

Focus on... Gaskets

More Choices to Meet a Steady Need

by William Flanders

Despite periodic downturns in markets such as telecommunications equipment and information systems, the overall need for EMI shielding has grown. This can be attributed to growth in wireless communications beyond the mobile phone, as well as the increase in processing power and density of components in all manner of electronics equipment. Applications such as cable and DSL modems and hard disk drives that previously did not need EMI gaskets are now requiring higher levels of shielding due to advancements in technology and functionality.

EMI shielding gaskets come in a variety of shapes, sizes and materials. If you have a seam or gap to shield there are plenty of gasket choices available. But choosing the appropriate gasket involves several key decisions. Shielding performance of a gasket can be affected by any number of factors including compression set, corrosion, force-deflection, mating flange tolerances, and environmental forces. Price-performance decisions must also be weighed.

Thus, while different applications demand different solutions, designers are often faced with multiple EMI gasket products which will meet their needs. This article looks at what gasket forms are currently available for commercial electronics shielding applications. It offers some perspectives that will help narrow your choices.

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The article is based on an earlier piece written by Gardner Bradlee, formerly with Chomerics.

Types Of Gaskets

Conductive Jacket Over Foam Gaskets

Fabric-over-foam: Most common forms of these gaskets are plated polyester or nylon (woven or non-woven) fabric over urethane or TPE (thermoplastic elastomer) cores. Platings typically are nickel-copper, nickel-silver, copper or carbon-silver. Alternately, aluminum foil fabrics can be used. Fabric-over-foam gaskets are made either by wrapping pre-cut, cured cores or by dispensing liquid foam into a jacket which is then cured in-line.

Advantages of fabric-over-foam gaskets are their lower price compared to elastomer or fingerstock gaskets, ease of use, variety of profiles, air sealing capability, and softness. Most fabric-over-foam gaskets now come with UL94-V0 flammability rating options. Disadvantages can be compression set, (depending on the foam used), and



Figure 1: Some examples of fabric-over-foam gaskets



Figure 2: An example of die-cut z-axis foam gasketing



Figure 3: A variety of fingerstock materials are available

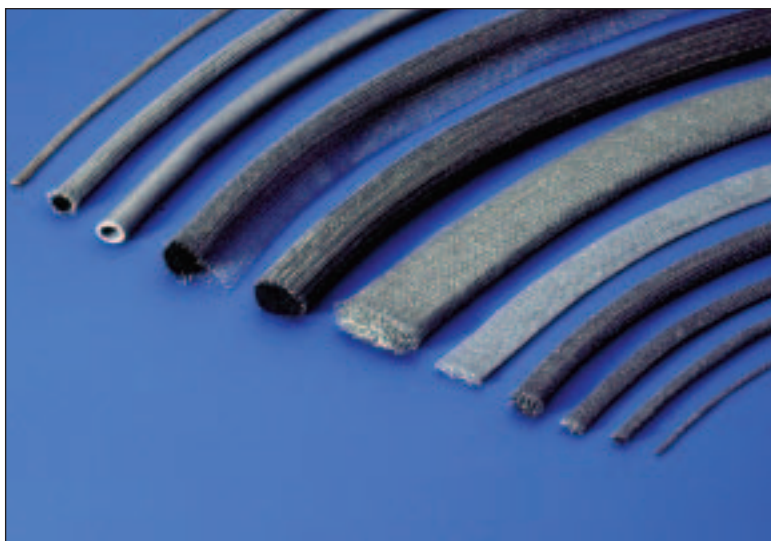


Figure 4: Wire mesh gaskets

performance in shear. New custom formulated silicone foam based gaskets have recently been introduced to overcome compression set characteristics and foam fatigue of urethane and TPE foams. This new foam allows designers the flexibility to use a fabric-over-foam gasket in place of fingerstock in applications where exposure to temperature cycling and repeated closure cycles demands a low compression set solution.

Conductive Yarn /Mesh Over Core: These gaskets feature silver plated yarns or meshes, as mentioned above, over hollow neoprene, urethane or silicone foam cores. As the quality of plated fabric has increased, gaskets of this type have decreased in popularity, especially in commercial applications.

Conductive Foams: Although not technically a jacketed material, new conductive foams have been introduced to be used in applications typically served by flat wrapped foam. These foam sheets are not intrinsically conductive but have been treated with a coating to allow for z-axis conductivity. This can be achieved by integrating plated textile fibers into a foam matrix. This option allows for repeated closure cycles without loss of conductivity. Conductive foams can be die cut into I/O panel, backplane gaskets, or frame gaskets.

All Metal Gaskets

Fingerstock: Also called springfingers, these gaskets are made from either beryllium-copper or stainless steel. Attachment methods can include integrated clips or PSA. Advantages to fingerstock are its excellent electrical properties at low compression-deflection and its ability to withstand shear forces. Compression set is usually excellent and for this reason fingerstock is the default choice for applications where long-term reliability is required in controlled environment applications. Some drawbacks to fingerstock are its price relative to comparable gasketing options, high force deflection, and difficulty of installation. Fingerstock is available in softer versions, but usually these are more brittle and prone to broken fingers if mishandled. Fingerstock is not recommended where environmental sealing is needed or corrosion is a major concern.

Mesh: Knitted wire gaskets are most often made from tin-plated, copper-clad steel (Ferrex^{®1}), monel, beryllium-copper (Be/Cu) or specialty steel. Advantages of wire mesh are its good metal to metal contact and low electrical resistance.

¹ Ferrex[®] is a trademark of Parker Hannifin Corporation.

Disadvantages are its limited profiles and relatively high susceptibility to compression set. Be/Cu and specialty steel gaskets with hollow cores are designed for better compression set.

Elastomer Gaskets

Typically, these gaskets are silicone elastomers filled with electrically conductive particles such as carbon, nickel, nickel-plated graphite, silver-plated aluminum, silver-plated copper, silver-plated nickel, silver-plated glass, or pure silver. Besides silicone, these gaskets are made with fluorosilicone, fluorocarbon and ethylene-propylene diene monomer (EPDM) elastomers.

Conductive elastomers present the widest variety of gasket forms. They can be extruded into a wide variety of profile strips, molded into customer shapes, die-cut from molded sheet stock, molded onto substrates such as plastics or metal, or dispensed onto a substrate. Historically, conductive elastomer development was driven by the military, however in the last decade it has been most affected by the telecommunications industry. Nickel-graphite filled silicones have grown tremendously in popularity due to their high shielding levels, corrosion resistance, and pricing compared to silver and silver plated particle filled elastomers. Although the volume resistivity of nickel-graphite based systems is lower than some of the silver based systems, shielding effectiveness is high (100dB from 100 MHz to 10 GHz) due to particle shapes which allow for better contact under compression as well as some absorptive characteristics of the filler.

Although conductively filled elastomers have been made for many years, the recent growth of the mobile wireless handset industry and supporting infrastructure has been a catalyst in the development of new forms of elastomer gaskets. Methods of application such as form-in-place (FIP) dispensing and overmolding onto substrates have grown in popularity as a result. Today advances in conductive elastomers for FIP have led to faster cure times, lower force-deflection, and lower costs.

The major advantages of conductive elastomers are their high shielding performance over a range of frequencies and their environmental sealing capabilities. Potential corrosion problems in outdoor applications can be overcome using specially treated fillers or by using a co-extrusion which combines a



Figure 5: Examples of extruded elastomers

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non-conductive elastomer weather seal with a conductive elastomer. Today there are UL94-V0 flammability-rated elastomers available. A disadvantage of conductive elastomers can be the cost of the gasket compared to alternatives, and for required tooling in the case of molded elastomers. Elastomers also do not function well in continuous, high shear applications.

Mixed Media Gaskets

Other types of EMI gaskets are available that use a mix of the above mentioned forms. These combinations include gaskets utilizing non-conductive foams or elastomers married with a mesh or metal gasket and are aptly named combo gaskets. They can provide both effective environmental sealing and EMI shielding. These mixed media gaskets are usually custom made. Other gaskets in this category include silicone sheets with oriented wires and mesh impregnated with neoprene or silicone elastomer. Although these can provide excellent environmental as well as EMI shielding significant pressure must be exerted to achieve this.

Application Perspectives

A good starting point for determining the appropriate EMI gasket is to look at the type of device that needs enclosure

shielding. This section will focus on a number of form factors of electronic devices to illustrate what and when a given type of gasket should be used.

Wireless Handheld Devices

The convergence of voice and data into handheld devices presents a number of challenges for shielding. While soldered metal cans provide one method of shielding modules on the board, many manufacturers have sought elastomer gasket solutions as an alternative or in conjunction with cans. These gaskets are in the form of plastic inter-board frames over-molded with soft conductive. Over molded frames can provide compartmental shielding and add stability and vibration dampening to the device. Form-in-place gaskets are an excellent solution for gasketing thin walls due to its small form factor.

Small Office / Home Office Information Systems and Communications Devices

Examples of these electronic devices are stand-alone desktop and portable PCs, home multimedia devices, and low end servers and data switches. These are generally high volume consumer products that have to meet EMI regulatory environments. This type of device requires effective yet inexpensive shielding and grounding. UL94-V0 rated material may also be required.

Common gasket applications include:

Enclosure seams: Conductive fabric-over-foam gaskets have become the gasket of choice for seam shielding. Because of price pressures and ease of installation, commercial grade urethane foam cores and nickel-copper or nickel-silver fabric jackets are used almost exclusively today. Commercial grade urethanes are soft enough to fill seams with wide tolerances. Foam compression set or fatigue is less of an issue because of fewer expected closure cycle. Long term reliability concerns are minimized because the average useful life of these devices is typically less than 5 years. The shielding effectiveness of today's fabric-over-foam gaskets is generally 80-90 dB from 100 MHz to 10 GHz.

I/O Panels: Flat, die-cut fabric-over-foam gaskets are excellent for filling gaps with tolerances over 0.015-in. wide. Because of the thin sheet metal materials used in I/O panels, compression forces must also be taken into consideration. Stamped metal gaskets will require greater closure force to function, but can compress into smaller gaps than a foam gasket. Advantages to foam based gaskets are the lower relative tooling costs and flexibility of design. In lower volumes unit pricing tends to be lower. New foams with z-axis conductivity allow for better compartmental shielding of connector cut-outs.

Mid to High Range Information Systems and Data/Voice Networking Equipment

Equipment in this category can range from mid-market data storage systems to rack mounted servers to large central office switching equipment. In general this equipment is

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located in controlled environments. Outside enclosures such as cellular base stations or pole mounted transceivers will require environmental sealing. Conductive elastomers are the best method for providing shielding and weather protection. Nickel graphite-filled silicones provide excellent shielding and good corrosion resistance.

These applications require high levels of shielding as well as long-term gasket performance. UL94-V0 rated gaskets are usually needed. In some cases, as with central office telecommunications equipment, industrial standards such as NEBS (Network Equipment-Building System) requirements play an important part in choosing the right gasket. Larger cabinets may house racks of switching cards or server blades that require shielding not only at the enclosure seam and door level but also at the rack shelf and faceplate/front panel level.

Enclosure panels, doors and seams: Depending on the shielding levels needed, gasket choices can include extruded conductive elastomers, fingerstock or fabric-over-foam. Panels and doors will experience more closure cycles so compression set is more of an issue. Low compression forces may dictate fabric-over-foam gaskets, but higher performance urethane foam or silicone foam cores may be needed to overcome foam fatigue and compression set resulting from extended exposure to elevated temperatures.

Modules: Server blades and rack mounted switch gear require shielding on the sides of the faceplates as well as at the top and bottom of the rack shelves. Shear forces as well as force stack-up must be taken into consideration. Fingerstock gaskets typically perform best under shear conditions. However, if grooves are designed into the side of a faceplate, fabric-over-foam gaskets can be equally effective and less costly. A D-shaped fabric-over-foam gasket in a groove will better absorb the shear forces and will be less likely to peel off.

Today you can find fabric-over-foam gasket profiles engineered to perform well under shear even when attached to a flat surface. These modified D shapes (see Figure 6) which have low wings on either side allow the mating edge to travel over part of the gasket before putting force against the side of the gasket. PSA strips placed close to the sides of the gasket also hold the gasket in place better under shear. On compact PCI (cPCI) style faceplates, both fingerstock and fabric-over-foam can be used as effective gaskets.

Fingerstock requires a T shaped rail for the gasket to slide on, while a fabric-over-foam gasket will require a groove. Most cPCI faceplate suppliers offer both forms of faceplates.

Fully enclosed modules, such as base station

transceivers used in outdoor applications, will most likely require internal compartmental shielding. This is usually achieved by gasketing the internal walls/ribs on the cover of the enclosure. Typically these enclosures are cast aluminum. One piece, molded elastomer gaskets with channels can be used. However, due to the thin walls being used in today's module designs, FIP elastomers present the most cost effective solution for placing small beads on the walls.

Backplanes: Shielding the connectors on backplanes can be achieved through several methods. Metal, elastomer or



Figure 6

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fabric-over-foam gaskets can be used. Elastomers provide the highest shielding levels. Extruded elastomer strips can be spliced into rectangles that are easily installed using pressure sensitive adhesive (PSA.) Hollow elastomer gasket profiles will provide the required compression-deflection. Metal springfinger gaskets can be applied, but they usually must be custom tooled. Flat fabric-over-foam gaskets can be die-cut to form a one piece “ladder style” gasket that is easily installed. If higher levels of compartmental shielding are needed, the sides of a wrapped gasket may have to be fully wrapped. New conductive z-axis foams are available that are less costly than a fully wrapped option and provide sufficient shielding for most applications.

Meeting NEBS Requirements For Commercial Telecommunications Infrastructure Equipment

EMI gasket considerations should not be taken lightly when designing equipment to pass NEBS specifications. GR-1089-Core stipulates that EMI testing on central office equipment should be conducted with open doors over the frequency range of 10 kHz to 10 GHz. Therefore, shielding at the rack shelf and module level is critical. While both fingerstock and fabric-over-foam gaskets can perform well in these tests, data shows shielding effectiveness of fabric-over-foam gaskets under sufficient compression will meet or outperform fingerstock shielding, especially at higher frequency levels.

GR-1089-Core is not the only NEBS test regimen you should consider when choosing a gasket. Several sections of the GR-63-Core specifications can be affected by gasket choice. Probably the section of most concern is 4-2 Fire Resistance. Most fabric-over-foam and fingerstock gaskets meet the required minimum oxygen index of 28% and minimum UL94 V-1 rating. There are also some conductive elastomer gaskets that can meet this requirement. However, other sections such as 4.5 Airborne Contaminants, 4.1.1 High temp exposure (transportation) and 4.6 Acoustic Noise must also be taken into consideration. Fabric-over-foam can enable designers to meet those requirements.

One advantage to a fabric-over-foam or conductive elastomer gasket is its air sealing characteristics. Fingerstock typically has slots in it that can be a potential source of air entry. Generally fabric-over-foam and elastomer gaskets are not adversely affected by the 4.5 Airborne Contaminants test. Below is a table showing some results of an airborne contaminants test performed on a nickel-silver fabric over urethane foam gasket and a nickel-graphite filled UL94V-0 rated silicone elastomer gasket.

As can be seen in Figure 7, there is some loss of attenuation. However, levels remain high enough to provide more than adequate shielding while still providing a degree of air and dust sealing.

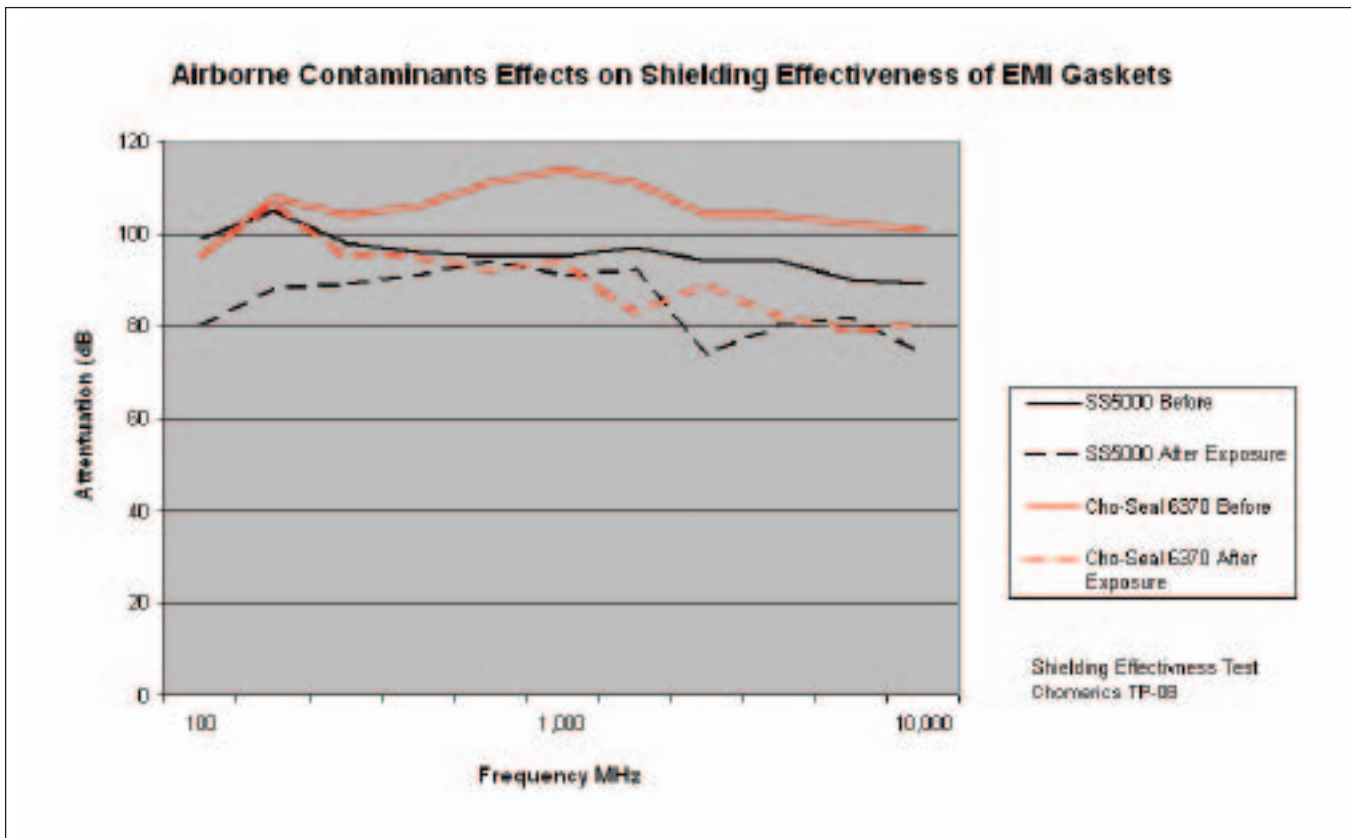


Figure 7: Airborne contaminants effects on shielding effectiveness of EMI gaskets

Section 4.1.1 requires high temperature exposure to 70°C for a 72 hour period to simulate transportation in extreme environments. For certain foams, compression set can be an issue. If this is a concern and fabric-over-foam is being considered, there are high performance urethanes and silicone foam based fabric-over-foam gaskets which can perform better in these high temperature environments.

With regard to section 4.6 Acoustic Noise, use of the right gasket, especially on the sides of line card faceplates, can help dampen noise. Enclosures that use forced air to cool line cards and employ fingerstock gaskets can sometimes emit a whistling noise as air is pulled through the slots in the gaskets on faceplates and rack shelves. Use of a fabric-over-foam based gasket can help reduce this effect.

A Word About Fabric-over-Foam Versus Fingerstock Gaskets

For many indoor electronic devices that require shielding, the choice of EMI gaskets will come down to either fingerstock or fabric-over-foam. Historically fingerstock has been the gasket of choice, especially in higher end electronics. It is reliable, proven and widely available. However, fabric-over-foam gasketing is quickly becoming the de-facto standard. This is due to improvements in the plating adhesion on jackets, advances in foam formulations, and the introduction of UL94V-0 flammability rated versions. These gaskets are also easier to handle and less prone to catching and breaking.

It is commonly believed that Be/Cu fingerstock shields better than fabric-over-foam. At low force-deflection this can be true. As an all metal gasket, electrical through-resistance characteristics are excellent. However, low through resistance does not always correlate to better shielding. Our own research at Chomerics (contact us for the data) shows that other factors such as the dimension and number of slots in fingerstock and surface contact area can affect shielding performance. For example, metal fingerstock is stiffer than a fabric-over-foam gasket and, under compression, fabric-over-foam gaskets contact a larger amount of flange surface area compared to fingerstock gaskets. The slots in the fingerstock can also allow EMI leakage depending on their size and the frequencies encountered. This supports the position that fabric-over-foam can often perform equally to if not better than metal gaskets, even in the most rigorous applications.

Summary

Choosing the right gasket requires knowledge of both electrical and mechanical requirements. Shear forces, environmental effects, compression set, and pricing are just some of the factors which influence which gasket is best for an application. Designers should be encouraged that a number of choices exist to fit their applications.

Although there is no one gasket that fits all applications, fabric-over-foam gaskets have progressed to a point where

they can be considered for applications in internal environments. Concerns over performance in shear, compression set, foam fatigue and abrasion resistance often prompt engineers in the past to choose other materials as the shielding method. Today, however, the variety of foam based gaskets is wide enough that they can be considered for shielding all manner of electronic enclosures. Fabric-over-foam gaskets using new high performance silicone foam means that fingerstock is no longer the only option when long term gasket performance is a requirement. Other advances such as z-axis conductive foam sheets allow for more design flexibility when considering flat gaskets without sacrificing performance.

It's in an engineer's best interest to know the differences in EMI gaskets. But shielding applications vary greatly and seemingly good gasket picks may not bring the expected results. The best EMI gasket choices are made with the help of experienced application engineers at established shielding companies. When they understand a customer's shielding requirements and resources they can provide invaluable advice for choosing the optimum EMI gasket. ■

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