Development of Commercial Grade EMI Gaskets

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INTRODUCTION

Traditional EMI gasket materials were developed for defense and aerospace electronics equipment. The system shielding requirements for such applications were extremely high, and severe environmental exposures imposed additional requirements on gasket materials. Both the performance and cost of such EMI gaskets reflected the demanding requirements of military specifications.

More recently, EMI gasket manufacturers have responded to the need for commercial grade materials, suitable for computer, telecommunication and industrial electronic equipment, by developing a number of conductive gasket products based on entirely new concepts. Data show these new EMI gaskets to be 20 to 40 dB less effective than their high-end predecessors, but more than sufficient for most commercial applications. As new worldwide emission and immunity requirements become effective, the need for these commercial grade EMC components is expected to increase.

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BACKGROUND

Electronic enclosures, in addition to their obvious physical and mechanical functions, must usually provide sufficient EMI shielding to contain radiated emissions and to protect against radiated susceptibility. From the late 1950s to about 1985, most of the equipment which required such EMI protection was used in military avionics and defense electronics, and was designed to meet stringent EMC specifications. Typical shielding requirements were 80 dB to 18 GHz, with many applications needing 100 dB and protection to frequencies as high as 40 GHz.

Compounding these exacting military EMC specifications (such as MIL-STD-461) were additional environmental requirements to assure reliable performance of shipboard, airborne and space-based electronics. These requirements typically included resistance to salt spray, temperature extremes, UV, jet fuel, hydraulic oils, cleaning solvents, space vacuum, vibration, EMP and numerous other aggressive environmental factors. Not surprisingly, the EMI gaskets developed to meet these severe requirements were priced consistently with their performance level and development costs.

As application of commercial EMI regulations began to expand in the mid-1980s, a new class of EMI gasket materials was needed. Obviously, these commercial applications did not require the stringent performance and environmental characteristics of their military counterparts. Shielding levels of 20 to 40 dB up to 200 MHz were sufficient for most 1980s-era equipment with clock speeds under 10 MHz. EMI gaskets based on carbon fillers, or point contacts spaced 10 to 20 cm apart, were often sufficient.

Today's 20 to 200 MHz clocks tend to require shielding on the order of 40 to 60 dB, up to frequencies of about 1 GHz. Carbon-filled gaskets or 10 to 20 cm point contacts are no longer good enough, and military grade gaskets are too expensive and still pack more performance than needed. Clearly a major challenge faced both users and gasket suppliers.

DESIGN AND APPLICATION ISSUES

In many respects, the shielding of a commercial enclosure to 40 to 60 dB is even more difficult than shielding a military enclosure to 80 or even 100 dB. (Mechanical engineers should note: 80 dB represents 100 times more shielding than 40 dB). The reason for this surprising fact is that most military enclosures consist of substantial metal housings, with stiff access panels and covers, plenty of fasteners, and well-shielded cables and cable entries.

Commercial enclosures, on the other hand, are often made of thinner sheet metal or metallized plastic, with few fasteners and with large gaps around panel seams and other apertures. To effectively shield such enclosure seams, commercial equipment designers require EMI gaskets

*See Advertisement on Page 9.

which deflect easily under extremely low closure forces.

Other design issues critical to cost-effectiveness include gasket termination and attachment. Conventional knitted wire mesh EMI gaskets cannot be cut cleanly; their ends require costly, labor-intensive termination procedures. Attachment of conventional gaskets can also be labor-intensive or may require machined grooves for self-retention.

NEW DEVELOPMENTS

Three major new developments have resulted in low-cost EMI gaskets which provide 60 dB of shielding at frequencies greater than 1 GHz, and offer the necessary compliance for low closure force applications:

- Conductive fabric over a foam core, with adhesive backing.
- Hollow silicone tube with conductive surface coating.
- Clip-on knitted mesh or conductive elastomers.

Gaskets based on these new concepts are typically priced from one-tenth to one-half as much as military-grade gaskets.

The conductive fabric approach is especially suited to large, cabinet-type enclosures which require substantial gasket deflection with minimum closure force. Various versions of this concept are now offered. Some manufacturers blow a urethane foam into a jacket of conductive nylon fabric. Another approach involves knitting conductive "yarn" over a thermoplastic elastomer foam core. Its advantages include low cost, electrical stability, and the ability to be spooled without forming permanent creases. Deflection of over 40 percent can be achieved with less than 0.2 kg/cm of closure force. Figure 1 is a microphotograph of the surface cross section of a sample conductive fabric gasket.

The coated silicone tube approach is primarily suited for small cross-section gaskets used in portable or hand-held devices, such as cellular telephones. These gaskets can be produced in diameters as small as 1.0 mm, and are generally fitted into housing grooves or molded channels. A closure force of approximately 0.3 kg/cm is sufficient to achieve 40-percent gasket deflection.

Clip-on gaskets are now available with knitted wire mesh over a foam core. These constructions are preferred by some computer and telecom switch gear manufacturers over adhesive-backed gaskets, especially around doors. They generally incorporate a stainless steel spring clip with specially designed "teeth" to bite through panel paint and assure low impedance grounding. Figure 2 shows some examples of commercial grade clip-on gaskets.

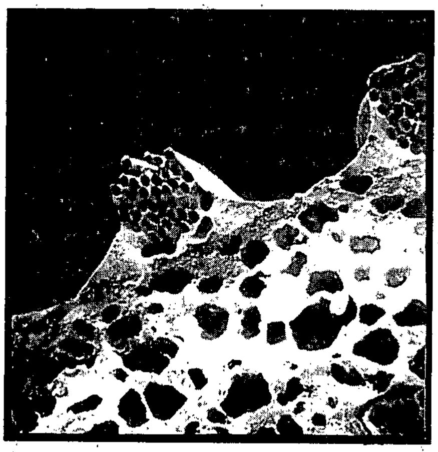

FIGURE 1. *Microphotograph of Conductive Fabric Gasket.*

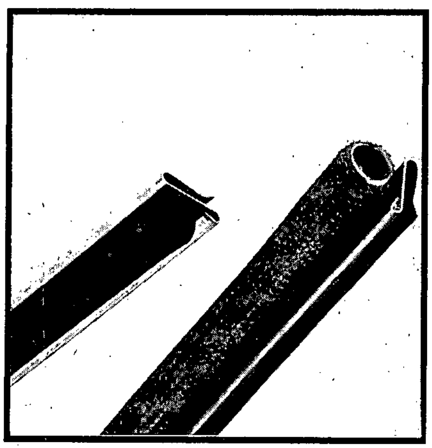

FIGURE 2. *Commercial Grade Clip-on Gaskets.*

Another recent development, suitable for use with any of these new EMI gasket products, is a premasked conductive flange tape which can eliminate plating of cabinet frames. Since both mating surfaces of enclosure joints must be highly conductive for good EMI protection, electronic cabinet frames are often tin-plated, then masked (on mating flange surfaces) and painted. One new tape provides stable, corrosion-resistant conductive flange surfaces without the need for plating or masking operations.

SHIELDING TESTS

Shielding effectiveness tests for radiated electric fields were performed in accordance with Paragraph 4.1.2 of MIL-STD-285, which describes methods and procedures for testing the attenuation characteristics of a shielded enclosure. A few modifications to the MIL-STD-285 method were made, as described below, to more appropriately characterize gasket performance rather than overall enclosure performance.

The shielding effectiveness tests were configured as shown in Figure 3. The test gasket was mounted to the flange of a test aperture on the wall of a shielded enclosure. The remainder of the enclosure had shielding integrity in excess of 120 dB, making it very suitable for measuring gasket materials in the 50 to 70 dB range.

Two modifications to the MIL-STD-285 method were incorporated. First, the open reference measurement was taken through the aperture in the wall of the shielded enclosure rather than in free space. This ensures that the attenuation of the aperture and

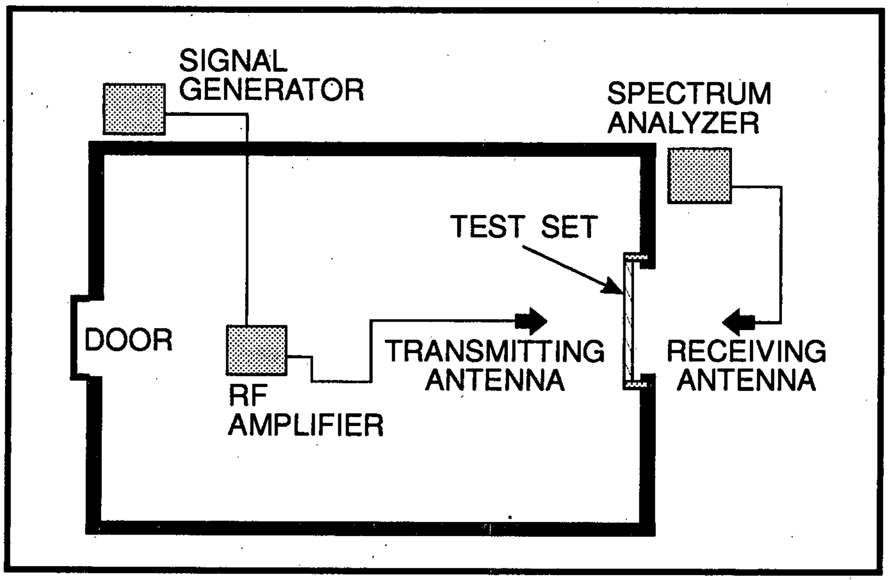

FIGURE 3. Shielded Enclosure Test Setup.

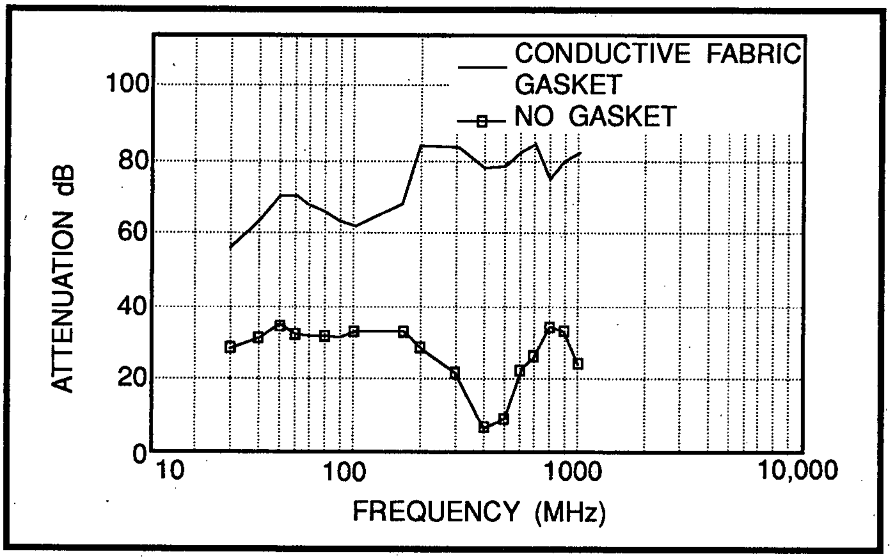

FIGURE 4. Shielding Test Results with Conductive Fabric Gasket.

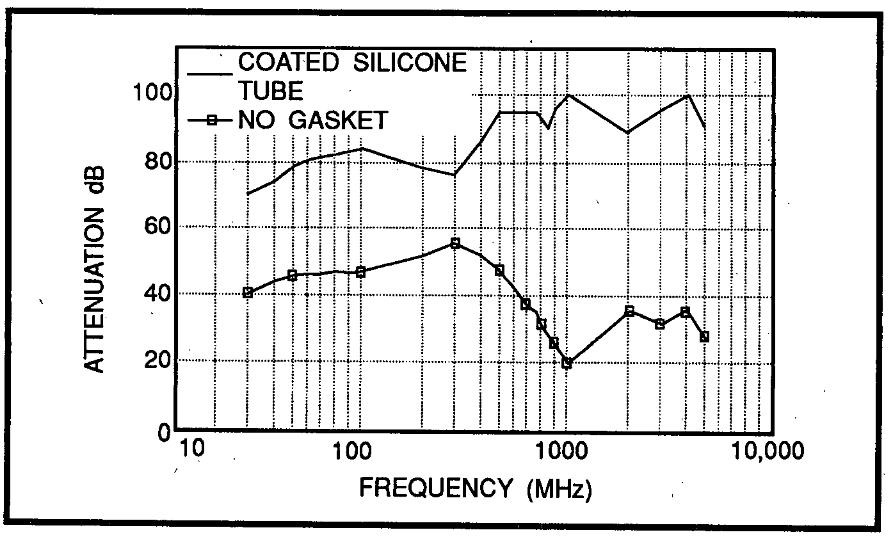

FIGURE 5. Shielding Test Results with Coated Silicone Tube.

the enclosure itself are characterized prior to gasket measurements. Second, shielding effectiveness was measured at 10 to 15 frequencies between 30 MHz and 5 GHz, rather than at a single frequency of 400 MHz.

The receiving antenna was placed inside the shielded enclosure. The transmitting antennas, signal generators, amplifiers and the spectrum analyzer were placed outside the shielded enclosure. In accordance with MIL-STD-285, the transmitting and receiving antennas were placed 0.6 meter apart plus the width of the cover plate. The spectrum analyzer and signal generator were placed 4.6 meters away from each other and on separate sides of the enclosure to achieve isolation between the transmit and receive test equipment.

As mentioned above, the reference measurement was taken through the open aperture with the antennas located as in the final test configuration. The closed reference was taken with the gasket mounted to the flange and deflected by a cover plate. Shielding effectiveness was calculated as the difference between the power level measured during the open reference and the power level recorded with the gasketed cover plate in place.

The test gasket made of conductive yarn was held in place by its pressure-sensitive adhesive backing, and tested under 50 percent deflection using a 0.6 by 0.6 meter aperture. The silicone tube test gasket was held in place by thin strips of copper tape spaced 15 cm apart, and was tested under 27 percent deflection using a 0.3 by 0.3 meter aperture. Gasket deflection was controlled by the use of plastic shims located at each fastener.

The shielding effectiveness measurements are illustrated in Figures 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.

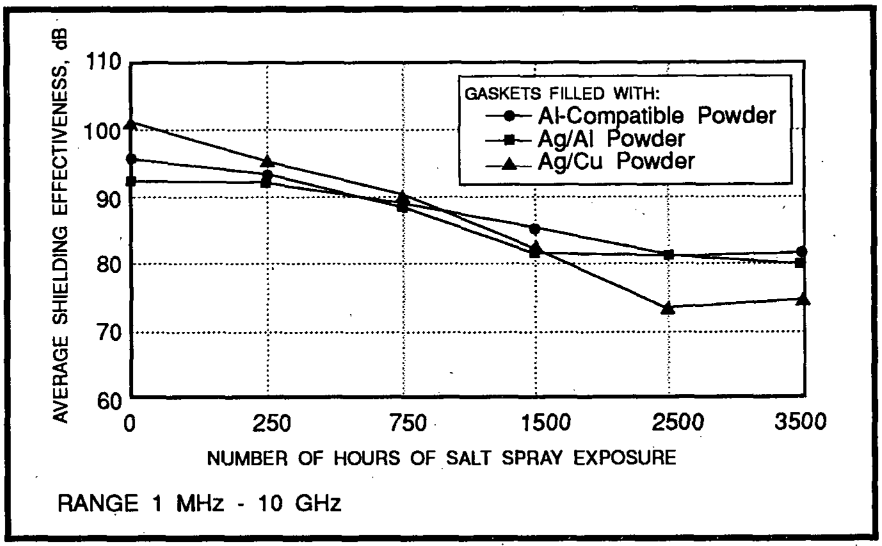

FIGURE 5. *Shielding Effectiveness vs. Salt Spray.*

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