

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

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11-19-14

*Presentation at ASETSDefense 2014*

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**United Technologies Research Center (UTRC), and  
United Technologies Aerospace Systems/Landing Gear  
(UTAS/LG)**

# Report Documentation Page

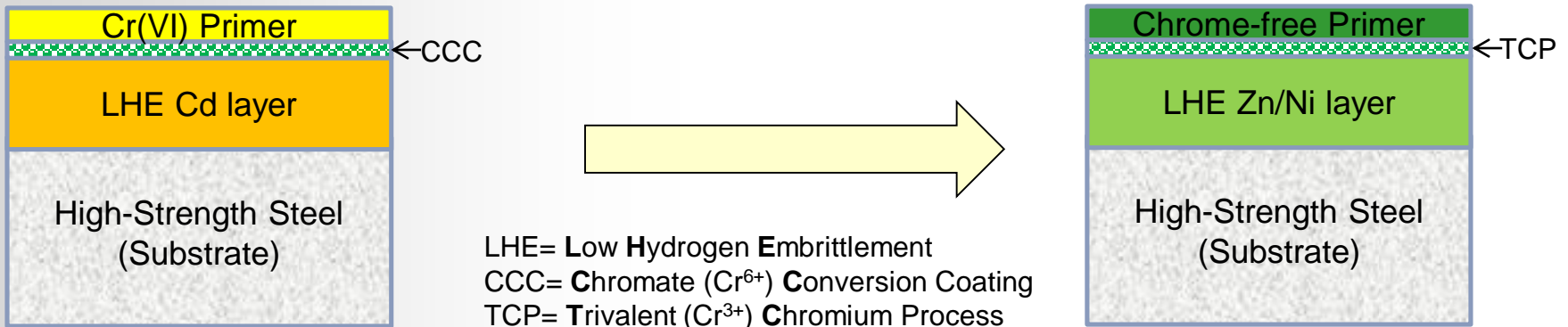
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# Background

- *Regulatory EHS restrictions on use of chromates and Cd*
- *Strontium chromate sunset in EU - REACH: 2017*
- *LHE ZnNi replacing LHE Cd in military and commercial landing gear systems*

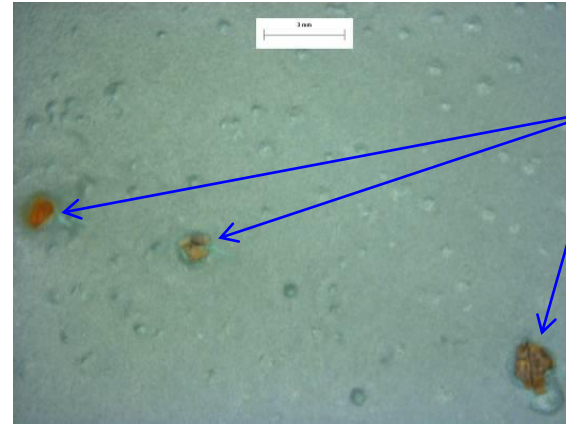
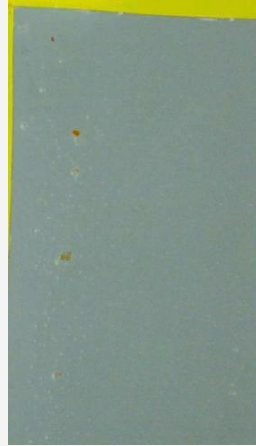


# Chrome-free Primer for Steel

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

After 1,700hrs ASTM B117

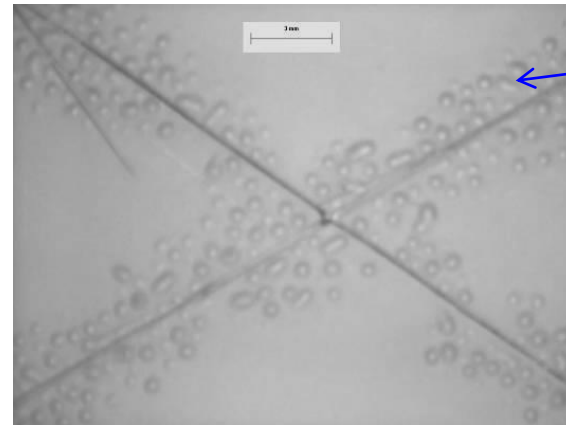
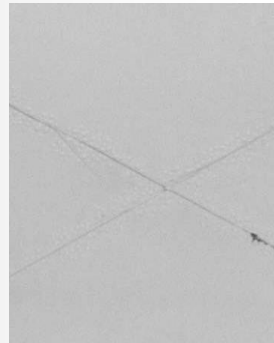
*Commercial solvent-based Epoxy primer*



*Blisters and Red Rust*

After 2,300hrs ASTM B117

*Commercial solvent-based Epoxy primer*

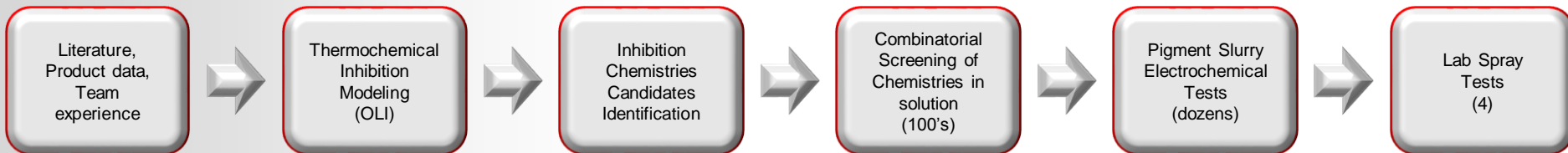


*Blisters Only  
No rust underneath*

# Approach

## Primer technology development steps:

- Corrosion inhibitor chemistries modeling and high-throughput screening in solution
- Promising inhibitor chemistries assessment utilizing DC potentiodynamic techniques
- Inhibitor chemistries down-selection and translation to pigment form
- Pigment formulation development and potentiodynamic testing in slurry form for effective release (solubility) and inhibition
- Inhibitor pigment incorporation in resin for salt-fog corrosion evaluation
- Physical and chemical properties evaluation (adhesion, fluids, solvents resistance, impact, topcoat compatibility, etc.)
- Field validation and industrialization



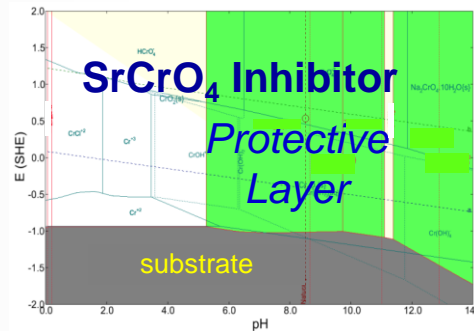
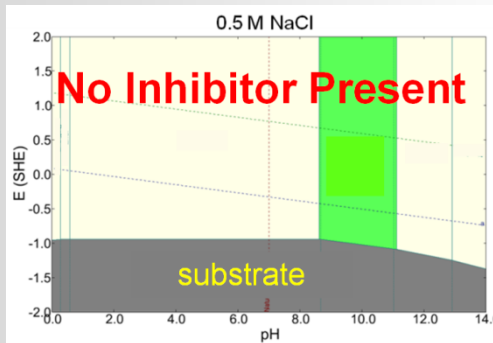
*From inhibitor chemistry identification to pigment formulation development and primer testing*

# High-Throughput Inhibitor Screening

Rapid inhibitor chemistries screening in solution

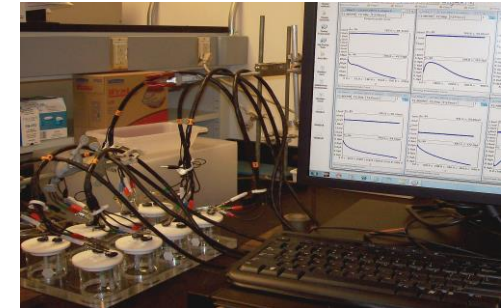
## Approach:

- High-throughput inhibition measurement:
  - 10 min/sample vs. 3-4 hrs/sample for DC polarization
- Screen candidate chemistries for inhibition in solution vs. chromate control vs. non-inhibited electrolyte baseline
- Statistical design of experiments (DOE) to identify effects, and develop and optimize formulation
- Thermochemical modeling (OLI) for inhibition space prediction and candidate virtual-space screening
- Pigment solubility prediction: OLI software

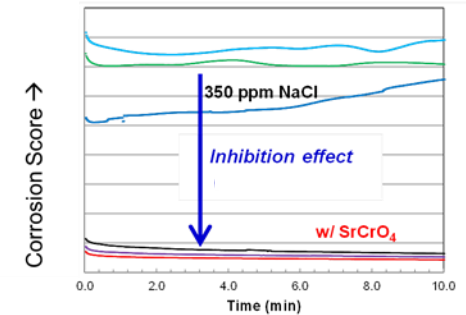


- Utilize potentiodynamic measurement for confirmation and detailed characterization of inhibitor

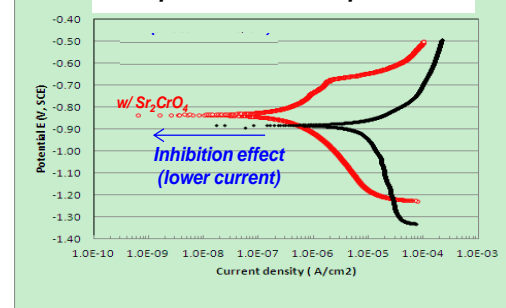
Multi-potentiostat test station



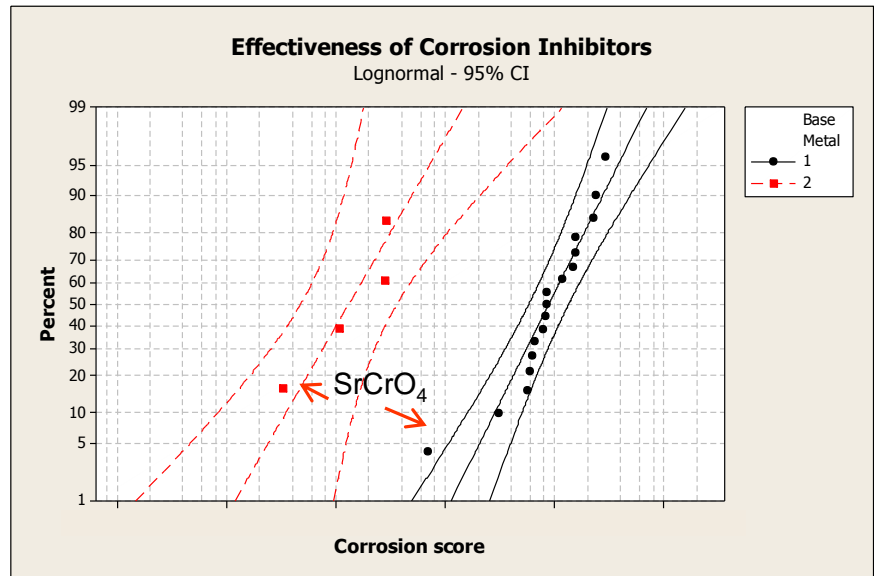
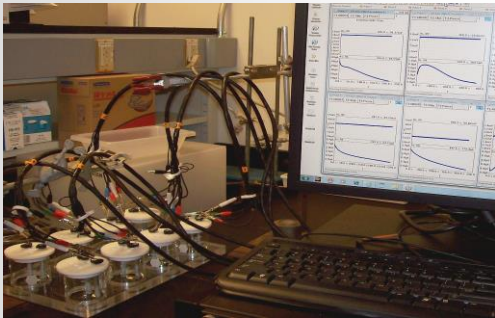
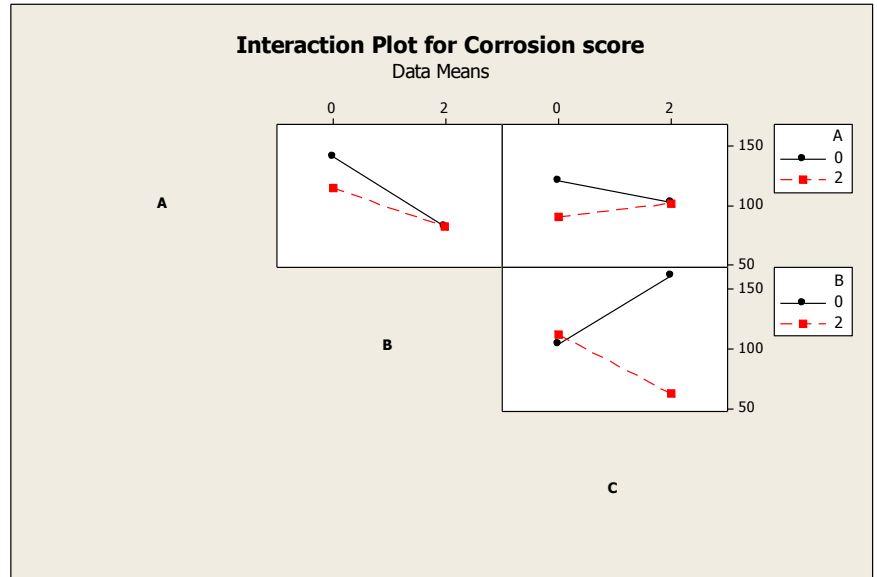
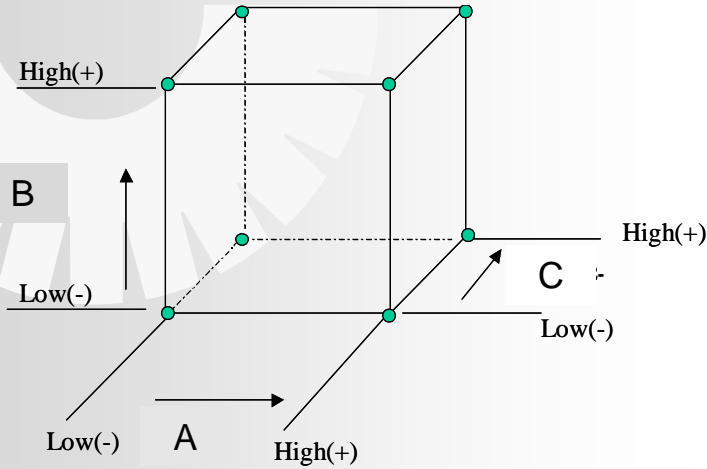
Inhibition current measurement: 10 min



Full polarization sweep: 3-4 hrs

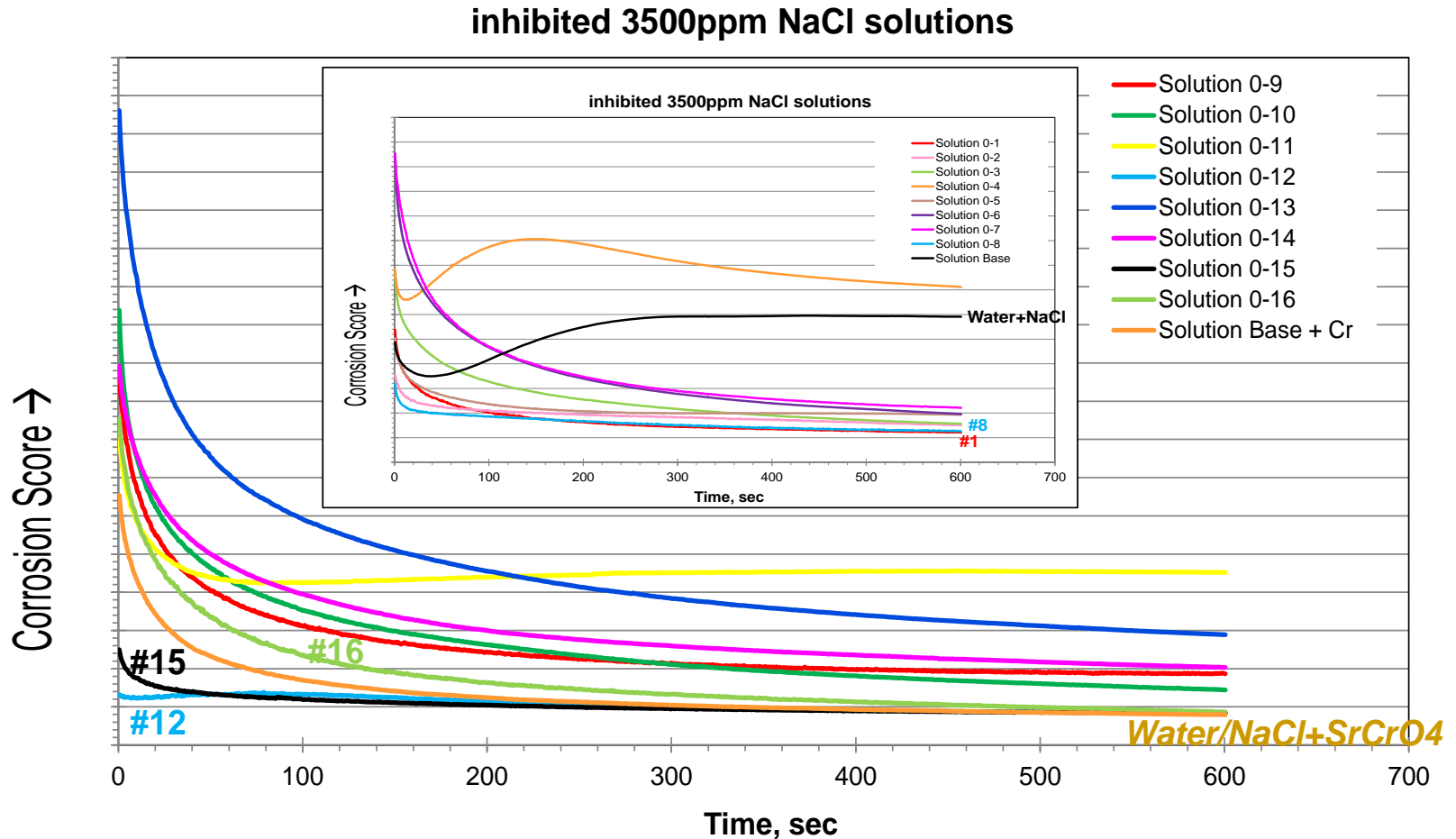


# High-Throughput Inhibitor Screening Methodology



# High-throughput Inhibitor Chemistries Screening

- DOE designs used to screen and determine main factors
- Once critical  $x$ 's determined RS DOEs executed to refine inhibitor formulation

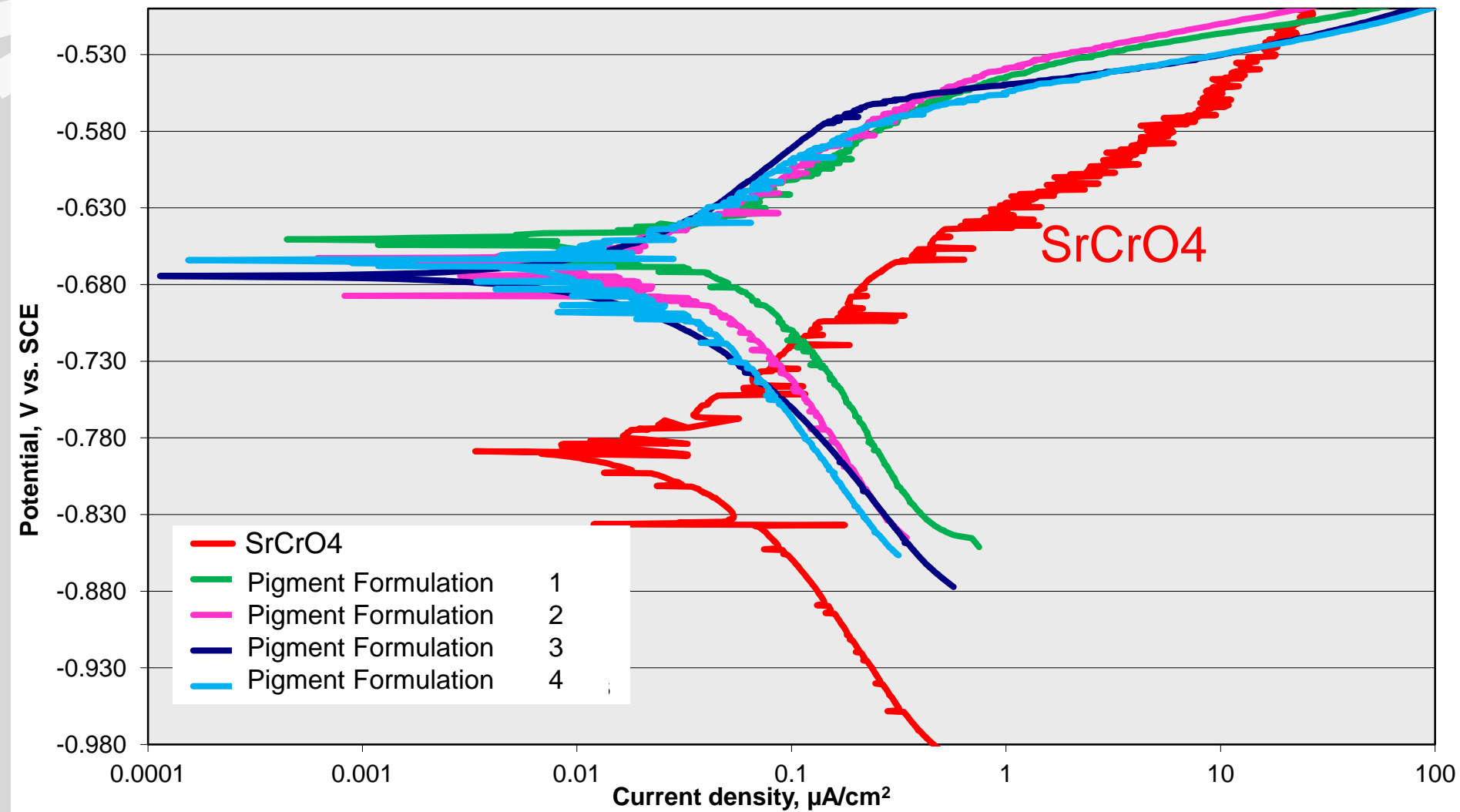




# Promising Inhibitor Formulations in Pigment Form

*Potentiodynamic testing of leading pigment formulations in slurry form*

In 3500ppm NaCl solution



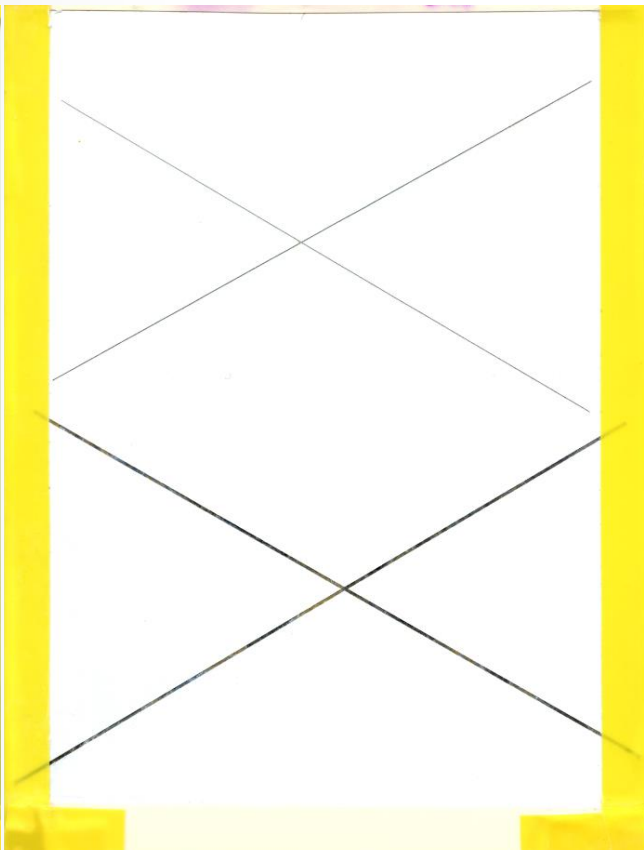
# ASTM B117 Exposure 2000+ hours – Testing Continues

*Non-optimized OEM-compounded primers exhibit good performance over both ZnNi and Cd plated steel*

Non-Inhibited primer over TCP/ZnNi/4130  
2,000hrs ASTM B117



Primed CCC/Cd/4130  
2,000hrs ASTM B117



Primed TCP/ZnNi/4130  
2,000hrs ASTM B117



# Adhesion, Hardness, Solvent, Fluids Testing - Passed

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## Adhesion

- *Dry and wet (24 hours in DI water) adhesion per ASTM D3330*

## Hardness

- *Passed - ASTM D3363*

## Solvent resistance

- *MEK per MIL-PRF-23377 (at least 50 passes without primer removal)*

## Fluid resistance: 24 hours and 30 days exposure

- *Aeroshell 33 grease*
- *Skydrol – room temp*
- *Super Bee 300 LF alkaline cleaner*
- *SafeWing aircraft de-icer*
- *Aviform runway de-icer,*
- *Jet A1 jet fuel*

# Summary – Next Steps

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- Primer formulation performing well on both TCP/ZnNi and CCC/Cd steel:
  - Lab-made primer 3,000hrs ASTM B117 – Scribed: No rust
  - OEM-compounded primer >2,000 hours ASTM B117 – Scribed No rust; Exposure continues
- Pigment formulation and loading optimization in progress
- Technology and manufacturing scale-up and maturation to TRL6 by end of 2015
- Field testing and validation to start in 2016