Demonstrating Viability of Low VOC Electrocoat Primers for General Depot Use (WP-201620)

Mr. Daniel Pope
Army Research Laboratory

Final Debrief

March 26, 2021

ESTCP

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
26/03/2021

2. REPORT TYPE
ESTCP Project Outbrief

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Demonstrating Viability of Low VOC Electrocoat Primers for General Depot Use

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER
WP-201620

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHOR(S)
Daniel Pope
Army Research Laboratory

An Nguyen, Thor Lingenfelter, Brian Rearick, Dave Walters
PPG

Wes Prince
Aalberts

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Army Research Laboratory
4600 Deer Creek Loop
Aberdeen Proving Ground, MD 21005

8. PERFORMING ORGANIZATION REPORT NUMBER
WP-201620

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Security Technology Certification Program
4800 Mark Center Drive, Suite 16F16
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
WP-201620

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The technical objectives of this project were to demonstrate increased corrosion protection and model cost savings possible through the use of electrodeposition primers in depot environments
• Uniform coating thickness over complex parts
• Near Zero VOC primers.
• Very high efficiency
• Reduced volume of wasted primers

15. SUBJECT TERMS
Low VOC Electrocoat Primers, General Depot Use, volatile organic compounds

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLASS	UNCLASS	UNCLASS	UNCLASS	27	Daniel Pope

19b. TELEPHONE NUMBER *(Include area code)*
410-306-1688

Project Team

Organization	Personnel	Role
ARL	PI: Daniel Pope	Project coordination and DoD oversight
PPG	An Nguyen, Thor Lingenfelter, Brian Rearick, Dave Walters	E-coat expertise, Project tasks execution
Aalberts	Wes Prince	Coordinate demo efforts at Aalberts

Technical Objectives

- Demonstrate increased corrosion protection and model cost savings possible through the use of electrodeposition primers in depot environments
  - Uniform coating thickness over complex parts
  - Near Zero VOC primers.
  - Very high efficiency
  - Reduced volume of wasted primers

Technical Objectives

- Objectives significantly changed from original proposal due to Depot support issues:
  - ♦ Anniston Army Depot, Anniston, AL
  - ♦ U.S. Marine Corps Logistic Base, Albany, GA
  - ♦ Letterkenny Army Depot, Chambersburg, PA

- Shifted to development of “business case” to gain support of higher level decision makers

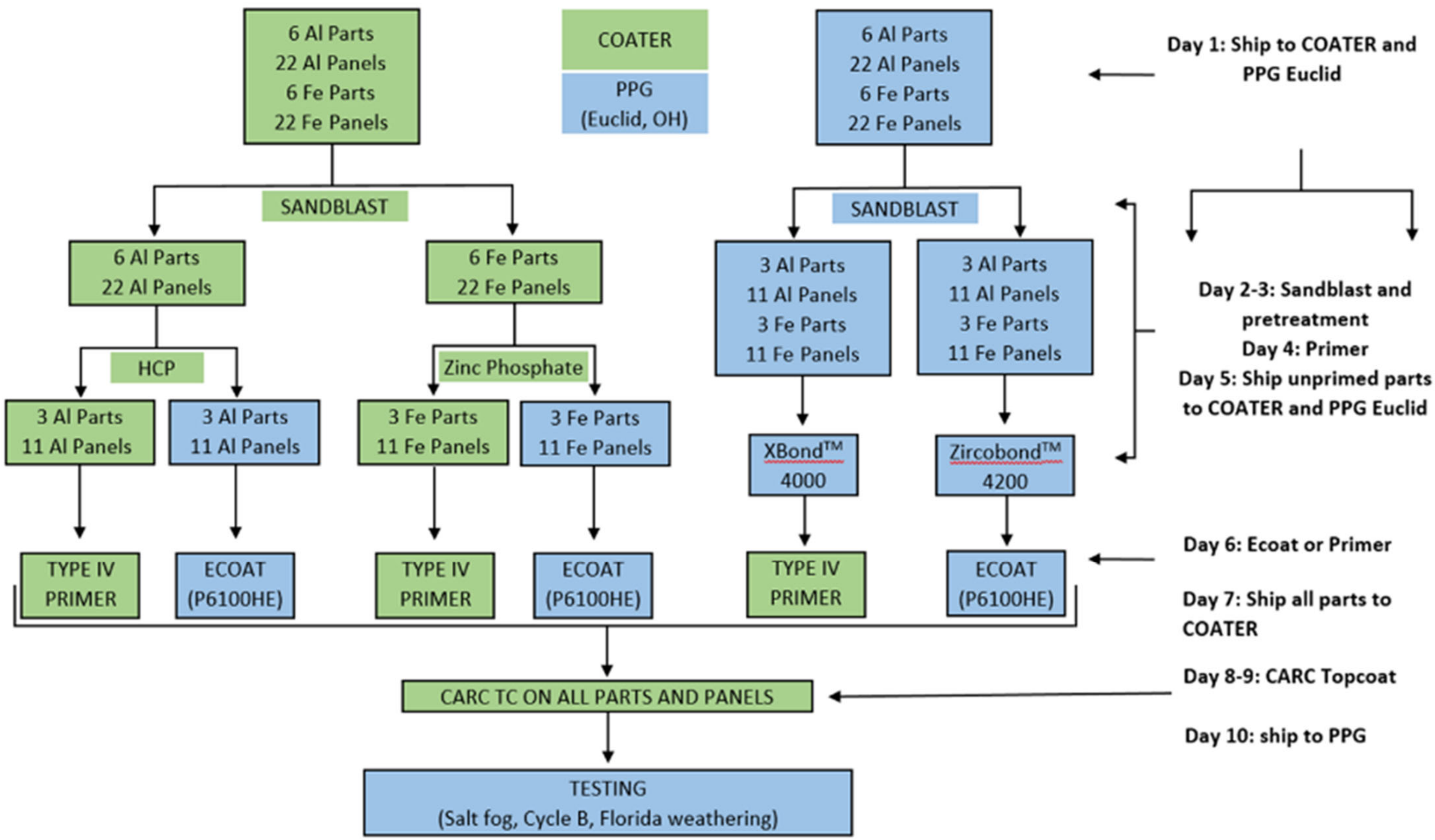
Performance Objectives

Performance Objective	Data Requirements	Success Criteria	Results
Quantitative Performance Objectives			
Product Testing – Electrocoat application properties	• MIL-DTL-53084 Section 3.6.3 Application properties	Continuous film after baking which conforms to the color, gloss and performance properties No mottling or color separation and free from craters or orange peel	Pass
Product Testing – Cure time.	• MIL-DTL-53084 Section 3.6.4 Cure time requirements	30 MIBK solvent rubs with no film softening	Pass
Product Testing – Adhesion	• ASTM D3359, method B.	No removal from the surface of the cross-cut area, classification 5B. Primer and the topcoat shall show less than 5 percent of the area affected, classification 4B	Pass
Product Testing Cyclic Salt spray resistance	• 40 cycles of GMW14872 • Control • Scribed • Chipped	40 cycles of GMW14872 on chipped and undamaged “spangler” panels (multi-metal steel coupons fabricated to illustrate welds, fasteners and edges where corrosion is particularly problematic), and chipped and scribed aluminum panels.	Pass

Site Descriptions

Site	Role
Army Research Lab	• Project coordination • Selection of toll coaters
PPG Coatings Innovation Center	• Overall Project execution • Lab scale accelerated corrosion testing
PPG Industrial Coatings Plant	• Zirconium pretreatment application • Industrial Electrocoat application
Aalberts Surface Treatment	• Sand blasting to desired part profile • Trivalent chrome pretreatment • Liquid spray applied coatings
Maryland Plating	• Zinc phosphate pretreatment on steel parts
NASA Corrosion Lab	• Outdoor exposure testing for corrosion resistance

Test Design



6 Al Parts
22 Al Panels
6 Fe Parts
22 Fe Panels
COATER
PPG
(Euclid, OH)
6 Al Parts
22 Al Panels
6 Fe Parts
22 Fe Panels
Day 1: Ship to COATER and PPG Euclid
SANDBLAST
SANDBLAST
6 Al Parts
22 Al Panels
6 Fe Parts
22 Fe Panels
3 Al Parts
11 Al Panels
3 Fe Parts
11 Fe Panels
3 Al Parts
11 Al Panels
3 Fe Parts
11 Fe Panels
Day 2-3: Sandblast and pretreatment
Day 4: Primer
Day 5: Ship unprimed parts to COATER and PPG Euclid
HCP
Zinc Phosphate
3 Al Parts
11 Al Panels
3 Al Parts
11 Al Panels
3 Fe Parts
11 Fe Panels
3 Fe Parts
11 Fe Panels
XBond™ 4000
Zircobond™ 4200
TYPE IV PRIMER
ECOAT (P6100HE)
TYPE IV PRIMER
ECOAT (P6100HE)
TYPE IV PRIMER
ECOAT (P6100HE)
Day 6: Ecoat or Primer
Day 7: Ship all parts to COATER
CARC TC ON ALL PARTS AND PANELS
Day 8-9: CARC Topcoat
Day 10: ship to PPG
TESTING
(Salt fog, Cycle B, Florida weathering)

Performance Assessment

- Accelerated corrosion chamber testing and beachfront exposure (13 months) illustrated clear performance advantages for electrodeposition primers.
- Cost modeling supports savings of 10 – 60% vs. spray applied primers

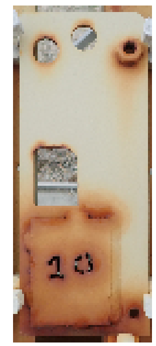
Zinc Phosphate pretreated, 53039 CARC topcoat.
GMW14872 20 cycles

Chipped (1pt. GOM) **Undamaged**

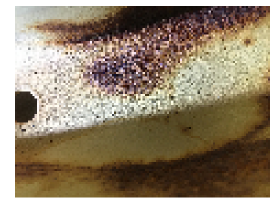
Type IV Ecoat Type IV Ecoat

NASA Beachside Exposure after 13 months

2K Epoxy Primer Coating System

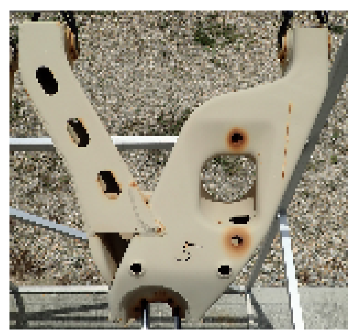


Pretreatment: Zinc Phosphate
Primer: MIL-DTL-53022 type IV
Topcoat: MIL-PRF-64159

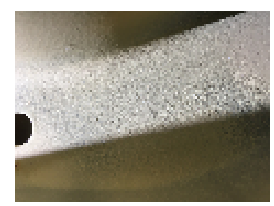


Control Arm Interior

Electrodeposition Primer Coating System



Pretreatment: Zinc Phosphate
Primer: Cationic Electrodeposition
Topcoat: MIL-PRF-64159



Control Arm Interior

Performance Assessment

Zinc Phosphate Pretreatment				Zirconium Pretreatment			
Chipped		Unchipped		Chipped		Unchipped	
53022 TIV	Electrocoat	53022 TIV	Electrocoat	53022 TIV	Electrocoat	53022 TIV	Electrocoat

Steel Spangler Panels Type IV vs. Electrocoat Primer
(40 cycles GMW14872)

Performance Assessment

Zinc Phosphate – 53022 Type IV

NASA KSC Atmospheric Test Facility
- Installed 4/2019
- Ratings/Observations/Images
- Reported Monthly

Zinc Phosphate – Electrocoat

Month 0 Exposure	Month 13 exposure
	
	

Performance Assessment

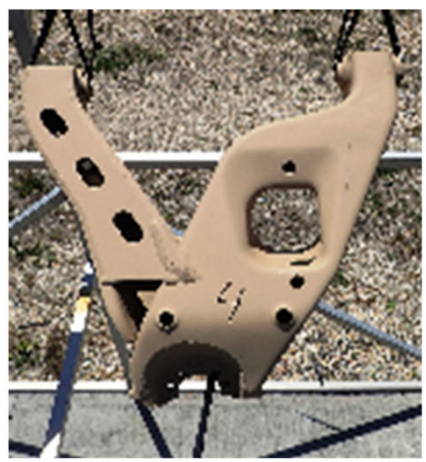
Zirconium – 53022 Type IV

NASA KSC Atmospheric Test Facility
- Installed 4/2019
- Ratings/Observations/Images
- Reported Monthly

Zirconium – Electrocoat

Month 0 Exposure	Month 13 exposure
	
	

Performance Assessment

Part #	(blasted) Pretreatment	Primer	Month 0	Month 13
1	Zinc Phosphate	53022 type 4		
4	Zinc Phosphate	Electrocoat		

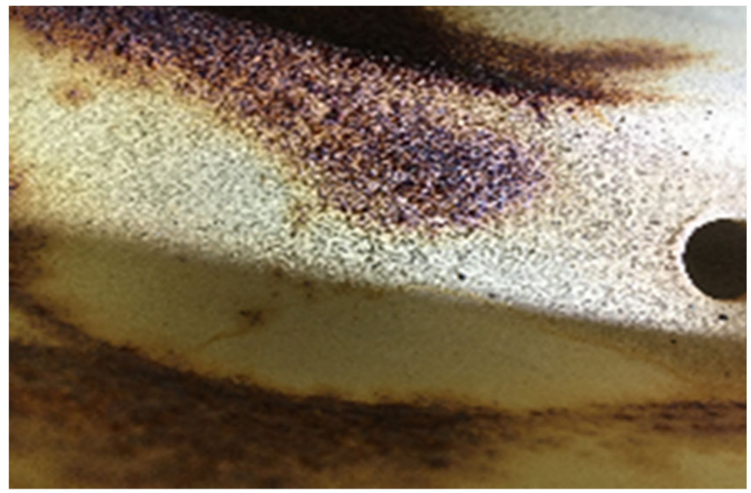
Performance Assessment

Part #	(blasted) Pretreatment	Primer	Month 0	Month 13
7	Zirconium	53022 type 4		
10	Zirconium	Electrocoat		

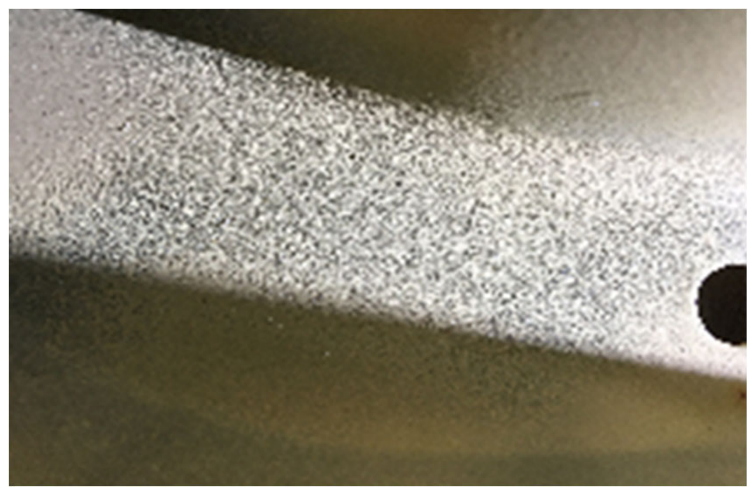
Performance Assessment

Interior View of Corrosion, 13 months NASA KSC Exposure

- Zinc Phosphate + 53022 Type IV



- Zinc Phosphate + Electrocoat primer



Cost Assessment

Model enables informed decisions on savings (or cost) incurred by installing Aerocron™ Electrocoat Primer versus conventional spray applied liquid coatings

Material Cost

- Paint cost
- Solids content
- Square foot coverage
- Cost/square foot coverage
- Pretreatment
- Waste handling and disposal

Operational Variables

- Square feet per year
- Hours of operation
- Number of shifts
- Labor costs – Supervisors, Part handlers, Servicing equipment

Utilities

Gas
- Cost per MCF
- MCF/Hour of Operation (from System Designer)

Electric
- Cost per KWH
- KWH on a 24 hour basis (from System Designer)
- KWH during hours of operation (from System Designer)

Cost Assessment

	E-Coat Dollars	Liquid Dollars	E-Coat Percentage	Liquid Percentage
Paint Costs + other additives	$10,607	$54,424	1.3%	5.7%
Surface Treatment	$0	$0	0.0%	0.0%
Waste Treatment	$0	$0	0.0%	0.0%
Capital Costs (per year cost over 10 year period)	$0	$0	0.0%	0.0%
Labor	$388,000	$388,000	46.8%	40.4%
Utilities	$429,712	$516,928	51.9%	53.9%
Total Annual Costs/Year	**$828,318**	**$959,352**	(131,033)	Difference
			14%	E-Coat Savings
Applied Costs/SF	**3.08**	**3.57**		

Scenario #1 - Assumptions:

1. Annual Square Footage processed – 269,000
2. 2 shifts / day, 4 full time labor equivalents
3. Capital costs – **ecoat equipment included @ $2M amortized over 10 years (this is an estimate only and final cost would need to be verified based upon actual equipment which could be higher or lower depending design and installation)**
4. No change in current pretreatment

Cost Assessment

	E-Coat Dollars	Liquid Dollars	E-Coat Percentage	Liquid Percentage
Paint Costs + other additives	$10,607	$54,424	1.7%	5.7%
Surface Treatment	$0	$0	0.0%	0.0%
Waste Treatment	$0	$0	0.0%	0.0%
Capital Costs (per year cost over 10 year period)	$200,000	$0	32.2%	0.0%
Labor	$194,000	$388,000	31.2%	40.4%
Utilities	$217,252	$516,928	34.9%	53.9%
Total Annual Costs/Year	**$621,858**	**$959,352**	(337,493)	Difference
			35%	E-Coat Savings
Applied Costs/SF	**2.31**	**3.57**		

Scenario #2 - Assumptions:

1. Annual Square Footage processed – 269,000
2. **1 shift / day, electrocoat enables higher throughput**
3. Capital costs – ecoat equipment included @ $2M amortized over 10 years (this is an estimate only and final cost would need to be verified based upon actual equipment which could be higher or lower depending design and installation)
4. No change in current pretreatment

Cost Assessment

	E-Coat Dollars	Liquid Dollars	E-Coat Percentage	Liquid Percentage
Paint Costs + other additives	$10,607	$54,424	2.5%	5.7%
Surface Treatment	$0	$0	0.0%	0.0%
Waste Treatment	$0	$0	0.0%	0.0%
Capital Costs (per year cost over 10 year period)	$0	$0	0.0%	0.0%
Labor	$194,000	$388,000	46.0%	40.4%
Utilities	$217,252	$516,928	51.5%	53.9%
Total Annual Costs/Year	**$421,858**	**$959,352**	(537,493)	Difference
			56%	E-Coat Savings
Applied Costs/SF	**1.57**	**3.57**		

Scenario #3 - Assumptions:

1. Annual Square Footage processed – 269,000
2. 1 shift / day
3. **No Capital costs – after ecoat equipment amortization**
4. No change in current pretreatment

Scale-up

- Qualified cationic electrodeposition primers are in production and use at defense OEMs
  - No barriers to increased demand for depot applications
- Each system would be custom engineered based on part volume, size and work-flow considerations at a given depot.
  - No restrictions on equipment availability.
- Costs scale with the size of the tank and some depots may want to include automated handling systems or dedicated pretreatment tanks.
- Despite performance and cost savings, biggest issue is availability of capital at depots to commission engineering and fabrication.

Technology Transfer

- Depot Implementation
  - PPG Industrial coatings and Land Based Defense sales teams will employ multiple tools to socialize the technology with target customers including:
    - Training workshops, live or via webinar
    - Presentations at key conferences
    - Technology fact sheets
    - Guidance documents
    - Community open houses
  - Continued support during engineering, fabrication, start-up and training phases of implementation

Technology Transfer

- Depot Implementation
  - Data generated provides real life comparisons
    - Performance gains on complex geometries
    - Understanding of short term and long term cost
  - Creative financing of the systems will be required
    - Federal funding through pollution prevention programs, stimulus funds, congressionally directed funding, SBIR programs
    - State specific funding sources
    - Cost-share arrangements with trade schools, vo-tech programs

Technology Transfer

- Toll Coating
  - "Do it for me approach" to obtain electrocoat benefits without capital expenses through toll coating with experienced electrocoat coaters
  - PPG Coating Services - **designs, builds and installs the majority of its coating production and support equipment**
    - Quick response times
    - Specialized coatings systems and processes
    - High production capability
    - Versatile equipment options
    - Large- and small-part coatings capability.

Key Points

- Ecoat provides superior protection on steel substrates, especially in recessed areas, welded regions, and sharp edges when compared to Type IV primer for both Zinc phosphate and Zr thin film pretreatment.
- For aluminum substrates, ecoat provides comparable protection to Type IV primer with both Cr IV and Zr thin film pretreatment.
- Even with required capital expenses, electrodeposition coatings can yield immediate cost savings relative to spray applied coatings
- From an environmental standpoint electrodeposition coatings offer near 100% transfer efficiency of a nearly 0 VOC coating, chrome free primer.

BACKUP SLIDES

Publications

- Provide a list of all publications, patents, awards, etc. resulting from this work.

Demonstrating Viability of Low VOC Electrocoat Primers for General Depot Use (WP-201620)

Performers: ARL, PPG Industries, Aalberts

Technology Focus

- Cationic electrodeposition primers for use in depot repair operations

Demonstration Sites

- *PPG Industrial Coatings Plant Euclid, OH*
- *Aalberts Inc., Baltimore MD*
- KSC Atmospheric Test Facility

Demonstration Objectives

- *Demonstrate performance and cost advtages of cationic electrocoat primers relative to incumbent MIL-DTL-53022 primers in a depot environment.*

Project Progress and Results

- *Demonstration completed, lab and outdoor exposure data collected illustrating superior performance of electrocoat primers*
- *Cost modeling completed demonstrating potential savings under a variety of scenarios.*

Implementation

- *Capital expenditures required for engineering, fabrication and installation of equipment remains largest barrier to adoption*
- *Toll coating is an option to obtain electrocoat performance benefits without capital expenditures*