Updates on Sustainable Surface Finishing and Coatings for Army Weapon Systems

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Army P2 Program Approach to Surface Coatings

Conduct demonstrations of more sustainable surface finishing processes at Army depots and installations from FY15-24

- Address inorganic coatings through Toxic Metal Reduction (TMR) program and organic through Securing the Availability of Green, Enhanced Coatings (SAGE-Coat)
- Combine short-term projects to implement current state-of-the-art with long-term projects to push the envelope
- Demand higher performance and new capabilities without sacrificing sustainability
- Go beyond mere compliance with current environment, safety and occupational health (ESOH) regulations
- Address all manner of sustainability threats so they do not result in product obsolescence and affordability issues
- Use Toxicity Assessment (TA) process to verify sustainability of alternatives
- Integrate ESOH considerations into future coatings development

Eliminate Cr(VI), Cd and other toxic constituents in priority applications

Achieve Army-wide reductions consistent with ESTCP reduction targets
Inorganic coatings (TMR program)

- Chrome Plating
- Cadmium Plating
- Other Metal Plating
- Finishes

- Chromic acid
- Sodium dichromate
- Cadmium compounds
- Cyanide compounds

Cross over

Paint Removers

- CARC and Other Paints
- Cleaners

Adhesives

- HAPs and VOCs
- NMP, MeCl, nPB
- Isocyanates
- Phthalates

Organic coatings (SAGE-Coat program)
Joint Applicability of Army P2 Products

Product: CARC topcoat
Spec: MIL-DTL-64159
Pollutant: Isocyanates

500,000+ gals/yr used
1M+ lb/yr isocyanates
Implementing by 2021

Identified Users
- Army
- Navy
- Air Force
- Marine Corps
- Joint

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2016 SecArmy & 2017 SecDef Environmental Award Winners

- ARL Chromium-Free Wash Primer Replacement Team
- Weapon System Acquisition, Small Program Category
- Technology crosses both TMR and SAGE-Coat
TMR Gaps: Finishes and Sealers

**Challenge Area**

- **Finishes**
  - Anodizing
  - Sealing

**Types of Coatings Important to the Army**

- Magnesium Anodizing
- Aluminum Anodizing
- Anodize Stripping
- Hard Anodize Sealing
- Zinc Plate Sealing
- Ion Vapor Deposition Alum. Sealing
- Black Oxide Sealing
- Polysulfide Aviation Sealant

**Targeted Chemicals**

- Sodium Dichromate, Chromic Acid
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- Chromic Acid
- Sodium Dichromate
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- Chromic Acid
- Various Chromate Salts
- Sodium Dichromate

**Distinct Dem/Vals Needed**

- Alkaline Fluoride-Silicate Solution
- Tartaric Sulfuric Acid
- Sodium Hydroxide, Fluorides, Iron Salts Nitric Acid, Sulfuric Acid
- Trivalent Chromium, Zirconium or Manganese/Fluoride
- Trivalent Chromium, Fluorozirconates
- Trivalent Chromium, Hexafluoro-zirconates
- TBD, May Require Reformulation
- Citric Acid

**Potential Alternative Technologies**

- Sodium Dichromate

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TMR Success: Wash Primer

- ARL completed multiple demonstrations with Cr(VI)-free, low VOC alternatives to wash primer
- Canceling DOD-P-15328 with replacement by TT-C-490 Type IV
- Six approved Type IV pretreatments on the qualified product database with more pending additional qualification
- Eliminates 58% of Cr(VI) used at LEAD and 24K lbs/yr Army-wide
**TMR Success: Conversion Coatings**

- ARL completed multiple demonstrations with Cr(VI)-free conversion coatings (spray and immersion)
- ZrO immersion technology demonstrated at ANAD and qualified to TT-C-490, Type IV
- Eliminates 39% of Cr(VI) used at LEAD and 100K lbs/yr of Cr(VI) waste from aluminum conversion coating Army-wide
Coatings of Interest

- Nickel Electroplating
- Hard Chrome Electroplating

Targeted Chemicals

- Chromic Acid

Alternative Technology

- Cold Spray with Nickel or Carbide-Nickel-Chrome Powders

- ARL developed a cold spray process to replace nickel electroplating for the AH-64 Apache Static Mast Support
- First qualified cold spray structural component for Army rotorcraft
- Qualification documents approved by AED for inclusion in Depot Maintenance Work Requirements (DMWRs) for Apache repair
SAGE-Coat Gaps: CARC and Other Paints

Current Products Coming Under Increased ESOH Regulatory and Scientific Scrutiny

Polyurethane CARC Topcoats
Epoxy CARC Primers
Aerospace Specialty Coatings
Electro-Magnetic Shielding
Magnesium Stoving Enamel
Adhesion Promoters

New Products/Capabilities with ESOH Gaps
Zinc-Rich Primers
Smart, Multi-Functional Coatings
All Other Paints

Types of Coatings Important to the Army
VOCs, NMP, Isocyanates
VOCs
Zn Chromate, Isocyanates, HAPs, VOCs
HAPs, VOCs
HAPs, VOCs
HAPs, VOCs

Targeted Chemicals
VOCs

Distinct Dem/Vals Needed
Aircraft
Missile Systems

Potential Alternative Technologies
Polysiloxanes to Replace Isocyanates
Reformulate with Exempt VOCs
Remove Zn Chromate
No projects planned
Reformulate with Exempt VOCs
Reformulate with Exempt VOCs
Reformulate with Exempt VOCs
No projects planned

RDECOM Adoption of DESHE Process

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SAGE-Coat Gaps: Paint Remover and Cleaners

Current Products Coming Under Increased ESOH Regulatory and Scientific Scrutiny

- Paint Removers
  - Manual
  - Immersion
    - Methylene Chloride
    - NMP, Methylene Chloride

Current Products Not Controlled by Specifications

- Cleaners
  - HAPs, VOCs, nPB
    - Hand-Wipe Cleaners
    - Immersion Cleaners
    - Vapor Degreasers
    - Parts Washers
  - Exempt VOCs, Cyclosiloxanes or t-Butyl Acetate with Methyl Amyl Ketone
  - Novel and Emerging Alternatives
  - Azeotropic Blends, Ionic Liquids, Furans
  - COTS Aqueous Solvents (Standardize)

Challenge Area

Types of Coatings Important to the Army

Targeted Chemicals

Distinct Derm/Val Needed

Potential Alternative Technologies

Benzyl Alcohol or Hydrogen Peroxide-based Products

Novel and Emerging Alternatives

Benzyl Alcohol, Di-Methyl Esters, Other Proprietary Products

Exempt VOCs, Cyclosiloxanes or t-Butyl Acetate with Methyl Amyl Ketone

Novel and Emerging Alternatives

Azeotropic Blends, Ionic Liquids, Furans

COTS Aqueous Solvents (Standardize)

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SAGE-Coat Gaps: Sealants and Adhesives

**Challenge Area**
- Current Products Not Controlled by Specifications
- Historic Products Needed for New Production

**Types of Coatings Important to the Army**
- Sealants
  - Aircraft, Missiles and Avionics
  - Ground Vehicles and Electronics
- Adhesives
  - Aircraft, Missiles and Avionics
  - Ground Vehicles and Electronics

**Targeted Chemicals**
- HAPs, VOCs, Chromate Compounds
- HAPs, VOCs
- HAPs, VOCs
- HAPs, VOCs

**Distinct Dem/Vals Needed**
- Commercially Available Products
- Experimental Products
- Small Caliber Primer Cup Sealant
- Small Caliber Primer Pocket Sealant
- Small Caliber Case Mouth Sealant
- Small Caliber Outer Blank Sealant
- Mortar Sealant
- Other Ammunition Coatings

**Potential Alternative Technologies**
- COTS with Exempt VOCs or Lower Total Solvents (Standardize)
- Reformulate with Exempt VOCs or Lower Total Solvents
- Di-Butyl Phthalate, HAPs, VOCs
- 100% Solids UV-Curable Spray Sealant, Others TBD
- Methacrylate-based Adhesive

**Historic Products Needed for New Production**
- Ammunition Sealants
- Ammunition Coatings

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SAGE-Coat Success: Zinc-Rich Primer

- ARL published new MIL-PRF-32550 metal-rich specification with placeholder classes for HAP-free, low VOC products
- Conditional qualification of six products (solvent-based epoxies and urethanes) was granted after 1-yr outdoor exposure
- Full qualification of HAP-free, low VOC products to be granted after 2-yr outdoor exposure, including more novel formulations
SAGE-Coat Transition: Paint Remover

- AMCOM and AED established CARC removal requirements
- NAVAIR published new MIL-PRF-32587 neutral paint remover specification with dedicated type for removing CARC
- ARL completed panel testing of alternatives and referred vendors to NAVAIR for qualification

### Coatings of Interest

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SAGE-Coat Transition: Cleaners

**Coatings of Interest**

- Cleaners
- Hand-Wipe & Immersion

**Targeted Chemicals**

- HAPs, VOCs

**Alternative Technology**

- Exempt VOCs, Cyclosiloxanes or t-Butyl Acetate with Methyl Amyl Ketone

- ARL revising MIL-PRF-32359 and MIL-PRF-32405 to streamline performance requirements and facilitate qualification
- 12 aqueous and 5 non-aqueous HAP-free alternatives tested
- DLA Aviation Hazardous Minimization Program supporting dem/val on Army aircraft and eventual qualification
Are the Alternatives Sustainable?

U.S. Army Public Health Center (PHC) evaluates all proposed TMR and SAGE-Coat alternatives using Toxicology Assessment (TA) process

- Literature review
- Computational modeling
- Data collection
- Toxicity testing, if necessary

TA level of detail commensurate with technology maturity

Data collected under TAs inform acquisition documentation and occupational exposure requirements

- Toxicity Clearance, Health Hazard Assessment
- Occupational Exposure Limits, Industrial Hygiene Plan
- Programmatic Environment, Safety and Occupational Health Evaluation
- Life Cycle Environmental Assessment

Feeds into proposed RDECOM standard operating procedure (SOP) for performing Developmental Environment, Safety and Occupational Health Evaluation
New Army Structure

AFC established 1 July 2018 as fourth four-star Army Command
- Modernizes the Army for the future
- Integrates future operational environment, threat and technologies to develop and deliver future force concepts, requirements and materiel capabilities
- Composed primarily of former TRADOC and AMC elements, including RDECOM

Initial focus will be on eight Cross Functional Team (CFT) pilots addressing the Army’s Big Six Modernization priorities
- Long Range Precision Fires*
- Next Generation Combat Vehicle*
- Future Vertical Lift*
- Network Command, Control, Communication & Intelligence
- Assured Positioning, Navigation and Timing
- Air and Missile Defense*
- Soldier Lethality*
- Synthetic Training Environment

*Ties to TMR and SAGE-Coat
TMR and SAGE-Coat are positioned to eliminate Cr(VI), Cd and other toxic constituents from the highest priority Army coating operations. Many alternatives have already been implemented or transitioned to responsible authorities, with the rest scheduled by FY24.

Future success will depend on our ability to adapt to the new Army structure and to continue finding partners to support our efforts:

- Funding partners (SERDP, ESTCP, NDCEE, DLA, D,CPO)
- Technology partners (Navy labs, Air Force labs, NASA, coating vendors)
- Transition partners (PEOs, PMs, CFTs, spec owners)
- End users (depots, arsenals, installations, OEMs)