The Validation and Approval of Chemical Agent Resistant Coatings
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<td>28 AUG 2012</td>
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## Authors

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## Abstract

Outline

- Who We Are & What we Do
- Standardization & Specifications
- Technical Challenges
- Selected CARC Efforts and discussions
- Final Thoughts
• ARL is the Lead DOD R&D Activity for CARC
  - Innovative formulations approaches
  - New raw materials selections
  - Advanced characterization

• Maintains Ownership for all key specifications regarding pretreatments, primers and topcoats for all tactical and related support equipment and munition coatings.

  • Elements above assist to implement and transition products to the field.
What we do...

• Develop materials for military unique coatings including pretreatments, primers, and topcoats
  – Chemical Agent Resistant Coatings
  – Munitions coatings
  – Industrial coatings for vehicle interiors

• Implement and transition new products
  – Specifications and Standards
  – Troubleshooting, consulting, and problem solving

• Analyze and solve technical problems related to coatings systems used on Army Materiel
Guiding Principles for Coating Systems

Implementation

Environmental

Survivability

Durability
Every item that the Army fields starts with a document, namely a specification. Multiple specifications may be required to define a specific item along with a standard on how to process the item.

- Cleaning Methods
- Pretreatment Methods
- Anticorrosive Primers
- Chemical Agent Resistant Coating (CARC) Topcoat

Governed by application and inspection specification, MIL-DTL-53072.
• Step 1 – Planning
• Step 2 – Research & Development
• Step 3 – Approval and Publication

• Reasons for development or revision of specifications:
  ✓ Environmental regulations (Hexavalent Chromate and HAPs)
  ✓ Performance requirements
  ✓ Advances in new technology
  ✓ Major gaps in technology

• Uniqueness of Coating and Corrosion Team Specifications:
  ✓ Notarized Statements of Composition

• Transition document for military to use in contracts
### Hierarchical Architecture of Multifunctional Coatings

#### Today

- **CARC Camouflage Polyurethane Topcoat (1.8 mil)**
  - Visible and NIR
  - Silica extender
  - Semitransparent binders

- **CARC epoxy primer (0.8 - 1.2 mils)**

- **Chemical Conversion Coating (0.2-0.3 mil)**

- **Substrate** (ferrous or nonferrous)

#### Tomorrow

- **Tailored CARC Coating**
  - Functional pigmentation
  - Controlled Roughness

- **Functional Primer**
  - Corrosion Protection
  - Texture

- **Advanced Corrosion Protection Layer**
  - **Substrate**
    - Ferrous
    - Nonferrous
    - Polymer Composite
Raw Material Selection and Design

Individual Coating Components

- Resin: Part A 60% solids, Part B: 100% solids reduced with TBA 25%
- Solvents: Water & Tert Butyl Acetate
- Pigments & Extenders: 50% V-12650 Cobalt Free, Extenders High density Polyethylene
- Additives: 2%
- Pigment(s)
- Extenders
- Additives
- Solvents
• Hexavalent Chromium Free Pretreatments for various substrates.*

• Alternatives to Isocyanate Based Topcoats*

• Elimination of Silica Flattened topcoats

• New Chemical Agent Testing Methodologies

• Alternatives to conventional cure
Pigments/Extenders

Polymeric beads
- Reduce chalking effect
- Improve UV resistance
- Improve performance

Army will Discontinue use of Silica based topcoats

Diatomaceous silica
Talc

• Integrated within Film
Silica vs. Polymeric Accelerated Outdoor Weathering Results

Q-Lab Arizona, Accelerated Outdoor Weathering Results

Delta E* vs. Q

|                  | 0MJK/m^2 | 70MJK/m^2 | 140MJK/m^2 | 210MJK/m^2 | 280MJK/m^2 | 350MJK/m^2 | 420MJK/m^2 | 490MJK/m^2 | 560MJK/m^2 | 630MJK/m^2 | 700MJK/m^2 | 770MJK/m^2 | 840MJK/m^2 | 910MJK/m^2 | 980MJK/m^2 | 1050MJK/m^2 | 1120MJK/m^2 | 1190MJK/m^2 | 1260MJK/m^2 | 1400MJK/m^2 |
|------------------|----------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 64159 Type I Silica | 0.00     | 0.49      | 0.88       | 1.01       | 0.92       | 0.80       | 0.75       | 0.77       | 1.22       | 1.02       | 1.82       | 2.81       | 3.52       | 3.90       | 4.26       | 4.52       | 5.16       | 5.55       | 5.45       |
| 64159 Type II Polymeric | 0.00     | 0.92      | 1.22       | 1.33       | 1.36       | 1.39       | 1.25       | 1.27       | 1.11       | 0.94       | 1.10       | 1.07       | 1.39       | 1.51       | 1.49       | 1.59       | 1.57       | 1.46       | 1.56       | 1.44       |
| 53039 Type I Silica | 0.00     | 0.34      | 0.45       | 0.51       | 0.48       | 0.75       | 1.26       | 1.49       | 2.62       | 2.98       | 5.02       | 4.83       | 5.79       | 6.46       | 6.70       | 7.22       | 7.24       | 7.37       | 7.47       | 7.80       |
| 53039 Type IV Polymeric | 0.00     | 0.28      | 0.53       | 0.61       | 0.65       | 0.78       | 0.86       | 0.85       | 0.82       | 0.65       | 0.54       | 0.60       | 0.53       | 0.71       | 1.01       | 1.65       | 2.28       | 3.04       | 3.45       | 3.59       |
Benefits of Polymeric Formulations vs. Silica Formulations

- Superior weather resistance—Minimal chalking and color degradation.
- Survivability—Spectral and specular reflection not affected by weathering. Infrared not affected during weathering.
- Superior mar resistance.
- Less paint weight- 20-25%
- Health and safety—No crystalline silica exposure during repair, sanding and removal operations.
- Longer service life—less cost for repainting.
ARL Approach and Considerations

Raw Material Selection

- Resin
- Pigments
- Polymeric Flattening Agents
- Additives
- Solvents

Tailored Coating

Providing Agent Resistance

Surface Enhanced

In situ Cross-Linked

Two Fold Approach: Incorporating chemistries to actively bind and crosslink to create barrier properties and support decontamination through additional surface modifications
Why UV Cure?

• OEM’s and Depot’s define production delays as a critical gap
• UV cure chemistry enables handling in 10 minutes vs. 6-8 hours (standard cure)
• Reduce VOC’s
• Highly adaptable and relevant for field repairs

Reduce Dry to Fly Time
Polyurethane/Acrylate Interpenetrating Polymer Network

UV Cure
10 min.
Time
24 hours

Co-blend
- UV initiated resin
- Hydroxyl functional polyurethane resin

Acrylate network
Set to handle
IPN of urethane/urea/aliphonate and acrylate networks
Field Ready
Rapid UV Cure WD CARC

2K Water Dispersible Paint with UV active additives

1. Mix and spray the same as MIL-DTL-64159
2. Allow 10 minute of flash off for evaporation
3. 10 minute cure process using H & S Auto Shot 1200W UVA lamp
UH-60 rotor blade section coated with black rapid cure CARC. Cured with two 1200W UVA lamps in tandem.
Accomplishments

• Patent Application Filed
• Formulations completed for green and black using low solar absorbing (LSA) pigmentation
• Optimized UV irradiance requirements for rapid cure (8 inch stand-off distance/ 10 minutes of UVA light exposure). Panel results show “set to handle” properties after 10 minutes following UV cure, dry hard property after 30 minutes following UV cure and MEK resistance in less than 24 hours.
• Demonstrated success of UV cure CARC on small section of UH-60 and CH-47 rotor blades.
Closing Thoughts

• Technology Gaps/Accomplishments are continually evolving.
• Our successes will be with the continued collaborations with our services, industry and academia.
• Our specification and technical manuals will define the requirements and processes.
• It is within this framework that the path will be most clear and straightforward.