RoHS Plating Selection Report

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Grayhill Inc.

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1.0 INTRODUCTION

The RoHS directive restricts the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ether. In order to comply with the RoHS directive, Grayhill Inc. has selected alternate plating finishes, tin/zinc and zinc/trivalent, to be tested for any affects to the performance of rotary switches. The selection of a plating is based on the test results of the representative samples, but will apply to all rotary switches. The representative sample of switches consisted of two series, 51 and 71, as well as two shaft sizes, .125" and .250". The samples were plated and divided into groups to be submitted to testing. The tests specified included, 48 and 96 hour salt atmosphere, humidity, thermal shock, rotational life and mounting strength. The results of the tests verified that both the tin/zinc plating and the zinc/trivalent plating are acceptable alternatives for the cadmium plating. The following will explain in greater detail the procedures, results, and conclusions of the tests.

2.0 PLATING SOLUTIONS

The two plating selections, tin/zinc and zinc/trivalent, are both RoHS compliant and are used for their protection against corrosion.

The tin/zinc plating follows industry standard AMS 2434B. It calls out a general composition of 70% tin and 30% zinc. The actual composition range is 60%-85% tin and 15%-40% zinc. The EMF value for tin/zinc plating is –0.90 Volts. The finish is dull in appearance.

The zinc/trivalent plating follows industry standard ASTM B 633 TYPE II. It calls out a supplementary chromate treatment. The EMF value for zinc/trivalent plating is –1.66 Volts. The finish is bright in appearance.

3.0 TEST PROCEDURES

3.1 Test Outline

The two plating finishes chosen to be tested by Grayhill Inc. were tin/zinc and zinc/trivalent. Four standard switch part numbers were selected as a representative sample of the rotary switch products. They include 51M30-01-1-12N, 51KM30-01-1-12N, 71MAS30-01-1-12N-C, and 71MBS30-01-1-12N-C. Each group of switches was divided into groups of ten samples, half with tin/zinc plating and half with zinc/trivalent plating. These groups of ten were then submitted for testing.

The tests for evaluation consisted of 48 hour salt atmosphere, 96 hour salt atmosphere, humidity, thermal shock, rotational life and mounting strength. The following page shows the test matrix used for the evaluation. (See Table 1)

The samples used in the rotational life test were tested for mounting strength after rotational life testing had completed. Tests to check the contact resistance and torque were added to the humidity, thermal shock and rotational life test procedures. After each test was complete, all switches were checked for plating delamination, shaft binding and hardware removal. After the salt atmosphere tests all switches were also checked for any excessive corrosion.

Table 1: RoHS plating test matrix

Test	Part Number	Plating	Sample Quantity
Salt Atmosphere (48 hours)	51M30-01-1-12N	Tin/Zinc	5
	51M30-01-1-12N	Zinc/Trivalent	5
	51KM30-01-1-12N	Tin/Zinc	5
	51KM30-01-1-12N	Zinc/Trivalent	5
	71MAS30-01-1-12N-C	Tin/Zinc	5
	71MAS30-01-1-12N-C	Zinc/Trivalent	5
	71MBS30-01-1-12N-C	Tin/Zinc	5
	71MBS30-01-1-12N-C	Zinc/Trivalent	5
Salt Atmosphere (96 hours)	51M30-01-1-12N	Tin/Zinc	5
	51M30-01-1-12N	Zinc/Trivalent	5
	51KM30-01-1-12N	Tin/Zinc	5
	51KM30-01-1-12N	Zinc/Trivalent	5
	71MAS30-01-1-12N-C	Tin/Zinc	5
	71MAS30-01-1-12N-C	Zinc/Trivalent	5
	71MBS30-01-1-12N-C	Tin/Zinc	5
	71MBS30-01-1-12N-C	Zinc/Trivalent	5
Humidity (Steady State) (240 hours)	51M30-01-1-12N	Tin/Zinc	5
	51M30-01-1-12N	Zinc/Trivalent	5
	51KM30-01-1-12N	Tin/Zinc	5
	51KM30-01-1-12N	Zinc/Trivalent	5
	71MAS30-01-1-12N-C	Tin/Zinc	5
	71MAS30-01-1-12N-C	Zinc/Trivalent	5
	71MBS30-01-1-12N-C	Tin/Zinc	5
	71MBS30-01-1-12N-C	Zinc/Trivalent	5
Thermal Shock (5 cycles)	51M30-01-1-12N	Tin/Zinc	5
	51M30-01-1-12N	Zinc/Trivalent	5
	51KM30-01-1-12N	Tin/Zinc	5
	51KM30-01-1-12N	Zinc/Trivalent	5
	71MAS30-01-1-12N-C	Tin/Zinc	5
	71MAS30-01-1-12N-C	Zinc/Trivalent	5
	71MBS30-01-1-12N-C	Tin/Zinc	5
	71MBS30-01-1-12N-C	Zinc/Trivalent	5
Life (Rotational) (25,000 cycles)	51M30-01-1-12N	Tin/Zinc	5
	51M30-01-1-12N	Zinc/Trivalent	5
	51KM30-01-1-12N	Tin/Zinc	5
	51KM30-01-1-12N	Zinc/Trivalent	5
	71MAS30-01-1-12N-C	Tin/Zinc	5
	71MAS30-01-1-12N-C	Zinc/Trivalent	5
	71MBS30-01-1-12N-C	Tin/Zinc	5
	71MBS30-01-1-12N-C	Zinc/Trivalent	5
Mounting Strength (Rotational Life samples)	51M30-01-1-12N	Tin/Zinc	5
	51M30-01-1-12N	Zinc/Trivalent	5
	51KM30-01-1-12N	Tin/Zinc	5
	51KM30-01-1-12N	Zinc/Trivalent	5
	71MAS30-01-1-12N-C	Tin/Zinc	5
	71MAS30-01-1-12N-C	Zinc/Trivalent	5
	71MBS30-01-1-12N-C	Tin/Zinc	5
	71MBS30-01-1-12N-C	Zinc/Trivalent	5

3.2 Salt Atmosphere (48 hours)

The switches were tested per MIL-DTL-3786H in accordance with method 101E of MIL-STD-202G. These samples were tested using test condition B, which states duration of 48 continuous hours for testing. The pass/fail criteria for this test as MIL-DTL-3786H states, after the test, switches shall be examined for evidence of excessive corrosion. Mounting hardware shall be removable at the end of the test. Excessive corrosion is defined as corrosion that interferes with the electrical or mechanical performance, or, in the case of plated metals, corrosion that has passed through the plating and exposed the base metal.

3.3 Salt Atmosphere (96 hours)

The switches were tested per MIL-DTL-3786H in accordance with method 101E of MIL-STD-202G. These samples were tested using test condition A, which states duration of 96 continuous hours for testing. The pass/fail criteria for this test as MIL-DTL-3786H states, after the test, switches shall be examined for evidence of excessive corrosion. Mounting hardware shall be removable at the end of the test. Excessive corrosion is defined as corrosion that interferes with the electrical or mechanical performance, or, in the case of plated metals, corrosion that has passed through the plating and exposed the base metal.

3.4 Humidity (Steady State)

The switches were tested in accordance with method 103B of MIL-STD-202G. These samples were tested using test condition A, which states duration of 240 hours for testing. A torque test was added and performed per 4.8.3.1.1 of MIL-DTL-3786H. The pass/fail criteria for this test included inspection for plating delamination, evidence of shaft binding taken from the results of the torque test, and hardware removal.

3.5 Thermal Shock

The switches were tested per MIL-DTL-3786H in accordance with method 107G of MIL-STD-202G. These samples were tested using test condition A, for a total of five cycles. A contact resistance test was added and performed per 4.8.5 of MIL-DTL-3786H in accordance with method 307 of MIL-STD-202G. The pass/fail criteria for this test included inspection for cracking or delamination of the finish, shaft rotation and hardware removal.

3.6 Life (Rotational)

The switches were tested per MIL-DTL-3786H in accordance with method 206 of MIL-STD-202G. These samples were tested using test condition F, which states duration of 25,000 cycles. A contact resistance test was added and performed per 4.8.5 of MIL-DTL-3786H in accordance with method 307 of MIL-STD-202G. A torque test was also added to some of the tests and performed per 4.8.3.1.1 of MIL-DTL-3786H. The pass/fail criteria for this test included inspection for delamination of plating and any evidence of shaft binding taken from the results of the torque test.

3.7 Strength of Mounting Bushing

The switches were tested per 4.8.3.3 of MIL-DTL-3786H. As stated, a torque of 15 pound-inches shall be applied to the mounting nut. The pass/fail criteria for this test is stated as no damage to the switch, or loosening or twisting of the bushing relative to the switch front plate assembly, nor shall there be any damage to the nonturn device.

4.0 TEST RESULTS

4.1 Results Overview

Once testing had completed, the switches were evaluated for plating delamination, shaft binding and hardware removal. Following the salt atmosphere tests, the switches were also checked for excessive corrosion. All switches from both the tin/zinc plating and the zinc/trivalent plating passed all evaluation criteria after test completion.

4.2 Salt Atmosphere (48 hours)

All samples completing 48 hours of salt atmosphere were examined for excessive corrosion. The samples did exhibit discoloration of the plated surfaces and residue, but there was no evidence of exposed base material and no affect on the mechanical performance of the switch. (See Figures A-1 through A-4 in Appendix) All mounting hardware could be removed and replaced. Therefore, all samples passed the evaluation criteria.

Test	Part Number	Plating	Pass/Fail
Salt Atmosphere (48 hours)	51M30-01-1-12N	Tin/Zinc	Pass
	51KM30-01-1-12N	Tin/Zinc	Pass
	71MAS30-01-1-12N-C	Tin/Zinc	Pass
	71MBS30-01-1-12N-C	Tin/Zinc	Pass
	51M30-01-1-12N	Zinc/Trivalent	Pass
	51KM30-01-1-12N	Zinc/Trivalent	Pass
	71MAS30-01-1-12N-C	Zinc/Trivalent	Pass
	71MBS30-01-1-12N-C	Zinc/Trivalent	Pass

4.3 Salt Atmosphere (96 hours)

All samples completing 96 hours of salt atmosphere were examined for excessive corrosion. The samples did exhibit discoloration of the plated surfaces and residue, but there was no evidence of exposed base material and no affect on the mechanical performance of the switch. (See Figures B-1 through B-4 in Appendix) All mounting hardware could be removed and replaced. Therefore, all samples passed the evaluation criteria.

Test	Part Number	Plating	Pass/Fail
Salt Atmosphere (96 hours)	51M30-01-1-12N	Tin/Zinc	Pass
	51KM30-01-1-12N	Tin/Zinc	Pass
	71MAS30-01-1-12N-C	Tin/Zinc	Pass
	71MBS30-01-1-12N-C	Tin/Zinc	Pass
	51M30-01-1-12N	Zinc/Trivalent	Pass
	51KM30-01-1-12N	Zinc/Trivalent	Pass
	71MAS30-01-1-12N-C	Zinc/Trivalent	Pass
	71MBS30-01-1-12N-C	Zinc/Trivalent	Pass

4.4 Humidity (Steady State)

All samples completing humidity testing were examined for plating delamination, binding of the shaft during rotation and hardware removal. The samples did exhibit minimal discoloration and residue, but there was no evidence of delamination of plating. The samples were also tested for torque, which showed there was no shaft binding. All mounting hardware could be removed and replaced. Therefore, all samples passed the evaluation criteria.

Test	Part Number	Plating	Pass/Fail
Humidity (Steady State) (240 hours)	51M30-01-1-12N	Tin/Zinc	Pass
	51KM30-01-1-12N	Tin/Zinc	Pass
	71MAS30-01-1-12N-C	Tin/Zinc	Pass
	71MBS30-01-1-12N-C	Tin/Zinc	Pass
	51M30-01-1-12N	Zinc/Trivalent	Pass
	51KM30-01-1-12N	Zinc/Trivalent	Pass
	71MAS30-01-1-12N-C	Zinc/Trivalent	Pass
	71MBS30-01-1-12N-C	Zinc/Trivalent	Pass

4.5 Thermal Shock

All samples completing thermal shock testing were examined for cracking or delamination of the finish, shaft rotation and hardware removal. There was no evidence of cracking or delamination of the plating during visual inspection of the samples. The shaft did not bind when rotated and all mounting hardware could be removed and replaced. Therefore, all samples passed the evaluation criteria.

Test	Part Number	Plating	Pass/Fail
Thermal Shock (5 cycles)	51M30-01-1-12N	Tin/Zinc	Pass
	51KM30-01-1-12N	Tin/Zinc	Pass
	71MAS30-01-1-12N-C	Tin/Zinc	Pass
	71MBS30-01-1-12N-C	Tin/Zinc	Pass
	51M30-01-1-12N	Zinc/Trivalent	Pass
	51KM30-01-1-12N	Zinc/Trivalent	Pass
	71MAS30-01-1-12N-C	Zinc/Trivalent	Pass
	71MBS30-01-1-12N-C	Zinc/Trivalent	Pass

4.6 Life (Rotational)

All samples completing rotational life testing were examined for plating delamination and shaft binding. There was no evidence of plating delamination during visual inspection of the samples. The samples were also tested for torque, which showed there was no shaft binding. Therefore, all samples passed the evaluation criteria.

Test	Part Number	Plating	Pass/Fail
Life (Rotational) (25,000 cycles)	51M30-01-1-12N	Tin/Zinc	Pass
	51KM30-01-1-12N	Tin/Zinc	Pass
	71MAS30-01-1-12N-C	Tin/Zinc	Pass
	71MBS30-01-1-12N-C	Tin/Zinc	Pass
	51M30-01-1-12N	Zinc/Trivalent	Pass
	51KM30-01-1-12N	Zinc/Trivalent	Pass
	71MAS30-01-1-12N-C	Zinc/Trivalent	Pass
	71MBS30-01-1-12N-C	Zinc/Trivalent	Pass

4.7 Strength of Mounting Bushing

All samples completing mounting strength testing were examined for damage to the switch, loosening or twisting of the bushing relative to the switch front plate assembly and any damage done to the nonturn device. There was no evidence of damage to the switch or nonturn device. There was also no evidence of loosening or twisting of the bushing relative to the switch front plate assembly. Therefore, all samples passed the evaluation criteria.

Test	Part Number	Plating	Pass/Fail
Mounting Strength (Rotational Life Samples)	51M30-01-1-12N	Tin/Zinc	Pass
	51KM30-01-1-12N	Tin/Zinc	Pass
	71MAS30-01-1-12N-C	Tin/Zinc	Pass
	71MBS30-01-1-12N-C	Tin/Zinc	Pass
	51M30-01-1-12N	Zinc/Trivalent	Pass
	51KM30-01-1-12N	Zinc/Trivalent	Pass
	71MAS30-01-1-12N-C	Zinc/Trivalent	Pass
	71MBS30-01-1-12N-C	Zinc/Trivalent	Pass

5.0 SUMMARY & CONCLUSIONS

Grayhill Inc. chose two alternate plating finishes as replacements for the cadmium plating that was used on the rotary products. The tin/zinc and zinc/trivalent platings were evaluated after a battery of tests to verify that there was no adverse affect on switch performance. The results of the testing have shown that both plating types are appropriate alternatives to cadmium plating.

6.0 APPENDIX

6.1 Photographs

6.1.1 48 hour Salt Atmosphere

Tin/Zinc Plating

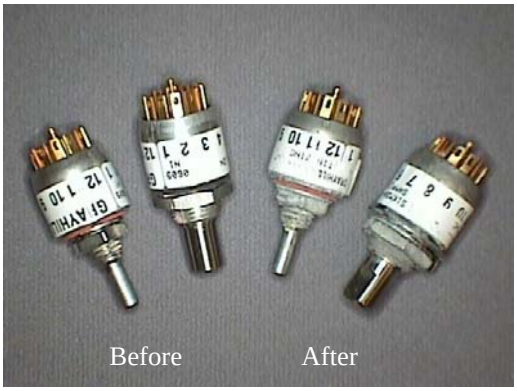

Figure A-1: 51Series

Figure A-2: 71 Series

Zinc/Trivalent Plating

Figure A-3: 51 Series

Figure A-4: 71 Series

6.1.2 96 hour Salt Atmosphere

Tin/Zinc Plating

Figure B-1: 51 Series

Figure B-2: 71 Series

Zinc/Trivalent Plating

Figure B-3: 51 Series

Figure B-4: 71 Series