Thank you for signing in early

The webinar will begin promptly at
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SERDP and ESTCP Webinar Series

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    - Required webinar ID: 619-000-322
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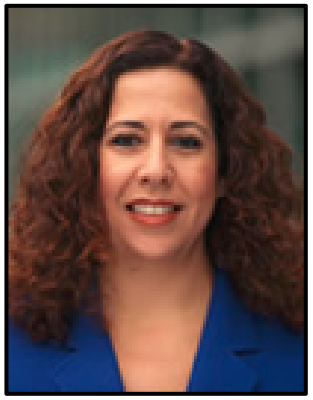
Developing and Demonstrating Non-Toxic and Sustainable Coating Systems for Military Platforms

June 6, 2019

SERDP DOD • EPA • DOE | ESTCP

Welcome and Introductions



Rula A. Deeb, Ph.D.
Webinar Coordinator

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Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Robin Nissan, SERDP and ESTCP
- **Environmentally Friendly and High-Performance Polysiloxane Topcoats for DoD Aircraft and Ground Support Equipment** (40 minutes + Q&A)
  Dr. Erick Iezzi, Naval Research Laboratory
- **Final Q&A session**

In Case of Technical Difficulties

- Use a compatible browser (Firefox, IE or Edge)
- If material is not showing on your screen or if screen freezes
  - Key in Ctrl + F5 to do a hard refresh of your browser
- If connecting to computer audio
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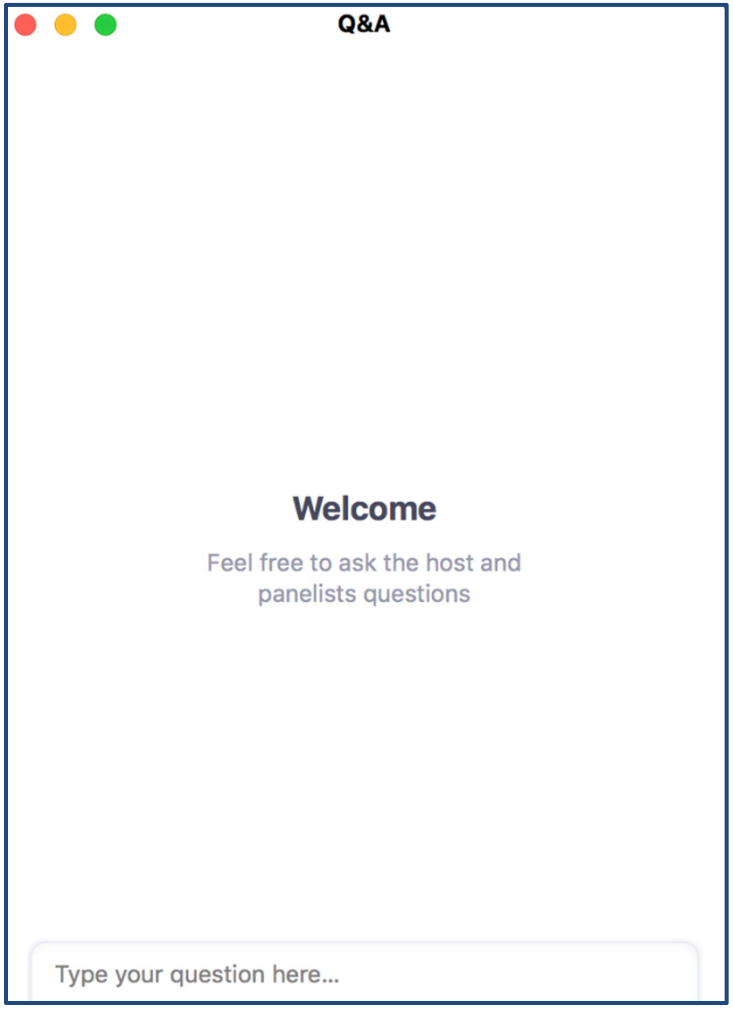
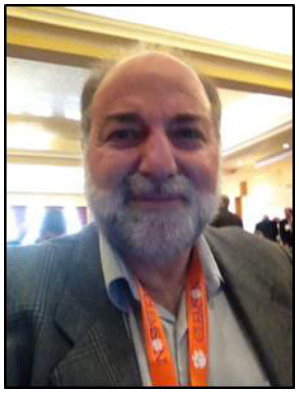
How to Ask Questions

- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Robin Nissan, Ph.D.
SERDP and ESTCP



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SERDP

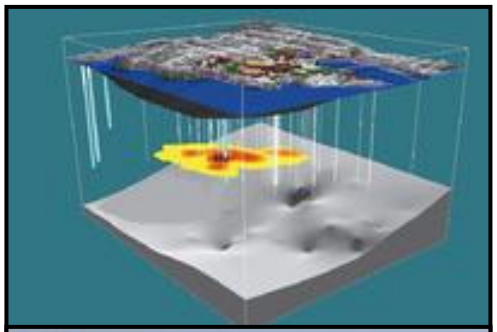
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

Program Areas

1. Environmental Restoration
2. Installation Energy and Water
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



Weapons Systems and Platforms

- Major focus areas
  - Surface engineering and structural materials
  - Energetic materials and munitions
  - Noise and emissions
  - Waste reduction and treatment in DoD operations
  - Lead free electronics

SERDP and ESTCP Webinar Series

Date	Topic
June 20, 2019	Infrastructure Adaptation Strategies to Mitigate Climate Change and Uncertainty
July 11, 2019	Vapor Intrusion: Modeling Tools and Cost Effective Mitigation
July 25, 2019	Understanding Underwater Munitions Mobility and Behavior on the Beach Face and in Shallow Muddy Environments
August 8, 2019	Building Energy and Water Efficiency Solutions
August 22, 2019	Pacific Island Ecology and Management: Recovery of Native Plant Communities
September 5, 2019	The Use of Advanced Molecular Biological Tools in Groundwater Contaminated with Chlorinated Solvents
September 19, 2019	Life Cycle Assessment and Developmental Environment Safety and Occupational Health Evaluation: Tools for Sustainment and Health

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Save the Date!

SERDP • ESTCP
SYMPOSIUM

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

December 3-5, 2019

Washington Marriott Wardman Park

Registration is open!

Environmentally Friendly and High-Performance Polysiloxane Topcoats for DoD Aircraft and Ground Support Equipment

Erick Iezzi, Ph.D.
U.S. Naval Research Laboratory

Agenda

- Polyurethane topcoats
  - Health and environmental issues
- Organosilicon polymers and polysiloxane topcoats
- Toxicity
  - Organosilane polymer vs. isocyanates
- Benefits to DoD
- Testing to DoD performance requirements
- Demonstrations on DoD assets
- Conclusions

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Polyurethane Topcoats

Health and Environmental Issues

- Polyurethanes
  - Exterior of DoD aircraft and support equipment
  - Two-component (2K) systems – require metering and mixing
  - Contain hazardous and air polluting chemicals
    - Isocyanates can cause skin irritation, symptoms of asthma, sensitization, and even death
    - HAP chemicals are potentially carcinogenic
    - VOCs contaminate the air
- Meet Navy and Air Force military performance specifications

Notes: 2K = two-component; g/L = grams per liter; HAPs = hazardous air pollutants; VOCs = volatile organic compounds

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Objectives

- Demonstrate environmentally friendly, high-performance polysiloxane topcoats on aircraft and support equipment
- Validate performance compared to qualified polyurethane topcoats
- Verify that topcoats provide a reduced environmental impact by analyzing air samples during spray applications and by calculating released VOCs

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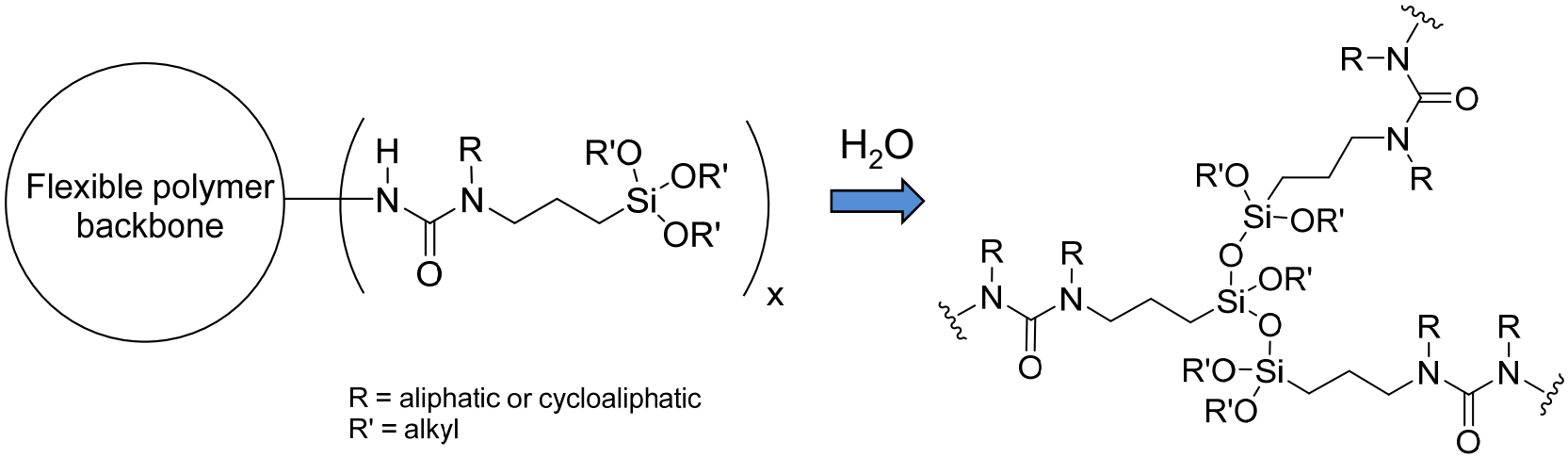
Chemical Formulation

NRL-Developed 1K Polysiloxane Topcoat



- Isocyanate and HAPs-free, <300 g/L VOCs, Fp >100 °F
- Single-component (1K), all-in-one-can system
  - No metering/mixing of components, resealable container

Notes: NRL = Naval Research Laboratory; 1K = one-component; Fp = flash point; R = organic group

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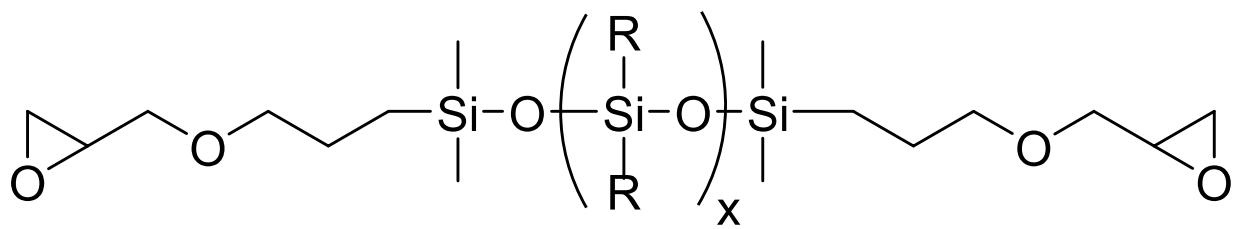
Chemical Formulation

NRL-Developed 2K Polysiloxane Topcoat



R = methyl, phenyl, and/or cyclohexyl

- Isocyanate and HAPs-free, <70 g/L VOCs
- Greater flexibility than commercial 2K polysiloxanes based on small molecule aminoalkoxysilanes

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Acute Nose-Only Inhalation Toxicity Testing

Organosilane Polymer vs. Isocyanates

- Test set-up
  - Conducted in accordance with EPA standards
  - 4-hour exposure of organosilane polymer solution to rodents
    - Concentration limit ~2 mg/L (~2000 mg/m^3)
  - 14-day observation period, then terminal necropsy
- LC50 Results
  - Organosilane polymer: 2020 mg/m^3 (all rodents survived)
  - HDI: 124 mg/m^3 (from SDS)
  - HDI homopolymer: 137-1150 mg/m^3 (from SDS)
- Organsilane polymer used in 1K polysiloxane topcoat has less than half the inhalation toxicity of isocyanates used in 2K polyurethane topcoats

Notes: HDI = hexamethylene diisocyanate; LC50 = lethal concentration to kill 50% population; SDS = safety data sheet

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Benefits to DoD

Polysiloxane Topcoats

- Isocyanate-free
  - Reduced health-related costs
  - Reduced monitoring/laboratory testing costs
- Enables concurrent maintenance in nearby areas during paint applications
  - No need to evacuate hanger-bays on ships
- Lower VOCs → could paint more often at depots
- 1K reduces generation of hazardous waste compared to mixed 2K polyurethanes
- Compatible with chromate-free primers
  - Potential for non-hazardous coating systems

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Performance Requirement Testing

Navy Aircraft and GSE Topcoats

MIL-PRF-85285E, Type II and IV Tests
VOCs
Gloss
Solvent Resistance
Fluid Resistance – Lube Oil, Hydraulic Fluid, and JP-5 Jet Fuel
Wet Tape Adhesion
GE Impact Flexibility
Room Temperature Flexibility
Low Temperature Flexibility
Heat Resistance
Weather Resistance
Cleanability
Heat Resistance
Strippability

- Polysiloxane topcoats evaluated to Navy performance tests
  - Navy aircraft topcoat
    - 1K Camouflage Gray Polysiloxane
  - Navy GSE topcoat
    - 2K Gloss White Polysiloxane
- Topcoats meet laboratory requirements

Notes: GSE = ground support equipment; JP-5 = Jet Propellant #5; 1K topcoat tested over a MIL-PRF-85582, Type II chromate epoxy primer; 2K topcoat tested over a MIL-DTL-53022, Type IV epoxy primer

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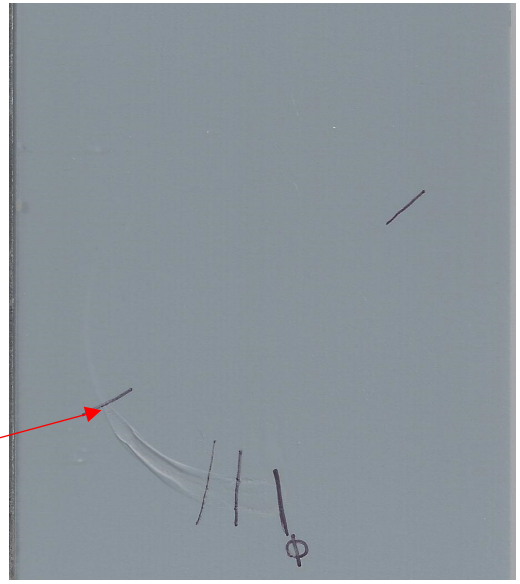
Performance Requirement Testing

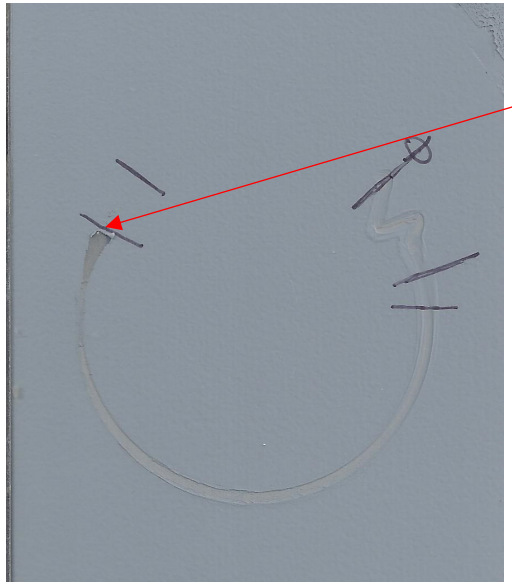
Navy Aircraft Topcoat

1K Polysiloxane



Set-to-touch: 30 minutes
Dry-hard: **2.5 hours**
Dry-through: 8.0 hours

2K Polyurethane



Set-to-touch: 1 hour
Dry-hard: **8.5 hours**
Dry-through: 9.25 hours

- 1K topcoat is more forgiving if accidentally touched by painters during applications on aircraft

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Performance Requirement Testing

Air Force Coating Systems

MIL-PRF-32239A Tests	1K Camouflage Gray Polysiloxane	Qualified 2K Camouflage Gray Polyurethane
Adhesion – Wet Tape	PASS, 5A	PASS, 5A
Fluid Resistance – Jet Fuel (JP-8)	PASS	FAIL; 4B adhesion, +5 change in pencil hardness, $\Delta E = 0.13$
Fluid Resistance – Hydraulic Fluid	PASS	PASS; 5B adhesion, 0 change in pencil hardness, $\Delta E = 0.99$
Low-Temperature Flexibility	PASS	FAIL
GE Impact Flexibility - Before Weathering	PASS, 10%	PASS, 10%
GE Impact Flexibility - After Weathering	PASS, 10%	FAIL, <10%
Strippability with Toxic and Non-Toxic Paint Removers	PASS with both strippers	FAIL, 100% of topcoat removed with toxic stripper, but only 75% removed with non-toxic stripper
Weather Resistance	PASS, $\Delta E = 0.81$	PASS, $\Delta E = 0.77$

<u>Notes</u>: JP-8 = Jet Propellant #8; 1K and 2K topcoats tested over a Mg-Rich epoxy primer with Prekote pretreatment

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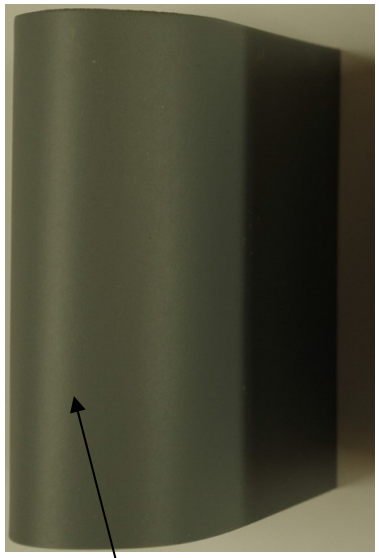
Performance Requirement Testing

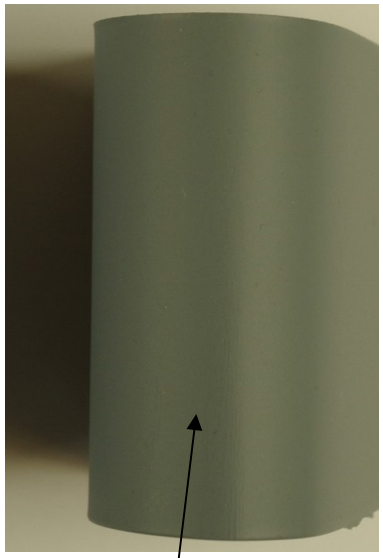
Air Force Coating Systems

1K Polysiloxane over Mg-Rich Primer



PASS: no cracks

2K Polyurethane over Mg-Rich Primer



FAIL: very small cracks

1K Polysiloxane over Chromate Primer

FAIL: small cracks

2K Polyurethane over Chromate Primer

FAIL: cracked across panel

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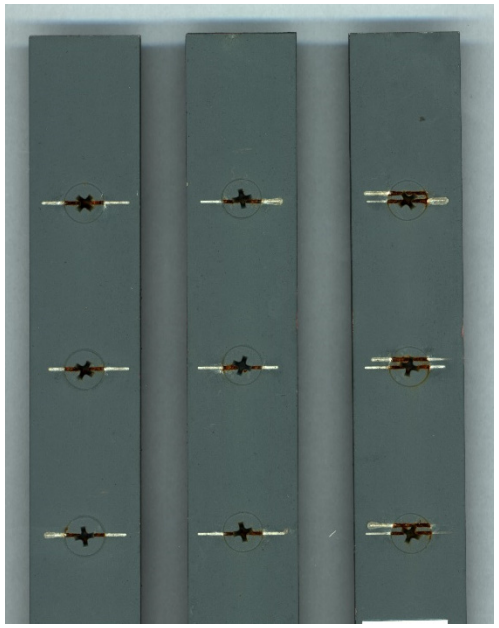
Performance Requirement Testing

Air Force Coating Systems

18 Months of Outdoor Exposure in Daytona Beach, Florida
AA2024-T3 Bare, Mg-Rich Primer, Cadmium Plated Steel Fasteners (Scribed)



1K Polysiloxane

2K Polyurethane

- 2K Polyurethane system – slightly better corrosion resistance

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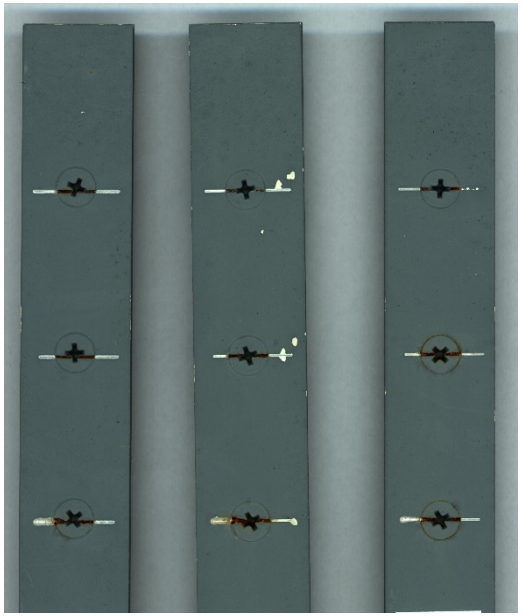
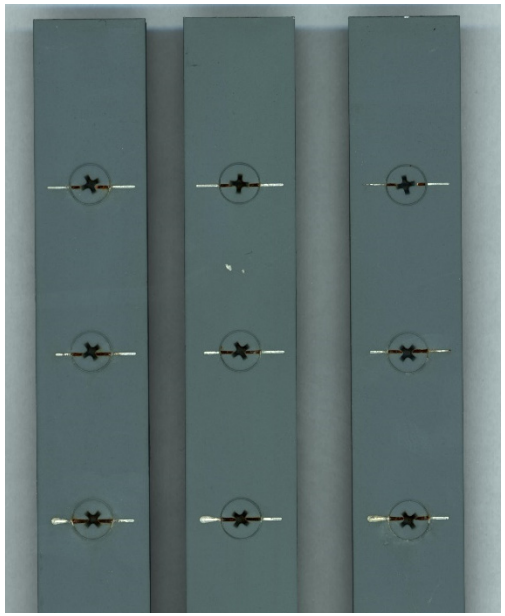
Performance Requirement Testing

Air Force Coating Systems

18 Months of Outdoor Exposure in Daytona Beach, Florida
AA2024-T3 Bare, Chromate Primer, Cadmium Plated Steel Fasteners (Scribed)



1K Polysiloxane



2K Polyurethane

- 1K Polysiloxane system – slightly better corrosion resistance

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Performance Requirement Testing

Air Force Coating Systems

- 1K Semigloss (SG) Polysiloxane
- Topcoat
  - 14 days system cure
  - Prepared surface
  - Applied second coat of 1K SG Polysiloxane
  - 14 days cure
- Good overcoat adhesion in all cases

Surface Preparation	Patti Adhesion (psi)	
	Zn-Rich Primer over Steel	Mg-Rich Primer over Al
None	2270	2531
Abrade, then apply Zip-Chem Sur-Prep AP-1	2047	2186
Abrade w/ 80-100 grit sand paper, then wipe w/ IPA	2254	2308

Notes: IPA = isopropyl alcohol

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Demonstrations on DoD Assets

1K Polysiloxane Touch-Up Kits for Field Repairs

- Easy-to-use
- Aerosol spray or brush application
- Polyurethane performance, but avoids isocyanate exposure to applicators
- Avoids costly 2K aerosol cans with limited pot-life
- Being qualified to MIL-PRF-81352 requirements

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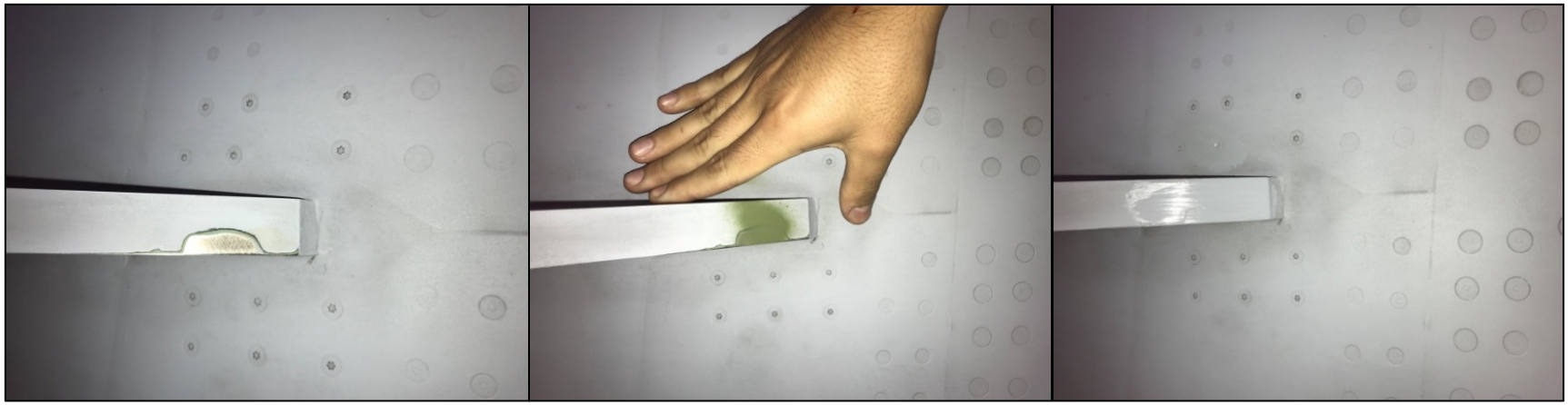
Demonstrations on DoD Assets

1K Polysiloxane Touch-Up Kits for Field Repairs

- Exterior repair on a F/A-18 Hornet by VFA-105 Squadron at NAS Oceana, Virginia (August 2018_
- 1-2 minutes of shaking once mixed reduces application time compared to standard methods
- 1K polysiloxane topcoat sprayed easily and blended well with surrounding 2K polyurethane



Sanded and Alodined | **Chromate Primer** | **1K Topcoat**

Notes: F/A = fighter/attack aircraft; VFA = Strike Fighter Squadron

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Demonstrations on DoD Assets

- 2K Gloss White Polysiloxane on a MRTT
  - NAS Oceana, Virginia Beach, Virginia
  - March 2017
- 1K Camouflage Gray Polysiloxane on a F/A-18 Hornet
  - NAS Patuxent River, Maryland
  - February 2019
- 1K Camouflage Gray Polysiloxane on an UH-1Y Venom
  - MCAB New River, Jacksonville, North Carolina
  - February 2019
- 1K Camouflage Gray Polysiloxane on an AH-1Z Viper
  - Marine Corps Base Camp Pendleton, California
  - March and April 2019
- 1K Semigloss Gray Polysiloxane on a B4 Maintenance Stand
  - MacDill AFB, Tampa, Florida
  - March 2019

Notes: MRTT = Mid-Range Tow Tractor; MCAB = Marine Corps Air Base; UH = Utility Helicopter; AH = attack helicopter

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Demonstrations on DoD Assets

2K Gloss White Polysiloxane on MRTT

2K Polysiloxane on Cab

2K Polyurethane on Door

- 12 month field inspection – March 2018
- 2K polysiloxane topcoat
  - Better color and gloss retention than a MIL-PRF-85285, Type II qualified 2K polyurethane topcoat after 1 year of field service

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Demonstrations on DoD Assets

1K Camouflage Gray Polysiloxane on F/A-18 Hornet

MIL-PRF-85582, Type II Primer

1K Spray Application on Vertical Stabilizers

1K Spray Application on Wings

After 1K Application

- 1K Polysiloxane more sag resistant than 2K Polyurethanes
- Stencils applied after 48 hours of curing
  - No delamination or marring
- Gloss decreased as 1K topcoat cured

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Demonstrations on DoD Assets

1K Camouflage Gray Polysiloxane on AH-1Z Viper

1K Spray Application on Fuselage

Unused 1K in Pot – Saved for Stenciling

Stenciling with Medium Gray 1K

1 Week After Painting

- Stencils applied after 24 hours of curing
  - No delamination or marring
- Medium gray stencils
  - Applied with recovered 1K topcoat used in pressure-pot the previous day
- Gloss decreased as 1K topcoat cured

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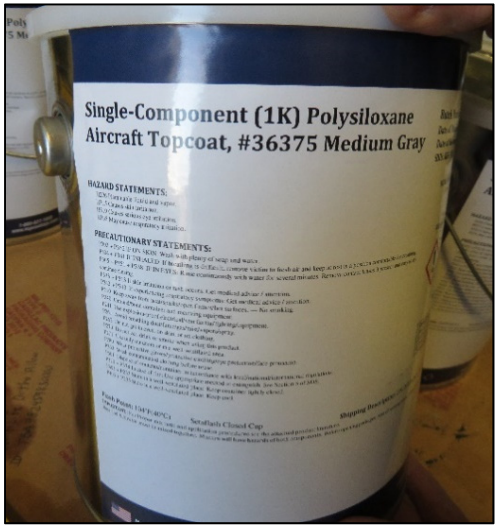
Polysiloxane Topcoat Manufacturing

- Manufactured to date
  - >75 gallons of camouflage and semi-gloss gray 1K polysiloxane topcoats
  - >25 gallons of 2K gloss white polysiloxane topcoat



Gallon Can of 1K Topcoat, #36375 Gray

Various Camouflage Colors

Cans of 2K Topcoat, #17925 White (2:1 Mix by Volume), and Example of Gloss Topcoat

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Conclusions

Polysiloxane Topcoats

- Environmentally friendly alternative to isocyanate-based polyurethanes
- 1K topcoat – “user-friendly”
  - No metering or mixing of components
  - Applicable to depot repaints or field repairs of aircraft and support equipment
- 1K and 2K topcoats
  - Equivalent or better laboratory performance compared to qualified 2K polyurethanes
- 2K gloss white topcoat
  - Better field performance on a MRTT after 1 year than a qualified Type II 2K polyurethane

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For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Surface-Engineering-and-Structural-Materials/Coatings/WP-201506

Speaker Contact Information

erick.iezzi@nrl.navy.mil; 202-404-2889

Q&A Session

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The next webinar is on June 20, 2019

Infrastructure Adaptation Strategies to Mitigate Climate Change and Uncertainty

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