

Commentary

Apr 5, 2005

Power Supply Failures: The Problem with Zinc Whiskers

Power module failure due to conductive particles (dust) bridging leads is a fairly common event. Figure 1 shows a typical dust debris pattern on a power module board. The pictured debris also includes conductive zinc whiskers from a source external to the power supply module.

Ion chromatography analysis of areas with little or no dust, showed low levels of ionic residues and no (zero) zinc residue. Conversely, areas of the board containing dust particles (as evidenced in Figure 1) show high chloride residue levels and a large amount of measurable zinc residue. The cumulative effect of high ionic and zinc contamination on failing areas of the boards is the external cause of the power module failures and is supported by data in Tables 1 and 2).



Ion Chromatography

Anion Data (-)				
Sample Description	Cl-	Br-	SO4	WOA
Hepta Filter	13.60	0.00	8.85	0.00
Blue Filter	38.04	0.00	26.54	0.00
Power Modular Board - Heavy Dust	1.91	0.00	2.00	2.13
Housing	15.43	0.00	3.41	0.00
Can Capacitor Exterior	6.61	0.00	4.05	0.00
Fan Blades (3 each)	9.69	0.00	5.96	0.00
Microprocessor Board - Heavy Dust Area	12.89	0.69	4.23	69.23
Microprocessor Board - No Visible Dust Area	3.87	0.74	1.69	77.49

Table 1

CationData (+)				
Sample Description	Na	Zn	K	Mg
Hepta Filter	3.07	18.45	3.14	0.17
Blue Filter	17.60	3.91	1.47	0.27
Power Modular Board - Heavy Dust	7.94	29.36	0.00	0.00
Housing	6.38	0.48	0.00	0.00
Can Capacitor Exterior	3.36	5.87	0.00	0.00
Fan Blades (3 each)	7.41	9.88	0.00	0.00
Microprocessor Board - Heavy Dust Area	2.14	19.36	3.11	0.00
Microprocessor Board - No Visible Dust Area	1.74	0.00	2.74	0.00

Table 2 (Note: all above values are in ug/in²)

Testing Protocol

All residues in this evaluation were characterized using Ion Chromatography per IPC-TM-650 2.3.28 and Dionex Transition metals analysis.

Filter Material Conclusions

1. Extracted samples of the Hepta filter material show high levels of zinc, chloride and potassium. SEM analysis showed zinc whiskers in the Hepta Filter material.
2. The length of the zinc whiskers all range from .27 to 1.5 mm with a diameter of .0025 mm.
3. The standard filter material showed lower levels of zinc, but higher levels of chloride, sulfate and sodium.

Power Module Conclusions

1. The wiping samples from the power module show high levels of zinc, sodium and chloride. Cleaning this area can be accomplished with a light wash with DI water and saponifier.

Microprocessor Conclusions

1. The microprocessor board showed no detectable zinc, but very high chloride levels in the area of the heavy dust. Cleaning this area can be accomplished with a light wash with DI water and saponifier.

But: what is the source of the contamination?

Experiment to grow Zinc Whiskers

Foresite conducted an experiment involving two zinc plated floor tiles taken from the ESD flooring where the power modules were stored. Neither tiles exhibited zinc whisker growth. To verify that neither tile exhibited zinc whiskers, each test site was inspected at 1000x magnification, and tape tested prior to any contaminant exposure

Three areas on each tile were used to assess whisker growth. Each of the selected areas were exposed to a different condition of cleanliness, were kept in an environmental chamber at 25°C / 85% RH and observed for 30 days. The humidity was controlled with 18 MΩ DI water, and not allowed to condense on the surface of the test sites. Both samples were grounded and placed vertically in the chamber. At the end of 30 day period, each area was tested for ionic cleanliness.

Initial observations of the zinc test sites

No zinc whiskers were seen on any of the six sites. The ionic analysis of the samples prior to testing showed low levels of chloride, sulfate and zinc. Each sample was locally extracted using the micro steaming system of the C3 tester. The ionic analysis was done using the Dionex AS4A-SC and the CS12 columns with conductivity detection. The Zinc analysis was done with the PAR UV-Vis post reaction test method and the CS12 column.

Baseline Ionic Data

Ion Chromatography

Anion Data (-)				
Sample Description	Cl-	Br-	SO4	NO3
<i>Data prior to contamination exposure</i>				
1A - No additional water - Control	0.27	0.00	0.17	0.00
2A - No Additional Water - Control	0.19	0.00	0.16	0.00
1B - Soapy Tap Water	0.29	0.00	0.21	0.00
2B - Soapy Tap Water	0.26	0.00	0.27	0.00
1C - DI Water	0.24	0.00	0.19	0.00
2C - DI Water	0.21	0.00	0.21	0.00

Table 3

Cation Data (+)				
Sample Description	Na	Zn	K	NH4
<i>Data prior to contamination exposure</i>				
1A - No additional water - Control	0.29	0.00	0.00	0.00
2A - No Additional Water - Control	0.33	0.00	0.00	0.00
1B - Soapy Tap Water	0.34	0.00	0.00	0.00

2B - Soapy Tap Water	0.37	0.00	0.00	0.00
1C - DI Water	0.24	0.00	0.00	0.00
2C - DI Water	0.29	0.00	0.00	0.00

Table 4

Ionic Data at the End of 30 days

Anion Data (-)				
Sample Description	Cl-	Br-	SO4	NO3
<i>Data prior to contamination exposure</i>				
1A - No additional water - Control	0.51	0.00	0.33	0.00
2A - No Additional Water - Control	0.49	0.00	0.34	0.00
1B - Soapy Tap Water	12.39	0.00	9.24	0.00
2B - Soapy Tap Water	13.25	0.00	10.68	0.00
1C - DI Water	0.15	0.00	0.19	0.00
2C - DI Water	0.12	0.00	0.21	0.00

Table 5

Cation Data (+)				
Sample Description	Na	Zn	K	NH4
<i>Data prior to contamination exposure</i>				
1A - No additional water - Control	1.08	0.00	0.00	0.00
2A - No Additional Water - Control	1.29	0.00	0.00	0.00
1B - Soapy Tap Water	1.21	25.65	0.00	3.24
2B - Soapy Tap Water	1.24	15.64	0.00	4.26
1C - DI Water	1.09	0.00	0.00	0.00
2C - DI Water	1.01	0.00	0.00	0.00

Table 6

Visual Observations

Visual Observations (1000x)	Week	Week	Week	Week
Sample Description	1	2	3	4
1A - No additional water - Control	No Whiskers	No Whiskers	No Whiskers	No Whiskers
2A - No Additional Water - Control	No Whiskers	No Whiskers	No Whiskers	No Whiskers
1B - Soapy Tap Water	5 per field	19 per field	34 per field	57 per field
2B - Soapy Tap Water	2 per field	4 per field	22 per field	41 per field
1C - DI Water	No Whiskers	No Whiskers	No Whiskers	No Whiskers

2C - DI Water	No Whiskers	No Whiskers	No Whiskers	No Whiskers
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Table 7

Conclusions

Without the proper level of ionic contamination, there is no zinc whisker growth as evidence by the test results indicated in Table 7. However, the presence of chloride, sulfate and amines seem to be directly related to the growth of zinc whiskers on zinc plated ground planes for floor tile.

The flooring in the factory was the root cause of the zinc whiskers due to a transference of zinc laden debris from the air system and the redeposit of the conductive dust particles on the power modules.

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