

JCAT

Corrosion Performance of AlumiPlate Coated Electrical Connectors with Trivalent Cr Post-Treatment

January 24, 2007

**New Orleans Marriott at the
Convention Center**

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Overview

- **Test alternatives to Cadmium Plated electrical connectors.**
- **Alumiplate Inc. provided NAVAIR with electrical connectors to evaluate the coatings for corrosion resistance and conductivity.**

Connectors Tested

All Connectors Comply to MIL-DTL-38999				
Test ID#	Material	Plating	Post-treatment	Number
AC3	AA6061	Alumiplate	Class III Chromate	6
AC1			Class 1A Chromate	6
AT2			25% TCP-HF	6
AT5			50% TCP-HF	3
CC3	PEEK		Class III Chromate	6
CC1			Class 1A Chromate	6
CT2			25% TCP-HF	6
CT5			50% TCP-HF	3
ACd	AA6061	OD Cadmium		3
CCd	PEEK	OD Cadmium		1
CPN	PEEK plug	Nickel		1
CP3	PEEK plug	Alumiplate	Class III Chromate	1

- TCP was Metalast TCP-HF
- Amphenol Inc. left out one important process that we had done on all previous Alumiplate coated connector testing. The retaining clip spring behind the coupling nut on the AlumiPlate Inc. coated aluminum connectors is supposed to be coated with a MIL 46010 Dry film Lubricate prior to final assembly.

Tests Performed

- Corrosion Tests

- ASTM B117 Salt fog [2000 hrs], half the connectors, removed and photographed at intervals of 1, 2, 5, 7, 8,10, and 12 weeks.
- ASTM G85 SO2 salt fog [500 hrs], half the connectors, removed and photographed at intervals of 2 days, 1 week, 10 days, 2 weeks, 16 days and 20 days.
- Corrosion tests (but no durability) per Mil-DTL-38999 4.5.12.2 and Mil-Std-1344A Method 1001.1. Mil-DTL-38999 4.5.12.2 states 1000 hrs for all series, except class C, H, K ,W & Y 500 hrs, and 2000 hrs for series J and M (conductive composite PEEK) in neutral salt fog. NAVAIR tests goes beyond that and add SO2 testing.

Tests Performed

- Conductivity Tests
 - Connectors were removed from Salt Fog chambers as outlined in the previous slide and measurements taken and recorded.
 - Conductivity tests per Mil-DTL-38999 3.38, 4.5.24 and MIL-STD-1344 Method 3007.

Corrosion Tests



- ASTM B117 Neutral Salt Fog, half the connectors
- Connectors hung with wax string from the top of the chamber

Corrosion Tests



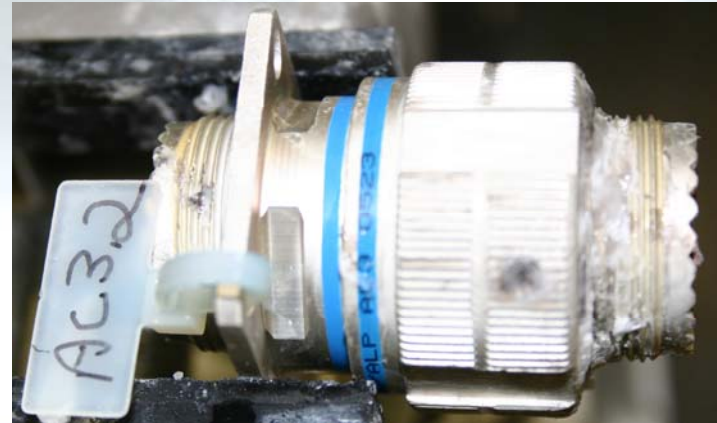
- ASTM G85 SO₂ Acid Salt Fog Test
- Connectors hung from wax string at the top of the Chamber

Corrosion Tests ASTM B117

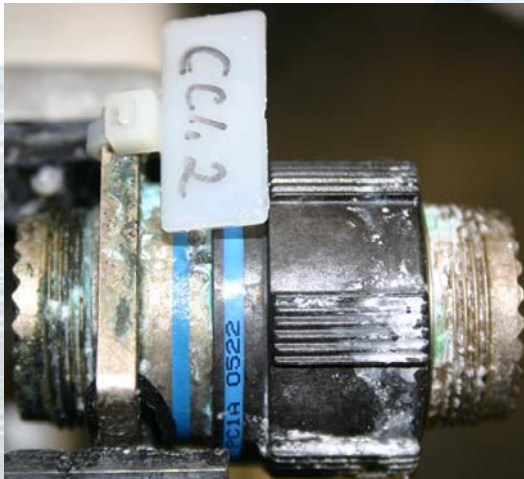
2000 Hrs



6061 Aluminum Connector W/OD Cadmium Plating



6061 Aluminum W/ Alumiplate coating W/ Class III Chromate



PEEK with Alumiplate coating
Class 1A Chromate



6061 Aluminum with Alumiplate
coating and 50% TCP Dilution

Corrosion Tests ASTM B117

2000 Hrs



6061 Aluminum W/ Alumiplate coating
coating Class 1A Chromate



PEEK W/ Alumiplate coating & TCP 25% dilution



6061 Aluminum W/ Alumiplate Coating
With TCP 25% dilution



PEEK W/ Alumiplate & Class III Chromate

Corrosion Tests ASTM B117

2000 Hrs



PEEK W/ Alumiplate coating & TCP 50% Dilution



PEEK W/ Alumiplate & Class III Chromate

Corrosion Tests ASTM G85

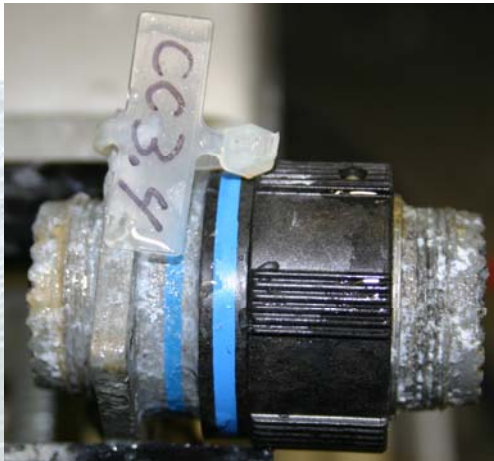
500 Hrs



Cadmium plated 6061T6 Aluminum



Alumiplate coated 6061-T6 Aluminum with Class III chromate



PEEK W/ Alumiplate & Class III Chromate



PEEK Connector W/ Nickel Coating

Corrosion Tests ASTM G85

500 Hrs



PEEK W/ Cadmium Plating



6061 Aluminum with Alumiplate coating
W/ Class 1A Chromate



PEEK W/ Class 1A Chromate



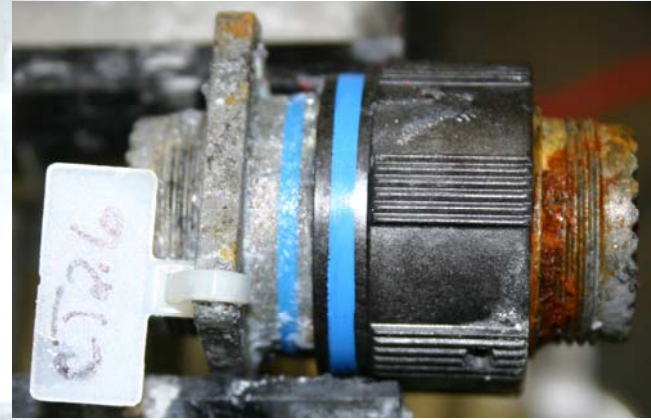
6061 Aluminum with Alumiplate
coating W/ TCP 50% dilution

Corrosion Tests ASTM G85

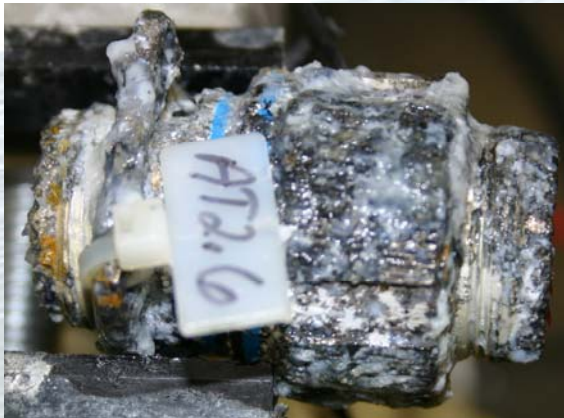
500 Hrs



6061 Aluminum with OD Cadmium Plating



PEEK W/ Alumiplate coating & TCP 25% dilution



6061 Aluminum W/ Alumiplate Coating
& 25% TCP dilution



PEEK W/ Alumiplate Coating W/ Class III Chromate

Corrosion Tests

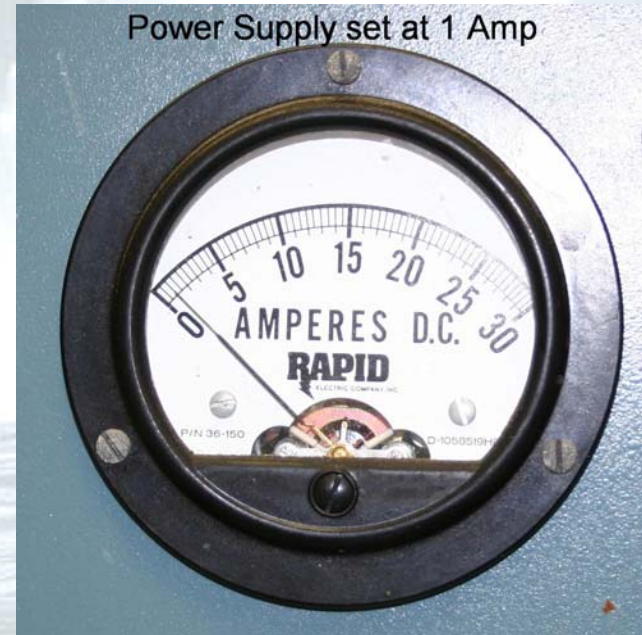
- Conclusions
 - All connectors performed equal to or better than Cadmium Plated controls
 - PEEK connectors performed the best with both the Chromate and TCP posttreatments
 - Aluminum connectors both the Chromate and TCP post treatments were comparable to the Cadmium controls.

Conductivity Tests



Test IAW MIL-STD-1344A Method 3007

Conductivity Tests



- Measurements taken from the rear accessory thread on one end and the flange on the other end of the mated pair
- 1 Amp DC at 1.5 volts is applied to the mated pair of connectors
- Measurements taken at the same interval as the corrosion tests
- All results in Millivolts
- Maximum allowed 2.5 millivolts per MIL-DTL-38999K 3.28 for class W, olive drab cadmium plated

Conductivity Tests Data ASTM B117

ID	B117								
		Conductivity (millivolts DC)							
	0 hrs	168 hrs	336 hrs	840 hrs	1167 hrs	1344 hrs	1680 hrs	2016 hrs	
AC3.1	0.154	0.505	0.309	0.185	0.558	0.673	0.123	0.778	AA6061 w/ Alumiplate w/Class III
AC3.2	0.108	3.12	0.059	0.200	0.225	0.011	0.205	0.174	
AC3.3	0.099	0.089	0.275	0.146	0.205	0.253	0.749	0.281	
AC3.4									
AC3.5									
AC3.6									
AC1.1	0.221	0.166	2.53	0.038	3.285	1.253	1.932	1.666	AA6061 w/ Alumiplate w/Class IA
AC1.2	0.197	1.17	0.498	0.923	1.660	1.840	1.977	0.711	
AC1.3	0.404	3.07	15.97	1.015	0.028	157.141	195.760	56.728	
AC1.4									
AC1.5									
AC1.6									
AT2.1	1.14	8.59	4.133	0.208	8.149	0.033	4.389	4.544	AA6061 w/ Alumiplate w/TCP 25% dilution
AT2.2	0.78	4.33	3.494	10.667	11.273	12.564	28.100	15.931	
AT2.3	10.95	missing	missing	missing	missing	missing	missing	missing	
AT2.4									
AT2.5									
AT2.6									
AT5.1	0.194	0.535	0.396	0.885	0.027	0.879	1.088	0.459	AA6061 w/ Alumiplate w/TCP 50% dilution
AT5.2									
AT5.3									
CC3.1	0.507	1.19	1.126	1.454	1.476	1.304	1.364	1.529	PEEK Connector w/Alumiplate w/Class III
CC3.2	0.572	1.03	0.89	1.382	1.421	7.685	1.291	1.272	
CC3.3	0.541	1.35	0.832	1.375	1.918	1.191	1.416	1.329	
CC3.4									
CC3.5									
CC3.6									
CC1.1	0.639	3.05	0.871	1.415	1.405	1.288	3.156	1.248	PEEK Connector w/Alumiplate w/Class IA
CC1.2	0.652	1.75	1.386	1.342	1.586	1.763	1.414	1.444	
CC1.3	0.54	1.24	0.906	1.447	1.555	1.722	1.332	1.307	
CC1.4									
CC1.5									
CC1.6									
CT2.1	0.444	0.864	1.186	2.457	1.444	1.157	1.527	0.030	PEEK Connector w/Alumiplate w/TCP 25%
CT2.2	0.442	1.53	0.817	1.272	1.298	1.994	1.503	1.528	
CT2.3	0.603	1.693	1.076	1.538	1.383	1.796	1.284	1.548	
CT2.4									PEEK Connector w/Alumiplate w/TCP 25%
CT2.5	0.506	1.14	0.855	1.636	1.314	1.330	1.278	1.213	
CT2.6									
CT5.1	0.806	1.32	0.968	1.836	1.454	1.756	1.345	1.706	PEEK Connector w/Alumiplate w/TCP 50%
CT5.2	0.834	1.19	0.956	1.352	2.037	1.530	2.235	2.527	
CT5.3									
ACd.1	0.168	1.17	0.488	0.557	0.799	0.670	0.825	0.947	AA6061 w/OD Cd
ACd.2									
ACd.3									
CCd									PEEK w/OD CD
CPN									
CP3									

Note: Class 1a Chromate not standard, Class III Standard



Conductivity Tests Data ASTM G85

ID	G85							
	Conductivity (millivolts DC)							
	0 hrs	48 hrs	168 hrs	240 hrs	336 hrs	384 hrs	480 hrs	
AC3.1								
AC3.2								
AC3.3								
AC3.4	0.075	0.231	0.425	0.294	214.439	0.037	0.614	AA6061 w/ Alumiplate w/Class III Chromate
AC3.5	1.120	2.251	12.890	13.580	0.078	38.410	21.870	
AC3.6	0.100	0.138	0.263	0.169	0.663	0.212	0.223	
AC1.1								
AC1.2								
AC1.3								
AC1.4	0.063	0.095	0.140	0.106	0.160	0.130	0.162	AA6061 w/ Alumiplate w/Class IA Chromate
AC1.5	0.123	0.214	0.328	0.351	0.200	0.564	0.532	
AC1.6	0.590	4.210	11.260	22.760	14.880	23.790	28.110	
AT2.1								
AT2.2								
AT2.3								
AT2.4	0.922	52.790	98.050	56.550	302.340	152.860	87.257	AA6061 w/ Alumiplate w/TCP 25% dilution
AT2.5	0.848	15.470	58.800	77.210	66.820	34.070	232.040	
AT2.6	1.340	18.150	47.340	66.300	4.630	19.250	10.950	
AT5.1								
AT5.2	0.393	0.888	4.230	14.240	41.620	50.060	88.620	AA6061 w/ Alumiplate w/TCP 50% dilution
AT5.3	0.159	1.243	4.830	14.250	84.910	46.990	0.280	
CC3.1								
CC3.2								
CC3.3								
CC3.4	0.502	0.567	0.945	1.060	0.661	0.836	1.145	PEEK Connector w/Alumiplate w/Class III Chromate
CC3.5	0.456	0.141	0.950	0.735	3.666	1.350	1.164	
CC3.6	0.473	0.566	1.160	0.948	0.941	1.240	1.496	
CC1.1								
CC1.2								
CC1.3								
CC1.4	0.638	0.753	1.780	0.945	1.154	1.405	1.656	PEEK Connector w/Alumiplate w/Class IA Chromate
CC1.5	0.621	0.704	1.384	1.270	1.083	1.049	2.053	
CC1.6	0.686	1.030	1.060	1.110	1.309	1.469	1.819	
CT2.1								
CT2.2								
CT2.3								
CT2.4	0.508	0.748	1.530	1.390	1.070	1.795	3.430	PEEK Connector w/Alumiplate w/TCP 25% dilution
CT2.5								
CT2.6	0.627	0.663	1.230	0.781	1.003	1.722	1.778	
CT5.1								
CT5.2								PEEK Connector w/Alumiplate w/TCP 50% dilution
CT5.3	0.800	0.670	1.260	1.340	0.855	1.580	1.409	
ACd.1								
ACd.2	0.199	1.066	0.797	0.384	0.368	0.444	0.513	
ACd.3	0.351	0.924	0.919	0.638	17.002	0.536	2.762	AA6061 w/OD Cd
CCd	0.469	1.170	13.450	39.250	129.950	140.431	42.580	PEEK w/OD CD
CPN	0.857	1.030	17.050	8.100	10.950	48.330	456.350	PEEK w/Ni coating
CP3	0.261	1.065	37.690	4.720	19.680	8.870	13.060	PEEK w/Alumiplate w/Class III Chromate

Conductivity Tests

- Conclusions

- ASTM B117 results, all connectors meet applicable requirements of the MIL-DTL-38999 Specification except AA6061 Aluminum w/ Alumiplate coating W/ 25% TCP Post Treatment
- ASTM G85 results, all connectors passed (2.5 Milliivolts) except AA6061 w/ Alumiplate coating W/ 25% TCP Post Treatment, Note: 6061 Alumiplate coating w/TCP 50% performed similar to cadmium controls
- PEEK connector plug w/ Ni coating and PEEK connector plug w/Alumiplate coating w/ Class III chromate conversion coating did not pass ASTM G85 salt fog but no ASTM B117 test was performed due to lack of connectors. Not enough data to form a conclusion, however they perform similar to Cadmium Plated controls.

Conclusions

- All connectors meet applicable requirements of the MIL-DTL-38999 Specification except AA6061 Alumiplate coating w/ TCP 25%
- Failure Criteria for these tests are in line with F-35 criteria that connectors must survive and maintain functionality.
- Recommend TCP only be used at the 50% concentration when used as a post treatment for 6061 Aluminum Alloy connectors
- PEEK connectors performed the best overall



Questions

Comments