Shielding Characteristics of Aluminum-compatible Gaskets

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INTRODUCTION

Sophisticated electronic devices require high levels of EMI shielding. Shielding components, including gaskets, are often necessary to maintain shielding integrity. Enclosures that use these EMI products are often fabricated from aluminum. Under certain environmental conditions, galvanic corrosion can occur between the aluminum enclosures and the gaskets, which were historically filled with silver-coated particles. A new conductive particle has been developed and designed to provide EMI shielding while minimizing galvanic corrosion of the aluminum. This material has been compounded into EMI gaskets and its shielding effectiveness has been tested and compared to silver-copper and silver-aluminum-filled gaskets before and after prolonged exposure to a salt spray environment. This study showed that gaskets compounded with the aluminum-compatible particle survived over 3500 hours of salt spray while maintaining a shielding effectiveness of 80 dB, thus ensuring an effective EMI seal in corrosive environments.

TEST RESULTS

Three types of gaskets were used in this study. Silicone rubber-based gaskets were prepared using silver-coated aluminum and silver-coated copper to meet MIL-G-83528. A third gasket, using the new aluminum-compatible particle to minimize galvanic corrosion, was also included in this study. The physical properties and electromagnetic pulse survivability of the experimental aluminum-compatible gasket were measured. In addition, all three gaskets were exposed to salt spray conditions and tested for shielding effectiveness at various intervals.

Conductive gaskets are now available which minimize galvanic corrosion of aluminum.

PHYSICAL PROPERTIES

After compounding, the physical properties of the aluminum-compatible gaskets were measured using standard test protocol. These properties were similar to those obtained from silver-coated metal-filled gaskets. Actual measurements are given in Table 1.

ELECTROMAGNETIC PULSE SURVIVABILITY

A gasket filled with the aluminum-compatible particles was subjected to EMP in accordance with MIL-G-83528A, Section 4.6.16. The test sample was three inches mean diameter with an average thickness of 0.062 inch and a width of 0.07 inch. As indicated in Table 2, the gasket survived electromagnetic pulse.

SALT SPRAY

An 18 cubic foot heated fog chamber, constructed in accordance with ASTM B-117, was used to simulate a salt spray environment. Temperature in the exposure zone was thermostatically maintained at 35°C (95°F). The humidifying tower was maintained at 48± 1°C (118± 2°F). Air pressure of 15 psi was used to provide the fog.

A salt solution containing 5 percent by weight USP sodium chloride was prepared using deionized water. Initial pH of the solution was 7.2 with a specific gravity of 1.030 g/cc. After spraying for 48 hours, the pH was 6.5 with a specific gravity of 1.033 g/cc, and after 148 hours, the pH was 6.9 with a specific gravity of 1.037 g/cc. These values fall within the ASTM-B-117 ranges of pH 6.5 to 7.2 and specific gravity of 1.0255 to 1.0400 g/cc.

TEST FIXTURE

To simulate gasket use in the field, aluminum test fixtures based on a design by the Naval Air Development Center (now called the Naval Air Warfare Center, Aircraft Division) in Warminster, PA, were used. These fixtures (Figure 1) contain a top and bottom plate on each side so that the EMI rubber gasket will be permanently mounted on one side and not be disturbed or removed for EMI shielding tests. On the other side, a nonconductive rubber gasket was used to close the fixture. The plate and gasket were removed after each salt spray exposure and the fixture was directly mounted to the plate of the shielding enclosure to test the shielding effectiveness. Test fixtures were also examined for visual signs of corrosion after each cycle of salt spray exposure.

At 250 hours, the fixture contain-

*See Advertisement on Page 291.

PROPERTY TESTED	TEST METHOD	TEST DATA
Volume Resistivity, ohm-cm	MIL-G-83528 (Pressure Probe)	2.5
	MIL-G-83528 (Surface Probe)	5.2
Durometer, Shore A	ASTM-D-2240	70±7
Tensile Strength, psi	ASTM-D-412	200 min.
Elongation, %	ASTM-D-412	100/300
Tear Strength, ppi	ASTM-D-624	25 min.
Specific Gravity	ASTM-D-792	2.5 ±13%
Volume Resistivity, (ohm-cm) After 48 hrs @200°C QA-1074	MIL-G-83528A Section 4.6.15	<10.0
Volume Resistivity, (ohm-cm) After 1000 hrs @160°C QA-1074	MIL-G-83528A Section 4.6.15	<10.0
Avg. Shielding Effectiveness, dB (1 MHz - 10 GHz)	MIL-G-83528A Section 4.6.12	96.0
EMP Survivability	MIL-G-83528A Section 4.6.16	Survived
Compression Set (%) 70 hrs @ 100°C	ASTM-D-395 Method B	<30.0
Electrical Stability After Break (ohm-cm) QA-1039	Modified ASTM-D-412	<10.0
Compression Deflection @100 psi (%)	ASTM-D-575 Method B	>3.5

***TABLE 1.** Physical Properties of an Aluminum-compatible Gasket.*

	PRETEST	POST-TEST	DEVIATION
Resistance	$2.92 \bullet 10^{-2}$ ohms	$9.40 \bullet 10^{-3}$ ohms	-68.1%
Volume Resistivity	$5.18 \bullet 10^{-1}$ ohm-cm	$1.65 \bullet 10^{-1}$ ohm-cm	-68.1%
Status		Pass	
PULSE CONDITIONS: Current Pulse: 9000 A Frequency: 1.18 MHz Decay Time: 991 ns			

***TABLE 2.** EMP Survivability Test Results.*

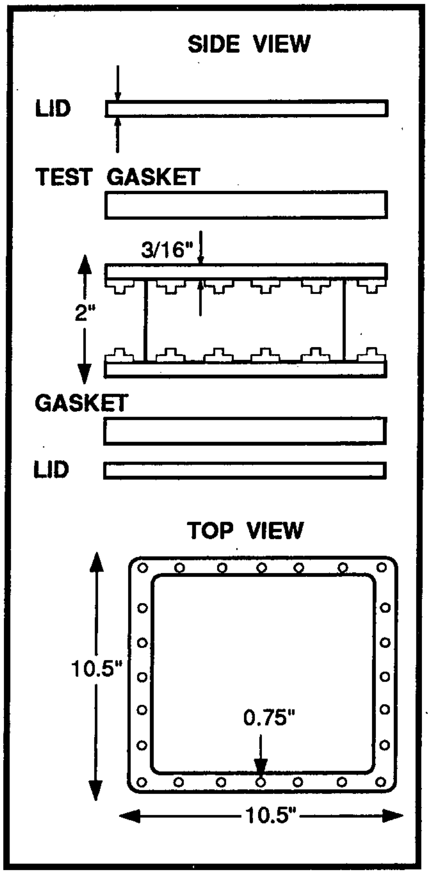

***FIGURE 1.** Salt Fog/EMI Test Fixture.*

ing the silver-copper-filled gasket exhibited the beginning stages of corrosion. At 2500 hours, the fixture containing the silver-aluminum-filled gasket showed evidence of corrosion. At 3500 hours, the silver-copper gasket and fixture were severely corroded; the silver-aluminum gasket and fixture were moderately corroded; and the aluminum-compatible gasket set showed very little corrosion. (Figures 2 and 3).

SHIELDING EFFECTIVENESS

Test fixtures containing gaskets filled with aluminum-compatible particles, silver-coated aluminum and silver-coated copper were tested for shielding effectiveness in the 1 MHz to 10 GHz frequency range in accordance with the test setup described in MIL-G-83528, Section 4.6.12, and MIL-STD-285 (Figure 4).

These fixtures were then placed in a salt spray chamber. At the end of 250, 750, 1500 and 2500 hours, the fixtures were removed and tested for shielding effectiveness. The test was concluded at 3500 hours and a final shielding effectiveness measurement was taken. The silver-coated copper sample retained only 73.4 percent of its original shielding effectiveness over the test period, while the silver-aluminum and aluminum-compatible gaskets maintained over 85 percent of their original shielding effectiveness. The average shielding effectiveness values are graphed in Figure 5.

It is important to note that although the shielding effectiveness of the silver-aluminum and aluminum-compatible gaskets were similar, the silver-aluminum gasket and fixture were moderately corroded while the aluminum-compatible gasket showed very little corrosion (Figures 2 and 3), thereby ensuring an effective environmental seal.

SUMMARY

This test program demonstrated that conductive gaskets filled with a new aluminum-compatible particle:

- Minimize the galvanic corrosion potential between filled gaskets and the aluminum enclosure. This ensures an effective environmental seal and maintains the integrity of the metal enclosure. As a result, electronic equipment maintenance costs

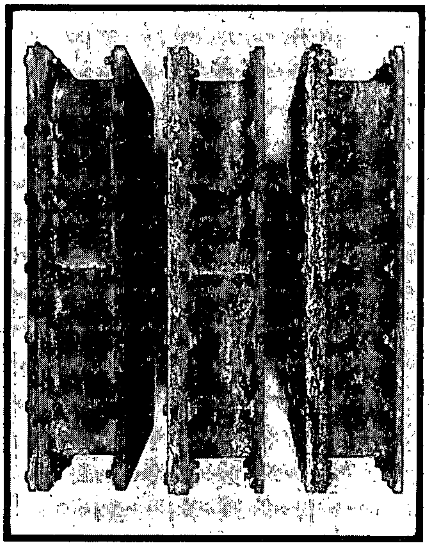

FIGURE 2. Closed Test Fixtures After 3500-Hour Salt Spray Exposure. From left to right: Aluminum-compatible filled gasket, silver-aluminum-filled gasket, silver-copper-filled gasket.

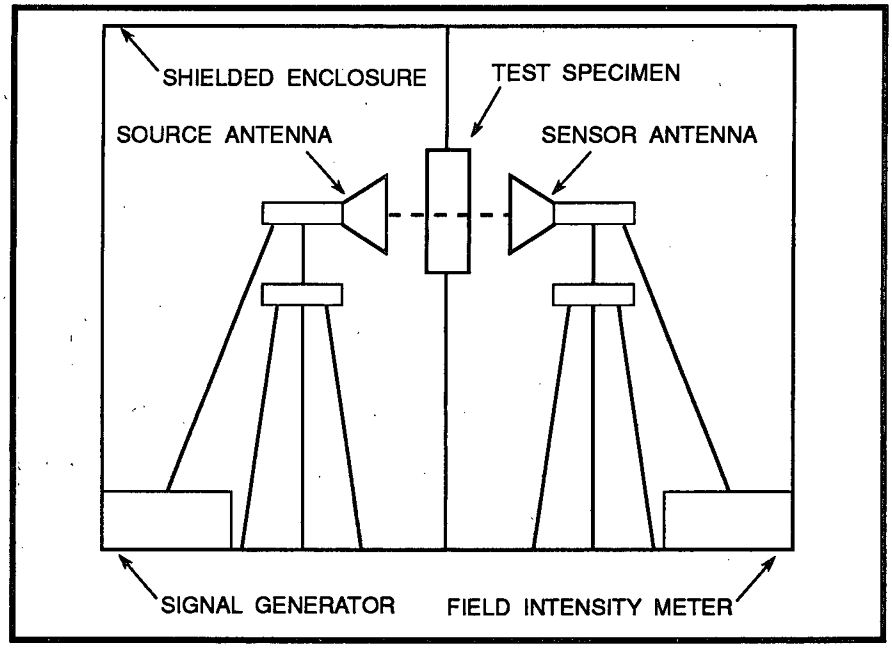

FIGURE 4. Shielding Test Setup.

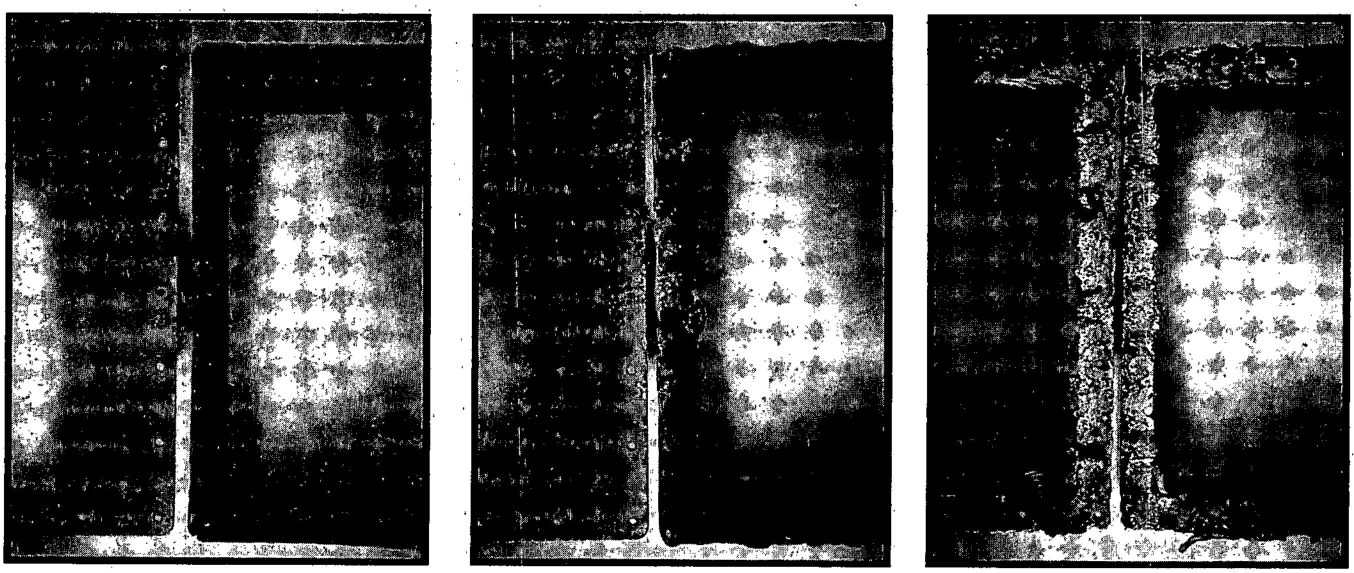

FIGURE 3. Open Test Fixtures After 3500-hour Salt Spray Exposure. From left to right: Aluminum-compatible filled gasket, silver-aluminum-filled gasket, silver-copper-filled gasket.

Continued on page 111

ures 4 and 5. Also plotted, for comparison, is data from tests performed with the cover plates mounted using the identical bolt pattern and shims, but with *no* gasket (to simulate a gasketless or nonconductive gasket system). Comparing the results from these tests to those which include the conductive fabric and silicone tube gaskets illustrates the benefit of an EMI gasket.

Designers of digital electronics equipment no longer need to "over-design" with military grade gasket materials or "under-design" with low performance gaskets or flange designs.

CONCLUSION

New types of commercial-grade EMI gaskets, offering the advantages of low cost, simple attachment and large deflection capability under modest closure force, have been demonstrated to provide over 60 dB of shielding effectiveness up to and beyond 1 GHz.

Designers of digital electronics equipment which must meet new EC emission and immunity requirements no longer need to "over-design" with military grade gasket materials or "under-design" with low performance gaskets or flange designs.

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SHIELDING CHARACTERISTICS OF ALUMINUM-COMPATIBLE GASKETS *. . . Continued from page 98*

are reduced, and gasket replacement costs are minimized.

- Survive over 3500 hours of salt spray exposure.
- Maintain shielding effectiveness of 80 dB in the 1 MHz to 10 GHz frequency range throughout salt spray exposure. This provides long-term product reliability.

In addition, the new aluminum-compatible particle is easily processed into silicone rubber to produce compounds which meet the typical physical properties of other particle-filled materials.

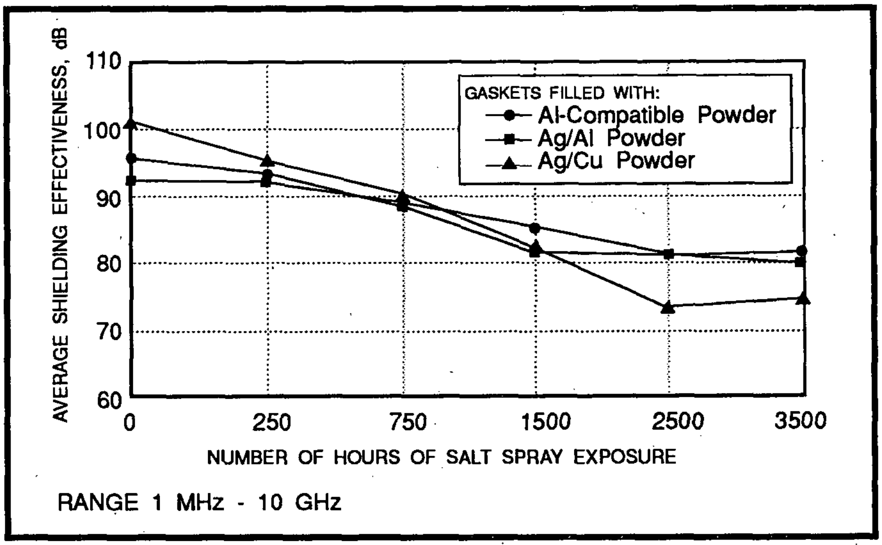

FIGURE 5. *Shielding Effectiveness vs. Salt Spray.*

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