MEETING MEDICAL EMI STANDARDS: CHOOSING THE RIGHT SHIELDING APPROACH

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of moisture. The second type is electrolytic and is due to current flow between two metals in the presence of an electrolyte. For commercial applications within controlled environments, galvanic-compatible materials are those within 0.5 to 0.6 volts. Typical galvanic activity is shown in Figure 5.

Compressibility: The height or diameter of the gasket must be large enough to compensate for the joint unevenness of the mating surfaces for the force applied (compressibility). The difference between the minimum and maximum compressed gasket height should equal the joint unevenness.

Compression force: Compression force is the force required to achieve maximum shielding effectiveness. The higher the pressure or compression force, the lower the impedance. A minimum closure force is recommended to obtain low surface contact resistivity and effective shielding. Minimum closure force is the pressure required to break through corrosive and oxide films to make a low resistance contact. Therefore, if insufficient pressure is applied to the seam, a high contact resistivity will exist and reduced shielding effectiveness will result. For a good joint seal, there needs to be low surface contact resistivity as well as low gasket resistivity (i.e., high gasket conductivity).

ANODIC (Most susceptible to corrosion)	
Magnesium	+2.37 v
Beryllium	+1.85 v
Aluminum	+1.66 v
Zinc	+0.76 v
Chromium	+0.74 v
Iron/Steel	+0.44 v
Cadmium	+0.40 v
Nickel	+0.25 v
Tin/Tin Lead	+0.14 v
Lead	+0.13 v
Copper	-0.34 v
Silver	-0.80 v
CATHODIC (Least susceptible to corrosion)	

Figure 5: *Typical galvanic activity.*

About Orbel Corporation

Since 1961, Orbel's custom design and manufacturing process has enabled unique engineered solutions for a variety of applications and industries. From conception through delivery, Orbel offers today's most effective EMI/RFI shielding, photo-etched precision metal parts, precision metal stampings, and electroplated metal foils. Areas of specialization include aerospace, telecommunications, electronics, microwave/RF, medical, automotive, and manufacturing. For more information, visit **Orbel.com** or call **610-829-5000**.

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Electromagnetic interference (EMI) between wireless devices and medical equipment is a growing concern in the healthcare industry. As wireless devices continue to proliferate in medical facilities, noise reduction, increased immunity to wireless RF emissions, and EMI mitigation all need to be addressed and managed.

Furthering its efforts to foster the development and deployment of advanced wireless medical communications, the U.S. Federal Communications Commission (FCC) has modified its rules for medical body area networks (MBANs). MBANs are low-powered networks that transmit a range of patient data from multiple body-worn sensors to a control device. MBANs can be used to monitor patient vital signs in real time, thereby providing advanced notice of potential problems. And, because they are wireless, MBANs make it easier to move patients to and from different facility areas. The FCC originally allocated 40 MHz of spectrum in the 2360-2400 MHz band for MBAN use on a secondary basis in 2012.

With this push toward more and more wireless devices within healthcare environments, EMI can have a detrimental effect on sensitive electronic components and circuits, and thus can endanger the health and lives of patients. There are many sources of EMI in the hospital environment, from electric motors to cellphones to computer circuits, power lines, and fluorescent lights to other medical systems such as electrosurgical units (ESU). Although regulations exist such as IEC 60601-1-2, these types of standards are developed by industry-specific organizations like the FCC and, more specifically, for medical devices, the FDA. These standards limit unnecessary electronic emissions and require immunity. In most cases, device manufacturers rely on shielding suppliers such as Orbel Corporation to have the technical capabilities and knowledge needed to suppress EMI. EMI shielding remains a challenging task.

Two Basic Shielding Approaches

There are two basic approaches for shielding electromagnetic emissions from a device or system as well as improving its immunity performance. One is shielding at the printed circuit board level utilizing proper design techniques. The second is to place the device or system in a shielded enclosure. This article discusses shielding products for use at both the printed circuit board level (board level shielding) and at the system evel (gasketing).

Board Level Shielding (BLS)

A board level shield can be viewed as a five-sided can. Available in unlimited sizes, shapes, and heights, board level shielding (BLS) (Fig. 1) is placed around the component or circuit on the printed circuit board that needs to be shielded. BLS is used to restrict the amount of electromagnetic energy propagating between the source and a receptor to acceptable levels. When designing and manufacturing BLS, the following elements need to be considered in relation to shielding effectiveness:

Figure 1: *Board level shielding (BLS) from Orbel Corporation can be manufactured in one-piece, two-piece, multi-cavity, and custom configurations.*

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Near-field effects: When the shield is in the near-field of the source, shielding performance will be impacted by the frequency of the source, the field configuration, position of the source, and distributed inductances and capacitances. In other words, the approach now becomes a "coupling" problem and should no longer be considered a radiated problem. Even when accounting for the apertures in a shield, calculating or estimating shielding effectiveness could still fall short of approximation. The coupling of the source to the shield, the effect of mutual coupling between elements, effect of the shield termination, and grounding technique all need to be accounted for. Currents diffusing through the shield, shield bends and corners, and the resultant generated external voltages also need to be considered.

Layout and hole considerations: The effectiveness of BLS is highly dependent on the proper design of the printed circuit board mounting area. Normally, the sixth side of this "box" will be a ground plane on the board. The number and spacing of traces, vias, and holes running from this shielded area to other board components can affect the effectiveness of BLS. With higher frequencies and shorter wavelengths, the size and number of holes can become issues along with thermal effects. However, this concern is tempered by the near-field effect. Capacitive and inductive coupling are more significant than aperture size for shielding.

Resonances: Another issue with higher frequencies is resonance effect (its coupling is a consequence of self-resonance of various structures). A 2-inch by ½-inch enclosure resonates at a first order mode of around 12 GHz. Even weak coupling at these high frequencies can induce strong oscillations that can then couple to any other point in the enclosure.

Thermal management: As devices become faster in frequency, they generate more heat. Hence, thermal management is also a design factor. Thermal management can be achieved through the use of thermal pads and heat sink—companies like Orbel can assist with various design options that may be available.

Gasketing

Gasketing is used to maintain shielding effectiveness through proper seam treatment. It is the effect of seams, in general, that accounts for most of the leakages in an enclosure design. The shielding effectiveness of a seam is dependent on materials, contact pressure, and surface area. Gaskets maintain conductive contact across mating surfaces. A solution to radiated problems is found by making all seams of adjoining metal pieces continuous. If there is no continuity between metal pieces, a radiating aperture for RF currents is created. This is where gasketing can be used.

Most gasket applications involve two types of forces, compression and shear (Fig. 2). When gaskets are installed under a flat cover panel in a compression configuration, pressure is used to preserve the shielding effectiveness of the seam. The alternative is a shear application where a flange or channel arrangement is maintained to preserve the shielding effectiveness and no sliding action occurs.

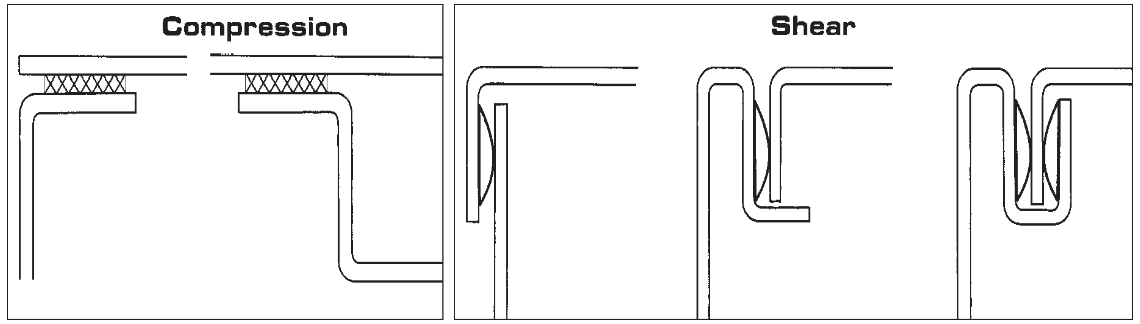

Figure 2: *Gasket application: compression configuration vs. shear application.*

Chosen based on specific shielding effectiveness requirements, application atmosphere, and spatial specifications, both beryllium copper (BeCu) gaskets and metalized fabric gaskets can be used to ensure maximum EMI compliance:

Beryllium copper gaskets: BeCu gaskets (Fig. 3) offer the highest level of attenuation over the widest frequency range and are useable in both compression and shear applications. Solid fingers have greater cross-sectional area, hence higher conductivity. In addition, the finger shape has the characteristics of an interconnecting ground plane with a large contact area. The inductance will therefore be low as well. The movement of the finger shape also provides a "wiping" action that aids in penetrating or removing any oxide buildup in the contact area. They are very forgiving to compression, meaning that it is very difficult to over-compress them causing compression set or breakage. Potential problem areas, depending on frequency range, are the slots between the fingers. At sufficiently high frequencies, these slots begin to permit RF energy transmission through the bounded slot configuration.

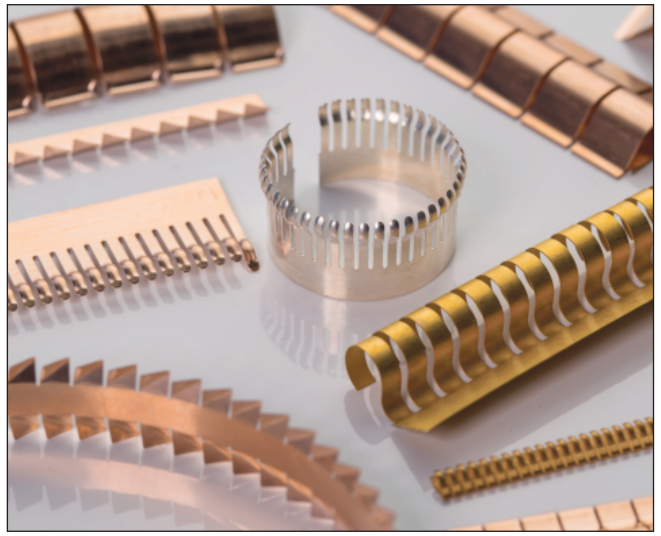

Figure 3: *BeCu gaskets from Orbel deliver the industry's highest EMI shielding effectiveness and are available in a variety of finishes.*

Metalized fabric gaskets: These gaskets (Fig. 4) are made of conductive fabric material over foam. Conductivity can be very low and hence offer very high attenuation—the amount of attenuation is determined by the level and matrix of the conductive particles used, and the compression force. These gaskets come in various styles and shapes (rectangular, square, D-shaped, bell-shaped, knife-shaped, etc.) that allow variouscompression ranges down to low values.

Gasket Design Guidelines

Generally, either of these gasket types will provide effective shielding (mechanical characteristics and cost generally determine choice of gasket). The effectiveness of the gasket is dependent on the use of proper design guidelines. Regardless of gasket type, important factors that must be considered during the selection process are RF impedance, material compatibility, corrosion control, gasket height, compression force, compressibility, compression range, compression set, and environment. For RF impedance control, high conductivity and low inductance is desired. It should not be a surprise that BeCu has the highest conductivity.

Corrosion: Corrosion is a concern as it can lead to reduced shielding effectiveness due to causing the gasket material to become insulative or creating new problem frequencies through nonlinear mixing. There are two types of corrosion. The most common is galvanic corrosion and is due to contact between two dissimilar metals in the presence

Figure 4: *Metalized fabric gaskets from Orbel are manufactured with a polyurethane foam core and nickel-plated copper-conductive fabric.*

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