Silver-glass-filled Gaskets Gain Military Specification Approval

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INTRODUCTION

The U.S. Air Force has recently approved silver-glass-filled conductive gaskets and have listed them as material type M in the military specification governing the use of conductive compounds (MIL-G-83528). The silver-glass materials are a light-weight, low-cost alternative to silver-coated copper, aluminum and nickel-filled systems.

To support their listing, the military specification grade silver-glass materials were tested for their vibration stability, EMP survivability, thermal aging stability and shielding effectiveness. Testing was conducted at DESC (Defense Electronic Supply Center) approved laboratories, and conducted under MIL-G-83528 procedures. This article presents the results.

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VIBRATION STABILITY

BACKGROUND

In 1977, a gasketing manufacturer evaluated the volume resistivity of silver-glass and silver-copper-filled gaskets that had been tested in a test fixture designed to simulate a vibratory environment. Their results showed the silver-copper material to be more electrically stable than the silver-glass gaskets. (Note: the silver-copper performance values promoted in the 1977 paper would not meet today's military standards.) The results of this paper were left unchallenged until 1987, when manufacturers of silver-glass particles and conductive gaskets allied themselves and developed a high performance, state-of-the-art silver-glass-filled elastomer to meet the military specification.

This material has proven, time and again, to be extremely stable during high frequency vibration. Qualification testing was conducted under MIL-G-83528, Section 4.6.13 protocol. The military specification limit requires the gasket to reach a maximum of 0.009 ohm-cm resistivity during vibration.

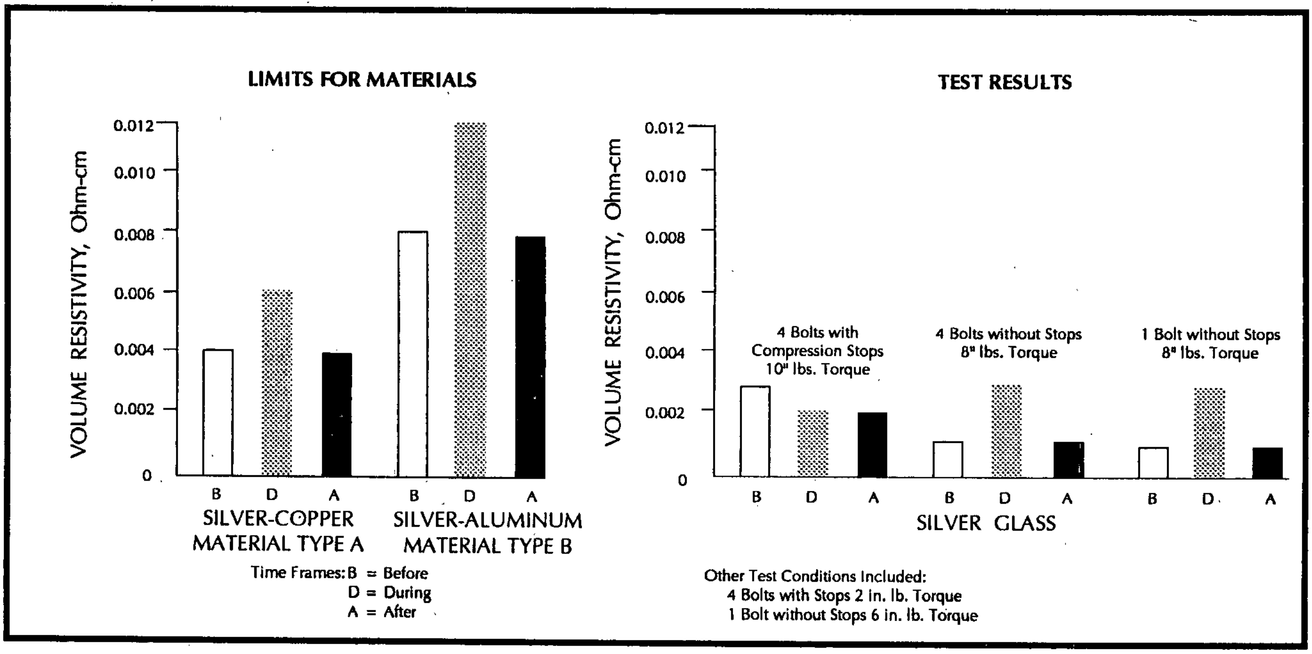


FIGURE 1. *Electrical Stability During Vibration of EMI Gaskets.*
NOTE: All Gaskets were 65 Shore A Hardness.

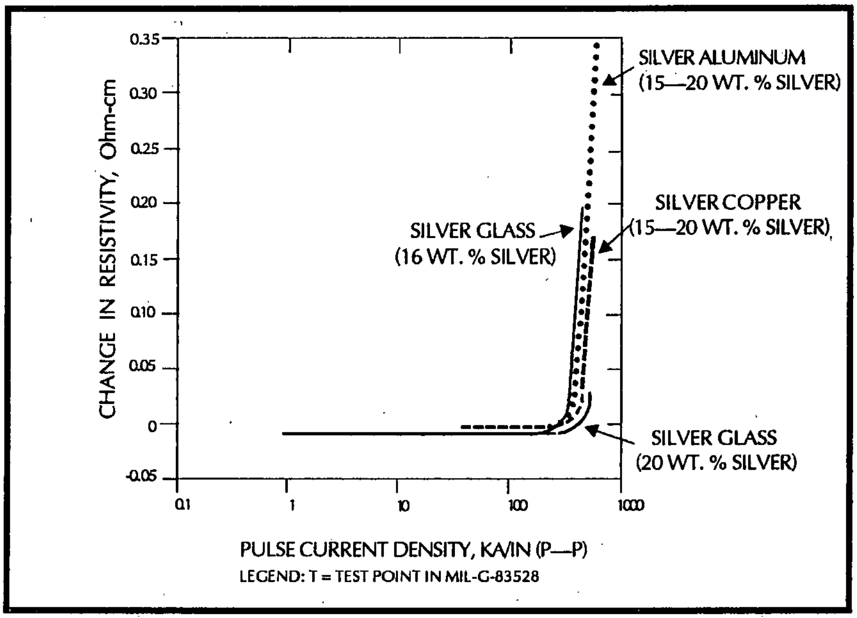
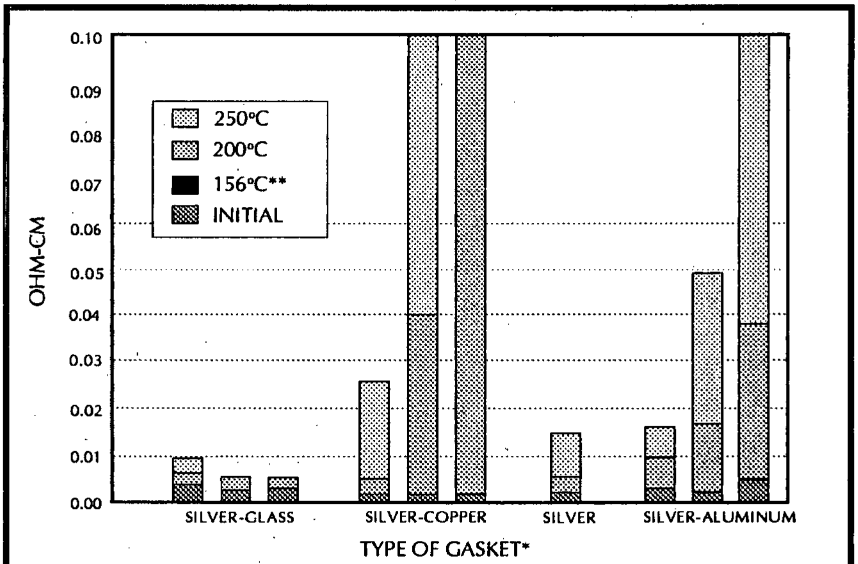


FIGURE 2. *EMP Survivability.*



- * Gaskets from three manufacturers were used in each silver-coated particle-filled system.
- ** Change neglible.

FIGURE 3. *Effect of Temperature on Aging, 48 Hours.*

Figure 1 shows the vibration stability of this material. It compares the limits for silver-glass material to the limits for silver-copper (Type A) and silver-aluminum (Type B) materials.

VIBRATION STABILITY TEST RESULTS

- Silver-glass-filled EMI gaskets maintain their high conductivity during the most severe vibration environments under MIL-G-83528 test procedures.
- Silver-glass-filled EMI gaskets are as stable under vibration as silver-copper and silver-aluminum-filled compounds.
- The shape of the conductive particles (sphere, irregular) has no bearing on the electrical stability under vibration of *properly made* conductive compounds.

ELECTROMAGNETIC PULSE SURVIVABILITY

Electromagnetic pulse testing was conducted on several commercial sources of silver-glass sphere EMI gaskets. The measurements were made according to the EMP qualification test procedures in MIL-G-83528, Section 4.6.16, and extended to very high intensity levels of simulated EMP. Comparisons of glass spheres with five different silver thickness levels were made to silver-aluminum, and silver-copper-filled materials. In all cases, the silver-glass spheres survived the military specification EMP criteria by very large margins. In fact, they survived pulse intensities far greater than the military specification test point. When conductive particles (silver, copper, glass, aluminum) are coated with the same weight-percent silver coverage, the EMP survivability is similar, as shown in Figure 2. Figure 2 illustrates that the break-down limit above the military specification test point is a function of the silver coating thickness on the particles. The silver-glass particles with a similar weight-percent silver coverage survives the same pulse intensities as silver-copper and silver-aluminum. Calculations show the very high thermal conductivity of silver coating protects the particle contact points from overheating.

EMP SURVIVABILITY TEST RESULTS

- Silver-glass-filled EMI gaskets survive and surpass EMP conditions per MIL-G-83528 testing procedures.
- Silver-glass compounds are equal to silver-copper and silver-aluminum in their pulse intensity failure point when they have the same silver content.

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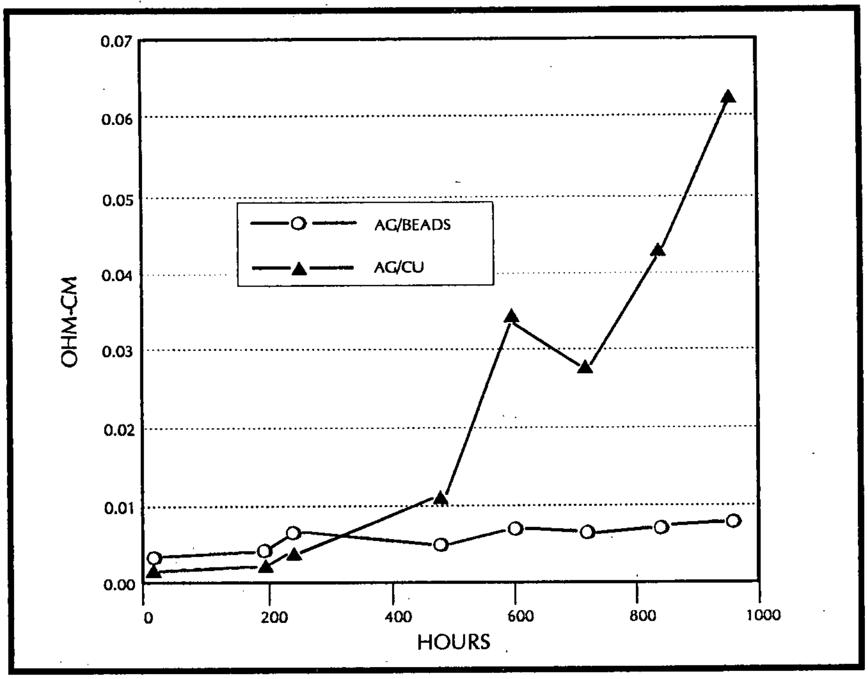

FIGURE 4. *Flanged Gasket Heat Aging, Surface Resistivity (200°C).*

FREQUENCY (Hz)	OPEN REFERENCE (dBm)	CLOSED ROOM REFERENCE (dBm)	SHIELDING EFFECTIVENESS (dB)
20 MHz	+10	< -126	>136
40 MHz	+20	< -126	>146
60 MHz	+20	< -126	>146
80 MHz	+20	< -126	>146
100 MHz	+20	< -126	>146
120 MHz	+20	< -126	>146
140 MHz	+20	< -126	>146
160 MHz	+20	< -126	>146
180 MHz	+20	< -126	>146
200 MHz	+20	< -126	>146
400 MHz	+20	< -126	>146
600 MHz	+20	< -126	>146
800 MHz	+22	< -126	>148
1 GHZ	+25	< -126	>151
2 GHZ	+28	< -110	>138
4 GHZ	+22	-104	122
6 GHZ	+20	-99	119
8 GHZ	+22	-98	120
10 GHZ	+20	-96	116
200 kHz ("H" Field) OdBm		-92	92

TABLE 1. *Shielding Effectiveness of Silver-glass-filled Silicones per MIL-G-83528.*

- All conductive particles ultimately reach a failure point (sudden increase in resistivity).
- A leading factor contributing to EMP survivability is the high thermal conductivity of the silver coating on the particle.
- The failure point can be controlled by increasing the silver thickness level.

THERMAL AGING STABILITY

Further testing of the military specification particle-filled gaskets to determine thermal aging stability was conducted. Samples of silver-glass, silver-copper and silver-aluminum particle-filled silicones were run at 250°C with volume resistivity measurements taken at time intervals of up to 48 hours. As illustrated by Figure 3, the silver-glass compound clearly exhibited superior heat aging stability with negligible increase in resistance at the full 48-hour time span over the as-received values. The other gaskets quickly and expectedly increased in resistivity as the test progressed.

A direct comparison was further made to compare the aging stability of the well established silver-copper-filled materials, to that of the silver-glass-filled systems. Test results for up to 1100 hours at 200°C follow. Additional research work is being developed to correlate the performance results of gaskets aged in a laboratory at time/temperature intervals to expected serviceable life in on-site conditions.

The exceptional aging stability of the silver-coated inert particles further supports the use of the silver-glass gaskets in critical shielding instances where it may be difficult to adhere to maintenance schedules, or where critical performance is required at all times (Figure 4).

SHIELDING EFFECTIVENESS

The shielding effectiveness of the silver-glass material is comparable to the other silver-coated particle-filled materials, as shown in Table 1.

SUMMARY

The results demonstrated that silver-glass-filled EMI gaskets are highly stable under severe vibration. The critical factor in

INSPECTION	UNITS	TOLERANCE	TYPE A SILVER COPPER	TYPE B SILVER ALUMINUM	TYPE M SILVER GLASS
Operating Temperature Range	°C °C		-55 +125	-55 +160	-55 +160
Specific Gravity	Sp gr	±13%	3.5	2.0	1.9
Hardness	Shore A units	±7	65	65	65
Compression/ Deflection	Percent	Min.	3.5	3.5	3.5
Tensile Strength	Pounds/ Sq. inch	Min.	200	200	200
Elongation	Percent	Min. Max.	100 300	100 300	100 300
Compression Set	Percent	Max.	32.0	32.0	30
Tear Strength	Pounds/ Inch	Min.	25	30	30
Volume Resistivity (as received)	Ohm-cm	Max.	.004	.008	.006
Shielding Effectiveness 20 MHz-10 GHz (E-Field)	dB	Min.	110	100	100
Electrical Stability during Vibration — During / After	Ohm-cm	Max.	.005 .004	.012 .008	.009 .006
Electrical Stability after Break	Ohm-cm	Max.	.008	.015	.009
Low Temperature Flex	°C	Max.	-55	-55	-55
Volume Resistivity (after life testing)	Ohm-cm	Max.	.010	.010	.015
EMP Survivability	kA per linear in. of perimeter	Min.	0.9	0.9	0.9
Fluid Immersion 2/ 3/	---	---	N/S	N/S	N/S

Manufacturers and users of conductive gaskets rely on MIL-G-83528 to list materials and processes that will satisfy their conductive shielding requirements cost effectively, and that reflect the state-of-the-art in conductive technology.

The high performance benefits of silver-glass materials, augmented by their light weight exceptional aging stability and low cost, support their use in critical applications.

***TABLE 2.** Performance Characteristics of Various Gaskets.*

this test is the compounding technique of the gasket, and not the conductive particle filler.

Moreover, silver-glass spheres were shown to survive pulses more than 300 times higher than required by the military specification. Here it is the thickness of the silver coating on the particle and its related high thermal conductivity that causes silver-glass additives to be completely unaffected by very high intensity EMP.

The most stable performance in the thermal aging test was demonstrated by silver-glass-filled gaskets, which work best in high operating temperatures and offer the longest useful service life.

A partial reprint of the characteristics of silver-copper, silver-aluminum and silver-glass, as detailed in MIL-G-83528, is given in Table 2.

Manufacturers and users of conductive gaskets rely on MIL-G-83528 to list materials and processes that will satisfy their conductive shielding requirements cost-effectively, and that reflect the state-of-the-art in conductive technology.

CONCLUSION

The high performance benefits of silver-glass materials, augmented by their light weight, exceptional aging stability and low cost, support their use in critical applications.

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