

Quantitative Determination of the Corrosion Resistance of Conductive Elastomers:

Part III. Materials Based on
Silver-Plated Aluminum Fillers
(Various Manufacturers)

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1 SUMMARY

A test program was conducted to determine the corrosivity (toward aluminum) and electrical stability of silver-plated-aluminum filled fluorosilicone elastomers subjected to salt fog exposure. The materials tested included MIL-G-83528B, Type D conductive elastomers from four competitors and a new material from Chomerics, CHO-SEAL® 1298. The elastomer-aluminum couples were exposed to 168 hours of neutral (ASTM 8117) salt fog.

The materials tested exhibited a wide range of corrosivity and stability. Corrosivities ranged from a 2.2 mg weight loss (CHO-SEAL 1298) to a 7.5 mg weight loss (competitor T material). CHO-SEAL 1298 and the materials from competitors S, J and T were electrically stable in salt fog, but competitor P's material underwent physical and electrical degradation resulting in an order-of-magnitude increase in volume resistivity.

These results demonstrate that the silver-plated-aluminum materials produced by five suppliers have different degrees of corrosion resistance. Specification MIL-G-835288 does not contain a corrosion resistance requirement. CHO-SEAL 1298 material offers the best combination of low corrosivity and electrical stability in a salt fog environment.

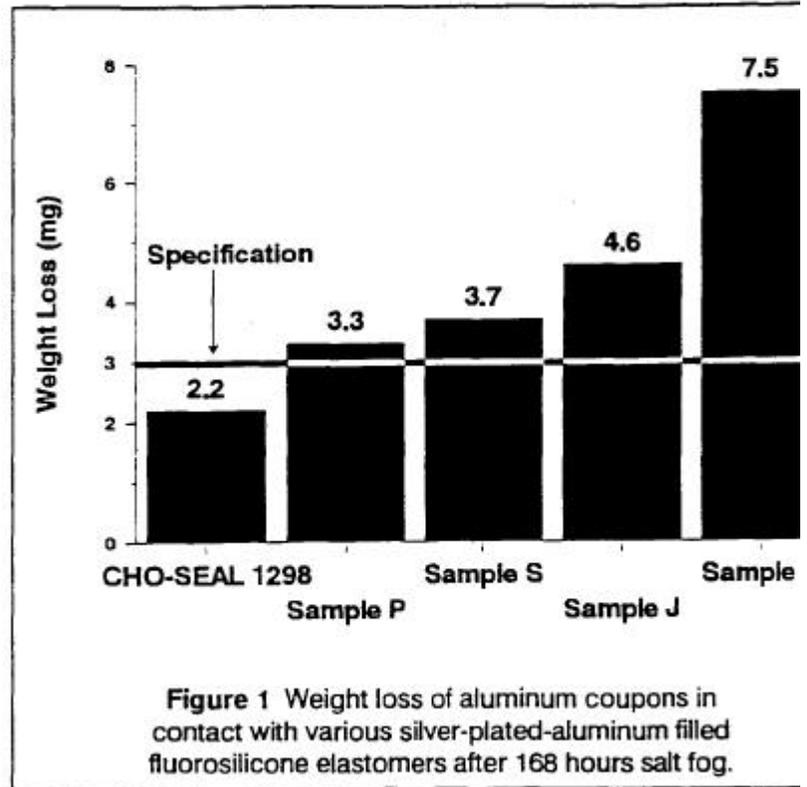
2 INTRODUCTION

EMI shielding requirements for electronic systems are becoming increasingly stringent in military and commercial aerospace systems.

This has led to increased use of conductive gaskets, sealants, and coatings ("conductive materials"). Such materials are used to provide low impedance interface between mating joints electronic enclosures and to enhance the shielding effectiveness of aircraft structures. The conductive materials usually incorporate silver, silver-plated particles or fibers, copper, nickel, graphite, monel, or other metals. The electronic enclosures and structural components are typically made from aluminum alloys. When exposed to corrosive environments, a galvanic couple will exist between the conductive material and the aluminum. This can result in corrosion of the aluminum, which is less noble than the conductive interface material. Depending on the type of conductive material, it too may deteriorate in a corrosive environment. Shielding effectiveness can degrade because of this conductivity loss or due to the buildup of nonconductive corrosion products between the conductive material and the mating flange.

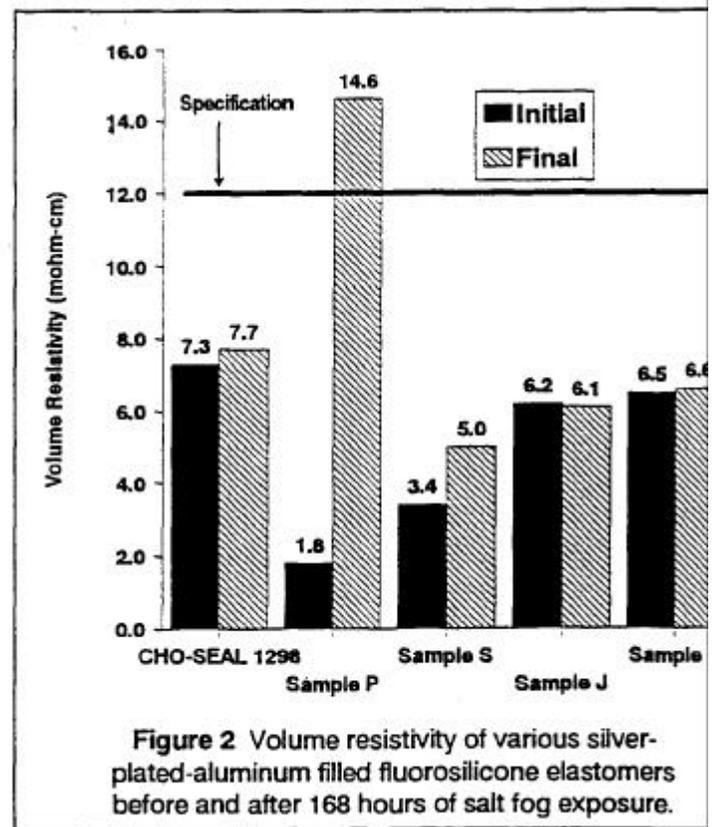
The foregoing discussion points to three aspects of conductive gasket "corrosion resistance." The primary aspect is corrosion of the mating aluminum flange material at the outer portion of the conductive gasket-flange interface. A second aspect is the ability of the conductive gasket to act as an environmental seal and prevent salt ingress between itself and the aluminum mating surface. A third aspect is the ability of the conductive gasket to maintain the shielding and sealing integrity of the enclosure structure. All three aspects are important. A significant loss of conductivity may lead to a low corrosivity toward aluminum, but the conductive gasket will fail to be effective as a shielding aid.

Conductive elastomers include silicones, fluorosilicones, EPDM, or fluorocarbon elastomers filled with silver, silver-plated core particles (copper, glass, aluminum, nickel), nickel, or carbon. They offer the best intrinsic sealing ability of any type of conductive gasket. Previous work ^{1,2,3} showed that CHO-SEAL 1298 material, a silver-plated aluminum filled fluorosilicone, was significantly less corrosive than silver, silver-plated-copper/nickel/glass, nickel, and carbon-filled elastomers. In this study, the corrosivity and stability of several other silver-plated-aluminum filled fluorosilicone materials was determined after salt fog exposure.



3 TEST PROCEDURE

The conductive elastomers tested were MIL-G-8352884 Type D materials from four competitors and Chomerics' CHO-SEAL 1298 material. Circular die cut samples of each material were compressed against 6061-T6 aluminum alloy test coupons (with a MIL-C-5541, Class 3 chromate conversion coating). The



1 P. Lessner, "Quantitative Determination of the Corrosion Resistance of Conductive Elastomers: Part 1. Materials Based on Silver and Silver Plated Fillers", Report No. CHO-TR19A, Chomerics, Inc., Woburn, MA, August, 1992.
 2 P. Lessner, 'Quantitative Determination of the Corrosion Resistance of Conductive Elastomers: Part II. Materials Based on Nickel and Nickel Coated Fillers', Report No. CHO-TR19B, Chomerics, Inc., Woburn, MA, September 1992.
 3 P. Lessner, 'Competitor Product Evaluation: Carbon Filled TPE Elastomer Corrosion Resistance', Report No. CHO-TC002, Chomerics, Inc., Woburn, MA, September, 1992
 4 "Gasketing Material, Conductive, Shielding Gasket, Electronic, Elastomer, EMI/RFI, General Specifications For", MIL-G-835288, United States Military Specification, July 1992.

aluminum coupon was weighed and the conductive elastomer thickness and volume resistivity were determined before assembly. Each fixture was bolted to a tray held at a 75° angle to the horizontal to allow for salt solution drainage. The fixtures were exposed for 168 hours in a Singleton Model 22 salt fog chamber. The chamber operating conditions were set according to ASTM 8117.

After salt fog exposure, the fixtures were disassembled. The aluminum coupon was cleaned for 15 minutes in concentrated nitric acid, rinsed, dried for one hour at 10W C, allowed to cool in a desiccator, and then weighed. Aluminum weight loss (removal) was calculated from the difference between the initial and final weights. The post-exposure volume resistivity and the thickness of the conductive elastomer were also determined.

Further details on the dimensions of the test specimens and test method can be found in CHO-TM1005

4 TEST RESULTS

Figure 1 shows the corrosivities of each material tested, expressed as aluminum weight loss. CHO-SEAL 1298 material is the least corrosive (2.2 mg average weight loss). Competitors P (3.3 mg), S (3.7 mg), and J (4.6 mg) materials are of intermediate corrosivity, and competitor T's material is the most corrosive (7.5 mg). T material is 3.4 times as corrosive as CHO-SEAL 1298.

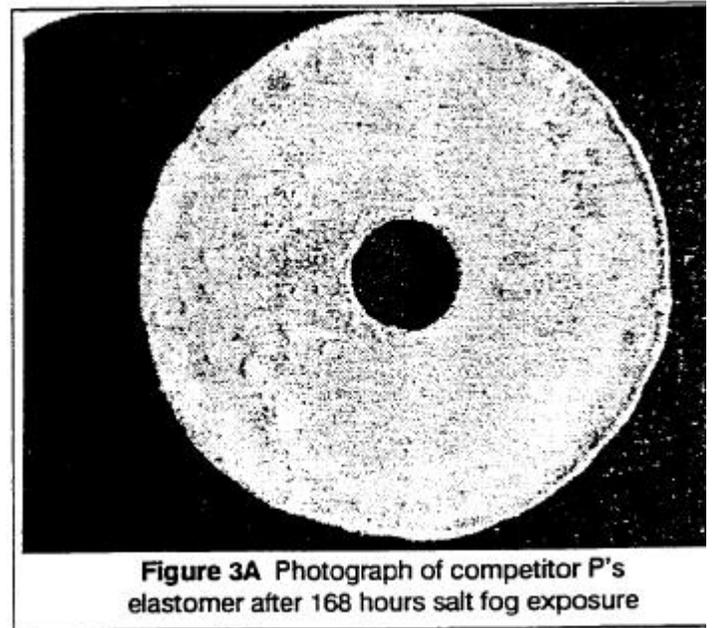


Figure 3A Photograph of competitor P's elastomer after 168 hours salt fog exposure

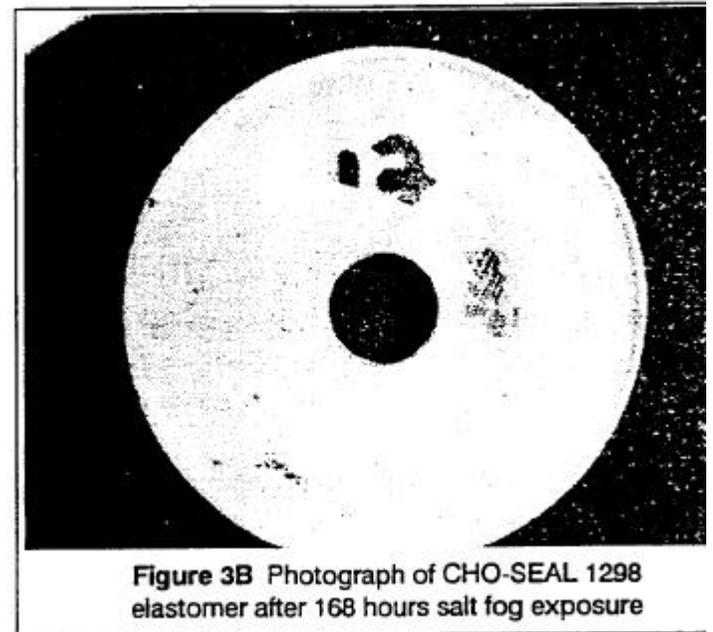


Figure 3B Photograph of CHO-SEAL 1298 elastomer after 168 hours salt fog exposure

Figure 2 shows the average volume resistivity of the elastomers samples before and after salt fog exposure. The CHO-SEAL 1298, J and T elastomers underwent little change in volume resistivity after salt fog exposure. Competitor S's elastomer showed an increase, but the final volume resistivity was still well within MIL-G-835288, Type D requirements.

Competitor P's material had low initial volume resistivity, but it increased to over 14 mohm-cm after salt fog exposure. Figure 3A is a photograph of one P material sample after salt fog exposure. The surface of the elastomer has many blistered areas; blisters were found on all of the P samples after salt fog exposure. The sample had a distorted circular shape. Figure 313 is a photograph of a CHO-SEAL 1298 sample

difference in corrosivity between silver-plated-aluminum and other silver-plated fillers were proposed. The aluminum core undergoes some corrosion instead of the mating aluminum flange material (i.e., the core is sacrificial). A key to successful formulation of a silver-plated-aluminum-filled elastomer is to balance the sacrificial nature of the aluminum core against the electrical and physical stability of the

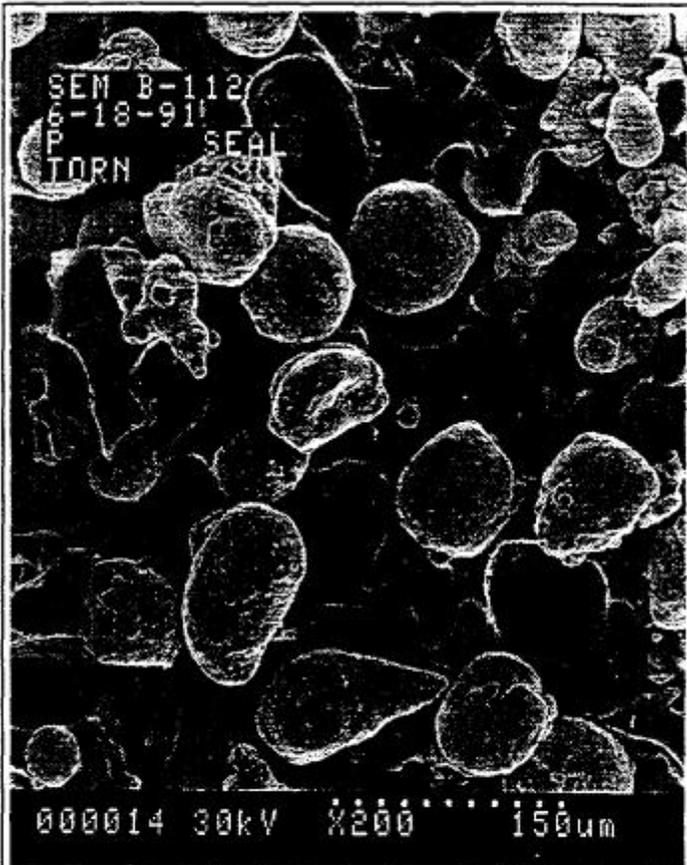


Figure 4A SEM photomicrograph of P material filler particles before salt fog exposure

after salt fog exposure. There was no blistering or distortion of any CHO-SEAL 1298 samples.

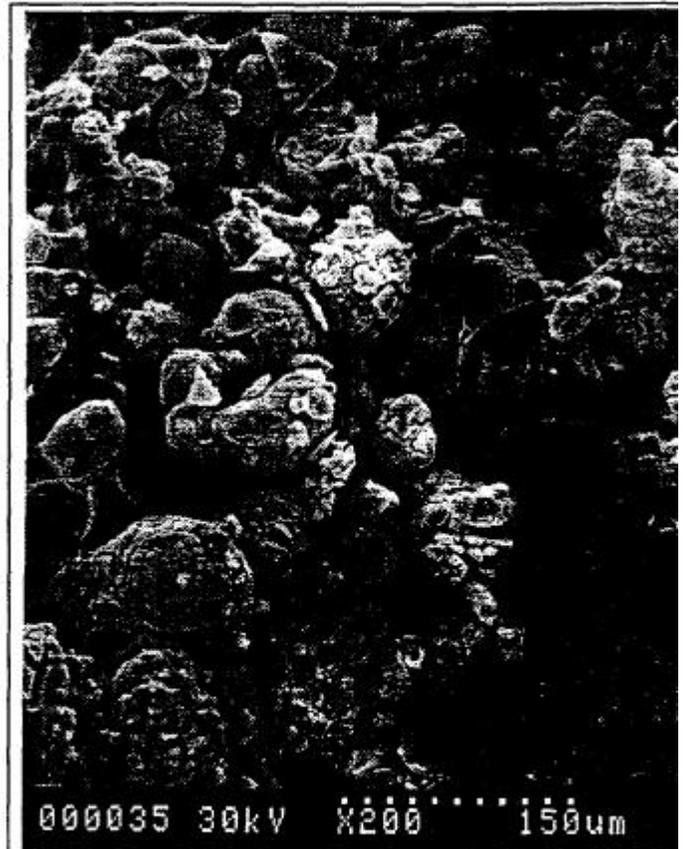


Figure 4B SEM photomicrograph of P material filler particles after salt fog exposure

conductive elastomer. The choice of core material and the method of silver plating determines the stability of the filler. The morphology of the silver plating and the particle size control the rate of oxygen reduction (cathodic reaction); this is another factor which affects the corrosion rate of the aluminum flange. The binder formulation (e.g., corrosion inhibitor:

5 DISCUSSION

In a prior report, (P. Lessner, "Quantitative Determination of the Corrosion Resistance of

and stabilizing additives) also affects the overall conductive elastomer stability.

Instability of the silver-plated aluminum filler particles causes the electrical instability of the P material. The elastomer surface blisters due to corrosion of the particles. Figures 4A and 4B show the P material filler particles before and

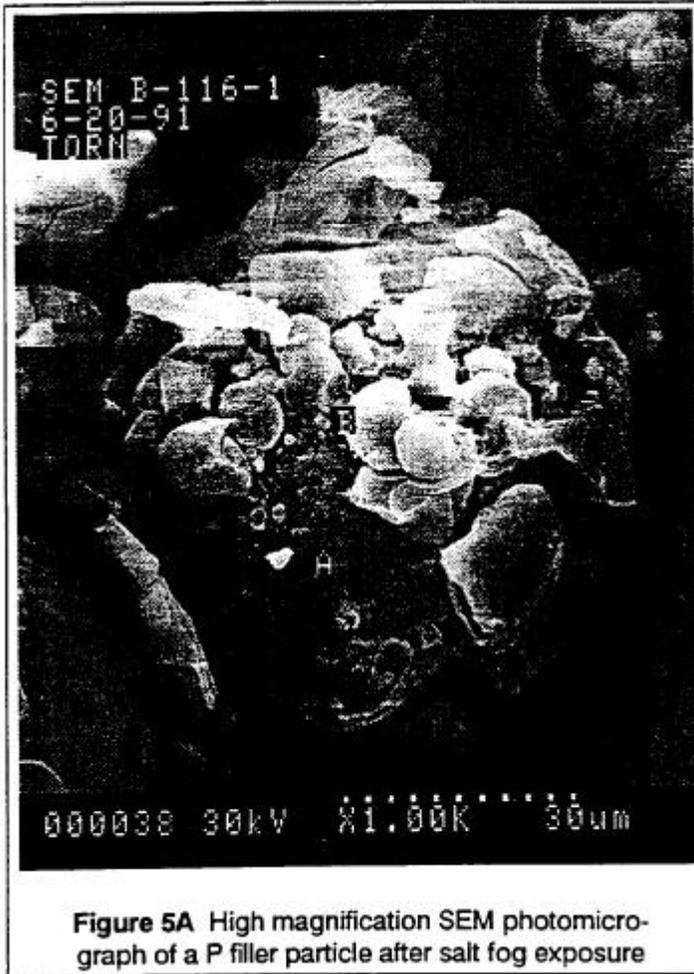


Figure 5A High magnification SEM photomicrograph of a P filler particle after salt fog exposure. Cracking of the silver plating and particle expansion occurred. Figure 5A shows a higher magnification SEM photomicrograph of a P filler particle in an advanced stage of degradation. Energy dispersive X-ray analysis (Figures 5B and 5C) shows that the silver plating became disbonded from the core, and large areas of aluminum were exposed.

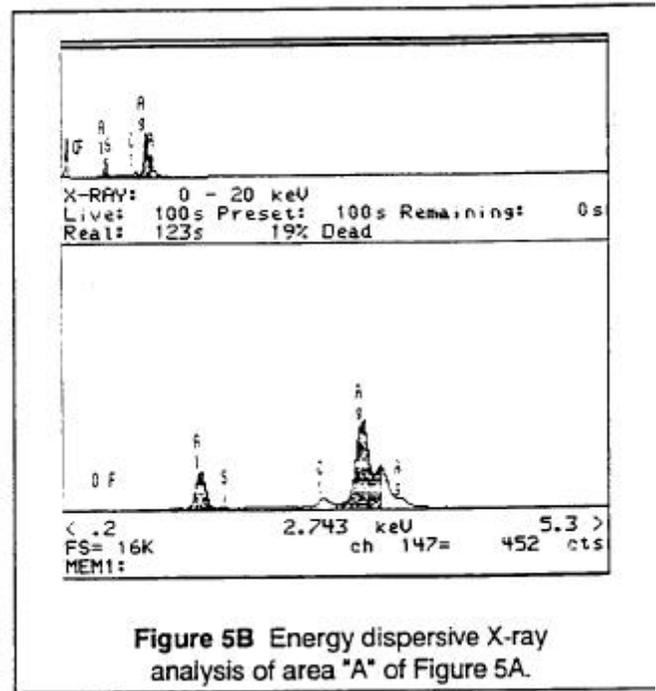


Figure 5B Energy dispersive X-ray analysis of area "A" of Figure 5A.

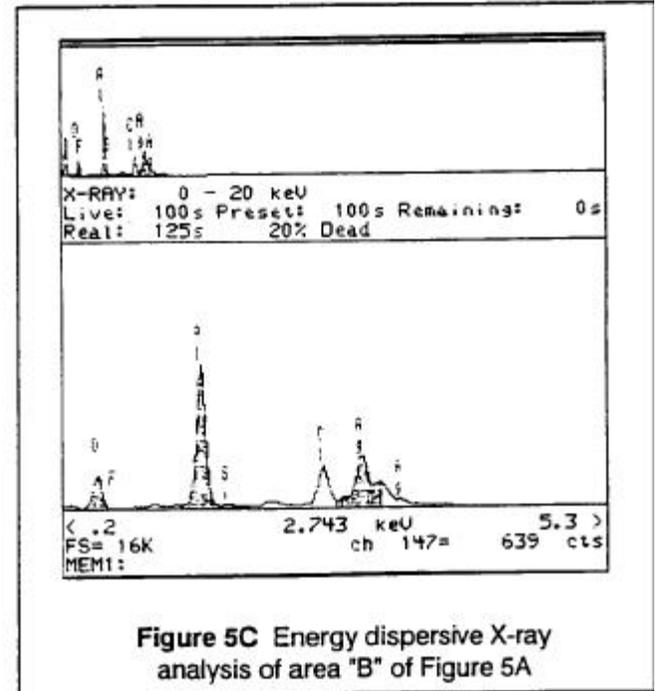


Figure 5C Energy dispersive X-ray analysis of area "B" of Figure 5A

6 CONCLUSION

The silver-plated-aluminum filled fluorosilicone elastomers exhibited a wide range of corrosivity and stability after salt fog exposure. The corrosivity ranged from 2.2 mg weight loss (CHO-SEAL 1298) to 7.5 mg weight loss (competitor T's material). CHO-SEAL 1298 and

competitors S, J, and T materials were all electrically stable in salt fog. However, competitor P's material blistered and underwent an order-of-magnitude increase in volume resistivity.

These results demonstrate that silverplated-aluminum materials produced by different suppliers have different corrosion resistance properties. This is not surprising, considering that neither MIL-G-835288 nor any other military or commercial specification covering conductive elastomers contains a corrosion resistance requirement. CHO-SEAL 1298 material offers the best combination of low corrosivity and high electrical stability in a salt fog environment.

7 ACKNOWLEDGEMENTS

David Greenwood, Russ Lucia and Li-Mei Huang obtained the experimental corrosion data. Tom Clement did the SEM and Energy dispersive X-Ray analyses.