

JCAT

Cadmium Repair Alternatives on High-Strength Steel

January 25, 2006

Hilton San Diego Resort

1775 East Mission Bay Drive

San Diego, CA 92109

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Overview

- **Find repair alternatives to damaged cadmium plated or any steel surface, such as Landing Gear and ground equipment.**
- **Ease of application, be able to apply at squadron level.**
- **Most Common repair method at squadron level, sand and paint.**

Products Tested

- **Sermetel 249, an aqueous inorganic metallic coating applied at room temperature. Contains Zinc and Aluminum powder. Brush or Spray application.**



Products Tested

- **Sermetel TDC, is a waterborne, inorganic, self curing, room temperature coating. Can be spray or brush on. Two part mix, binder and Zinc Powder**



Product Tested

- **Z.R.C Cold Galvanizing Compound, aerosol or brush on. 95% Zinc Powder, Acetone, MEK and Propane. Applied at room temperature, self curing.**
- **Aerosol Cans used for this test**



Controls and Substrates

- **Used 4130 steel substrates, 4” x 6” x .030”**
- **Used 4340 steel .25” round bars, Type 1.A1 ASTM F519.**
- **Cadmium Plated (immersion) substrates and round bars used as controls, no post treatment , round bars baked IAW ASTM F519.**

Tests Performed

- **In Service Hydrogen Embrittlement Testing per ASTM F 519 annex 5.**
- **Bare corrosion testing using ASTM B117 salt fog**
- **Paint Adhesion Testing per ASTM D 3359**
- **Painted corrosion testing per ASTM B117 and ASTM D 1654, used MIL-PRF-23377 Class C2 and MIL-PRF-85285 primer and topcoat.**
- **Cadmium Plating per ASTM F-519 Table 2 Treatment B**

Hydrogen Embrittlement Testing

- Done in 2 phases, phase 1 of round bar testing along with bare corrosion results will determine phase 2 testing.
- All specimens tested at 45% of tensile strength for 150 hrs.
- All Specimens must pass to be considered Non-Embrittling
- Specimens tested immersed in DI water, Sea Water per ASTM 1154 and Anti-Icing fluid per Mil-A-8243, 4ea
- Phase 2 testing featured round bars that were “damaged”, the groove was taped off, and undamaged.



“Damaged” round bars

Hydrogen Embrittlement Test Results Phase 1

- **Sermetel TDC (factory applied) failed all 4 sea water tests and 3 of 4 DI water tests in phase 1, no anti-icing fluid tests were preformed due to this poor result.**
- **Sermetel 249 (factory applied) failed 2 of 4 DI water tests and passed all 4 sea water tests and anti-icing fluid tests.**
- **ZRC cold galvanizing failed 1 of 4 sea water tests and passes all 4 DI water and anti-icing fluid tests.**

Hydrogen Embrittlement Data Phase 1

Phase 1	
150 Hour Test at 45%	
Navair Applied Sermetel TDC	
Enviroment	result
DI Water	failed at 24.6 hours
DI Water	passed at 150 hours
DI Water	passed at 150 hours
DI Water	passed at 150 hours
150 Hour Test at 45%	
Factory applied Sermetel TDC	
Enviroment	result
DI Water	failed at 24 hours
DI Water	failed at 6.2 hours
DI Water	passed at 150 hours
DI Water	failed at 117 hours
Sea Water	failed at 4 minutes
Sea Water	failed at 7 minutes
Sea Water	failed at 6 minutes
Sea Water	failed at 24 hours

150 Hour Test at 45%	
Factory applied Sermetel 249	
Enviroment	result
DI Water	passed at 150 hours
DI Water	passed at 150 hours
DI Water	failed at 103 hours
DI Water	failed at 27 hours
Sea Water	passed at 150 hours
Sea Water	passed at 150 hours
Sea Water	passed at 150 hours
Sea Water	passed at 150 hours
De-icing fluid	passed at 150 hours
De-icing fluid	passed at 150 hours
De-icing fluid	passed at 150 hours
De-icing fluid	passed at 150 hours
150 Hour Test at 45%	
Navair applied ZRC Cold Galvanized	
Enviroment	result
DI Water	passed at 150 hours
DI Water	passed at 150 hours
DI Water	passed at 150 hours
DI Water	passed at 150 hours
Sea Water	passed at 150 hours
Sea Water	failed at 128 hours
Sea Water	passed at 150 hours
Sea Water	passed at 150 hours
De-icing fluid	passed at 150 hours
De-icing fluid	passed at 150 hours
De-icing fluid	passed at 150 hours
De-icing fluid	passed at 150 hours

Hydrogen Embrittlement Test

Results Phase 2

- **Sermetel TDC and 249** were not tested due to poor results in phase 1 testing and bare corrosion data.
- **ZRC Cold Galvanizing** failed 2 of 4 damaged coating in sea water and passed all four DI water and anti-icing fluid tests
- **Cadmium plated round bars** only 3 of 24 failed.
- **ZRC Cold Galvanizing and cadmium plating** had very similar results



Round Bar Test in Progress

Hydrogen Embrittlement Test

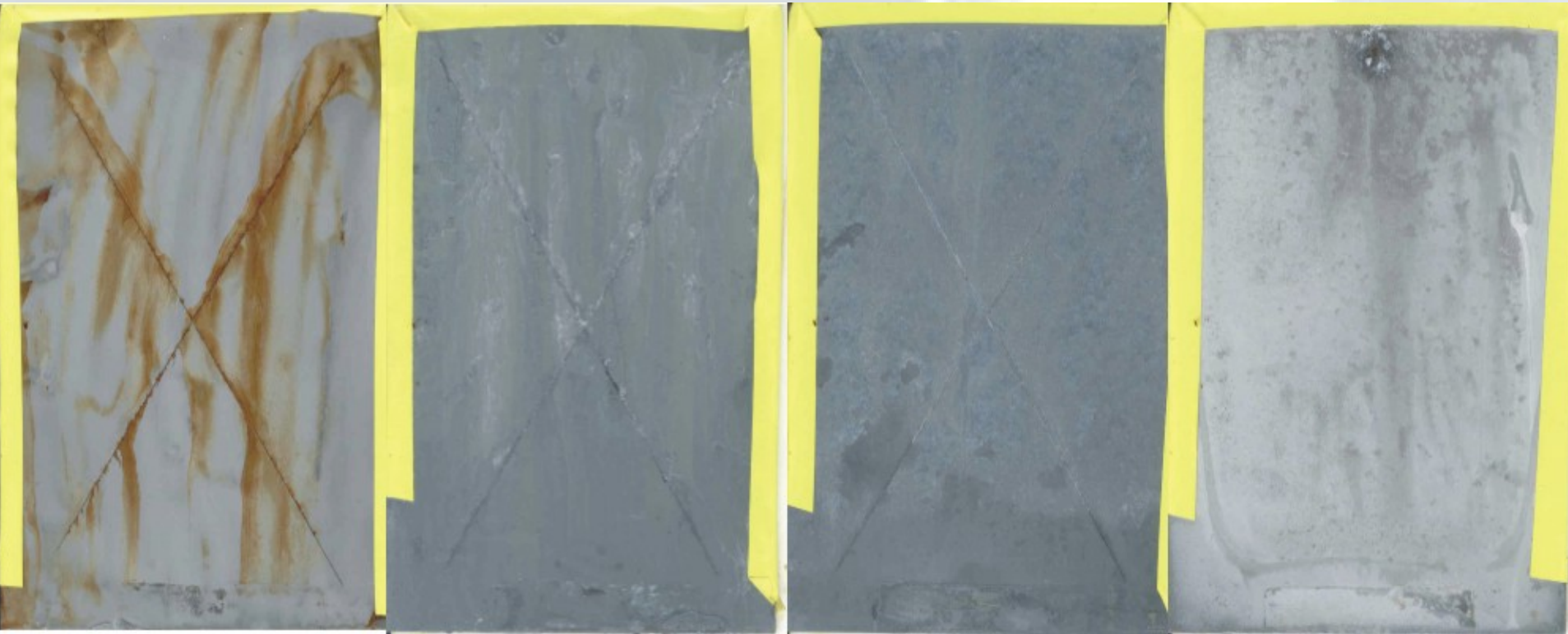
Data Phase 2

150 Hour Test at 45%			150 Hour Test at 45%		
Navair applied ZRC Cold Galvanized			Navair Applied Cadmium Plating		
Enviroment	Damaged	result	Enviroment	Damaged	result
Di water	Yes	passed at 150 hours	Di water	Yes	passed at 150 hours *
Di water	Yes	passed at 150 hours	Di water	Yes	passed at 150 hours *
Di water	Yes	passed at 150 hours	Di water	Yes	passed at 150 hours *
Di water	Yes	passed at 150 hours	Di water	Yes	passed at 150 hours *
Di water	Yes	passed at 150 hours	Di water	no	Failed at 77 hours *
Di water	Yes	passed at 150 hours	Di water	no	passed at 150 hours *
Sea Water	Yes	passed at 150 hours	Di water	no	passed at 150 hours *
Sea Water	Yes	passed at 150 hours	Sea Water	Yes	passed at 150 hours *
Sea Water	Yes	failed at 14 hours *	Sea Water	Yes	passed at 150 hours *
Sea Water	Yes	failed at 98 hours *	Sea Water	Yes	Failed at 107 hours *
De-icing fluid	Yes	passed at 150 hours *	Sea Water	no	passed at 150 hours *
De-icing fluid	Yes	passed at 150 hours *	Sea Water	no	Failed at 1hour *
De-icing fluid	Yes	passed at 150 hours *	Sea Water	no	passed at 150 hours *
De-icing fluid	Yes	passed at 150 hours *	Sea Water	no	passed at 150 hours *
			De-icing fluid	Yes	passed at 150 hours *
			De-icing fluid	Yes	passed at 150 hours *
			De-icing fluid	Yes	passed at 150 hours *
			De-icing fluid	Yes	passed at 150 hours *
			De-icing fluid	no	passed at 150 hours *
			De-icing fluid	no	passed at 150 hours *
			De-icing fluid	no	passed at 150 hours *
			De-icing fluid	no	passed at 150 hours *
			De-icing fluid	no	passed at 150 hours *
			De-icing fluid	no	passed at 150 hours *

Bare and Painted Corrosion Tests

- **Surface Preparation on 4130 steel 4" x 6" x .032" panels.**
- **Solvent Wipe**
- **Grit blast**
- **Dry compressed air cleaning**
- **Turco HTC immersion cleaner at 130 Degrees F for 15 minutes.**
- **Cadmium plated panels only, acid dip 10 seconds**

Bare Corrosion Test 24 hrs ASTM B117



Sermetel 249

Sermetel TDC

**ZRC Cold
Galvanize**

**Cadmium
Plating**

Bare Corrosion Test 7 Days ASTM B117



**Sermetel
TDC**



**ZRC Cold
Galvanize
unscribed**



**ZRC Cold Galvanize
scribed**



**Cadmium
Plating**

Bare Corrosion Test 14 days ASTM B117



**Sermetel
TDC**



**ZRC Cold
Galvanize
unscribed**



**ZRC Cold Galvanize
scribed**



**Cadmium
Plating**

Bare Corrosion Test 21 days ASTM B117



**Sermetel
TDC**



**ZRC Cold
Galvanize
unscribed**

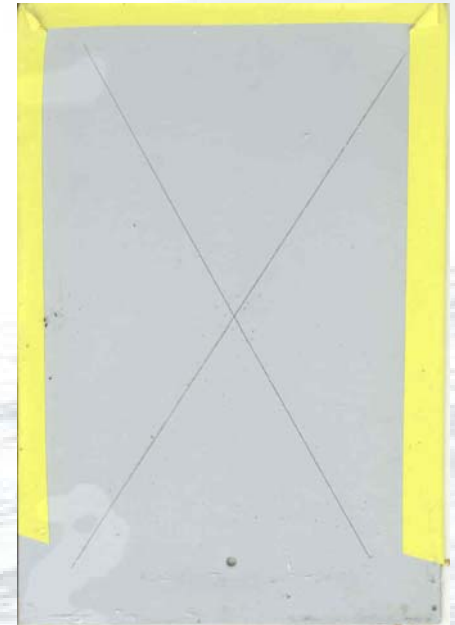
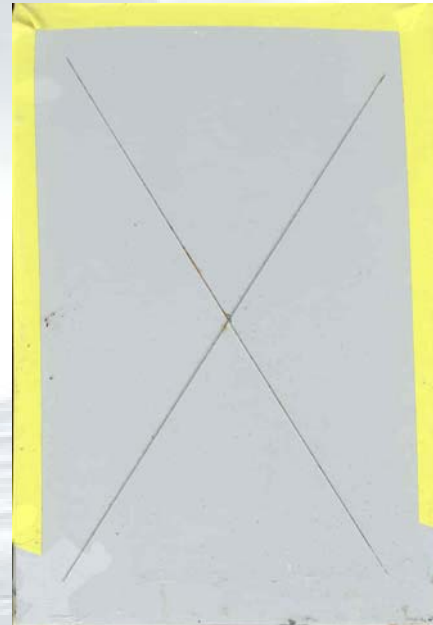
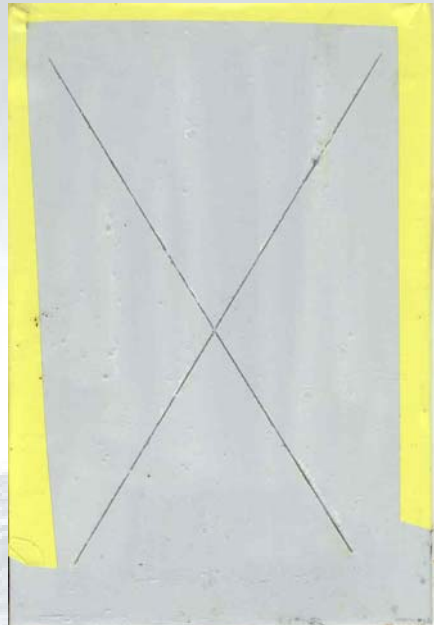
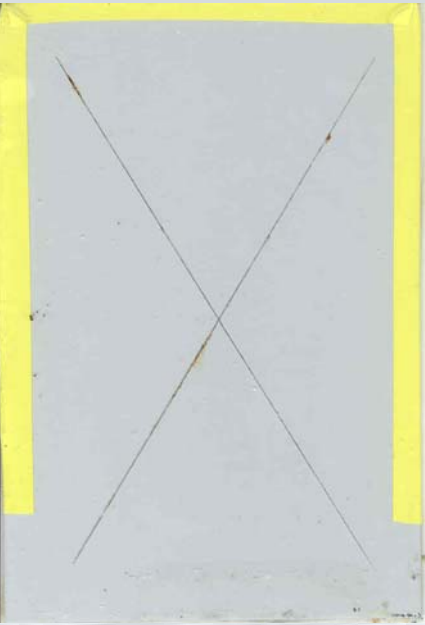


**ZRC Cold Galvanize
scribed**



**Cadmium
Plating**

Painted Corrosion 24 Hrs ASTM B117



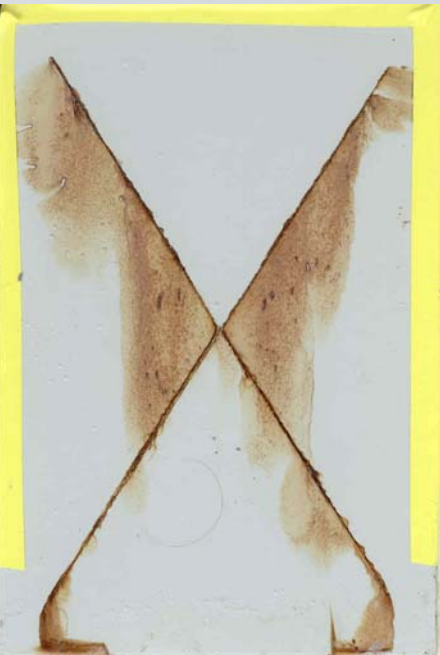
Sermetel 249

Sermetel TDC

**ZRC Cold
Galvanize**

Cadmium Plating

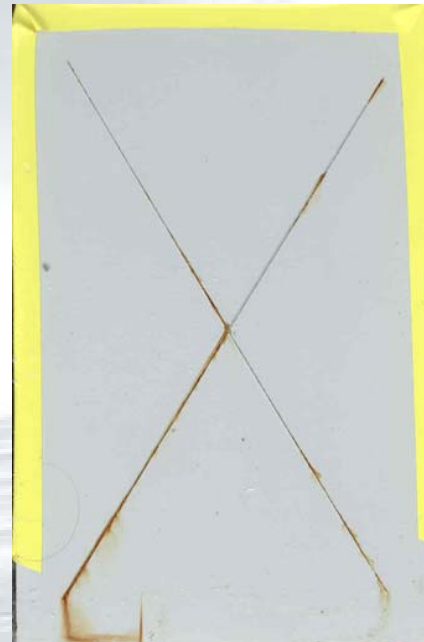
Painted Corrosion 7 Days ASTM B117



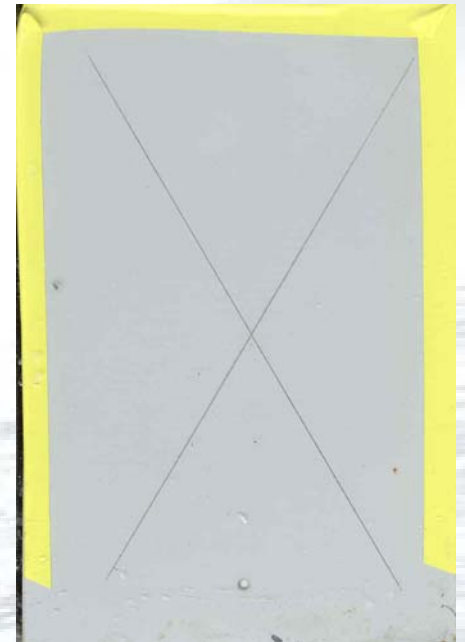
Sermetel 249



Sermetel TDC



**ZRC Cold
Galvanize**

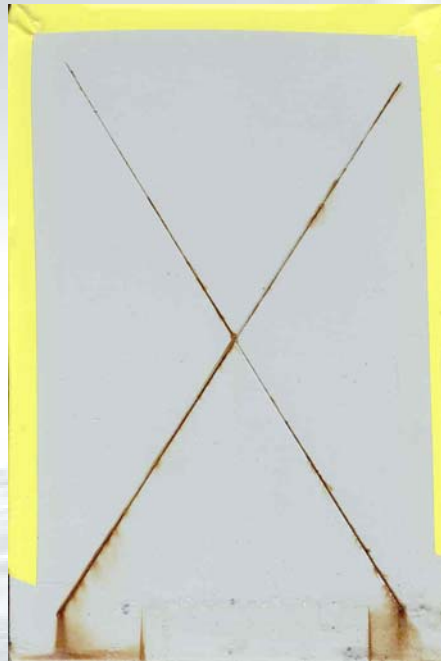


Cadmium Plating

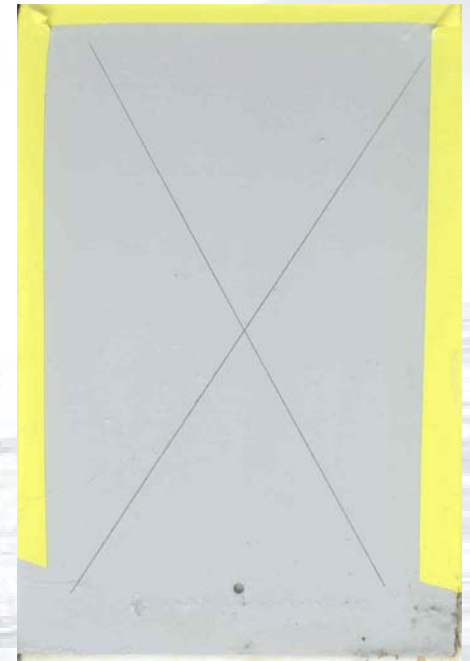
Painted Corrosion 14 Days ASTM B117



Sermetel TDC



**ZRC Cold
Galvanize**

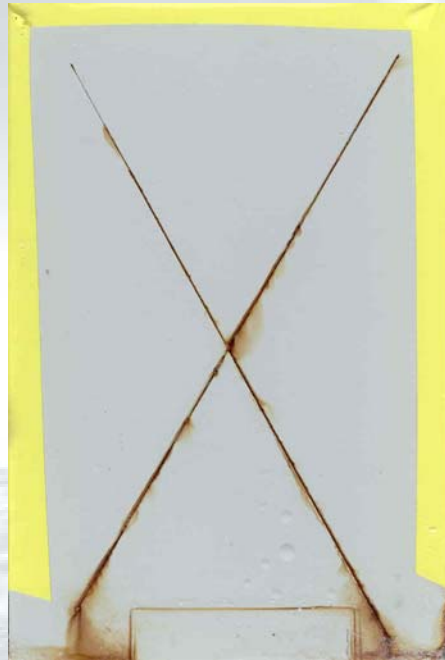


Cadmium Plating

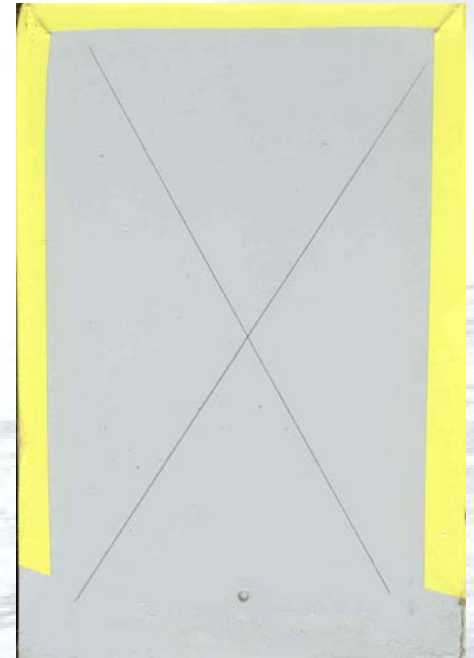
Painted Corrosion 21 Days ASTM B117



Sermetel TDC



**ZRC Cold
Galvanize**



Cadmium Plating

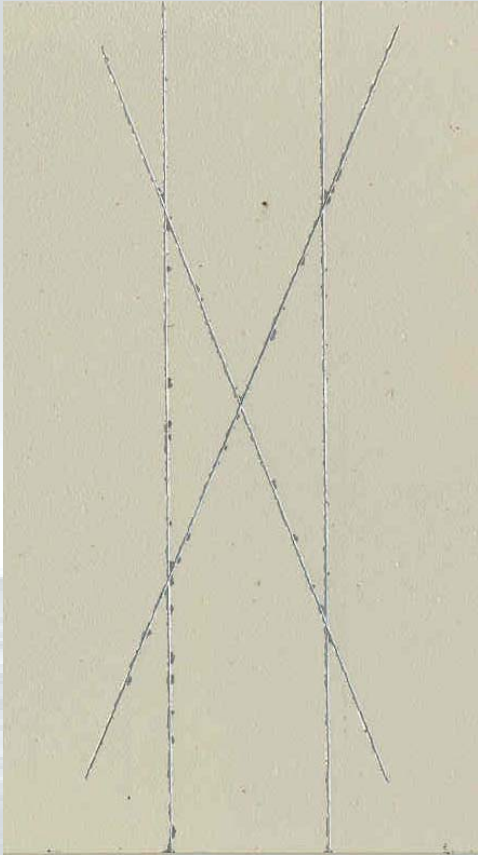
Paint Adhesion Test

- Tested Primer on bare steel and Primer on ZRC Cold Galvanize to steel.
- Used 3 primer systems, Mil-PRF-53022, MIL-PRF-85582N, MIL-PRF-23377 Class C2.
- Each primer system tested Dry, 1 day wet at room temperature, 4 days wet at 120 F, 7 days wet at 150 F.
- Averaged a rating of 4 for all ZRC Cold Galvanizing tests.
- ASTM D 3359 Method A, ratings based on paint removed after peeling tape, 5 being the best no peeling or removal, 4 trace peelings or removals, 3 jagged removals up to 1/16", 2 jagged removals up to 1/8", 1 removal of most area's under the tape and 0 removal beyond the area of the X

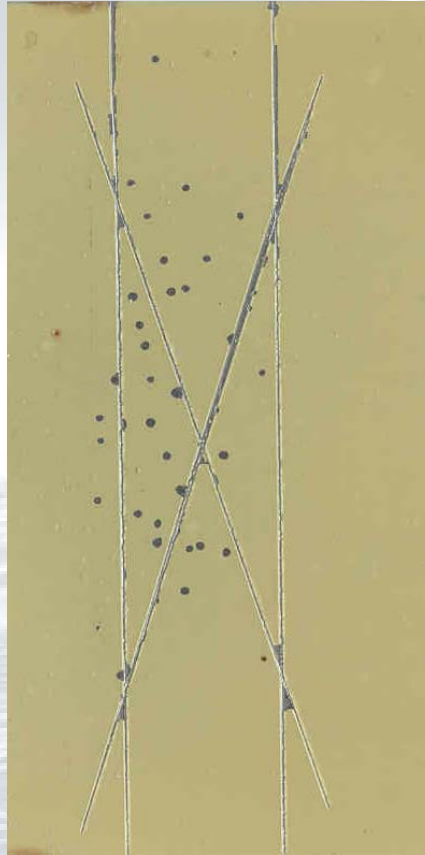
Paint Adhesion Test Data

Num	Cold Galvanize	Paint	Paint Adhesion Results	
21	No	53022	Dry	5
22	No	53022	1 Day Wet	4
23	No	53022	4 Day Wet	4
24	No	53022	7 Day Wet	1
25	No	23377C	Dry	5
26	No	23377C	1 Day Wet	5
27	No	23377C	4 Day Wet	5
28	No	23377C	7 Day Wet	5
29	No	85582N	Dry	5
30	No	85582N	1 Day Wet	5
31	No	85582N	4 Day Wet	4
32	No	85582N	7 Day Wet	3
33	Yes	53022	Dry	4
34	Yes	53022	1 Day Wet	4
35	Yes	53022	4 Day Wet	4
36	Yes	53022	7 Day Wet	4
37	Yes	23377C	Dry	4
38	Yes	23377C	1 Day Wet	4
39	Yes	23377C	4 Day Wet	4
40	Yes	23377C	7 Day Wet	4
41	Yes	85582N	Dry	4
42	Yes	85582N	1 Day Wet	3
43	Yes	85582N	4 Day Wet	4
44	Yes	85582N	7 Day Wet	4

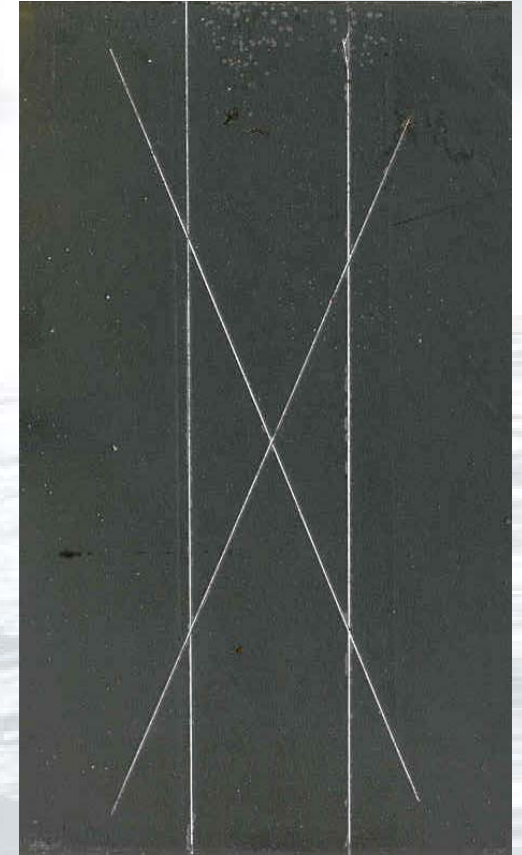
Paint Adhesion Test Data



**53022 7 Day Wet
Over ZRC CG**



**23377C 7 Day Wet
Over ZRC CG**



**85582N 7 Day Wet
Over ZRC CG**

Conclusions

- **Sermetel 249 is not a viable repair coating due to its poor performance in the bare and painted corrosion tests.**
- **Sermetel TDC is not a viable repair option due to poor performance in the Hydrogen embrittlement tests.**
- **ZRC Cold Galvanizing is a viable repair option for ground equipment only. More testing is needed to determine if it can be used on high strength steel.**

Future Testing

- Repeat Hydrogen embrittlement tests for ZRC Cold Galvanizing immersed in Sea water to double check results.
- Apply Non Chrome Post Treatment (TCP) to ZRC Cold Galvanizing to enhance paint adhesion and corrosion resistance.
- Test ZRC Cold Galvanizing IAW HSS JTP
- Coordinating with Lakehurst NJ on testing that could lead to field demo on Test Equipment



Questions

Comments