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GASKET AND MECHANICAL SUPPRESSION TECHNIQUES IN COMPUTER DESIGN

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Abstract

Numerous articles have appeared describing electrical circuit noise suppression techniques to be used in computer applications, but few articles, other than those addressing gaskets, are available describing mechanical "containment" approaches for noise suppression. While most EMI engineers seem to understand the value of providing "good" metal to metal contact at seams, sealing holes, and grounding all loose metal parts, a review of these concepts for a specific type of box should prove helpful. This article is intended to provide basic guidelines as well as specific mechanical type suggestions to reduce noise problems associated with computer designs.

Introduction

State of the art pc's and workstations commonly contain noise generating sources emitted from circuits operating at clock speeds between 20 and 40 Mhz. While these computing devices are shielded, in a realistic sense, the box direct shielding is usually of somewhat less concern than the noise leakage through box seams, holes, and joints. In addition, these shield discontinuities have more effect on magnetic than on electric field leakage.

Three factors determine the amount of direct radiated leakage through a shield discontinuity.

1. The maximum linear dimension of the opening
2. The wave impedance
3. The frequency of the noise source

Since maximum dimension, not area, determines the amount of leakage in the direct radiated path, the best way to visualize shielding effectiveness of discontinuities is to consider the characteristics of a slot antenna on magnetically induced shield currents.

Slot Antenna Characteristics

Noise fields induce current flow in a shield, and these shield currents then generate additional fields. The new fields that have been reduced somewhat by resistive heating cancel the original field at some regions in space, causing a further reduction in the original field strength. For maximum cancellation to occur, the shield currents must be allowed to flow undisturbed in the manner in which they were induced by the incident field. If a shield discontinuity forces the induced currents to flow in a different path, the shielding effectiveness of the shield is reduced. The further the current is forced to detour from its "natural" path, the greater the decrease in shielding effectiveness.

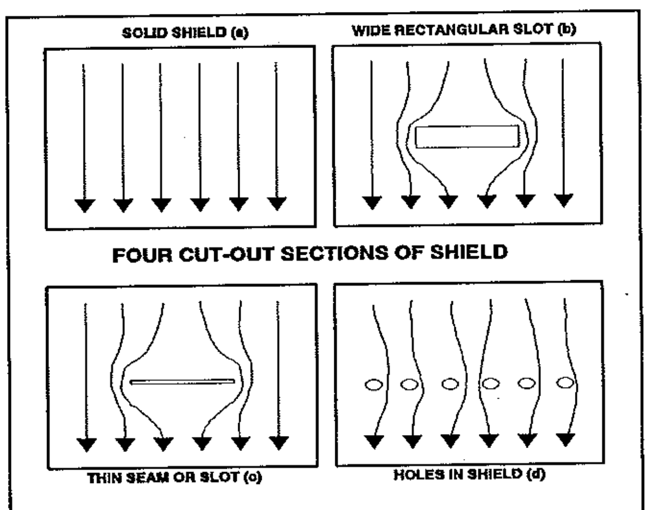

Figure 1 - Surface Current Flow in Shield Effected by Holes

Figure 1 shows how current flows in a continuous shield and how discontinuities can affect the currents induced in the shield. Figure 1a shows induced currents in a solid shield with no discontinuity. Figure 1b shows a wide rectangular slot detouring the induced currents, while

Figure 1c shows almost the same effect on current flow with a much narrower slot. Figure 1d shows that the group of small holes has a much less current detouring effect than the slots, producing less leakage even though the total area is the same as the slot.

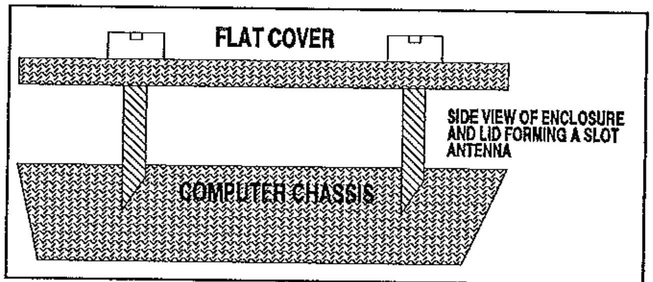

Figure 2 - Cover Showing Traditional Slot Antenna

A rectangular slot antenna, even if very narrow such as the cover seam shown in Figure 2, can cause considerable leakage if the slot length is longer than 1/100 wavelength of the radiating source. Even then, if only a 20 MHz source was the concern, a small slot would not be much of a problem if oriented for minimum current disturbance. However, the side of a computer or workstation is large, and the clock speed of the computer is only an indicator of the frequency content of the noise since to operate at higher frequencies, internal circuit gates must possess significantly fast rise and fall times. Thus, the source of radiated noise in the 100 Mhz and above range propagates in every direction. Therefore, although the box seams do not appear large, they nearly always offer considerable disturbance to internal induced current flow.

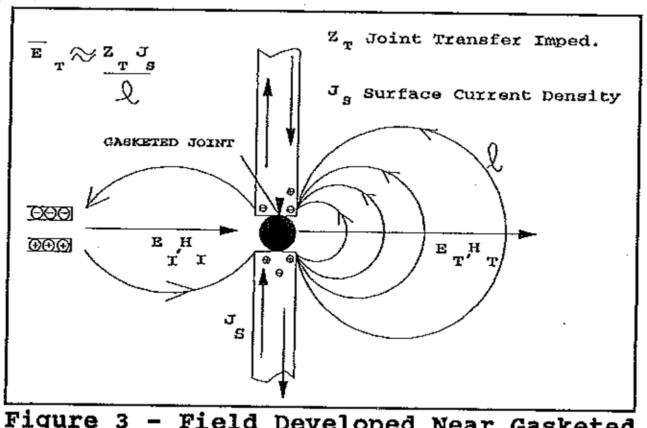

Figure 3 - Field Developed Near Gasketed Joint Due to Current Flow

Waveguides and Mechanical Considerations

When a gasketed joint such as shown in Figure 3 exists, the current flow in the shield sees a less abrupt impediment to natural flow than a hole would create, but it is still disturbed to the point that directed fields will be created. A second Figure (4) shows a waveguide condition without a gasket. The figures show a radiating source and current flow through a shield slot. In either case, although the current flow is somewhat disturbed at the joint, the overall impedance of the joint is decreased.

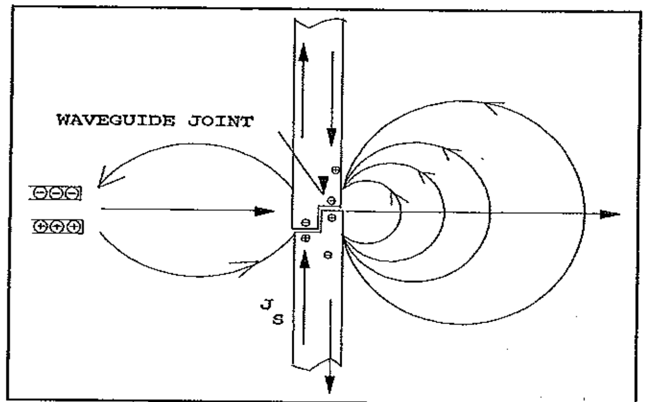

Figure 4 - Field Generated Through a Waveguide

For the waveguide, the high frequency surface currents tend to "jump" the seam boundary rather than be confined to the physical turns and changes in the conductive structure. Therefore, by adding some waveguide characteristics to the seam, internal current will be less disturbed than otherwise would exist, and shielding effectiveness will be greater.

For the gasket filled slot, the gasket provides a conductive seal across the slot, again allowing better natural current flow than would otherwise exist.

Conductive Gaskets

Obviously solid joints provide the maximum shielding. Joints with waveguide designs are more desirable then straight through seams, and gasketed joints (for specific applications) are even more desirable. Using rivets or screws to hold a joint together are less effective at sealing a joint, with screws better then rivets. Screws should be spaced as close as practical, with conductive gasket material used to provide more complete electrical continuity across the joint.

For computer and workstation applications, various gasket types and sizes as shown in Figure 5 are available depending on the final application intended for the computer. Tactical computers require greater shielding protection, both environmentally and electromagnetically, than do computers intended for home or office use.

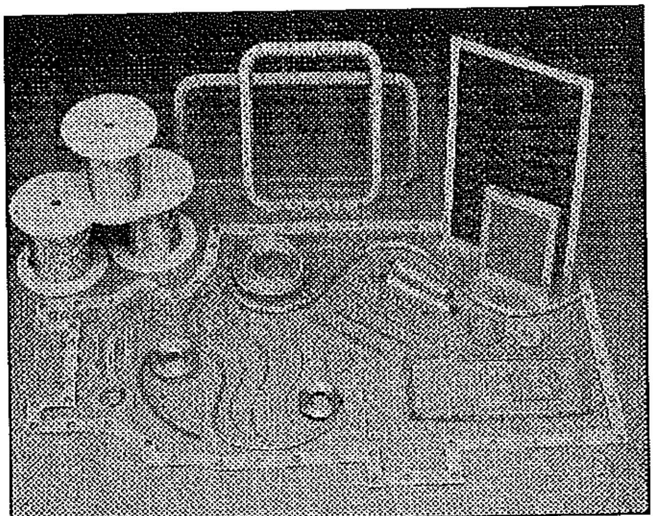

Figure 5 - Several Gasket Types (courtesy of Spira)

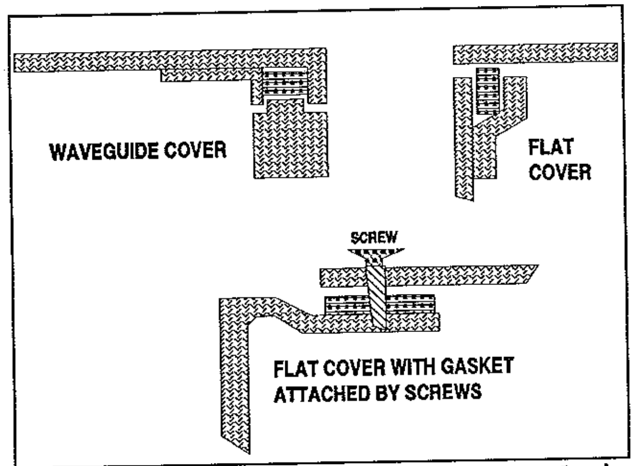

Figure 6 - Elastomer Gasket Used in Bolted Down Applications

As previously stated, conductive gaskets are used primarily to provide a semi-continuous electrical bond between two metal surfaces along nonuniform seams in enclosures. While silver filled elastomers are the more common gasket material for military hardened applications, knitted wire mesh, soft preformed metal gaskets, and Beryllium copper spring fingers are also commonly used in less stringent computer applications.

Conductive Elastomers

Filled elastomers usually consist of small conductive carbon or silver beads emersed in a rubber type material. Silver (Ag) is the most popular loading material, providing the highest shielding effectiveness in stringent computer applications.

Silver has a low electrical resistance, is a soft metal that can be "crushed" between two harder metals, and suffers much less corrosion than other metals or carbon when encased in rubber, leading to a longer life span and greater shielding effectiveness than alternative techniques.

Conductive elastomers, however, have their own unique problems. According to Benn[1], the concentration of silver filler in the elastomer makes up nearly 70 percent of the gasket by weight. At this high of loading, the elastomer loses much of its physical properties, often resulting in poor tear resistance, and the inability to return to its original form after compression (compression set). Compression set is the permanent reduction in volume of the gasket while under pressure. Compression set usually results in a corresponding loss in shielding effectiveness for the gasket.

The major problem occurs when elastomers are used to provide a continuity bond between different metal surfaces, or between any two metal surfaces and a different fill material. This problems relates to the electro-chemical characteristics of the materials formed by the bond. When Ag and aluminum (Al) are mated together in the presence of moisture, they form a galvanic cell with a galvanic voltage about 0.7 volts. Also, since Ag is more noble than Al, when Al is used with Ag, the Al will corrode. Gasket manufacturers are currently investigating the use of sacrificial materials to inhibit corrosion of case and gasket materials.

Aluminum oxide (Al_2O_3) formed on the Al surface is another problem. Conductive coatings for metal surfaces in these applications have been developed which minimize the corrosion effects by minimizing the formation of Al_2O_3. While the protective finish provided by MIL C 5541, Class 3 Chromate conversion coating minimizes the oxidation process, it also greatly effects the shielding effectiveness of the gasket material[2].

Conductive elastomers are best used in bolt down applications similar to those shown in Figure 6 where they can be replaced after several compressions provided some mechanical offset to reduce closure force on the gasket is also provided. While the rubber material on the outside of the gasket provides significant hermetic sealing, silver filled elastomers should not be used in applications where they provide a seal between aluminum surfaces in contact with a salt water atmosphere. For permanent high closing force mounting, a condition where compression set and high pressure are not a factor, a flat conductive elastomer is well suited.

Recently a dual elastomer gasket design has been introduced that is intended to provide better mechanical conformance than provided by previous elastomer designs. The gasket, shown in Figure 7, manufactured by Vanguard Products of Danbury, Connecticut, consists of a continuously extruded high-strength nonconductive silicone rubber coated with a thin conductive silver-filled rubber on the outside.

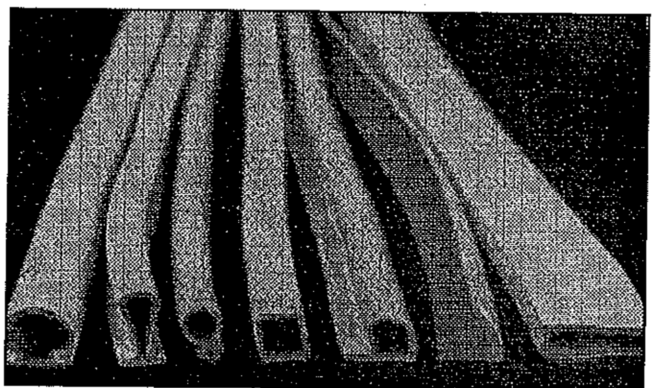

Figure 7 - Vanguard's Silver Co-extruded Gasket

Some major advantages are realized with the extruded approach. First, extrusions are inexpensive to build and can be manufactured very quickly. Major tooling is not a problem. Second, again according to Benn[2], because the silver filler is only present in the outer layer, the silver thickness can be better regulated leading to further reduced manufacturing costs. Finally, the elastic inner core, since it is free of conductive filler material, can maintain its resistance to multiple compressions with corresponding reduced aging.

Foamed Gaskets

Nonconductive foamed type gaskets covered with metallized fabric provide good compression force and compression-set resistance for relatively lower costs than elastomers, but they also have limited application. Shielding limitations relate to providing no better shielding than that provided by the fabric itself. Also, since the sponge foam usually absorbs moisture, the foam material can deteriorate due to fungus action. A typical mesh covered gasket and a carbon filled gasket, both manufactured by Pawling Corporation, are shown in Figure 8. These gaskets are attached to a metal clip for easy installation.

Metal (Punched) Meshes

Metal Meshes, even soft metal gaskets, have good attenuation properties while lacking in environmental protection. These gaskets are often used in conjunction with an outer rubber gasket to provide a moisture seal.

Soft metal gaskets are pre-shaped and stamped out of a solid sheet to produce sharp edges spaced evenly throughout both sides of the sheet. When compressed, the edges contact the metal enclosure edges causing a very good low impedance bond to be formed. Metal meshes act in a similar manner by providing good metal to metal contact between the conductive wires and the enclosure edges.

A problem with all metal mesh or gasket designs is compression force and

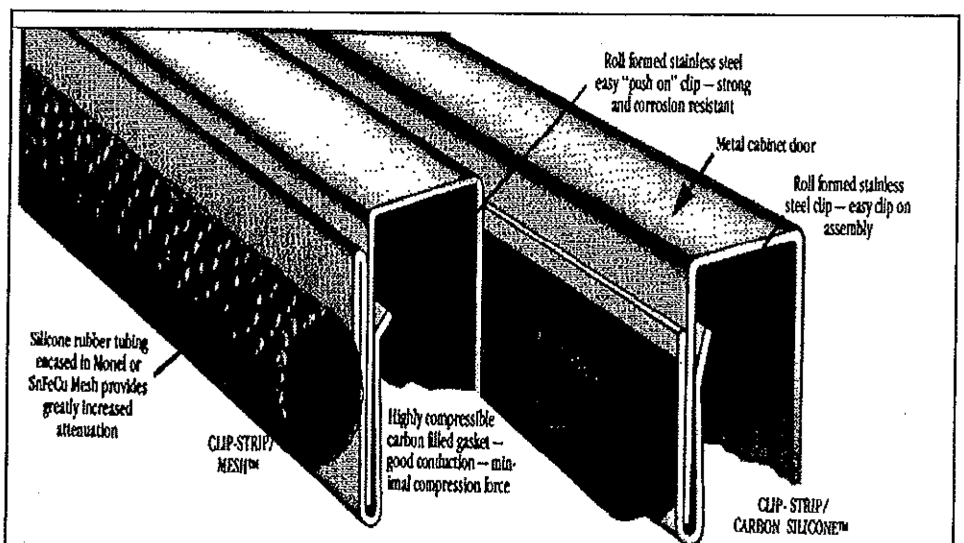

Figure 8 - Mesh Covered and Carbon Filled Gaskets (courtesy of Pawling Corp.)

A problem with all metal mesh or gasket designs is compression force and compression set. Over compressing the gasket results in "flattening" the sharp edges or metal wires causing loss of the low impedance bond. In addition, compression set is usually permanent once the gasket is set in place.

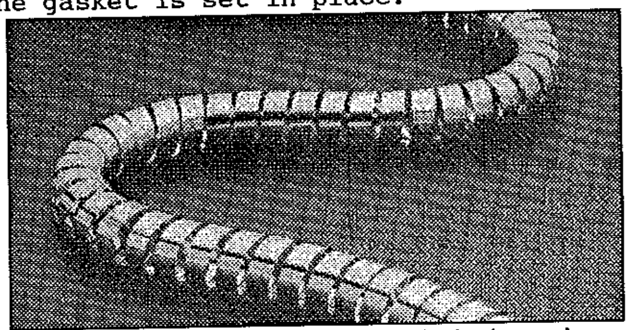

Figure 9 - Spring Type Gasket (courtesy of Spira)

Beryllium Copper Finger-Stock (Springs)

When the gasket will be subjected to multiple compressions, beryllium copper gaskets in the form of small spring fingers or spiral type gaskets like the one shown in Figure 9 are most popular. A typical use is in commercial computer application shown in Figure 10. In a straight line they provide less direct shielding effectiveness than other gasket materials, so are usually used with a wave guide slot

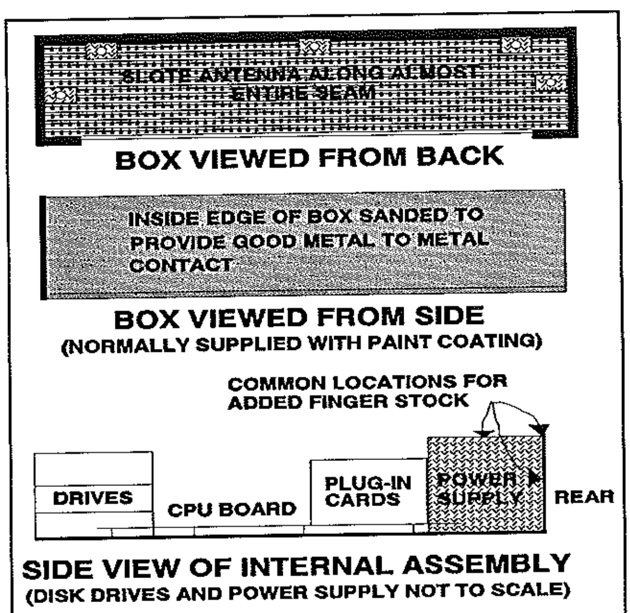

Figure 10 - Commercial Computer Applications For Finger Stock Gaskets

or wide metal flange if high radiated shielding attenuation is necessary such as shown for the workstation in Figure 11. Note in Figure 11 that the door is hinged and compressed into the finger stock with a latching mechanism when closed.

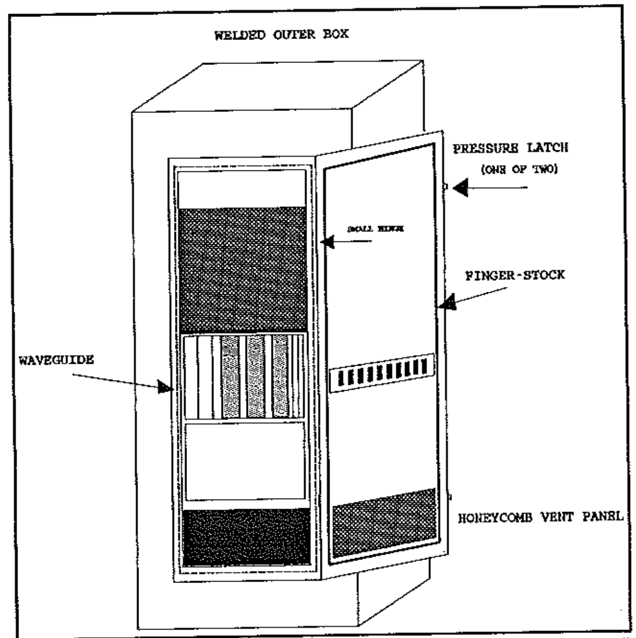

Figure 11 - Highly Suppressed Workstation With Finger Stock on Door

In commercial computers, as was previously shown, only a few beryllium copper fingers are used, primarily to provide a low impedance ground path between the outer cover and base chassis. Another very popular application for this gasket type is for the connector to shield braid conductive barrier in a compressed ring configuration.

Beryllium copper gaskets are slightly more expensive than other materials, and are subject to corrosion and oxidation when exposed to humidity. Finger-stock has some advantages over other gasket types. It can be repaired when a finger breaks off, and can also be sanded and/or cleaned to return to its original low impedance contact state.

It is important to again note that some mechanical means, such as the waveguide standoff for the elastomer shown in Figure 12, or a low compression force is necessary to prevent compression set. Figure 13 shows a similar waveguide standoff application with a Beryllium Copper finger spring type gasket.

Gasket Comparisons

Table 1 from Benn[1] compares relative general gasket properties from each of the gasket types. Notice the dual elastomer design provides high attenuation with no compression set.

Table 1
General Gasket Comparisons

Type	Attn. dB	Comp. Force.	Comp. Set %	Cost
Dual Elast	110	low	none	mod.
Elast	90-100	high	7-15	high
Clad Foam	60-80	low	15-20	mod.
Mesh	90-100	high	12-20	mod.
Bery. Coppr.	100	med	1-2	high

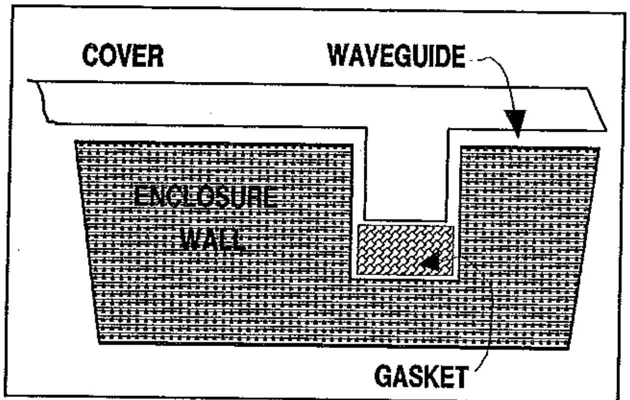

Figure 12 - Waveguide With Elastomer Gasket and Standoff

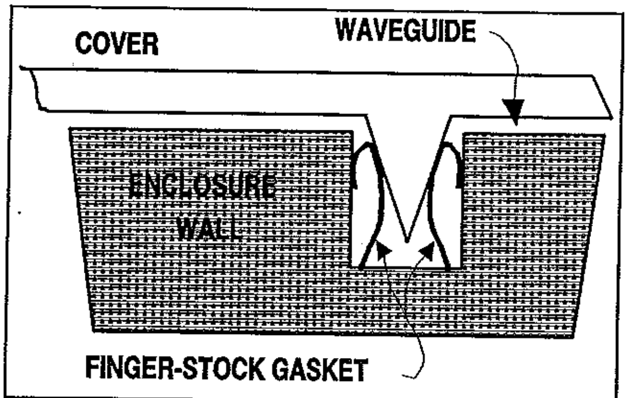

Figure 13 - Waveguide With Finger-stock Gasket and Stop

Table 2 from O'Shea[3] is also interesting in that it compares three gasket types over specific frequencies using measured values from a transfer impedance type test.

Table 2

Gasket Attenuation Comparisons in dB

Frequency	BeCu	Wire Mesh	Ag Elast.
10 KHz H-field	55	30	35
10 KHz E-field	120	100	100
10 MHz	140	100	100
1 GHz	100	90	100
10 GHz	105	unmeas.	100

Determining which gasket type and/or which mechanical assembly is best suited for various applications is often a confusing task. In addition to the applications previously described, the following general examples are useful.

1. Permanently mounted cover plate on indoor box with no environmental problems and low compression: soft metal gasket with screw down top

2. Permanently mounted cover plate on sensitive emission indoor/outdoor box with no EMP problems and high compression: silver filled elastomer mounted in a grooved waveguide and screw secured to a rigid metal top

3. Access plate on military box with uneven joints and frequent opening and closing: elastomer with regular replacement on rigid metal cover with compression latch assembly (if allowed)

4. Hinged door with waveguide controls on sensitive emission box: Beryllium Copper finger stock with pressure latch assembly and honeycomb vent panel

5. Removable cover plate on low compression indoor/outdoor box: sponge elastomer (disposable) on flat metal edge; bent welded metal box assembly

6. Removable cover plate on low compression indoor box with high shielding effectiveness requirement: wire mesh on bent welded metal box assembly

Acknowledgement

Acknowledgement is given to Richard Steele of LOCUS, Inc. for his help in identifying sources of information regarding recent advances in and problems with filled elastomers.

Footnotes

(1) Benn, Robert C., **Dual Elastomer EMI Gasket Concept**, ITEM Magazine, 1991.

(2) H.W. Denny and K.R. Shouse, **EMI Shielding of Conductive Gaskets in Corrosive Environments**, IEEE Symposium, Washington D.C., August 1990.

(3) O'Shea, **This is the Gasket. What is the Test?**, Evaluation Engineering, August 1991.