COST-EFFECTIVE APPLICATIONS OF EMI GASKETS

EMI gaskets are used by the electrical/electronics industry for the purpose of complying with the FCC and VDE commercial EMI/RFI requirements. The costs associated with the use of gaskets, which include the purchase price, as well as the costs of applying and maintaining the gasket seal are of significant concern to the industry. This article discusses these cost factors and addresses the maintenance problems and liabilities associated with the selection and use of the various EMI gaskets available today. Guidelines are presented to maximize shielding effectiveness achieved with gaskets.

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INTRODUCTION

EMI gaskets are used extensively by the electrical/electronics industry to assist in complying with various EMI radiated emission requirements. These requirements include compliance to Department of Defense TEMPEST and EMI test limits, as well as FCC and VDE EMI test limits. Generally the radiated emission TEMPEST requirements are about two orders of magnitude (40 dB) more stringent than the DoD EMI requirements, and the DoD EMI radiated emission requirements are about two orders of magnitude (40 dB) more stringent than the FCC and VDE EMI requirements. This means that, in terms of difficulty, complying to the FCC and VDE requirements is relatively easy. However, the expense can be high in terms of the percentage increase in the cost of manufacturing the equipment. The FCC requires that the manufacturers of the equipment that falls under their jurisdiction be responsible for compliance throughout the life of the equipment. As such, the cost of not complying for the life span of the equipment can be very costly (i.e., redesign and retrofit can result in a catastrophic cost).

The cost of complying with the FCC (as well as DoD, EMI and TEMPEST) radiated emission requirements can be reduced to within acceptable limits by understanding the problems associated with the radiation and suppression of radiated electromagnetic waves. Because of the relatively low FCC compliance EMI radiated emission suppression levels, EMI gaskets are not always needed. However, the proper selection and use of EMI gaskets can often significantly reduce the expense associated with compliance costs. This cost savings is based on gaskets which are *designed into* the component; in cases of retrofit, the cost can be much higher. The paragraphs that follow describe the generation and propagation of electromagnetic (EM) waves from wires, the method used to shield the fields, low cost methods of implementing EMI gaskets and problems associated with obtaining reliable shielding throughout the life of the equipment.

THE GENERATION, PROPAGATION AND SHIELDING OF EM WAVES

The equipment covered by FCC and VDE requirements contains circuits which generate RF energy that

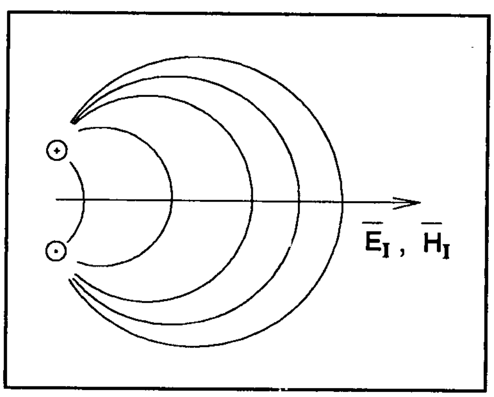

Figure 1. EM Field Emanating From a Transmission Line Pair.

falls within the bandwidth of radios and other communication equipment. This energy travels on wires from one circuit to another, where the wires connecting the two circuits act as antennas. The energy emanating from the wires is transmitted out of the equipment in the form of electromagnetic (EM) waves. When the magnitude of the waves are of a higher amplitude than is allowed by the specification limits, electromagnetic interference, or EMI results.

The fields which radiate from the wires are similar to the fields which radiate from electric dipole antennas. Figure 1 illustrates an EM field emanating from a transmission line pair.

From antenna theory, engineers have determined that the impedance of the wave is equal to $\overline{E}/\overline{H}$, where the relationship of $\overline{H}$ to $\overline{E}$ is approximately equal to the following:

where

$$\overline{H} \cong 2\pi\,\overline{E}R/377\,\lambda \quad (R < \lambda/2\pi)$$
$$\cong \overline{E}/377 \quad (R \geq \lambda/2\pi)$$

$\lambda = 3 \times 10^8/f$ (meters)
R = Distance from radiating wire to point in question (meters)

When the wave of Figure 1 strikes a shielding barrier, a current J_{SI} (i.e., surface current density on the incident side) is generated on the shield, as illustrated in Figure 2. The current is equal to approximately two times the value of H in amperes/meter of the incident field (the field that radiates from the wire and strikes the barrier). In turn, the current is attenuated by the skin depth of the barrier where the current on the transmitted side, J_{ST}, will generate another EM field. The magnitude of the "E" field in volts/meter emanating from the barrier will be J_{ST} (current density in amperes/meter on the secondary side) times the impedance of the barrier in ohms. The secondary field is what is detected by the test antenna.

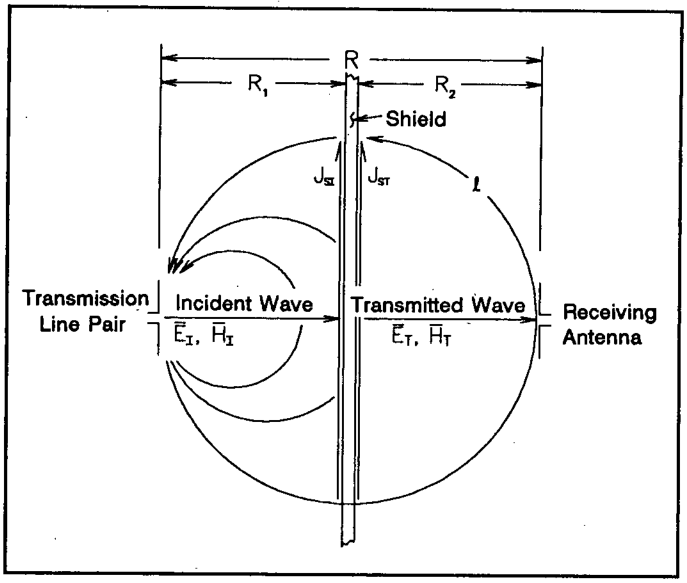

Figure 2. Current Generator by an EM Wave.

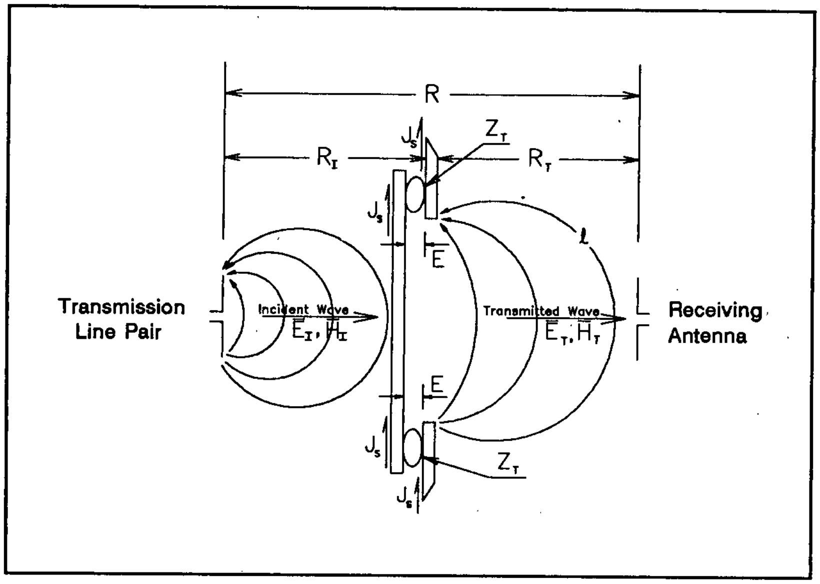

Figure 3. Field Radiating From Shielding Joint.

If the shielding barrier has a joint in it, the current will flow across the joint, creating a voltage which is equal to J_{SI} times Z_T (the current in amperes/meter times the transfer impedance of the joint in ohm-meters). As illustrated in Figure 3, a field will radiate from the joint and be observed by the test antenna. If the field so detected is above the limits specified by the requirements, the transfer impedance (Z_T) of the joint must be reduced. This can be accomplished by the use of additional fasteners or by the use of EMI gasket material.

COST EFFECTIVE USE OF GASKETS

Commercial electronic equipment is generally housed in nonconductive die-cast or molded plastic cabinets. The cabinets are coated with a conductive material to provide the required shielding for compliance to FCC or VDE limits. This is usually accomplished by plating the inside of the cabinet with an electroless coating (aluminum, nickel, copper, tin, etc.) or with a conductive paint. This coating will reduce the EM fields penetrating the cabinet walls to within acceptable levels. However, the joints of the cabinet provide a convenient path for the EM fields to penetrate the cabinet. These fields are reduced to acceptable levels by providing conductive paths between the joint surfaces of the cabinet. This can be performed by the use of additional fasteners or by the use of EMI gasket material. The use of EMI gasket material can be a very cost-effective means of achieving the shielding at the joint surfaces. The cost of using EMI gasket material can be significantly less than the cost of using fasteners. However, to obtain the cost-effective advantage, provisions must be made in the die or mold to provide room for the gasket material and for methods of holding the gasket material in place.

Many types of effective EMI gasket material are available. Two are illustrated in Figures 4 and 5 and are as follows:

1. Commercial grade convoluted spring EMI gasket material. The material is made from low cost stainless steel, and can be purchased in cut-to-size lengths for pennies per inch. The material can provide an EM bond of one milli-ohm per meter length, and can be held in place by the use of pinch bosses or retaining holes.
2. The commercial grade convoluted spring gasket material attached to a neoprene sponge elastomer. An adhesive backed tape is supplied with the elastomer, where the purpose of the elastomer and tape is to hold the EMI bonding material in place.

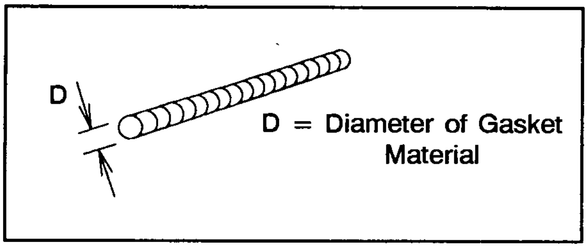

Figure 4. Convoluted Spring Gasket Material.

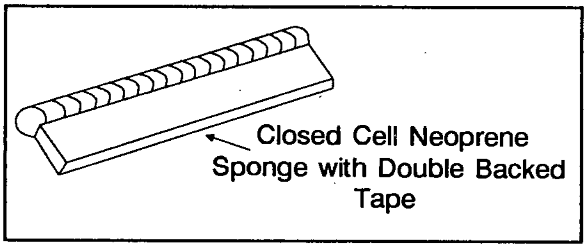

Figure 5. EMI Strip Gasket Material.

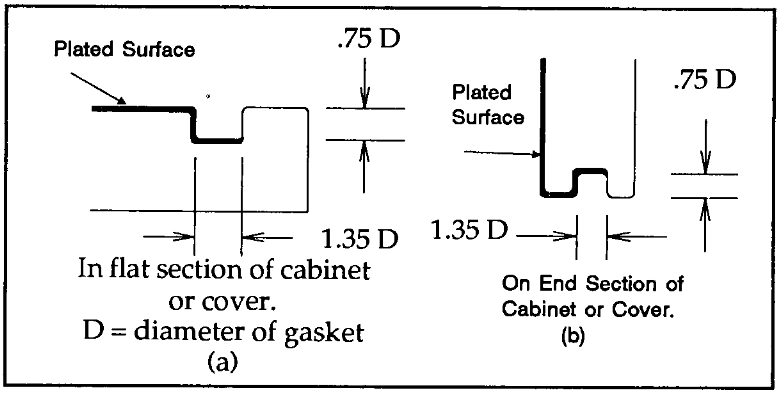

Figure 6. Recommended Groove For Convoluted Spring Gasket.

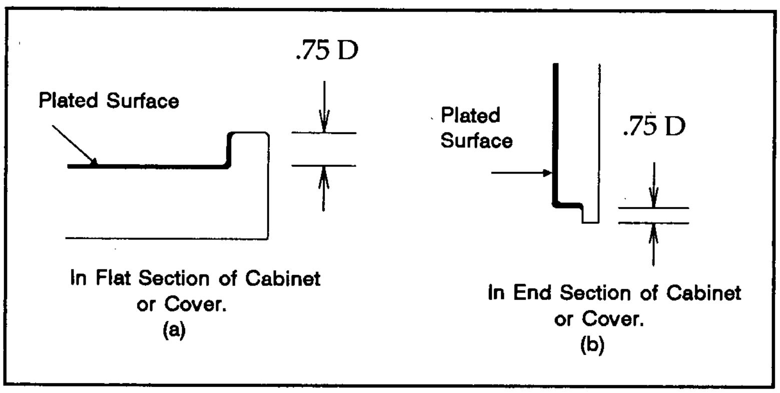

Figure 7. Alternative Groove For Convoluted Spring Gasket.

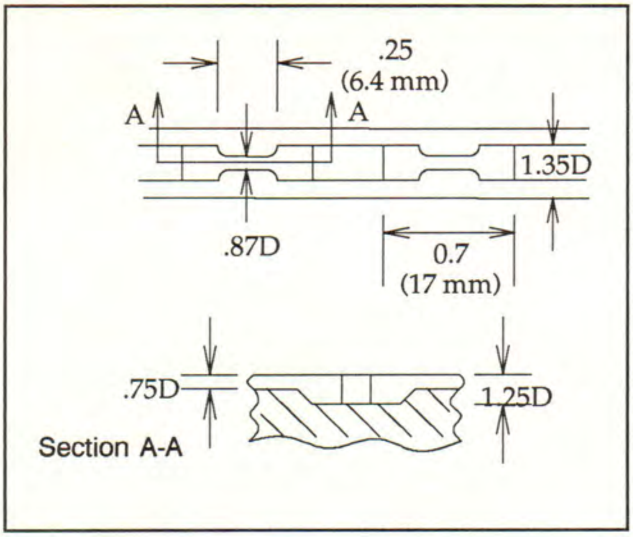

Figure 8. Pinch Bosses.

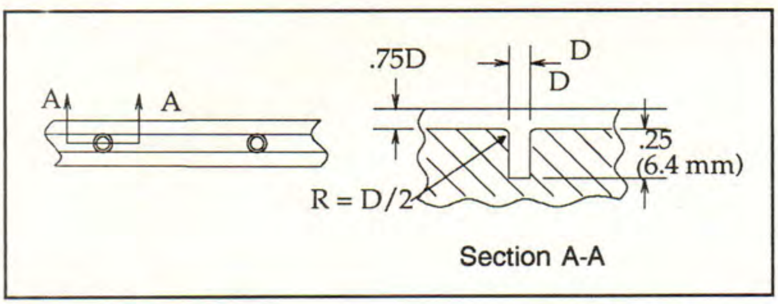

Figure 9. Retaining Hole.

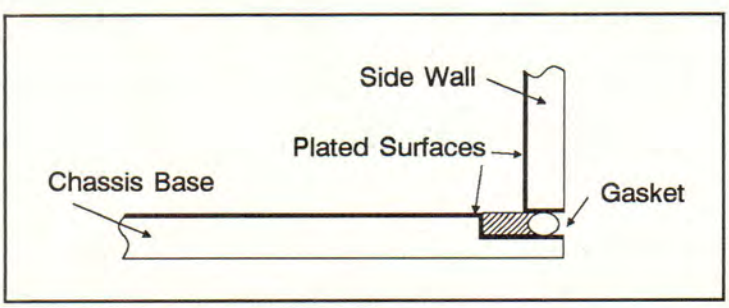

Figure 10. Cabinet Design.

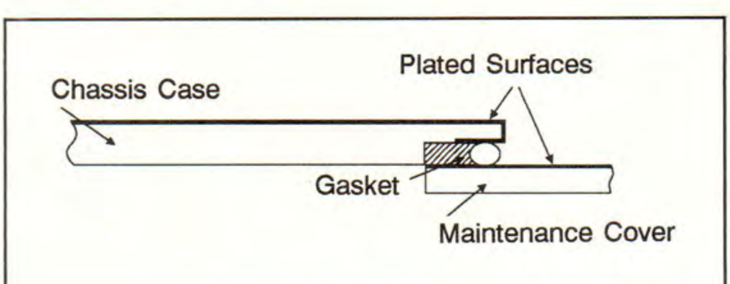

Figure 11. Alternative Cabinet Design.

In using the convoluted spring gasket material, (or any similar EMI gasket material), a groove must be provided in the die or mold to house the gasket. The recommended groove is illustrated in Figure 6 where the width of the groove is about 35 percent wider than the gasket material and the depth is about 75 percent of the width (diameter) of the gasket material. Figure 7 also illustrates a method which has been effectively used to protect the gasket.

The recommended diameter of the gasket material is between 0.06 and 0.15 inches (1.5 mm to 3.8 mm). Assuming a 25 percent maximum deflection of the gasket, this will accommodate a 0.015-to-0.037-inch gap (or unevenness) between the joint surfaces to be EM bonded. Designers should remember that the purpose of the gasket is to provide a conductive path between the separate parts of the case. Therefore, care must be exercised to ensure that the conductive plating on the separate parts interface with the gaskets.

The grooves or configurations of Figures 6 and 7 provide a place for the gaskets to sit. However, provisions must be made to hold the gasket materials in place. This is accomplished by providing pinch bosses or retaining holes along the groove. The pinch bosses and retaining holes are illustrated in Figures 8 and 9, respectively. Because the requirements are relatively easy to meet, continuous gasketing throughout the length of the joint is not required (i.e., small segments along the length of the joint can be used effectively). The actual optimal length and number of segments of EMI gasket material will not be known until the EMI testing on a finished prototype equipment is completed. One- to 1 1/2-inch segments on one or two of the four sides of a small cover is often sufficient. The grooves of Figures 6 and 7 must be placed in the die or mold during the

Material	Finish	Initial	Resistance (Milliohms) at 400 hr 95% RH	at 1000 hr 95% RH
Alum				
2024	clad/clad	1.3	1.1	2.0
2024	clean only/clean only	0.11	5.0	30.0
6061	clean only/clean only	0.02	7.0	13.0
2024	light chromate conversion/same	0.40	14.0	51.0
6061	light chromate conversion/same	0.55	11.5	12.0
2024	heavy chromate conversion/same	1.9	82.0	100.0
6061	heavy chromate conversion/same	0.42	3.2	5.8
Steel				
1010	cadmium/cadmium	1.8	2.8	3.0
1010	cadmium-chromate/same	0.7	1.2	2.5
1010	silver/silver	0.05	1.2	1.2
1010	tin/tin	0.01	0.01	0.01
Copper	clean only/clean only	0.05	1.9	8.1
Copper	cadmium/cadmium	1.4	3.1	2.7
Copper	cadmium-chromate/same	0.02	0.4	2.0
Copper	silver/silver	0.01	0.8	1.3
Copper	tin/tin	0.01	0.01	0.01

Figure 12. Resistance Measurements of Selected Materials.

early design phases. The pinch bosses or retaining holes can be placed in the die or mold after the EMI testing is completed and optimal required gasketing is known. During the EMI testing, the segments of EMI gasket material can be held in place using tape or other non-destructive methods of retainment.

In applying the gasket material to the unit case, the following principles should be applied.

- **Pinch bosses**

1. The gasket material is cut to the appropriate length (outside-to-outside distance between pinch bosses).
2. One end of the gasket material is pushed between one set of pinch bosses.
3. The gasket is stretched about 5 percent (to put the gasket under slight tension) and the loose end is pushed into the other set of pinch bosses.

- **Retaining hole**

1. The gasket material is cut to the appropriate length (distance between holes plus 0.4 inches).
2. One end of the gasket is inserted into one hole.
3. While holding the inserted end in the hole, the gasket is stretched and inserted into the other hole all the way to the bottom.
4. Holding devices (i.e., fingers, etc.) are released.

Note: A silicone RTV or other adhesive can be used to positively secure the two ends inside the hole.

The EMI gasket strip material that is attached to the neoprene sponge elastomer of Figure 5 uses adhesive backed tape to hold it in place. The standard thickness of the material is either 1/16, 3/32 or 1/8 inch. The recommended segments or lengths of gasket material are 1 to 1 1/2

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