AFCTIO Project Updates

AF Corrosion Managers Conference
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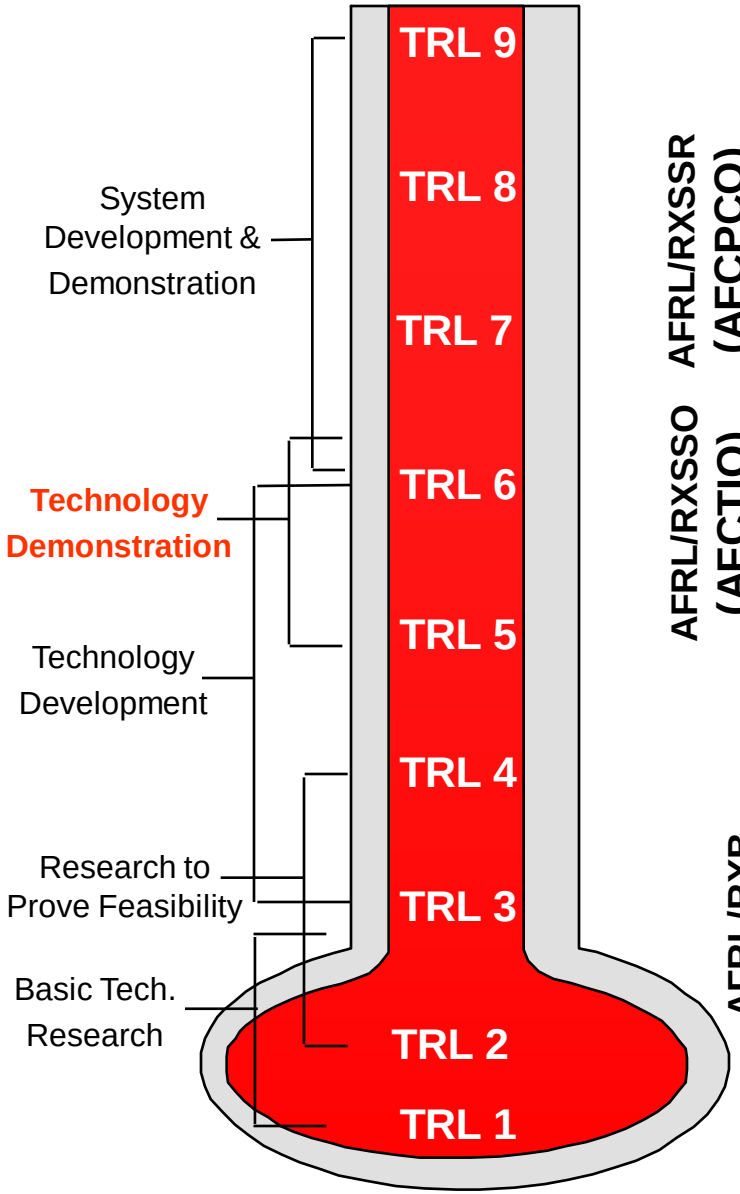
Overview

- Technology Readiness Levels (TRLs)
- Flexible primer
- UV Cureable Stencils/Markings
- Hot Dip Galvanization for GSE
- Fuel Tank Coatings (AMS-C-27725)
  - DIEGME Resistance
- AvDEC Gaskets for C-17 Antennas
- Plastic Media Blasting (PMB) Update
  - MIL-P-85891A
- Deployable UV Cure Kit (DUCK)
- Complete Non-Chrome Coating Systems
  - Alodine 5200/Sicopoxy/Deft APC
  - (PreKote or BoeGel)/Mg Rich Primer/Deft APC
- POCs for Projects

Technology Readiness Assessment (TRL)



AFRL/RXSSR (AFCPCO)	• Best material formulation, application processes, and equipment proven through successful mission operations
	• Best material formulation, application processes, and equipment qualified through test and demonstration
	• Best material formulation, application processes, and equipment demonstrated in an operational environment
AFRL/RXSSO (AFCTIO)	• Best material formulation, application processes, and equipment demonstrated in a relevant environment
	• Top material formulations validated in a relevant environment
AFRL/RXB	• Candidate material formulations tested against full spectrum of tests in laboratory. Material specification is frozen
	• Screening test weed out poor material formulations. Detailed material specification is developed
	• Material formulations vary wildly. Key requirements are documented
	• Basic principles of materials observed and reported. Requirements are non-specific and incomplete

Flexible Primer

TRL 3-4

Why do we need high flexibility in a primer?

Corrosion Protection Mechanisms of Coatings

Barrier – Keep Electrolyte from Metallic Substrate

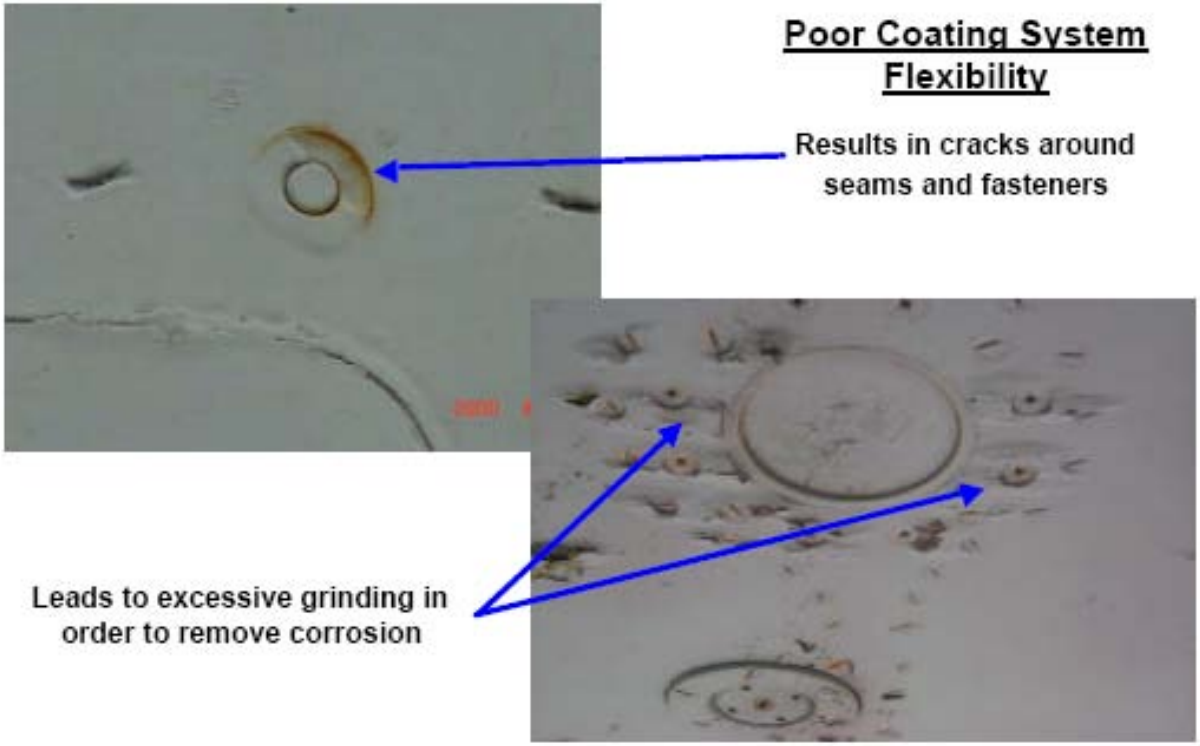
Inhibitors – Retard Ion Flow in Electrolyte

The ideal scenario:

Maintain BARRIER properties as long as possible.

Achieved by using highly flexible primer coatings and topcoats.

Once barrier breached, inhibitors in the coating system reduce the rate of corrosion.



Flexible Primer

TRL 3-4

Corrosion Protection Mechanisms of Coatings

Barrier – Keep Electrolyte from Metallic Substrate

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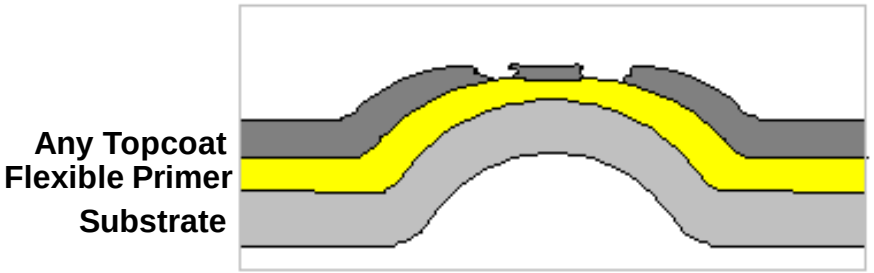


CTIO has evaluated numerous formulations to determine if there are products that provide equal or better protection than the high VOC polysulfide primers:

- **Lower VOC Polysulfide**
- **Polythioether**
- **Polythio-Epoxy Hybrids**

None were found that will stop a crack from propagating from a topcoat to the substrate.

- **If flexibility was high, TOUGHNESS was not**

Flexible Primer

TRL 3-4

Feasibility Study of Polyureas

Polyurea coatings exhibit tremendous TOUGHNESS, as shown by their current applications:

- Truck Bed Liners
- Tank Liners
- Chemical Storage
- High Abrasion Applications

Attributes:

- Chemical Resistant
- Water Resistant
- Abrasion Resistant
- High Tensile Strength
- Flexible
- Quick Cure

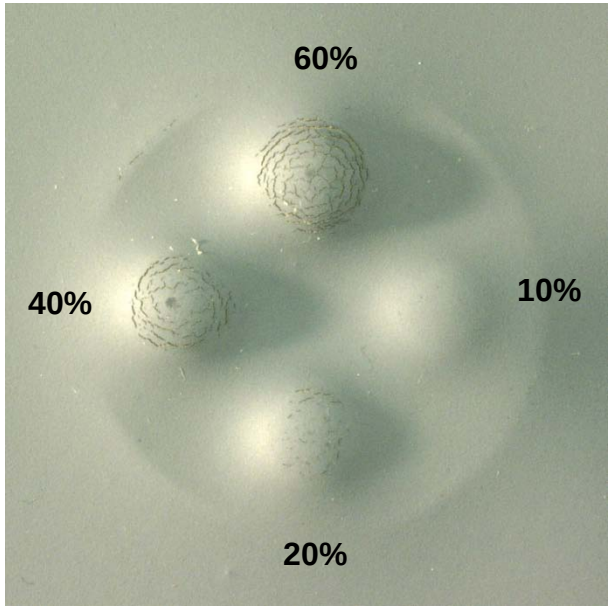
CTIO initiated a feasibility study for using polyureas as primer coatings where high flexibility and toughness are needed.

Flexible Primer

TRL 3-4

Feasibility Study of Polyureas

Initial testing



Reverse Impact:	All Pass*
Lo temp flexibility :	Mixed Results
Room Temp 2” Mandrel:	All Pass
500 hrs B-117 salt pray testing:	All pass
Adhesion:	All Pass

* Topcoats over polyurea cracked during test but the polyurea blunted any crack propagation to the substrate

UV-Curable Stencils/Markings

TRL 5

UV-Curable Coatings – cure only when exposed to correct dose/intensity of UV light at specific wavelengths

- **Single Component, no mixing, no waste**

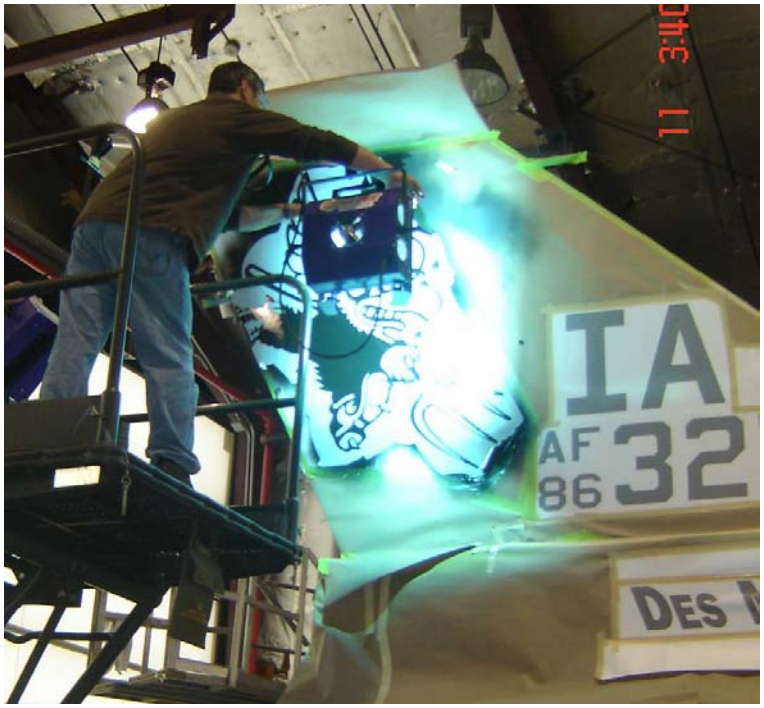
Advanatages:

- **Required cure time is seconds or minutes vs. 3 – 7 days required for conventional polyurethane systems**
- **Environmentally friendly – usually low/zero VOC**
- **Enables extremely rapid touch-ups and repainting**

AFRL Approach: Capitalize on low risk, potentially high reward applications to demonstrate the technology…

UV-Curable Stencils/Markings

TRL 5



1st App: Iowa ANG, Dec 07, F-16 tail

2nd App: 911 AW, Apr 08, C-130

Nov 08 Eval – 7 months and 340+ flying hours

- **No adhesion loss; color degradation ~1/2 that of the conventional markings on aircraft**

Hot Dip Galvanization for GSE

TRL 7

CTIO initiated a project in Sep 07 at the request of PACAF to investigate HDG for support equipment in highly corrosive environments.

Fuel Tank Coatings

TRL 7

- **PROBLEM:** Fuel Tank Topcoat Peeling (FTTP)
  - Primarily confined to vapor areas
  - Some on lower skins generally in lowest areas of tank where denser fluids would settle

Fuel Tank Coatings

TRL 7

- **GOALS FOR THIS EFFORT:**
  - **Develop DIEGME Resistant Coating for Integral Fuel Tanks**
    - Compatible with
      - BMS 10-39(epoxy)
      - AMS-C-27725(polyurethane)
    - Any Chemistry Accepted
    - No Chemical Stripping Requirement

Three Products

Axon Products, Inc.: FT-9-Y4

Poenix Coatings: Phoenix Exo-Kote

NIC Industries: CeraKote C556

  - **Develop Laboratory Test and Parameters**
    - Implement in AMS-C-27725 as Type IV
    - Use Field Test to Verify

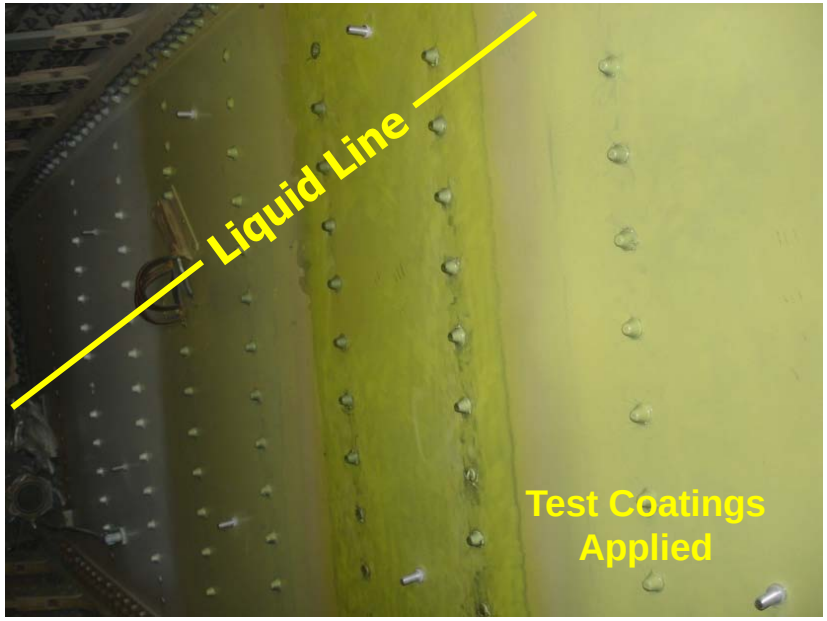
DIEGME test parameters

- **No Force cure**
- **Mixture 80/20 DIEGME/water**
- **Half submerge specimens in mixture**
- **At 170 ºF constant**
- **Duration 6 weeks**
- **Pencil hardness**
  - **immersed and not immersed**
- **Cross-Hatch adhesion**
  - **immersed and not immersed**

Fuel Tank Coatings

TRL 7

- **THREE COATINGS IN FIELD TEST – B-52 Fuel Tank**
  - **Applied at Tinker AFB – September 2007**
  - **BMS 10-39 peels as witnessed before**
    - **Test coatings peel as well –** Unlikely
      - Back to drawing board to develop better coatings
    - **Test coatings still intact –** Implement coatings
      - Continue to monitor - determine longevity
        - **Test coating < PDM cycle –** Improve formulation
        - **Test coating exceeds PDM –** Inspect every PDM
  - **BMS 10-39 does not peel as witnessed before**
    - Conditions not met to evaluate test coatings
      - Continue to monitor test coatings

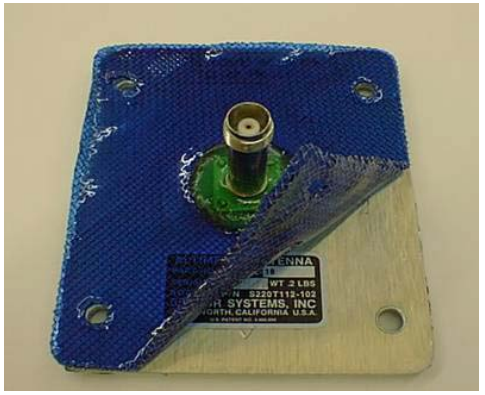


- **PERFORM QUALIFICATION TESTING IN PARALLEL**
  - SAE G-8 Letter sent Dec 08
  - Wet Samples Received 1 Apr 09
  - Testing underway

AvDEC Gaskets for C-17 Antennas

TRL 8+

- **Provide Boeing & C-17 SG performance & validity of AvDEC gasket material during antenna installations**
  - **AvDec Gaskets**
  - **PR-1775 B-2 sealant**
  - **Corban 27L (some)**
- **Environmental testing**
  - ☑ **Mixed Metal Corrosion**
  - ☑ **Cyclic Loading and Exposure**
  - ☑ **Thermal Conditioning**
- **Antenna Performance Testing**
  - **Impedance/RF Patterns**
  - **Modified HALT (“Bake & Shake”)**
  - **Lightning Strike**



AvDEC Gaskets for C-17 Antennas

TRL 8+

Phase I - Results

- Thermal Conditioning Results
  - From easiest to hardest to take apart:

    Corban 27, AvDEC gaskets, B-2 sealant
- Corrosion Results:
  - AvDec gasket material or Corban 27L material is a better material to use between two faying surfaces
  - Edge seal required for better corrosion protection

Phase II - Results

- Antenna Performance Testing
  - Impedance/RF Patterns
    - No difference among Corban 27, AvDEC gaskets, & B-2 sealant

Plastic Media Blasting

TRL 8+

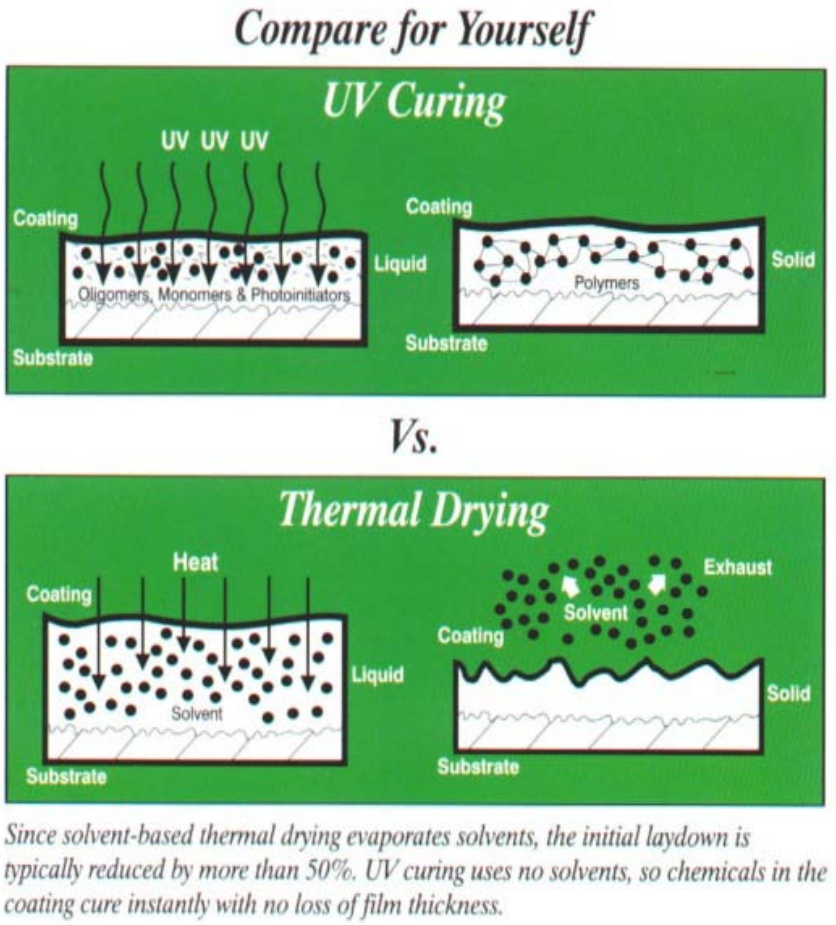
- 2008 round of 1st article testing to MIL-P-85891A have been completed
  - Approved suppliers list in T.O. 1-1-8
  - AFCPCO can supply the list
- Spec Requirements
  - Based on '80's raw materials
  - Trying to locate funds for updated testing

- Be aware that Charge Lot (50,000 lbs) & Batch (a.k.a. Finish) Lot (10,000 lbs) data are required to be provided with EACH shipment
  - Can have info quality of media
  - May be sent to the buyer

Deployable UV Cure Kit (DUCK)

TRL 4

- UV cure is a method of rapid-curing a coating with a UV Curable coating
- These are coatings/paints that cure in seconds/minutes under UV light rather than 3+ days via chemical reaction (as with today's polyurethane topcoats)
- Perform the necessary tests to ensure the coating systems are capable to be applied to the airframe with the same effectiveness as current Mil –Spec coatings
- UV coatings typically have very low to 0 VOC's
- UV coatings are typically temperature independent, will cure in cold temperatures

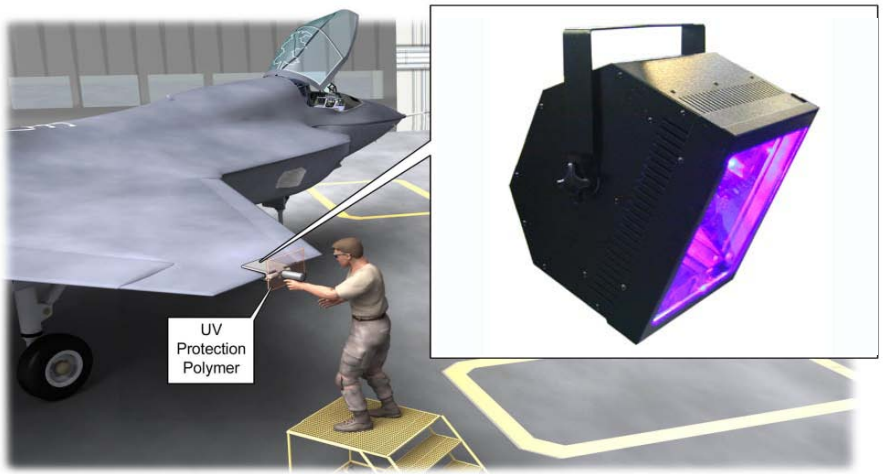


Since solvent-based thermal drying evaporates solvents, the initial laydown is typically reduced by more than 50%. UV curing uses no solvents, so chemicals in the coating cure instantly with no loss of film thickness.

Deployable UV Cure Kit (DUCK)

TRL 4

- **Purpose:**
  - Deliver UV technologies out to the Field
  - Develop a kit capable of curing a small repair <9ft^2 in less than 4 hrs
  - Will allow maintainers to do flight line touchups in environmentally restrictive areas



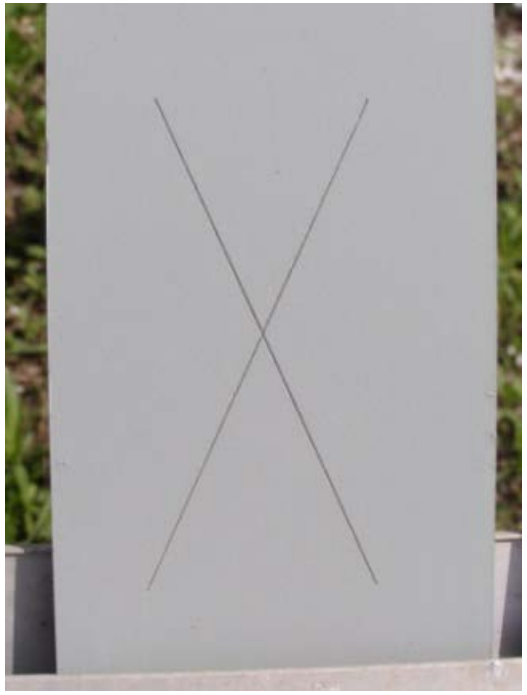
- **Kit will include**
  - **UV lamp (Hg Arc)**
  - **UV Cure coatings**
    - **Topcoats**
    - **Primers**
    - **Pretreatments**
- **Training Video**
- **Restocking Information**
- **PPE/MSDS**
- **Small telescoping stand**
- **Carrying Case, to be able to be deployed by 1 technician**

Alodine5200/Sicopoxy/Deft ELT

Non-Chrome Coating System

TRL 7

- **Lab Testing: Alodine 5200/Sicopoxy/Deft ELT (APC) Nonchrome system performed the best of all Nonchrome Systems evaluated**
- **Daytona Beach outdoor exposure: results at 9 months**



Test Coating

Alodine 5200

Sicopoxy

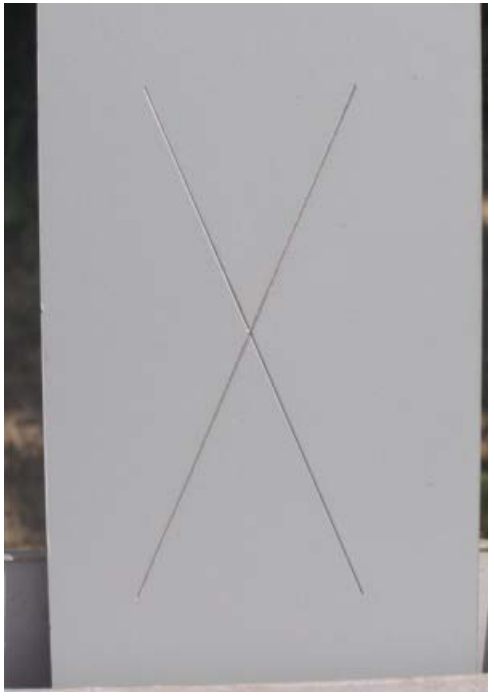
Mil-PRF-85285

Control

PreKote

Mil-PRF-23377

Mil-PRF-85285



- **CTIO, AFCPCO, & RXSC worked with AETC to conduct a field test of Alodine 5700/Sicopoxy/Deft ELT (APC) @ Randolph AFB**

NOTE: Alodine 5200: Concentrate --- Alodine 5700: Premixed RTU

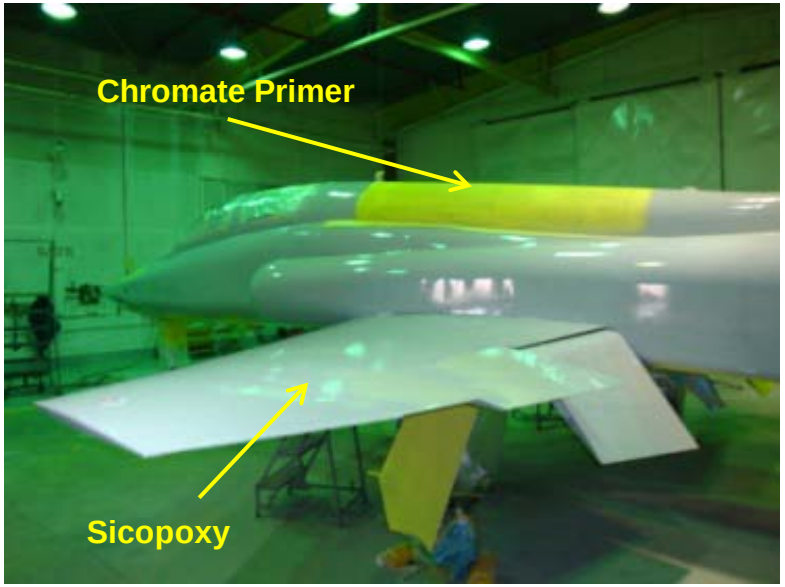
Alodine5200/Sicopoxy/Deft ELT

Non-Chrome Coating System

TRL 7

Field Test

- **T-38**
  - **Test Area:** ~45% of left side
  - **Coating System:**
    - Alodine 5700
    - SICOPOXY
    - MIL-PRF-85285
  - **Application:** Randolph Sept 08
  - **Deployed:** Randolph
- **Evaluate:** 6 months and 1 year
- **Rate of Corrosion:** monitored by sensors at Randolph AFB
- **Witness panels:** CTIO



Mg-Rich Primer
What is it?

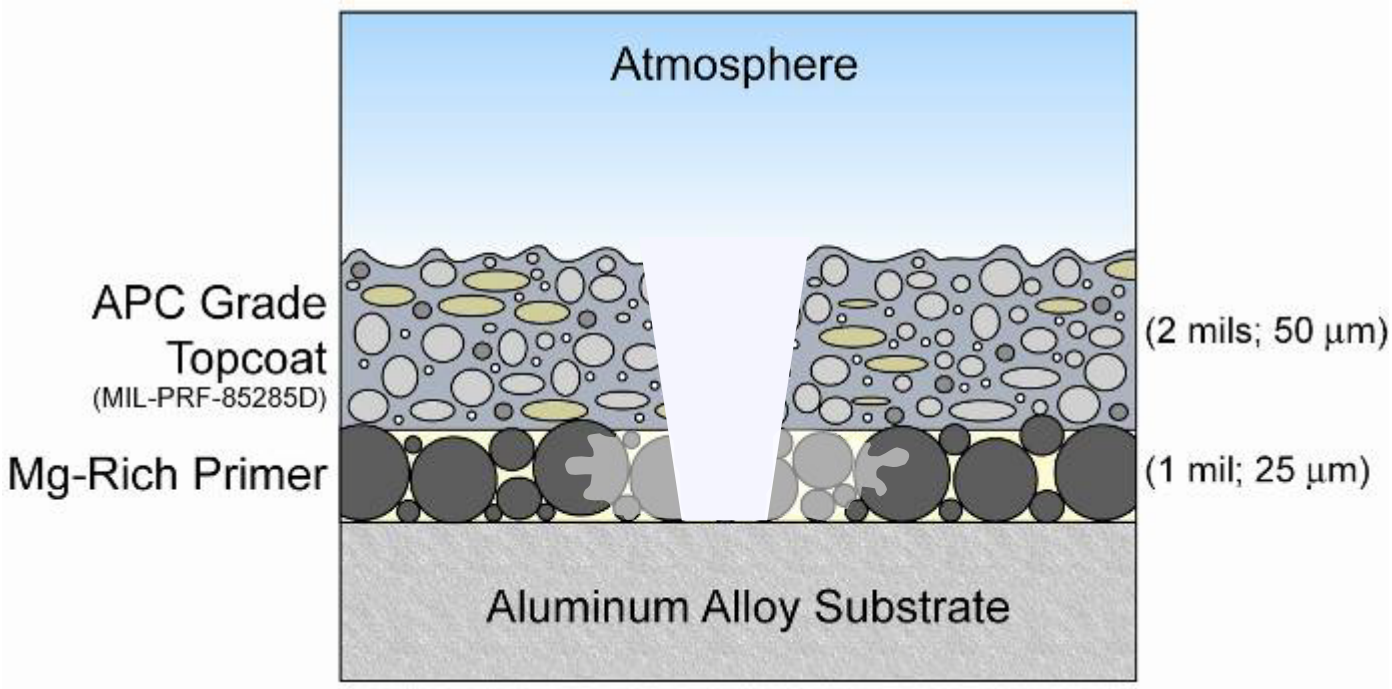
TRL 4+

- Developmental non-Cr primer as part of a fully non-Cr coating system
- Concept developed by NDSU
- Licensed & product development by a major aerospace coating company
- Provides “cathodic” corrosion protection of the substrate
  - analogous to a Zn-rich primer for steel
  - does not use inhibitors
- NEW TECHNOLOGY = NEW RULES; still some unknowns, may require special considerations
- Designed as “Drop In” for MIL-PRF-23377
- Best results with PreKote.

Mg-Rich Primer
How does it work?

TRL 4+

- **<u>Corrosion Prevention</u>: provided by barrier properties of the primer and topcoat (conventional); both Mg pigment and substrate protected**



- **<u>Corrosion Control</u>: Mg particles are more active than the aluminum; the pigment corrodes and the substrate doesn't**

Mg Rich Primer
Status

TRL 4+

- **Inconsistent Results:** Navy, CTIO, and Outdoor Exposure
- **Round Robin:**
  - 5 Organizations: B-117 **- Terminated at 500 hours**
  - 2 Organizations: Daytona Beach and KSC
- **Navy pursuing patent for possible fix**
- **Akzo Nobel working on issue:**
  - Briefed CTIO 23 January 2009 – Found Solution
- **Samples shipped to CTIO mid March –** Testing underway
- **GOAL: F-16 Field Test** and **MIL-PRF-32239 Qualification**
  - If screening tests successful

Co-Inhibitor Study: 1500 Hours Neutral Salt Spray
Topcoat: Aerodur 5000, Substrate: 2024-T3

TRL 4+

Negative Control over PreKote	Standard MgRP over PreKote	Inhibitor 2 w/ MgRP over PreKote	10P8-11 over Alodine 1200

CTIO POCs

- Fuel Tank Coatings (DIEGME resistant)
- Mg Rich Primer

Mike Spicer 937-255-0942

- Flexible Primer
- UV-Curable Stencils/Markings
- Hot Dip Galvanization for GSE

Corey Bliss 937-255-0943

- C-17 AvDEC Antenna Gaskets
- Plastic Media Blasting
- Complete Non-Chrome Coating Systems
  - Alodine 5700/Sicopoxy/Deft APC

Bill Hoogsteden 937-656-4223

- Deployable UV cure Kit (DUCK)

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