



# **UV-Curable Coatings for DOD Aircraft Depot Maintenance (ESTCP Project WP-0804)**

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# Report Documentation Page

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# Overview



- **Current processes**
- **Team and project approach**
- **Performance baseline/JTP requirements**
- **Coating selection**
- **Planned activities/Project timeline**
- **Summary**
- **Related Efforts**



# Current Aerospace Coatings



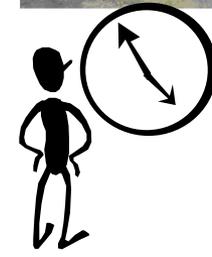
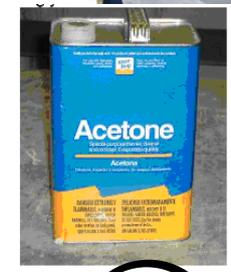
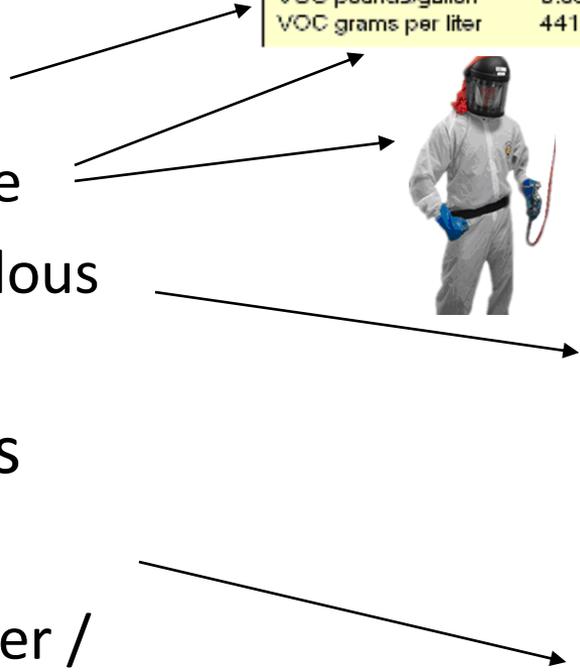
## ■ Environmental burdens

- Air Emissions
- Worker exposure
- Generate hazardous waste

## ■ Production delays

- Long cure times
  - 4 hr for primer / 8-72 hr for topcoat
- Bottlenecks in production

BASE CHARACTERISTICS*		CATALYST CHARACTERISTICS*	
Wt./Gal.	10.11 lbs.	Wt./Gal.	9.00 lbs.
% solids by weight	63.31	% solids by weight	73.64
% solids by volume	46.36	% solids by volume	69.62
VOC pounds/gallon	3.68	VOC pounds/gallon	2.34
VOC grams per liter	441	VOC grams per liter	281





# Project Objectives



- **Dem/Val UV-curable aerospace topcoats:**
  - Simple geometry off-aircraft components
  - Interior/exterior flat surfaces
  - Aircraft markings
- **Verify through lab and field testing technology will:**
  - Meet aerospace performance requirements
    - Flexibility
    - Gloss
    - Weatherability
    - Fluid Resistance
  - Reduce environmental burden and costs
  - Increase production throughput



F-16 Tail



C-130 Escape Hatch



# Project Team

**ESTCP Principal Investigator**  
Glen Baker



**AFRL/RXSC - Program Management**  
Tom Naguy  
Randy Straw (CTC)



**CTC**  
Matthew Campbell, *CTC* Project Manager  
Anthony Kingera, Technical Support  
Steve Finley, Technical Support



**Coatings Technology Integration Office (CTIO)**  
**Lab Testing**  
Corey Bliss



**Principal Stakeholders**  
Ogden Air Logistics Center  
Oklahoma City Air Logistics Center  
Warner Robins Air Logistics Center  
NAVAIR Depot Jacksonville  
USCG Aircraft Repair and Supply Center



**Subcontractor**  
Bayer Material Science/Deft





# Technical Approach



## Project Approach



### Task III – Technology Transition

- Modify specifications and technical orders/manuals
- Purchase/transition equipment to OO-ALC and train staff
- Compare performance versus baseline data
- Prepare Final Cost & Performance and Final Reports
- Prepare Final Briefing

### Task II – Demonstration/Validation

- Make final selection of coatings for dem/val (*completed*)
- Conduct lab testing and optimization (*in-progress*)
- Conduct field testing (*in-progress*)

### Task I – Planning for Demonstration/Validation

- Draft Project Management Plan (PMP) (*completed*)
- Conduct Initial Cost-Benefit Analysis (ICBA) and Performance Baseline (*completed*)
- Draft Joint Test Protocol (JTP) (*completed and approved*)
- Draft Demonstration Plan (*completed and approved*)



# Joint Test Protocol

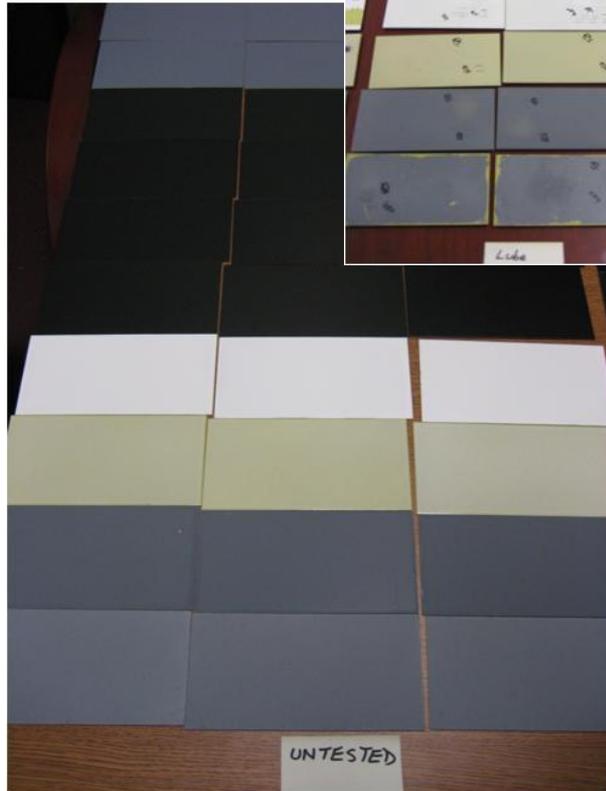
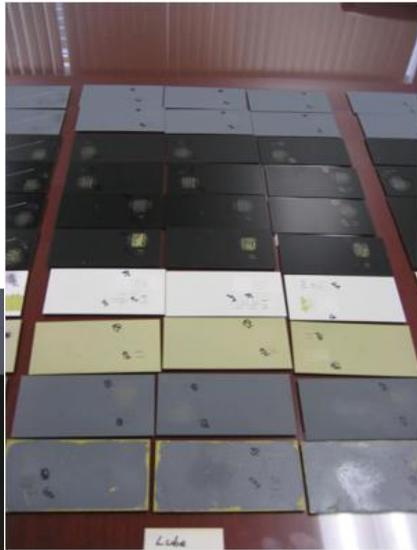


- **MIL-PRF-85285 (minimum) and MIL-PRF-32239 (advanced performance)**
  - Adhesion
  - Flexibility
  - Color/gloss match
  - Color/gloss retention
  - Fluid resistance
  - Repairability

<b>Appearance</b>	
Color	$\Delta E$ of less than 1 from standard
Gloss	At 60 : $\geq 90$ for gloss; $\leq 5$ for flat
<b>Adhesion</b>	
Wet Tape	No peel away; target rating of 4A or 5A
Cross Hatch	No peel away; target rating of 4B or 5B
<b>Flexibility</b>	
Low Temperature	No cracking or adhesion loss over 1 inch bend (gloss and semi-gloss) or 2 inch bend (flat)
GE Impact	Minimum of 40% elongation; no cracking, crazing, or loss of adhesion
<b>Resistance</b>	
Pencil Hardness	2B or harder; initial hardness - data point for fluid resistance
Fluid Resistance	Softening no more than two (2) pencil hardness unit; no blistering or defects after exposure to lube oil, hydraulic fluid and JP-8 fuel
<b>Resistance</b>	
Accelerated Weathering (Color and Gloss)	Color change ( $\Delta E$ ) of less than 1 after 500 hours; Min gloss of 90 for gloss; max five (5) for flat
Heat Resistance	Color change ( $\Delta E$ ) of less than 1 after exposure to 250 $^{\circ}$ F for 60 minutes
Humidity Resistance	No blistering, softening, loss of adhesion or defects
Cleanability	Cleaning Efficiency $\geq 75\%$
<b>Repairability</b>	
Scuff sand /Wet Tape	No peel away; target rating of 4A or 5A
Scuff sand /Cross Hatch	No peel away; target rating of 4B or 5B
<b>Stripability</b>	
Chemical Strippers	Removal of the coating to the substrate
Dry Media (blasting)	Removal of the coating to the substrate
Laser Stripping	Removal of the coating to the substrate



# Coating Selection





# COTS Selection Results



Coating	Adhesion	Flexibility	Hardness	Fluid Resistance	Weathering
Bayer/Deft Flat Black	Equals performance of controls	Needs improvement	In desired range	Pass all MIL-PRF-85285 requirements	Passes 3,000 hours for <1 $\Delta E$ color change
DSM Desotech Gloss White	Marginal failure on crosshatch	Needs improvement	In desired range	Pass on hardness/adhesion	Needs improvement

- **Analysis of off-the-shelf coatings**
  - Flat black coatings nearly match controls
  - Gloss coatings require more work
  - Flexibility, gloss, and color retention developmental work
  - Proceed to optimization reformulation



# Critical Decisions



- **Critical decisions made based on screening testing:**
  - Reformulate Bayer/Deft coating to meet one (1) black and two (2) gray colors
  - Reformulate DSM coating to meet two (2) gloss white colors
- **Critical decision for cure technology:**
  - **Coating cure must be made with UVA light (315 – 400nm)**
    - UVA required to safely operate light in open maintenance environment
    - UVA requirements more difficult for coating development; DSM Desotech base formulation made for full spectrum cure
  - **H&S Autoshot Cure-Tek 1200W lamp used for coating reformulation**
    - Intense large area UVA lamp commercially available



# Black/Gray Reformulation Results



## Preliminary JTP Testing Results by Independent Laboratory

TEST	SPECIFICATION	36173 Gray (85285)	37038 Black (APC)	36173 Gray (APC)	36173 Gray (UV)	36118 Gray (UV)	37038 Black (UV)
		Control Coating	Control Coating	Control Coating	21BK003	21GY001	21GY002
<b>Color &amp; Gloss</b>							
Delta E from Standard	< 1.0	0.2	1.2	0.2	0.9	10.1	0.9
60	5 MAX.	3.8	1.1	2.5	4.0	4.3	4.9
85	9 MAX.	4.0	5.1	3.9	10.1	8.0	11.8
<b>Adhesion</b>							
MEK	25 DOUBLE RUBS	Pass	Pass	Pass	Pass	Pass	Pass
WET TAPE	4A OR 5A	5A	5A	5A	2A	4A	3A
CROSS HATCH	4B OR 5B	4B	4B	4B	3B	4B	5B
<b>Flexibility</b>							
GE IMPACT	40% MINIMUM	20%	20%	10%	10%	2%	10%
<b>Weatherability – 500 Hour Xenon Arc</b>							
60 DEG. GLOSS	5 MAX.	3.1	Not Reported	2.3	1.2	1.9	0.9
85 DEG. GLOSS	9 MAX.	4.6	Not Reported	3.5	4.8	8.6	7.0
Delta E from Initial	1.0 MAX	0.6	Not Reported	0.1	2.8	1.0	1.0
<b>Resistance</b>							
HEAT RESISTANCE	Delta E <1.0	0.1	0.1	0.1	0.9	0.3	0.2
<b>Fluid Resistance</b>							
INITIAL	Max 2 Pencil Drop	3H	4H	4H	3H	H to 2H	2H to 3H
Mobil Jet 254	24 HR @ 250 F.	3H to 4H	2H to 3H	4H to 5H	F	HB	H
7808 Lube Oil	24 HR @ 250 F.	5H	4H to 5H	5H	B	B to 2B	B to HB
Hydraulic Fluid	24 HR @ 150 F.	5H	5H	5H	F	HB to F	F to H
JP-8	7 DAYS @ 77F.	5H	4H	5H	3B	3B to 2B	F to H

Hardness Scale: 4B < 3B < 2B < B < HB < F < H < 2H < 3H < 4H < 5H



# Gloss White Reformulation Results



- **DSM Desotech reported following results after approximate 9 month effort:**
  - Gloss (did not meet initial 90 at 60 degrees requirement)
  - Adhesion (failure on cross hatch)
  - Weathering (color change over delta 1; but gloss loss <10 at 500 hours)
  - GE Impact Flexibility (unable to meet 10%)
  - Heat resistance (color change over 3 at 1 hr)
  - Opacity (coating was translucent; primer partially visible)
  - Fluid resistance (color change; no adhesion loss for most fluids)
  - **NO CONFIDENCE COATING COULD MEET JTP REQUIREMENTS**
- **Based on reported results, following decisions made:**
  - DSM Desotech NOT to proceed to JTP testing
  - New subcontract with Bayer/Deft to reformulate gloss white based on lessons learned from Camo Coatings



# New Gloss White Effort



- **New gloss white coatings effort initiated January 1, 2010**
  - Targeting low intensity UVA cure allowing widest possible lamp selection
  - 60 degree gloss of 90+ extremely difficult to hit
  - Approach using waterborne UV-polyurethane dispersion (UV-PUD) to allow low intensity cure, flexible coating, high gloss
- **Current progress of best gloss white system:**
  - GE Impact flexibility of 60% (higher than reported for any UV coating)
  - 60 degree gloss of 85 (close to requirement of 90)
  - Passes humidity resistance
  - Initial hardness of 2B (needs improvement)
  - Adhesion to primer of 5B
  - Opacity of 96% (95% minimum requirement)
  - Expected completion of formulation and ready for color matching, June 2010



# Cure Technology Requirements



- **Cure technology critical for successful transition:**
  - Demonstration sites surveyed for critical lamp properties
  - **Maneuverability needs to exceed commercial model stands**
    - Cure area at side of aircraft, underside of wing, or locations close to ground level
    - Ability to mount lamp on standard aircraft maintenance stands
  - **Maximize cure area**
    - Areas greater than cure area require multiple cure operations
- **Class I, Division I Explosion Proof certification requirement for most areas**
  - Lamps to be used in aircraft hangars and paint booths
  - Exposure to jet fuel, paint, and other explosion risks



# Cure Technology Progress



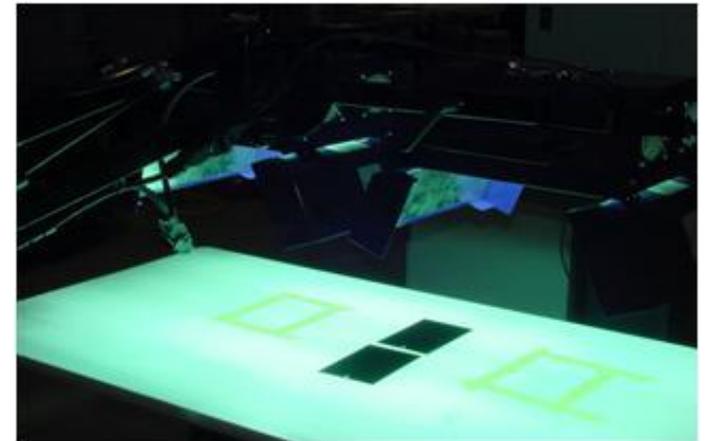
- **Demonstration Lamp Purchased:**

- H&S Auto-shot Cure-Tek 2400W
- Double-heads allow cure area ~3 square feet
- Flexible stand for multiple orientations
- No explosion proof UVA lamp model currently available



- **Proposed Implementation Lamp**

- Certified as Class I, Division I explosion-proof
- Required further development by lamp vendor
- Explosion-proof model is possible





# Demonstration Activities



- **Field application and demonstration - Summer 2010**
  - Time savings
  - Environmental savings
  - Ease of use
- **Monitor aircraft at home stations for one year**
  - Visual appearance
  - Color/gloss stability
  - Adhesion
  - Fluid resistance



# Demonstration Targets



## • Hill Air Force Base

### C-130

- Escape hatches
- Life raft covers
- Landing gear door
- Rudders
- Prop tips
- Stenciling

### F-16

- Flaperons
- Horizontal stabilizers
- Stenciling



## ■ USCG Elizabeth City

### HH-60 (primary)

- Doors
- External fuel tanks
- Stenciling

### HU-25

- Panel covers
- Stenciling



## ■ NAVAIR Jacksonville

- Off-aircraft components
- Avionics
- Stenciling



# Technology Transition



- **Initial transition - Hill AFB**
- **Update technical documentation**
  - **General series and weapon system specific technical orders/manuals**
  - **Performance specifications**
- **Transition UV application and curing equipment**
- **Train site personnel**





# Related Efforts



- **Continued evaluation of reformulated UV-curable primers, one-coats, and systems**
- **Evaluation of UV lamp technology from USAF needs perspective**
- **UV-curable rain erosion coating technology search**
- **Large area applications**



# Summary



- **Coatings and potential applications identified**
- **Reformulation activities underway**
- **Lab testing and field demonstrations in 2010**
- **Field evaluation 2010-2011**
- **Implementation upon successful demonstration**



# Points of Contact



- **USAF Environmental & Energy Quality Team**
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