Chrome-Free Paint Primer for Zn/Ni Plated High-Strength Steel

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#UTC Aerospace Systems -Landing Systems (LS)
**United Technologies Research Center (UTRC)*

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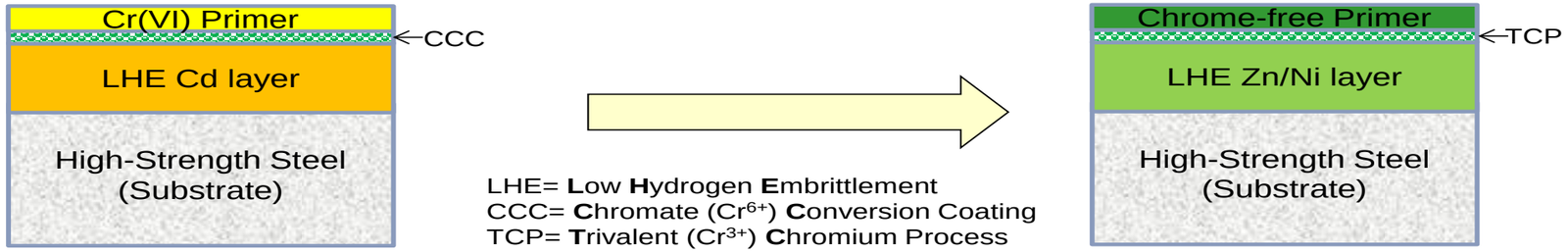
Background

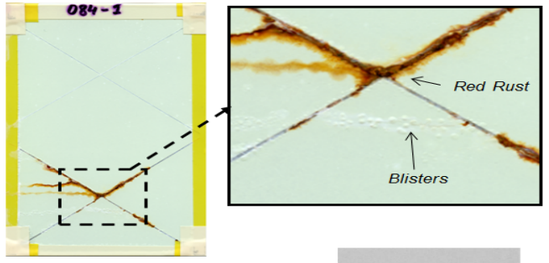
- Regulatory restrictions on use of chromates and Cd; both are toxic
- Strontium chromate being phased out in Europe starting 2019: REACH
- LHE ZnNi replacing LHE Cd in military and commercial landing gear systems



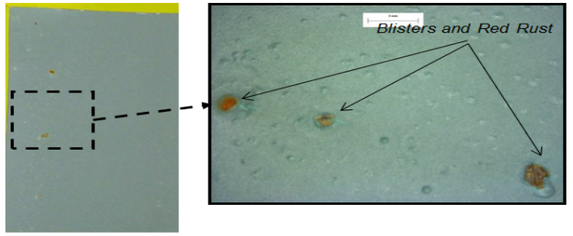
LHE= **L**ow **H**ydrogen **E**mbrittlement
CCC= **C**hromate (Cr^{6+}) **C**onversion Coating
TCP= **T**rivalent (Cr^{3+}) **C**hromium Process

Commercial primers (most developed for Aluminum) do not provide adequate corrosion inhibition for LHE ZnNi or Cd plated low alloy steels

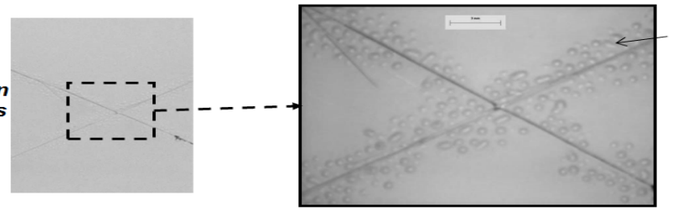
Solvent-based epoxy primer on type-II ZnNi/4130 steel after 500hrs ASTM B117



Solvent-based epoxy primer on CCC/Ti-Cd steel After 1,700hrs ASTM B117



Solvent-based epoxy primer on type-II ZnNi steel after 2,300hrs ASTM B117



Good News

Plating system meets requirements !

Bad News

Chromate-free aircraft primers don't perform well on Zn-Ni plating !

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Approach

Primer technology development steps

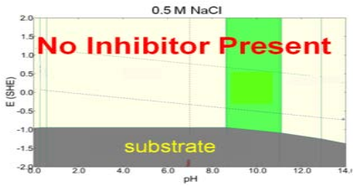
2013: Corrosion inhibitor chemistries modeled and tested with high-throughput screening

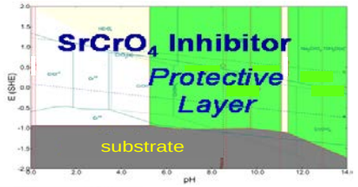
2014: Pigments constructed from promising chemistries, tested in lab-sprayed primers

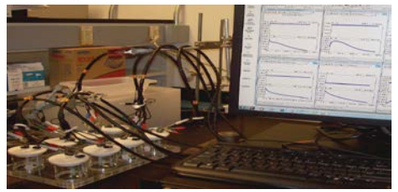
2015: Preferred pigments optimized, tested as production-sourced primers, mfg scale-up

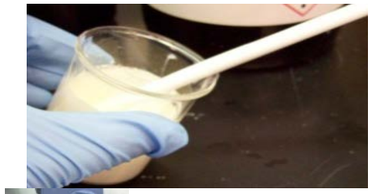
2016/17: Qualification testing, Internal specifications implementation, Comm. availability

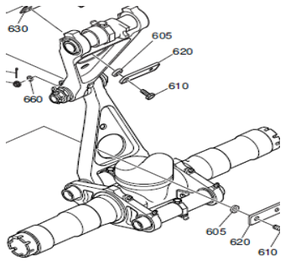
2013 → **2014** → **2015** → **2016/17**











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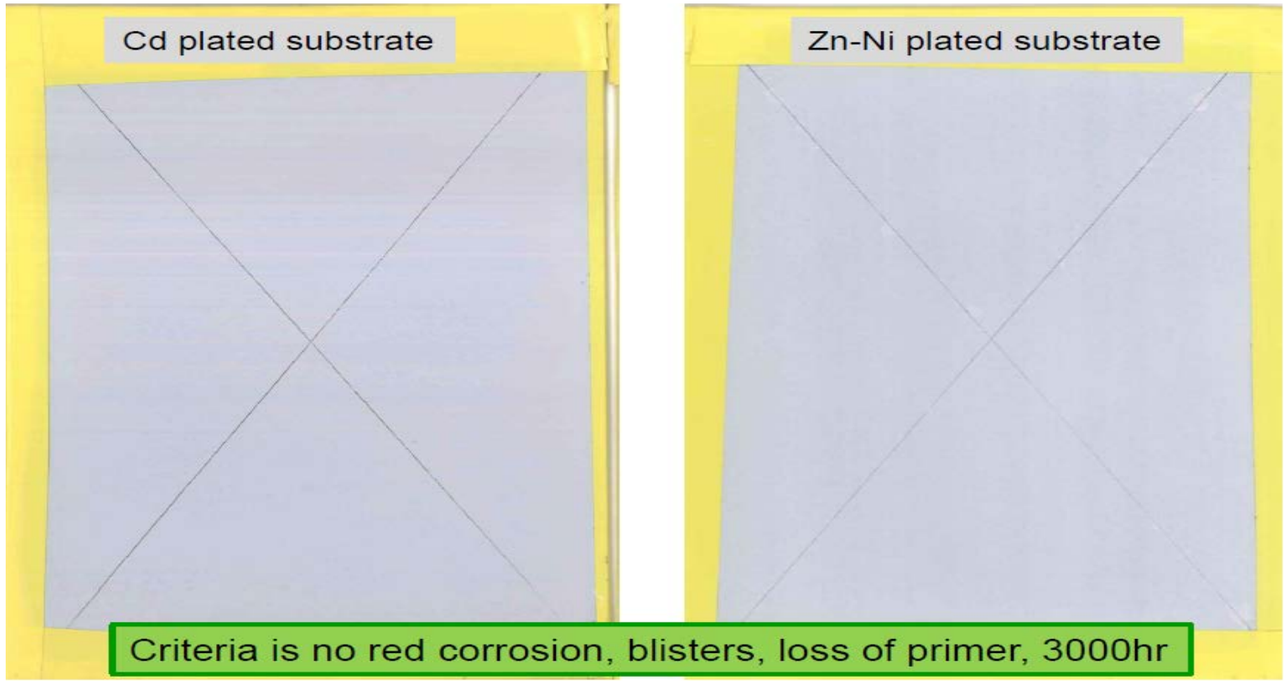
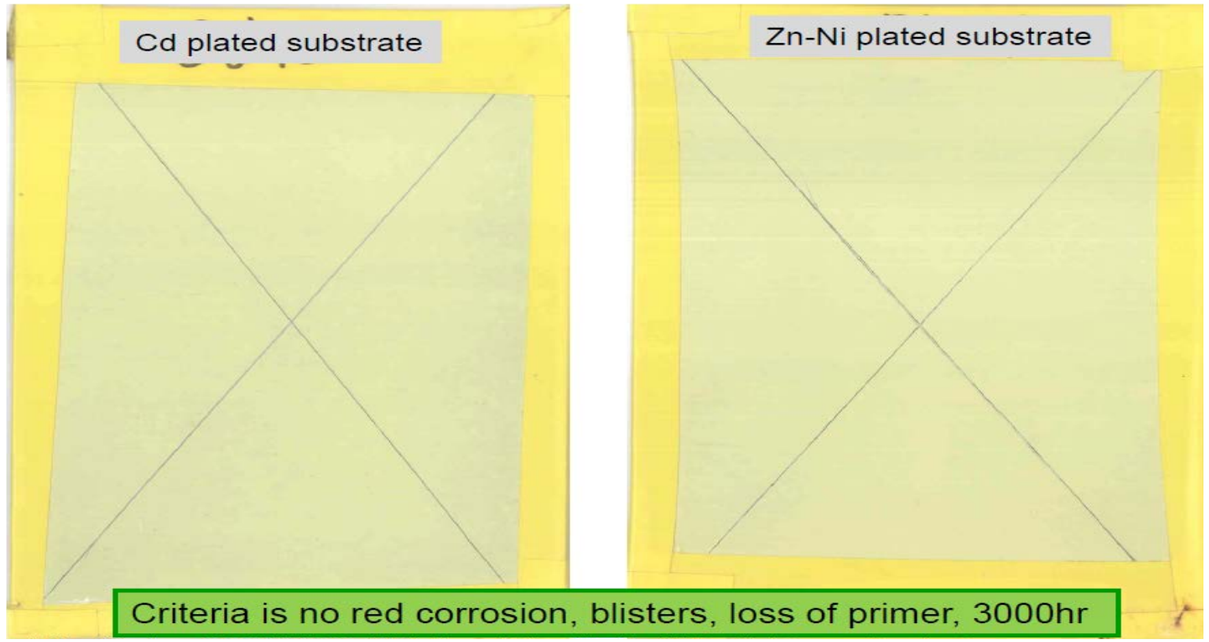
Salt-fog ASTM B117 Results



Water-borne primer formulation after 3,100 hours

Solvent-borne primer formulation after 4,300 hours



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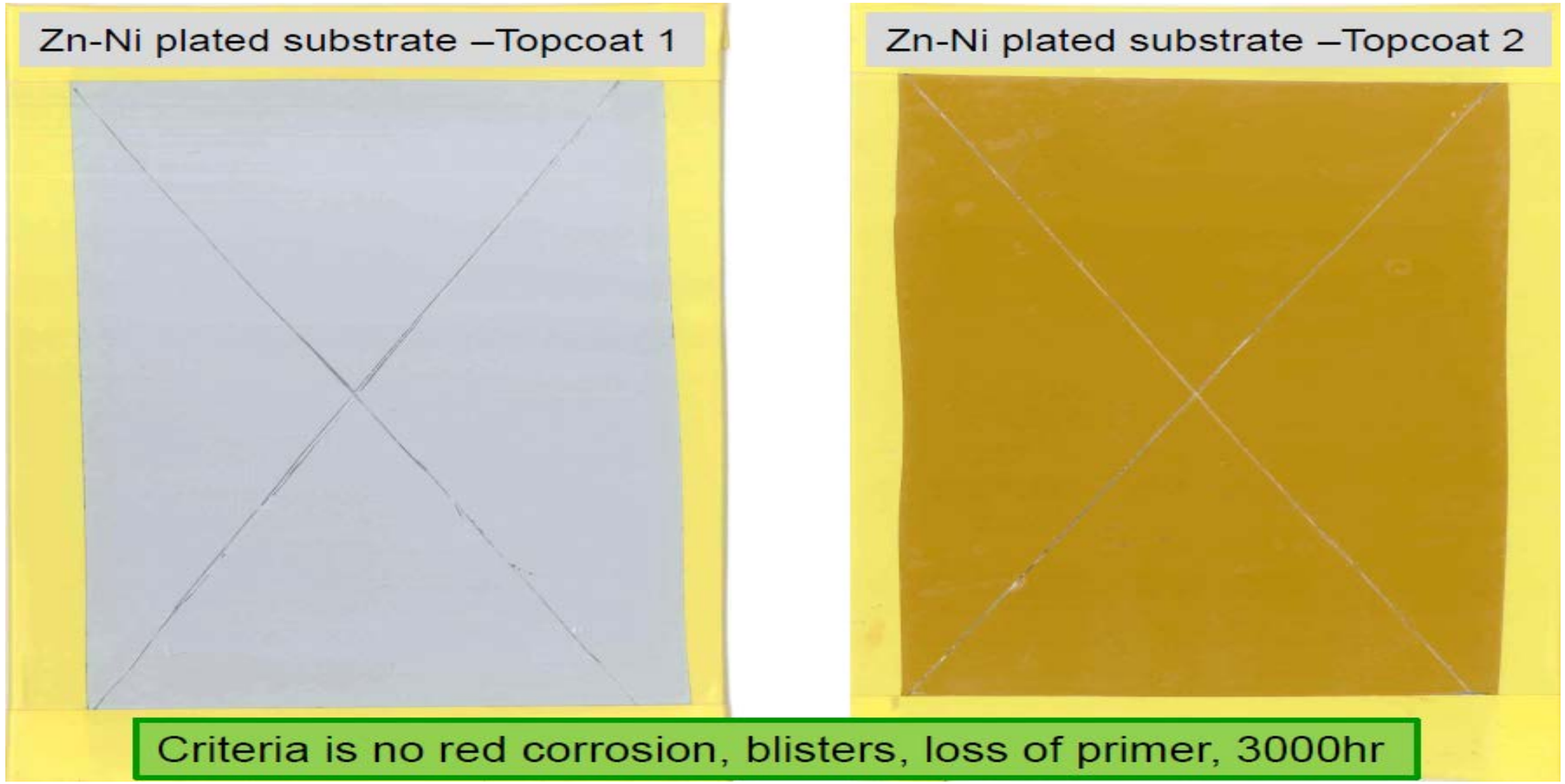
Salt-fog ASTM B117 Results

Top-coated solvent-borne primer after 3,500 hours



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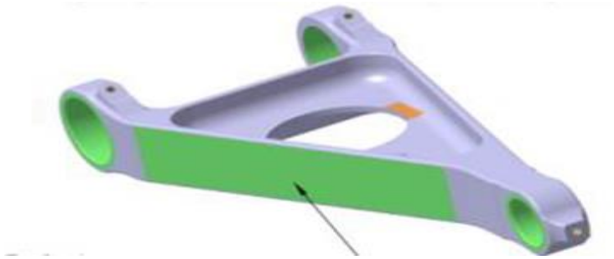
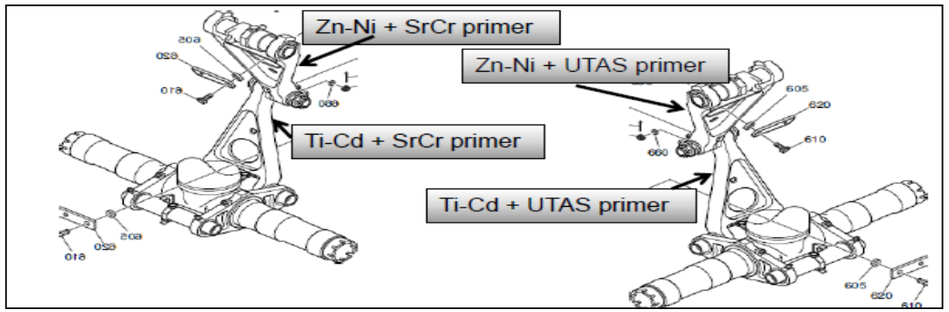
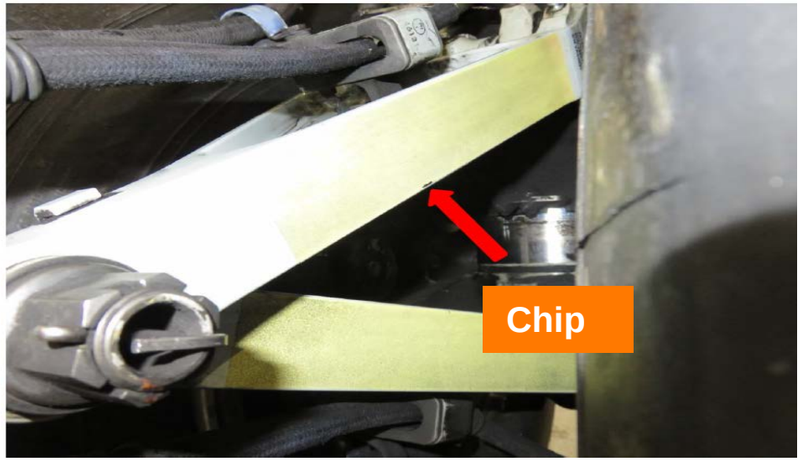
Flight-testing on-going: 1st Inspection Results

Four (4) torque links installed on a de Havilland Dash 8-400 revenue service aircraft
Inspection: Every 1-2 months up to 6 months, then 3 months up to 2 years





Non-chrome primer



Cr^{6+} primer (control)

No evidence of corrosion, blistering, primer. Some loss of primer or paint loss due to service induced impact (chipping) after 1536 hours / 1364 flight cycles. Slight color change due to brake dust, dirt and grime embossing onto the primed window areas

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Beach front test

- Beach front tests carried out at Battelle's Florida test site at Ponce Inlet
- Samples evaluated include, 4130 steel with Zn-Ni or Cd, Galvanized steel, Al 2024 with Alodine
- Primers tested include, chromated (baseline), Solvent or water based non-chromated primer
- Samples exposed oceanfront test site, oriented at 45 degrees elevation, samples facing the ocean
- Each sample is evaluated under ASTM 1654 every three months; 6 months results presented here

Material	Primer	Blistering Score	Comments
4130 Steel (Zn-Ni)	Chromated (baseline)	10	Lost Green color
	Non-Cr (Solvent)	10	Mildew, but scribe area did not blister
	Non-Cr (water)	10	
Galv. Steel	Non-Cr (Solvent)	10	
Al 2024 + Alodine	Non-Cr (Solvent)	10	

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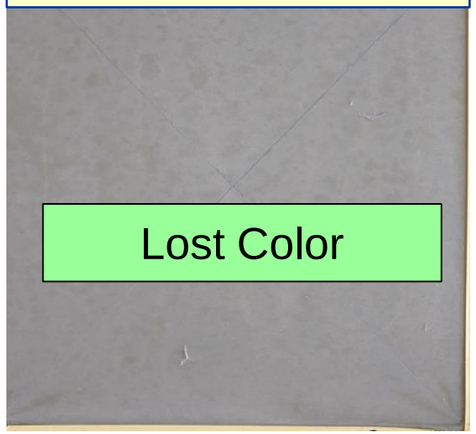
Beach Front Test Results

4130 Steel/Zn-Ni

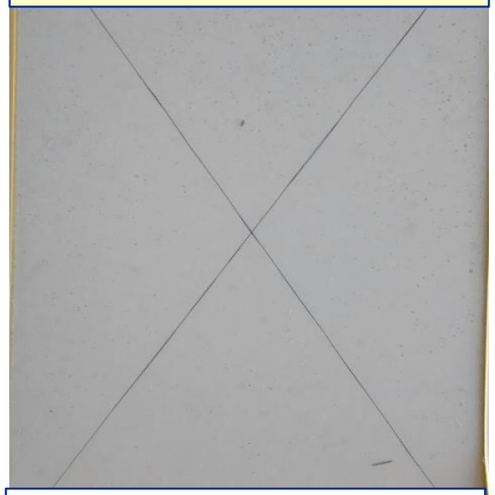


Chromated

4130 Steel/Zn-Ni

Non-Chromated (Solvent)

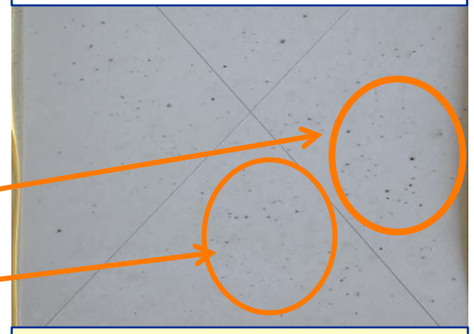
4130 Steel/Zn-Ni



Non-Chromated (Water)

Galvanized Steel

Non-Chromated (Solvent)



Aluminum 2024 with Alodine

Mildew

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Rain erosion test

- Rain erosion test carried out at UTAS SIS facility at Brecksville, OH
- Test foil was run at 500 mph with 1”/hr simulated rain fall for 30 minutes
- Panels was soaked in water for 2-4 hours prior to the test
- Success Criteria: No loss of primer or Primer+ topcoat beyond 0.25” from paint edge

Primer	Plating	Topcoat	Performance
Chromated	Zn-Ni/Cd	None	Pass
Chromated	Zn-Ni/Cd	Two types	Pass
Non-Cr (solvent)	Zn-Ni/Cd	None	Pass
Non-Cr (solvent)	Zn-Ni/Cd	Two types	Pass
Non-Cr (water)	Zn-Ni/Cd	None	Failed
Non-Cr (water)	Zn-Ni/Cd	Two types	Failed

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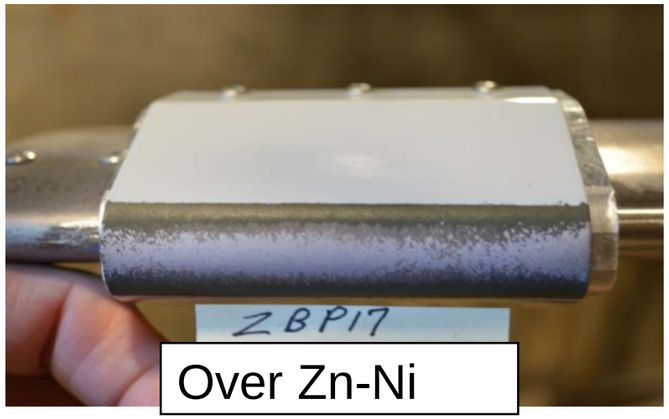
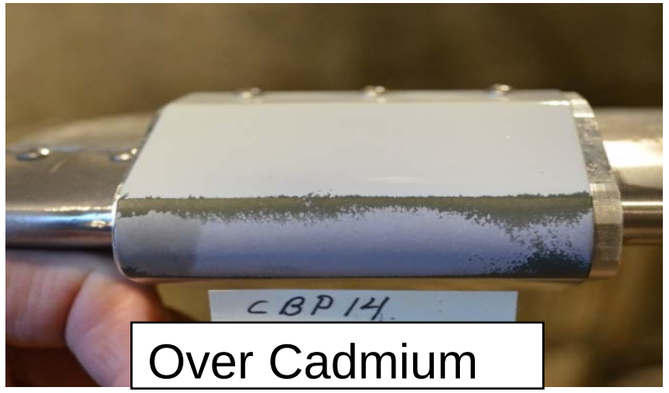
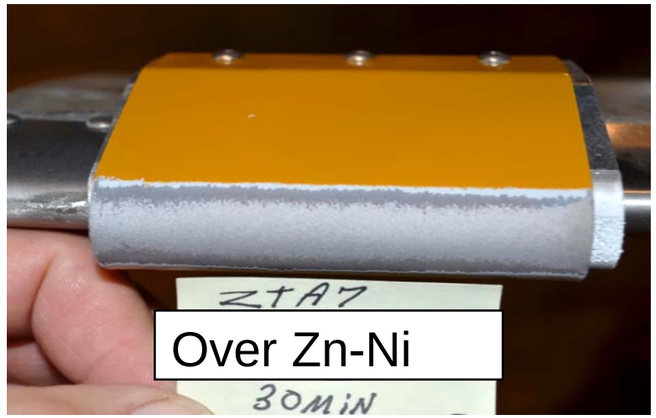
Rain Erosion Test Results

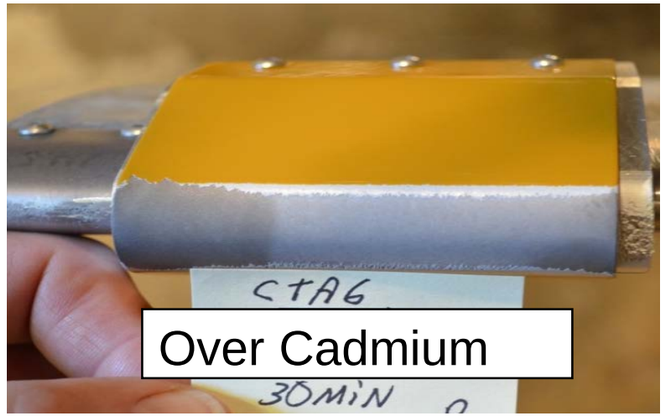
Conventional Cr-Primer



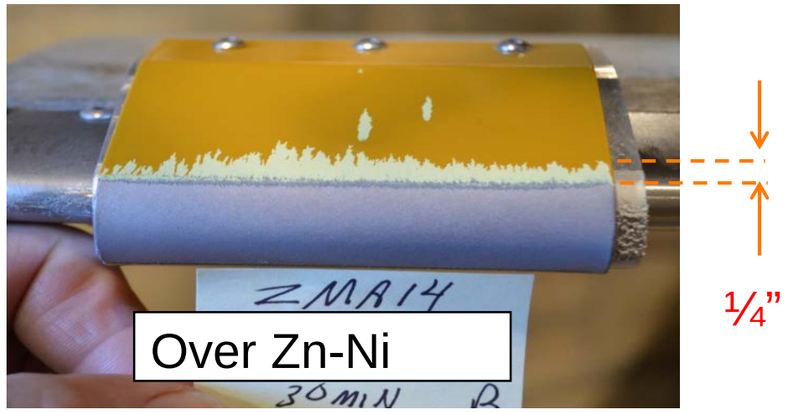


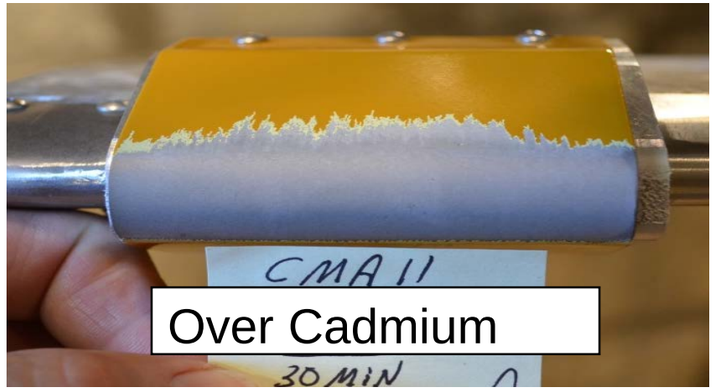
Non-Cr (solvent)





Non-Cr (water based)





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Next Steps

2016/2017:

- Multi-site application round robin (on going)
- Flight testing (on going)
- Beach-front testing (on going)
- Cross-substrate: Aluminum (on going)
- Complete qualification testing of multiple suppliers
- Implement internal specifications, product introduction
- Develop and implement commercialization strategy for the anti-corrosion pigment and its use in various protective coatings

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