Chemical Agent Resistant Coatings
Status Update

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# Chemical Agent Resistant Coatings Status Update

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*Prescribed by ANSI Std Z39-18*
Outline

• Who we are & What we do……

• Key areas of Interest and efforts
  - Topcoats, Primers, Pretreatments and Munitions

• Water Dispersible & Solvent Based Chemical Agent Resistant Coatings (WD-CARC & Moisture Cure CARC)

• Next Generation of Coatings
• 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 munitions coating

  ❖ Elements assist to implement and transition products
Guiding Principles for Coating Systems

Environmental  Survivability

Durability
Increased Options for Balanced Requirements

Survivability Requirements

Coating Requirements

Environmental

UV Resistance

Flexibility

Affordable Multifunctional Coating Solutions

Affordability

New coatings formulations

More Survivable and Durable Platforms
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

- Produce materials that balance three critical requirements
  - Survivability (camouflage, chemical agent resistance)
  - Durability (appearance, corrosion, compatibility, etc.)
  - Environmental compliance and pollution prevention

- 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
Recent Coatings represent superior durability, environmental compliance

Stereotypes associated with Emulsions, Water Based or Hexavalent Chromium Free chemistries no longer hold true

Current efforts establishes solid foundation for present and future survivability enhancements and multifunctional capabilities

ARL has eliminated standard coatings used and are implementing a new generation of coating technology throughout DOD
**Today**

<table>
<thead>
<tr>
<th>CARC Camouflage Polyurethane Topcoat (1.8 mil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Visible and NIR</td>
</tr>
<tr>
<td>- Silica extender</td>
</tr>
<tr>
<td>- Semitransparent binders</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARC epoxy primer (0.8 - 1.2 mils)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Chemical Conversion Coating (0.2-0.3 mil)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Substrate (ferrous or nonferrous)</th>
</tr>
</thead>
</table>

**Tomorrow**

**Tailored CARC Coating**

- Functional pigmentation
- Controlled Roughness

**Functional Primer**

- Corrosion Protection
- Texture

**Advanced Corrosion Protection Layer**

<table>
<thead>
<tr>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Ferrous</td>
</tr>
<tr>
<td>- Nonferrous</td>
</tr>
<tr>
<td>- Polymer Composite</td>
</tr>
</tbody>
</table>

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Raw Material Selection and Design

Individual Coating Components

- Resin: Part A 60% solids
- Part B: 100% solids reduced with TBA 25%
- Pigments & Extenders: 50%
  - V-12650 Cobalt Free
  - Extenders High density Polyethylene
- Solvents: Water & Tert Butyl Acetate
- Additives 2%
- Pigments & Extenders: 50%
Core Interests for Coating Development

- Hexavalent Chrome Free Pre-Treatments
- Zinc Phosphate Alternatives for Ferrous
- Low Solar Absorbing and Insulative
- Reactive or self decontaminating
  - Super hydrophobic & oleophobic coatings
  - UV cured coatings
  - Powder coat (Primer and Topcoat)
  - Anti-skid CARC
  - High Temperature Resistant
    - Intumescent types
Cr6+ Free Pretreatment for DoD Applications

- Mandated for all tactical and support platforms
- Free of hexavalent chromium (Cr 6+)
- No volatile HAPs
- Ease of application using existing infrastructure
- Equal or better corrosion performance to current Cr 6+ wash primers
- Broad substrate/topcoat compatibility
- Cost effective
Cr6+ Free Pretreatment for DoD Applications

Multi-Substrates:
• Steel 1010, 1008
• Galvanized steel
• Stainless steel
• Al 2000/5000/6000/7000 series
• Ceramic/Composite

• **Coating:** must be compatible with existing military topcoats and primers
  – Three vendors have responded with products
  – SERDP effort with PPG & ARL for Zinc Phosphate Alternative

• **Process:** Depot and Repair
Low Solar Absorbing CARC

- 2 year weathering excellent: Less than 1 color unit change
- Formulated four Primary Colors
- IR requirements will shift from 380nm -900nm to 380nm-2000nm with emphasis on 750nm to 1700nm.
- Visible unchanged
- Key highlight: COST, cobalt spinal increase of 300% and availability erratic
- Formulation will be cobalt free for 383 Green, AC Green, 383 Brown
- 383 Green to change to 808 Green to identify change
- Open to other approaches*
Coatings
For Munitions Technology

Purpose
- Provide capability for new or existing coatings to improve munitions response to IM (Insensitive Munitions) threats

Result
- Coating formulation and technologies for IM design
- Demonstration of integrated technologies for improved IM behavior in packaging and missiles.

Payoff
- Improved tactical and combat system survivability
- Reduced transportation and storage burden
- Transition technologies
OBJECTIVE:

- Develop coatings with improved thermal protection
- Demonstrate coatings to enable a controlled burn and prevent violent reaction
Technical Challenge

- Paint delamination
  - Cracking and chipping

- Rough Handling – esp. at extreme temp

- Impact resistant

- Flexibility

- Moisture resistance

- Material compatibility

- Cost
Coatings
For Munitions Technology

Technical Thrusts
Coating Development- all munitions that require thermal control

IM Performance
- Mechanical properties (-65 to 165°F)
- Blast protection
- Thermal protection

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Topcoat Formulations

- New Polyols
  - Completely water soluble, no co-solvents needed
- Tert-butyl acetate (VOC exempt) to dissolve and disperse isocyanate
- Attempt to reduce NCO:OH indexing to reduce solvent content

\[
\begin{align*}
R'N\equiv C=O + R'OH & \rightarrow R'NH\cdot O\cdot R' \\
\text{(isocyanate)} & \text{(polyol)} & \text{(urethane)}
\end{align*}
\]

\[
\begin{align*}
R'N\equiv C=O + H_2O & \rightarrow R'NH\cdot OH \\
\text{(isocyanate)} & \text{(water)} & \text{(carbamate)}
\end{align*}
\]

\[
\begin{align*}
R'NH_2 + R'-N\equiv C=O & \rightarrow R-NH=NH\cdot R' \\
\text{(amine)} & \text{(isocyanate)} & \text{(urea)}
\end{align*}
\]
Role of Polyurethane

- Unacceptable CAR at NCO:OH < 4
- NMR and FTIR to measure quantify ratio of side products vs. NCO:OH ratio
- Adjust additives, reaction conditions, etc.
  - to make more favorable distribution

\[
\text{Urethane: } R_N\text{H}_\text{O}_\text{O}_R' \\
\text{Urea: } R_N\text{H}_\text{N}_\text{H}_\text{O}_R' \\
\text{Biuret: } R_N\text{C}_\text{N}_R' \\
\text{Allophanate: } R_N\text{C}_\text{O}-\text{CH}_2-R'
\]

(Urea + isocyanate)
(Urethane + isocyanate)
Pigments/Extenders

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

- Diatomaceous silica
- Talc

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The Details

• Development and implementation of Water-Dispersible and Moisture Cure CARC System—affects 3 million gallons of paint annually
  – 2.3 Million Topcoat & approximately 1 million in Primers
  – New Generation CARC topcoat: enhanced flexibility and UV resistance.
  – Elimination of Hazardous Air Pollutants from existing primers

• Low Solar loading pigmentation development
  – Reduce temperature build up on military assets
  – Prolong service life of coating
  – Enhance camouflage capabilities
• New types to include 1.0, .5 and zero VOC (Lbs/gal) with zero HAPs flattened with non-silica based raw materials.
• Inclusion of 34201 color (Woodland Desert Sage). Currently used on CH-47
• Elimination of reference to MIL-T-81772 Aircraft Thinner (100% VOCs)
• Allowing vendors to provide exempt solvent package
Touch up Kits –QPL Specifications as TYPE III-Self Contained Kits

- Aerosol
- Roller
- Brush
- Cartridge

VENDORS: Hentzen Coatings
MILSPRAY/Spectrum
Sherwin Williams
Technology and Commercial Applications

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Corrosion Resistant Materials for Armor

Aluminum Alloy 5059 For Armor Applications Foreign Comparative Test Program

- Updated military Al armor specification MIL-DTL-46027K

- Over $14M to date in acquisition
  - $12M+ in direct procurement of AA5059 for RG-33 MRAP
  - Over $1.1M of acquisition by OEMs for internal testing, design, and prototyping
  - AA5059-H131 chosen as primary (100%) common hull material for all 8 variants of the PM FCS-BCT Manned Ground Vehicle (MGV) by Boeing (LSI), General Dynamics, and BAE Systems

- Related work - military specification MIL-DTL-32262 created for 6061 Al
Synergistic Interaction for Maximum Impact
New Generation of Coatings

• Survivability
  ➢ Topcoat Agent & Bio Resistant
  ➢ Passive: completely inert
  ➢ Active: self-decontaminating
  ➢ Appearance
    ➢ Functional pigmentation
    ➢ and extenders
    ➢ Controlled surface morphology

• Durability
  ➢ UV resistant
  ➢ Enhanced Corrosion resistant

• Environmental Compliance
  ➢ Water Dispersible resins/Low VOCs
  ➢ Elimination of Hazardous Air Pollutants
  ➢ Polymeric Flattening agents used for all topcoats

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.