Securing the Availability of Green, Enhanced Coatings for U.S. Army Applications (SAGE-Coat)

For ASETSDefense
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The Army requires:

- Capability to perform organic surface coating operations on weapons systems at industrial facilities, motor pools, repair shops and in the field
- Continued availability of surface coating products and processes that are ESOH sustainable while also meeting performance requirements

Emerging ESOH challenges include:

- Increased scrutiny from regulatory and scientific communities
- Previous regrettable substitutions
- Uncertainty caused by lack of specification control
- Obsolescence with new production runs of legacy systems
- Side effects of “smart” coating capabilities

If not addressed:

- Continued Soldier/civilian/community exposure to ESOH impacts
- Liabilities including lawsuits, NOVs, interruption of operations
- Unavailable/unaffordable products due to regulation, PR, market pressure, etc.
- Weapon systems not maintained properly may be deemed non-mission capable
Sustainable Painting Operations for the Total Army (SPOTA) program was extremely successful

- Demonstrated and fielded 30+ new surface coating products
- Overhauled the CARC system with higher performing, more sustainable products
- Eliminated Army use of TCE and MeCl dip tanks
- Paved the way for qualification of sustainable cleaners and thinners
- Won SecArmy and SecDef environmental awards, among others

However…

- SPOTA focused primarily on eliminating HAPs
- SPOTA focused primarily on ground vehicles and support equipment
- SPOTA was last funded in 2011 and officially ended in 2013
- Many technology gaps remain and continue to emerge
Gaps: Paints & Coatings

**Challenge Area**

- Current Products Coming Under Increased ESOH Regulatory and Scientific Scrutiny
- New Products/Capabilities with ESOH Gaps

**Types of Coatings Important to the Army**

- Polyurethane CARC Topcoats
- Epoxy CARC Primers
- Aerospace Specialty Coatings
- Zinc-Rich Epoxy Primers
- Smart, Multi-Functional Coatings
- All Other Coating Products

**Targeted Chemicals**

- VOCs, NMP, Isocyanates
- VOCs
- Zn Chromate, Isocyanates, HAPs, VOCs
- HAPs, VOCs
- HAPs, VOCs
- HAPs, VOCs
- Numerous

**Distinct Demonstrations Needed**

- Aircraft
- Missile Systems
- Numerous

**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
Gaps: Paint Removers & Cleaners

Challenge Area

Current Products Coming Under Increased ESOH Regulatory and Scientific Scrutiny

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

Types of Coatings Important to the Army

- Current Products Not Controlled by Specifications
  - Cleaners
    - HAPs, VOCs, nPB
      - Hand-Wipe Cleaners
      - Vapor Degreasers
      - Parts Washers

Targeted Chemicals

- 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)

Distinct Demonstrations Needed

- Potential Alternative Technologies
- Also supportive of AERTA requirement for Alternative Products in Cleaning and Degreasing Processes

Important to the Army

- 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)

Challenge Area
Gaps: Sealants, Adhesives, Ammo

Challenge Area
- Current Products Not Controlled by Specifications
  - Sealants
    - Aircraft, Missiles and Avionics
    - Ground Vehicles and Electronics
  - Adhesives
    - Aircraft, Missiles and Avionics
    - Ground Vehicles and Electronics
- Historic Products Needed for New Production
  - Ammunition Coatings

Types of Coatings Important to the Army
- Sealants
  - HAPs, VOCs, Chromate Compounds
- Adhesives
  - HAPs, VOCs
- Ammunition Coatings
  - Di-Butyl Phthalate, HAPs, VOCs

Targeted Chemicals
- HAPs, VOCs
- COTS with Exempt VOCs or Lower Total Solvents (Standardize)
- Reformulate with Exempt VOCs or Lower Total Solvents
- 100% Solids UV-Curable Spray Sealant, Others TBD

Distinct Demonstrations 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
- Methacrylate-based Adhesive

Potential Alternative Technologies
- No projects planned
- 100% Solids UV-Curable Spray Sealant, Others TBD

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What are SAGE-Coat’s objectives?

- Develop and demonstrate alternative surface coating products that proactively address known and anticipated ESOH sustainability threats
  - Preclude product obsolescence, availability and affordability issues stemming from domestic and global regulatory pressures
  - Avoid $200M in associated compliance and health costs
  - Reduce 400,000 lbs/yr of VOC emissions from high use primers
  - Eliminate exposure to isocyanates from 200,000 gals/yr of topcoats
  - Achieve standardization and quality control of 2,000+ off-the-shelf products
  - Ensure future leap-ahead technologies are ESOH sustainable
  - Transition solutions to 40+ Army and USMC installations plus OEMs
  - Enable VOC reductions at facilities in non-attainment with Ozone NAAQS
SAGE-Coat Program Plan

WAVE 1
- Spot paint removers
- Metal-rich primers
- Cleaners
- CARC primers
- CARC topcoats
- Sealants
- Adhesives

WAVE 2
- Non-Chromated Electromagnetic Shielding Coating
- HAP-Free, Low VOC Stoving Enamel for Magnesium Substrates
- Other Aerospace Specialty Coatings with Reduced HAPs and VOCs
- Immersion Depainting Alternatives to N-Methyl Pyrrrolidone
- Next Generation Sustainable Cleaning and Depainting Chemistries
- Non-Phthalate Plasticizers for Small Caliber Ammunition
- Sealants
- Sustainable Cement for Production of Mortar Systems

FY16 FY17 FY18 FY19 FY20 FY21 FY22 FY23

Other Gaps?
**Objective:** Eliminate HAPs and reduce VOCs found in CARC spot paint removers

**Magnitude of impact:**
- Eliminate 100% of methylene chloride from Army painting operations
- Avoid OSHA requirements for medical surveillance of paint stripping workers

**Intended end product:** Qualified HAP-free, low VOC products effective at stripping CARC topcoats and primers

**Technology:**
- Primarily benzyl alcohol and hydrogen peroxide-based commercial alternatives
- Some leveraged developmental alternatives (NAVAIR)

**Weapon systems impacted:** Everything coated with CARC

**Transition path:**
- TT-R-2918: Remover, Paint, No HAPs
- New specification TBD: Neutral HAP-Free Paint Remover

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**FY16**
- Research and gather alternatives
- Finalize test matrix

**FY17**
- Evaluate alternatives in laboratory
- Demonstrate on boneyard parts
- Provide input for spec revisions
**Objective:** Eliminate HAPs and reduce VOCs in newly implemented zinc rich primers

**Magnitude of impact:**
- Projected zinc-rich primer usage up to 100K gals/year
- Avoid 50K lbs/year HAP emissions and at least 20K lbs/year VOC emissions based on that usage

**Intended end product:** Qualified HAP-free, low VOC spray-on zinc rich primers that can be used in depot environments

**Technology:**
- Currently qualified products reformulated to be HAP-free with less than 2.8 lbs/gal VOCs (ideally 2.1 lbs/gal)
- MIL-PRF-32550 revised to eliminate 3.5 lbs/gal VOC class

**Weapon systems impacted:** Ground vehicles and ground support equipment

**Transition path:** MIL-PRF-32550: Metal Rich Primer (new specification published 11 Aug 2016)

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**Timeline:**
- **FY16**
  - Create specification
  - Notify vendors of reformulation
- **FY17**
  - Evaluate alternatives in laboratory and outdoor exposure
- **FY18**
  - Complete small-scale demo
  - Publish revised spec and QPL
Objective: Eliminate HAPs and reduce VOCs found in immersion, hand wipe and spray cleaners

Magnitude of impact:
- Reduce 300K lbs/year VOC emissions from 50K gals/year of cleaners used Army-wide
- Even greater impact if replacing paint thinners historically used as cleaners

Intended end product: HAP-free, low VOC cleaners that meet revised requirements of MIL-PRF-32405 and MIL-PRF-32359

Technology:
- Numerous commercially available products
- MIL-PRF-32405 and MIL-PRF-32359 revised and republished with Qualified Product Lists (QPLs)

Weapon systems impacted: Ground vehicles, aviation platforms, missile platforms, ground support equipment

Transition path:
- MIL-PRF-32359: Cleaner, General, for Ground Vehicles and Ground Support Equipment, HAP-Free
- MIL-PRF-32405: Cleaner, Hand Wipe, for Aviation and Missile Systems, Metallic Substrates, Low or Exempt VOC
- TACOM/AMCOM to implement through revised TMs, DMWRs

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FY16
- Modify cleaner qualification requirements

FY17
- Laboratory test alternatives against new requirements

FY18
- Issue specifications, QPLs, NSNs
- Transition through TMs, DMWRs
- **Objective:** Significantly reduce VOC level in CARC primers

- **Magnitude of impact:**
  - Drive VOC content from 2.8 lbs/gal to 2.1 lbs/gal (threshold) or 1.0 lb/gal (objective)
  - Reduce up to 500K lbs/year VOC emissions from 350K gals/year usage across DoD

- **Intended end product:** Qualified HAP-free primers with VOC content as low as possible and dry times that meet depot throughput requirements

- **Technology:** Ultra low VOC CARC epoxy primers using:
  - New polymer/resin technology
  - Catalysts, accelerators, additives to reduce dry time
  - Different blends of VOC exempt solvents

- **Weapon systems impacted:** Ground vehicles and ground support equipment

- **Transition path:**
  - MIL-DTL-53022: Solvent-Based Epoxy Primer
  - MIL-DTL-53030: Water-Based Epoxy Primer

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**FY16**
- Obtain and evaluate industry samples of alternative solvents, resins and additives

**FY17**
- Formulate new primers
- Conduct laboratory testing

**FY18**
- Demonstrate in production environment
- Verify corrosion and application properties

**FY19**
- Validate long-term performance
- Revise specifications to include new type
Objective: Eliminate CARC topcoat dependence on isocyanates

Magnitude of impact:
- Army uses 600K gals/year of topcoats containing 1-2 lbs/gal of isocyanates
- Alternative chemistry projected to displace 1/3 of usage initially (200K lbs/year isocyanates) while providing capability for 100% conversion if necessary

Intended end product: Qualified HAP-free, low VOC CARC topcoat formulated without isocyanates

Technology: Multiple chemistries under consideration:
- Polysiloxanes
- Hybrid alkyd/epoxy
- Low/no isocyanate polyurethane

Weapon systems impacted: Everything coated with CARC

Transition path: Consolidation into single CARC topcoat spec with three types:
- Waterborne 2-component polyurethane
- Solvent-borne 1-component polyurethane
- Non-isocyanate chemistry

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FY16
- Research industry formulations
- Acquire raw materials

FY17
- Formulate clear coat compositions
- Evaluate dry time and film formation

FY18
- Create lab batch samples in black
- Fine tune formulations to improve performance

FY19
- Scale up batches and introduce base colors
- Demonstrate on Army and USMC assets

FY20
- Publish revised specifications and QPLs

1,6 Hexamethylene Diisocyanate

O=C=NN=C=O
**Objective:** Replace end-user prioritized hazardous sealants and adhesives with environmentally preferable alternatives of equivalent performance

**Magnitude of impact:**
- Consolidation and better specification control of over 2,000 commercial products
- Streamlining of RCRA compliance and reduction of hazardous waste disposal costs

**Intended end product:** Modernized sealant and adhesive specifications with sustainable qualified products

**Technology:**
- Numerous commercially available products
- Potentially new/reformulated products if necessary
- Potentially new specifications if existing not sufficient

**Weapon systems impacted:** Primarily ground vehicles and aviation platforms

**Transition path:** Revised/new specifications, QPLs, NSNs

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**Evaluation and Consolidation of Sustainable Alternative Sealants and Adhesives (SAGE 16-02)**

- **FY16**
  - Conduct survey, populate database, determine priorities for replacement

- **FY17**
  - Evaluate performance criteria for existing specifications and NSNs

- **FY18**
  - Consolidate overlapping specs, NSNs
  - Laboratory testing of alternatives

- **FY19**
  - Develop new specs to fill any gaps
  - Demonstrate alternatives at depots

- **Later**
  - Spin out alternatives
  - Publish specifications and QPLs
U.S. Army Public Health Center evaluates all proposed alternatives using Toxicology Assessment (TA) Process

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

TA review concurrent with project maturity

Data will inform acquisition documentation and occupational exposure requirements

- Toxicity Clearance, Health Hazard Assessment
- Occupational Exposure Limits, Industrial Hygiene Plan
- Programmatic Environment, Safety and Occ. Health Evaluation
- Life Cycle Environmental Assessment
- DESHE is a process and not a report or document
- Purpose: Develop and document a baseline level of ESOH performance data for each level of research in order to support risk-based decisions
  - Should include human toxicity (mammalian), fate and transport, eco-toxicity and safety data
- Phased approach to gather, develop and document ESOH performance data for materials, processes and technologies during all phases of RDT&E
  - Data requirements determined by Budget Activity or TRL
  - Early stages – qualitative data
  - Higher maturity technologies – more robust, quantitative data
  - Data should be collected using regulatory-approved methods (ASTM, OECD) and consistent with Good Laboratory Practices
Securing the Availability of Green Enhanced Coatings

- Going beyond mere compliance with ESOH regulations
- Addressing all manner of sustainability threats so they do not result in product obsolescence and affordability issues

- Using TA and DESHE processes to verify sustainability of alternative products
- Integrating ESOH considerations into future coatings development

- Demanding higher performance and new capabilities without sacrificing sustainability
- Combining short-term projects to implement current state-of-the-art with long-term projects to push the envelope

We are looking for partners!