-FY20
- End/transition point: 4Q-FY21



TFSAA Is a Competing Technology

12/4/18

DISTRIBUTION A. Approved for public release: distribution unlimited.

7

Lab Phase

SERDP • ESTCP
SYMPOSIUM
#SerdpEstcp2018

Cr6+-Free Surface Activation and Preparation for Metal Plating (TMR 13-03)



Project Description

- ARL validated Cr6+ free chemical strippers for Type III anodized aluminum which met technical, environmental, and performance requirements
- This project established a baseline for multiple parameters, identified effective commercially available alternatives and evaluated their performance and substrate effects



AH-64 Loader/ Downloader (base plate, backside plate and forward plate assemblies) Receives Type III Anodize and Dichromate seal

Progress Report

- Project applies to both TSAA and Type III Hard anodize
- Completed all laboratory testing except for TSAA
- Down select of final products completed and include NaOH, Enerox/Stripol (Nitric Acid) and Metalast AOS 100 (Sulfuric Acid) and possibly LNC Deoxidizer (Ferric Sulfate (40-50%), Nitric Acid (10-20%), Trade secret (1-5%))
- Demonstrations in progress

Schedule

- Demonstration: 1Q-FY20 through 4Q-20
- End/transition point: 4Q-FY21



Cr6+-Free Hard Chrome Electroplating (TMR 14-01)



Project Description

- AMCOM and the Faraday team is developing a Cr6+- free NLOS plating process that results in a hard chrome plate that meets aviation performance requirements and is ready for transition
- Lab testing is being conducted at Faraday for process optimization and performance
- 17 other companies and OEMs are participating on the team
- Future demonstration is scheduled for CCAD



Landing Gear Parts Receive an Chromium Electroplated Coating (AMS QQ-C-320)

Progress Report

- Process optimization testing is in work by Faraday
- Significant progress made with bath stability/variables and taber wear requirements
- Taber wear comparable or better than Cr6+ chrome
- Focus is on microcracking issue using optimized bath
- Different looping waveforms are being tested to provide layers of coatings that will crack independently
- Reprogramming will be required to extend the program for optimization

Schedule

- Demonstration: 1Q-FY20 through 4Q-FY21
- Project End/Transition: FY23
- Full implementation requires a total of 4 tanks

*Cold Spray Is a Complimenting Technology
(LOS VS NLOS)*



Cr6+- Free Post-Treatment Sealers for Legacy Coatings (TMR 16-02)



Project Description

- AMCOM-ARL team will develop, validate, and demonstrate Cr6+ free post-treatment sealers for IVD aluminum and hard coat (Type III) aluminum anodize surface treatment used on aviation.
- Lab testing will be conducted at ARL followed by demonstrations at CCAD.



AH-64 Loader/ Down Loader Receives Type III Anodize and Dichromate seal

Progress Report

- CCAD and AEM prepared IVD aluminum coated panels and sealed them with traditional and alternative sealers
- AMZ prepared Type III hard anodized panels and sealed them with traditional and alternative sealers
- ARL lab testing complete
- Down selecting to best candidates for demo

Schedule

- Demonstration: 2Q-FY19 through 4Q-FY19
- Project End/Transition: 2Q-FY20



Alternative Non-Chromate Sealers for Black Oxide (TMR 16-01) and Manganese for Ferrous Metals (TMR 17-01)



Project Description

- ARL has been testing COTS Cr6+ free sealers that conform to MIL-DTL-13924 (Black Oxide) and MIL-DTL-16232 (Manganese Phosphate)



Some Parts in Apache Intermediate Gearbox Receive Black Oxide Surface Treatment

Progress Report

- Black Oxide
 - ARL processed black oxide test panels and completed majority of laboratory tests
 - Down selection in progress for demo
 - Several candidates seem to out perform Cr6+ (B117)
- Manganese phosphate
 - B117 testing complete
 - Other testing underway
 - Outdoor exposure testing initiated

Schedule

- Demonstration: 4Q-FY18 through 3Q-FY19
- Project End/Transition: 3Q-FY20
- May demo parts at ANAD (TBD)



Cold Spray – Demonstration of Portable System as Hard Chrome Alternative (TMR 16-03)



Project Description

- ARL will demonstrate and transition Cold Spray (CS) coatings to eliminate Cr+6 in numerous hard chrome applications at CCAD
- CS facilities will be established at CCAD
- CS processes will be scaled up and qualified for candidate parts UH-60, AH-64, T-55 & T-700
- Process will serve as an additional alternative to hard chrome plating



CrC-NiCr Cold Spray Coating AH-64 T-700 Turbine Shaft

Progress Report

- AED test requirements are being addressed by ARL
 - TMR and SERDP
- Powders now commercially available
- Identified parts, established JTP, conducted installation meeting with CCAD
- Developing powder spec and processing parameters
- CCAD working to establish cold spray service development contract (Moog Inc.)

Schedule

- Project End/Transition: Q2-FY21

Cold Spray provides significant repair and coating capabilities for CCAD



Cyanide-Free Copper and Silver Electroplating (TMR 15-02)



Project Description

- AMCOM and CCAD are demonstrating non-cyanide products and processes for copper and silver plating/strike that are ready for transition into a production environment
- Will also demonstrate non-chromic acid and non-cyanide stripping methods to remove copper and silver plating
- Will evaluate cold spray technology as an alternative in the future
- Demo is being conducted in the Plating Shop pilot line



**Spur Gear, P/N
70351-08088-102 with
Silver Plating**

*Can also be applied
using cold spray*

Progress Report

- Round 3 Cu and Ag coupons are in work
- Fatigue coupons have been plated
- Hydrogen embrittlement coupons are plated
- Initiating round 1 of the stripping phase

Schedule

- Demonstration scheduled for completion 3Q-FY19
- Project End/Transition 3Q-FY20



Cr6+-Free Conversion Coatings (TMR 14-02)



Project Description

- ARL with support from AMCOM, CCAD and AEM is demonstrating non Cr6+ immersion alternatives to replace chromated aluminum conversion coatings (zirconate chemistry)
- Alternatives will conform to performance criteria of MIL-DTL-5541, MIL-DTL-81706 and TT-C-490 and will transition after two years of field validation



Engine Nacelles with
Zirconium Pretreatment

Progress Report

- Completed inspection of engine nacelles (2.5 year) and immersion demo (1.5 year) at CCAD during week of 25 June 2018
- NAVAIR presently revising MIL-DTL-5541 to include new type III, Class IV, which will be the pretreatments used during aviation demonstrations
- All parts and panels from ANAD and CCAD demonstrations removed from CCAFB site and data being compiled for final report

Schedule

- Demonstrations complete 4Q-FY18
- Project End/Transition: 4Q-FY19
- 5541 spec 1Q-FY19



Zn-Ni Plating to Replace Cadmium Plating (TMR)



Project Description

- Zn-Ni plating is the most advanced alternative for replacement
- Air Force and Navy (ES3) have performed significant testing on Zn-Ni coatings
- AMRDEC AED has accepted most of the ES3 data, however, hydrogen re-embrittlement and expanded fatigue testing is required for Army aviation acceptance



Parts on the AH-64 Swash Plate Receive Cadmium Plating

Progress Report

- TMR is currently developing a program to qualify Zn-Ni plating for aviation and ground vehicles
- AMCOM G4 is generating a Phase I program plan which involves:
 - Expanded fatigue testing
 - Hydrogen re-embrittlement
 - Survey of BLDG 340 to identify what changes would be required to establish a Zn-Ni plating line
- Currently developing fatigue requirements
- Funding concerns for FY19

Schedule

- Demonstration Complete: 1Q-FY21 (soft date)
- Project End/Transition: 1Q-FY22 (soft date)



Improved Magnesium Protection for DOD Aviation and Weapon Component Technology (TAGNITE)-ESTCP



Project Description

- Project managed by ARL and Technology Applications Group (TAG) with participation from AMCOM, CCAD and AEM
- Project advances Tagnite anodizing technology to legacy components (some contain steel inserts)
- Provides capability to convert existing magnesium components at the depot using masking technology
- Leverages local CCAD projects to strip organics using paint strippers with agitation/heat and conversion coatings using soda blast
- Leverages SAGE-Coat and DLA project to develop more sustainable seal coat to replace Rockhard



3 Magnesium Legacy Components with Tagnite Applied on CCAD D Line

Progress Report

- Demonstration has been completed including soda blast strip and Tagnite/Rockhard application
- Near Term Actions (Path to Implementation for 3 UH-60 Components)
 - Briefed APEO Engineering and Technology at PEO Aviation
 - Get Masking Kit and Tag Chemical NSN's
 - Obtain manuals, suggested maintenance schedule for process equipment
 - Induct masking and Tagnite procedures into CCAD as Tech Sheets
 - Update B.00 Process Standard to include Tagnite
 - Revise CCAD Process Standard for Soda Blasting
 - Document savings (approximately \$3M over the first 5 years)

Progress Report Continued

- Project End (LRIP)/Transition: 1Q-FY22
- Longer Term Actions (Path to Full Rate Production)
 - Socialize capability with CCAD Customers (Navy, Coast Guard)
 - Participate in ESPC Phase ID to scale up production capability (approximately 120 components/yr)



Citric Acid Passivation (NDCEE)



Project Description

- Demonstration conducted by NDCEE with participation from AMCOM, CCAD and AEM
- Passivation of stainless steel removes surface contamination and forms a passive oxide layer
- Citric acid passivation replaces nitric acid passivation of stainless steel which is supplemented with a Cr6+ sealer
- Demonstration of citric acid passivation revealed it performed as well or better than existing process without the use of Cr6+



**CCAD Citric Acid
Passivation Tank L-2**



**AH-64 Main Rotor Head Assembly Bolt
Shoulder After Citric Acid Passivation**

Progress Report

- Demonstration is complete
- Retested two alloys
- 15-5PH passed on second test run
- PH13-8Mo more panels required
- Updated process standard will have to be submitted to AED for approval
- Projected savings of \$192,699 per year

Schedule

- Demonstration complete
- Project End/Transition: 3Q-FY19



Challenges

- Alternative processes that require multiple tanks will be difficult to integrate into the Plating Shop (e.g. TSAA or ZnNi)
- Not all demos will provide Full Rate Production (FRP) capability (ESPC Phase ID may support FRP)
- CSI components may require additional testing
- Waste water treatment system currently based on Cr6+
- Experience is telling us that long term demos are difficult to execute using strictly CCAD personnel
 - Turn key contracts are a more favorable option



Summary

- TMR program status summary
 - 2 projects in planning phase (ZiNi and Trichrome strip)
 - 6 projects in laboratory phase
 - 2 demonstrations being executed (Cu/Ag and conversion coatings)
 - 2 projects in implementation phase (Tagnite (ESTCP) and Citric Acid Passivation (NDCEE))
 - Near term demos
 - Black oxide sealer
 - Manganese phosphate sealer
- Implementation challenges exist for some projects particularly the T-Line and FRP for Tagnite, Trichrome and ZnNi
 - Waste water treatment must be addressed
- TMR requirements must be properly integrated into the ESPC Phase ID planning and execution
- CCAD Plating Shop IPT
 - Will continue to use this forum to manage the program, coordinate with all the team players and address challenges/issues



Questions?

Acknowledgement of Funding Organizations



ARMY
Environmental Quality
Technology Program
POLLUTION PREVENTION



TMR Schedule for CCAD

Process	2015				2016				2017				2018				2019				2020				2021				2022							
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4				
Facility Assessments, Design, Construction (ESPC Phase ID)																	Req				Design				Construct											
Tri Chrome Plating (TMR 14-01)																																				
Trichrome Stripping																																				
Tartaric Sulfuric Acid Anodize (TMR 15-01)																																				
Stripping of Anodic Coatings (TMR 13-03)																																				
Non Cyanide Copper and Silver Plating-Strike (TMR 15-02)																																				
ARL Tagnite ESTCP, Develop Sealer, Stripping (ESTCP)																																				
Non Chromated Sealers (TMR 16-02)																																				
Black Oxide & Mang Phos Sealers (TMR 16-01 & 17-01)																																				
Cr6+ Free Conversion Coatings (TMR-14-02)																																				
Citric Acid Passivation (NDCEE)																																				
ARL Cold Spray Plating (Cr) Supplements Trichrome																																				
ZiNi Replacement for Cadmium Plating (TMR)																																				

Green: Lab testing

Blue: Demo

Red: Transition from LRIP to FRP

Purple: Evaluation

ZiNi Timeline Preliminary

Toxic Metal Reduction (TMR) CCAD 16 OCT 18

Note: Production always takes priority over demonstrations!

Next On Site Demo: Black Oxide and Manganese Phosphate Sealers

Tagnite is in implementation phase. Additional data being generated for CAP

