

# HCAT/JCAT Program Review Meeting



## Cadmium Alternatives for High-Strength Steel JTP – Phase II

**Marriott New Orleans  
New Orleans, LA  
24 JAN 07**

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# Report Documentation Page

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# Project Overview



## Objective

Assess DoD-selected cadmium alternatives in accordance with the DoD-approved Joint Test Protocol (JTP) for both traditional plating and brush plating of HSS applications (JTP available at [www.jgpp.com](http://www.jgpp.com) – JCAT links)

## Approach

- Three-phased approach (JTP Test Matrix)
  - Phase I (preliminary requirements focused)
  - Phase II (overall performance focused)
  - Phase III (fatigue testing focused)
- Down-selection of candidates for further testing after each phase of testing is complete (Phases I & II)

# Project Team Members



- **AFRL – Dr. Elizabeth Berman**
- **CTC – Ms. Tamera Crocco and Ms. Leanne Debias**
- **NAVAIR – Mr. Steve Brown**
- **Boeing – Mr. Joe Osborne**
- **ARL – Mr. Brian Plosankis**
- **WMTR – Mr. Jay Curry**
- **Hill AFB – Mr. Nate Hughes**
- **Alumiplate – Mr. Gus Vallejo**
- **Marshall Laboratories – Mr. John Marshall**



# Phase I Overview and Selection Process



## Coatings tested during Phase I

- Traditional plating (primary coatings):
  - Sputtered Aluminum (Marshall Labs)
  - Electroplated Aluminum (Alumiplate)
  - LHE Zn-Ni (Dipsol IZ-C17)
  - Acidic Zn-Ni (Boeing, Seattle)
  - Sn-Zn (Dipsol)
- Brush plating (repair coatings):
  - Brush Zn-Ni (SIFCO 4018)
  - Brush Sn-Zn (LDC 5030)
  - Spray Aluminum-ceramic (Sermetel 249/273)

## Tests Conducted

- Hydrogen Embrittlement
- Re-embrittlement
- Adhesion

## Down-Selection Process to Phase II

- WebEx Teleconference to review results
- Team Members voted on Phase II candidates – *Completed Jan 06*



# Alternative Selection – Phase I



## Coatings selected for Phase II

- Primary test coatings
  - LHE Zinc-Nickel (Dipsol IZ-C17)
  - Electroplated Aluminum
  - Sputtered Aluminum
  - Controls - Cadmium and IVD Al
- Repair test coatings
  - Aluminum-Ceramic Repair Coating (Sermetel)
  - Zinc-nickel brush repair
  - Tin-Zinc brush repair
  - Control – Cd Brush

***All Phase II testing methods will be performed according to the procedures and requirements in the JTP***



# Phase II Tests



Test Category	Test	Testing Facility
<b>General Properties</b>	Appearance	CTC (POC – Leanne Debias)
	Throwing power and alloy composition uniformity	CTC
	Strippability	NAVAIR (POC – Steve Brown)
	Galvanic potential	ARL (POC – Brian Plosankis)
<b>Adhesion</b>	Bend adhesion	NAVAIR
	Paint adhesion	NAVAIR
<b>Corrosion</b>	Unscribed NSS* (bare)	ARL
	Scribed NSS* (bare)	ARL
	Galvanic corrosion resistance	ARL
	Fluid corrosion resistance	ARL
	Scribed, painted salt spray	NAVAIR (paint), ARL (test)
	Scribed and unscribed SO <sub>2</sub> salt spray	NAVAIR
<b>Lubricity</b>	Run-on/Break-away torque	WMTR (POC – Jay Curry)
	Torque-tension & torque-tension of corrosion-exposed fasteners	WMTR
<b>Reparability</b>	Appearance & Thickness	CTC
	Bend adhesion	ARL
	Paint adhesion	ARL
	Scribed and unscribed salt spray	ARL
<b>Quality Assurance</b>	Hydrogen embrittlement – notched bar	NAVAIR



# Status of Phase II Testing



Coating	Vendor	Received from vendor	In Testing		
			NAVAIR	ARL	WMTR
<b>Primary</b>					
Cd Plate - Control	OO-ALC	2/16/07*	2/26/07*	2/26/07*	2/26/07*
IVD Aluminum - Control	OO-ALC	2/16/07*	2/26/07*	2/26/07*	2/26/07*
Sputtered Alumium	Marshall Labs	12/4/06**	1/12/07	1/29/07*	1/12/07
Electroplated Alumium	Alumiplate	10/23/06	11/30/06	1/29/07*	1/12/07
LHE Zinc – Nickel	Dipsol of America	11/13/06	11/30/06	1/29/07*	1/12/07
<b>Repair</b>					
Cd Brush – Control	Boeing St. Louis	11/13/06	11/30/06	1/29/07*	NA
Sermetal	Boeing St. Louis	11/13/06	11/30/06	1/29/07*	NA
LHE Zinc - Nickel Brush	Boeing St. Louis	11/13/06	11/30/06	1/29/07*	NA
LHE Tin - Zinc Brush	Boeing St. Louis	11/13/06	11/30/06	1/29/07*	NA

\*Anticipated dates

\*\* Flat panels only



# Phase II Down - Selection Process



- **Same Down-Selection Procedure Will be Used at the End of the Phase II As Was Used at the End of the Phase I**
  - Down-Selection Test Report to be issued for AFRL/JCAT review (JUL 07)
  - WebEx teleconference to review the Phase II Test Report (AUG 07)
  - Team Members to Vote on Candidates for Inclusion in the Phase III effort
    - Any alternatives with clear deficiencies in a number of test categories will be eliminated from Phase III testing
    - If all Phase II test results are acceptable, then all primary and repair coatings will be tested in Phase III



# Phase III Testing



- **Phase III Testing Methods**

- Primary Coatings

- Rotating beam fatigue - smooth bar
    - Rotating beam fatigue - notched bar
    - Bend adhesion (quality assurance)
    - Hydrogen embrittlement (quality assurance)

- Repair Coatings

- Rotating beam fatigue – smooth bar

- **Phase III Test Facilities**

- All fatigue testing will be performed at WMTR
  - NAVAIR will perform the quality assurance testing



# Timeline



<b>Activity</b>	<b>Start Date</b>	<b>End Date</b>
<b>Selection of Alternatives from Phase I</b>	<b>Nov-05</b>	<b>Jan-06</b>
<b>Formulation of Phases II and III Test Plan</b>	<b>Jan-06</b>	<b>Mar-06</b>
<b>Purchase/receive materials &amp; secure subcons for Phase II</b>	<b>Mar-06</b>	<b>Sept-06</b>
<b>Ship and coat samples for Phase II</b>	<b>Sept-06</b>	<b>Jan-07</b>
<b>Phase II Testing</b>	<b>Nov-06</b>	<b>Jun-07</b>
<b>Phase II Interim Report</b>	<b>Feb-07</b>	<b>Jul-07</b>
<b>Selection of Alternatives for Phase III</b>	<b>Jul-07</b>	<b>Aug-07</b>
<b>Purchase/receive materials &amp; secure subcons for Phase III</b>	<b>Aug-07</b>	<b>Jan-08</b>
<b>Ship and coat samples for Phase III</b>	<b>Jan-08</b>	<b>Apr-08</b>
<b>Phase III Testing</b>	<b>Apr-08</b>	<b>Sep-08</b>
<b>Final Technical Report (JTR)</b>	<b>Aug-08</b>	<b>Nov-08</b>

# Summary



- **Selected alternatives from Phase I have been coated**
- **Alternatives are currently in Phase II testing (CTC, NAVAIR, ARL, WMTR)**
- **The Phase II Interim Report is planned to be complete in JUL 07**
- **A web-ex teleconference will be held to review the report and select alternatives for Phase III – AUG 07**
- **Phase III is planned to begin in AUG 07**



# Back-Up Slides



## Testing Procedures



# Description of Testing Methods



- **General properties (primary coatings)**

- Appearance – visual exam
- Throwing power
  - Test fixture surrounds panel, with one access slot
  - Fixture + panel is placed in solution at 3 different orientations
  - Uniformity of coating is measured at 3 locations on each panel
- Strippability
  - Specimens are stripped by vendor-recommended method
  - Half of specimens are tested
  - Remaining specimens are recoated and tested
    - Hydrogen Embrittlement
    - Adhesion
- Galvanic Potential
  - Three types of measurements are performed over 5 days: open circuit potential measurement, electrochemical impedance spectroscopy, and tafel analysis



# Description of Testing Methods (continued)



- **Adhesion (primary coatings)**
  - Bend adhesion
    - Specimen is bent back and forth through 180° until the coating and/or substrate ruptures
  - Wet tape paint adhesion
    - Primers are applied to test panels (14 day cure)
      - MIL-PRF-85582 Type I, Class C1
      - MIL-PRF-85582, Type I, Class N
      - MIL-PRF-23377 Type 1, Class C
    - Panels are immersed in distilled water at following conditions:
      - 23°C for 24 hours
      - 49°C for 96 hours
      - 65°C for 168 hours
    - Perform tape adhesion according to ASTM D3359, Method B



# Description of Testing Methods (continued)



- **Corrosion (primary coatings)**
  - Unscribed and Scribed Neutral Salt Spray (bare)
    - Bare panels exposed to a 5% NaCl solution sprayed at 35°C, until coating failure
  - Galvanic corrosion resistance
    - Components of test assemblies: 2024 or 7075 Al test block, coated with MIL-PRF-85582, Class 1, Type N, test washer (4 alloys), nuts, bolts, anodized washers
    - Test assemblies are exposed to salt fog for 168 hours and cyclic corrosion for 336 hours
  - Fluid corrosion resistance
    - Immerse panels in specified fluid at 100°F for 7 days
    - Test fluids: sea water, deicers, paint removers, cleaners, lubricants (14 total)





# Description of Testing Methods (continued)



- **Corrosion (continued)**

- Scribed Painted Neutral Salt Spray

- Test panels are primed with
      - MIL-PRF-85582 Type I, Class C1
      - MIL-PRF-85582, Type I, Class N
      - MIL-PRF-23377 Type 1, Class C
    - Test panels are exposed to 5% NaCl solution at 35°C for 3000 hours or until red rust

- Scribed and Unscribed SO<sub>2</sub> Salt Spray

- Unpainted panels and scribed, painted panels (same primers as above)
    - Expose to 5% NaCl and SO<sub>2</sub> gas IAW ASTM G85 A4 until coating failure (red rust)



# Description of Testing Methods (continued)



- **Lubricity (primary coatings)**
  - Run-on/Breakaway Torque
    - Record maximum locking torque after 2 complete turns from point where the top of the nut is flush with the end of the bolt
    - Breakaway torque is measured during removal of the nut
    - Measure for 15 lock/breakaway cycles and examine at 10x for thread damage
  - Torque Tension
    - Measure torque and induced load with test fixture for the range of 30%-60% of the bolt UTS
    - Repeat for a total of 5 cycles
  - Torque Tension of corrosion-exposed fasteners
    - Assemble bolts/nuts/washers onto an Al test block
    - Torque to 60% of UTS for bolt and exposed to cyclic corrosion for 28 days
    - Measure breakaway torque and compare to unexposed set



# Description of Testing Methods (continued)



- **Repairability (repair brush coatings)**
  - Initial qualification – coating applied to bare substrate and tested
  - Final qualification – candidate primary coating of choice is abraded to generate a bare area and then repaired with a brush plating
  - Testing Methods
    - **Appearance** – visual exam
    - **Bend adhesion** – bend specimen back over itself until rupture
    - **Thickness** – cross-section and microscopy
    - **Scribed and unscribed salt spray (bare)** – until failure
    - **Paint adhesion** – apply primers, immerse in distilled water at same temps/times as primary coatings, and perform cross-hatch adhesion according to ASTM D3359, method B
- **Quality assurance – HE testing to compare to Phase I**

