

HCAT/JCAT Program Review Meeting



Cadmium Alternatives for High-Strength Steel JTP – Phase II

**Marriott New Orleans
New Orleans, LA
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**Air Force Technical Point of Contact: Dr. Elizabeth Berman
CTC Subtask Manager: Tamera Crocco**



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 – 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
General Properties	Appearance	CTC (POC – Leanne Debias)
	Throwing power and alloy composition uniformity	CTC
	Strippability	NAVAIR (POC – Steve Brown)
	Galvanic potential	ARL (POC – Brian Plosankis)
Adhesion	Bend adhesion	NAVAIR
	Paint adhesion	NAVAIR
Corrosion	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 ₂ salt spray	NAVAIR
Lubricity	Run-on/Break-away torque	WMTR (POC – Jay Curry)
	Torque-tension & torque-tension of corrosion-exposed fasteners	WMTR
Reparability	Appearance & Thickness	CTC
	Bend adhesion	ARL
	Paint adhesion	ARL
	Scribed and unscribed salt spray	ARL
Quality Assurance	Hydrogen embrittlement – notched bar	NAVAIR



Status of Phase II Testing



Coating	Vendor	Received from vendor	In Testing		
			NAVAIR	ARL	WMTR
Primary					
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
Repair					
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



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

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 SO₂ Salt Spray

- Unpainted panels and scribed, painted panels (same primers as above)
 - Expose to 5% NaCl and SO₂ 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**

