Connector Hardware Compatibility of Cadmium and Dissimilar Metal Finishes

Executive Summary

Amphenol intermated cadmium plated MIL-DTL-38999 connectors to various finishes and performed a 500 hour salt spray test. After completion all shells survived, and results proved AP-93 to be backwards compatible to cadmium.

Problem Statement

Cadmium is banned in the EU and concerns have resulted in lowering the uses in the US. This leads to a search for a new metal finish.

Dissimilar metals form galvanic cells when in a suitable electrolyte which accelerate corrosion.

Cadmium finished connectors cannot all be replaced, so a suitable replacement must not accelerate corrosion at a pace which would cause premature failure of standard testing.

Test Plan

Fully Built MIL-DTL-38999 connectors would be made with cadmium plug shell and mated with a wall mount receptacle of various finishes. This would also be tested with cadmium wall mount receptacles with various finishes on the plug shell.

The mated pairs would go through some of the testing in MIL-DTL-38999M which would highlight effects of galvanic corrosion. The primary tests were the shell to shell conductivity test of EIA-364-83 and the salt spray testing of EIA-364-26.

The shell-to-shell conductivity was taken three times: before salt spray testing, after salt spray testing, and lastly after durability cycling (500 cycles of mating and un-mating). These shall be noted as Shell-to-shell Conductivity Tests 1, 2, and 3 respectively. Shell-to-shell Conductivity Tests 1 and 2 had a failure if the result was 2.50 or greater and Shell-to-shell Conductivity Test 3 was a failure if the result was 5.00 or greater.

Visual examination would take place after the 500 hour salt spray and evaluated to EIA 364-26. This allows corrosion of at risk sites which includes threads and recesses which could collect salt fog.

The finishes to be tested were:

- Cadmium (Baseline)
- Zinc Nickel with a hexavalent chromate
- Zinc Nickel with a trivalent chromate (Provided by ASF)
- Tri-Nickel Alloy (Henceforth AP-93)
- Nickel PTFE (Henceforth Durmalon)

Results

All shells passed Shell-to-shell Conductivity Test 1.

The connectors were evaluated and deemed acceptable visual results after salt spray. Zinc nickel coatings form a white oxide, as it is a sacrificial coating which was deemed acceptable if the part could still function.

All shells passed Shell-to-shell Conductivity Test 2

All shells survived the 500 mating cycles

AP-93 showed passing results for conductivity. Upon this test, we would deem this plating intermateable with cadmium.

Further investigation with larger sample sizes, will be performed.

Shell to Shell Conductivity Data

Plug Finish	Receptacle Finish	Shell to Shell Cond. 1	Shell to Shell Cond. 2	Shell to Shell Cond. 3
Failure If Greater Than		**2.50 mV**	**2.50 mV**	**5.00 mV**
Cadmium	Cadmium	0.07	0.04	See Note 1
Cadmium	Cadmium	0.08	0.01	1.58
Cadmium	Cadmium	0.04	0.02	0.27
Cadmium	Cadmium	0.05	0.02	0.24
Cadmium	Durmalon	0.26	0.12	2.6
Cadmium	Durmalon	0.18	0.07	3.98
Durmalon	Cadmium	0.21	0.2	0.66
Durmalon	Cadmium	0.3	0.3	1.65
Cadmium	BZN w/ Cr6	0.26	0.3	0.5
Cadmium	BZN w/ Cr6	0.31	0.2	10.05
BZN w/ Cr6	Cadmium	1.5	0.98	0.87
BZN w/ Cr6	Cadmium	0.69	1.53	1.6
Cadmium	AP-93	0.13	0.07	1
Cadmium	AP-93	0.14	0.06	1.11
AP-93	Cadmium	0.28	0.31	0.24
AP-93	Cadmium	0.32	0.47	0.4
BZN w/ Cr3	Cadmium	0.8	0.57	0.54
BZN w/ Cr3	Cadmium	0.7	0.59	1.69
Cadmium	BZN w/ Cr3	0.2	0.09	0.97
Cadmium	BZN w/ Cr3	0.65	0.17	0.18

Note 1: This connector was handled in such a fashion which prevented data from being obtained.

Figure 1. – Cadmium to Cadmium

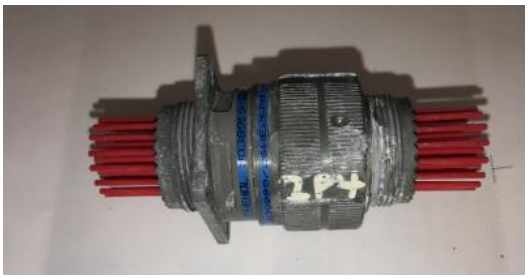

Figure 2. – Cadmium to Cadmium

Figure 3. – Durmalon to Cadmium

Figure 4. – Cadmium to Durmalon

Figure 5. – Cadmium to AP-93

Figure 6. – AP-93 to Cadmium

Figure 7. – Cadmium to BZN w/ Cr6

Figure 8. – BZN w/ Cr6 to Cadmium

Figure 9. – Cadmium to BZN w/ Cr3

Figure 10. – BZN w/ Cr3 to Cadmium