ENGINEERED SOLUTIONS

# EMI COMPLIANCE: CHOOSING THE RIGHT SHIELDING AND GASKETING

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Compliance to EMI regulations is essential in today's global market and applies to almost any electronic/electrical device. Also, almost every country in the world now requires meeting not just EMI emissions standards, but also immunity requirements. There are essentially two basic approaches for reducing or shielding electromagnetic emissions from a device or system as well as improving its immunity performance. The first 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 available shielding products for use at both the printed circuit board level (board level shielding) and at the system level (gasketing).

## Board Level Shielding (BLS)

A board level shield can be viewed as a five-sided can. Available in a variety of sizes 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 attenuate 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:

**Near-field effects:** Many complications occur 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 the parasitic or distributed inductances and capacitances. In other words, the approach now becomes a "coupling" problem and should no longer be considered a radiated problem. So, even with accounting for the apertures in a shield, calculating or estimating shielding effectiveness of a shielded enclosure or box 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 need to be accounted for. Currents diffusing through the shield, shield discontinuities (i.e., bends, corners), and the resultant generated external voltages all 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 the spacing of vias and/or traces running from this shielded area to other board components can affect the effectiveness of BLS. What may occur is that the designer forgets about the various noise escape paths through the interlayer traces, vias, pads, and holes.

With higher frequencies and shorter wavelengths, the size and number of holes are becoming 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.


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

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**Resonances:** Another issue with higher frequencies is resonance effect. Its coupling is a consequence of self-resonance of various structures. These structures behave as cavity resonators. A 2-inch by ½-inch enclosure resonates at a first order mode of around 12 GHz. Even weak coupling at these extremely 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.

### Gaskets

Gaskets are used to maintain shielding effectiveness through proper seam treatment. It is the effect of these seams and discontinuities, in general, that accounts for most of the leakages in an enclosure design. The shielding effectiveness of a seam is dependent upon the materials, contact pressure, and surface area. Gaskets maintain conductive contact across mating surfaces. A solution to radiated problems is found by making all the joints or 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 gasket material can be used. These conductive surfaces must be cleaned of any insulating finish. Although close-spaced fasteners (approximately 25mm or 1 inch) could be used alone, gaskets are preferred in order to reduce the number of fasteners and compensate for mechanical variations or joint unevenness.

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, the pressure is used to preserve the shielding effectiveness of the seam. The alternative is a shear application where a flange or channel arrangement (i.e., knife edge) is maintained to preserve the shielding effectiveness and no sliding action occurs.

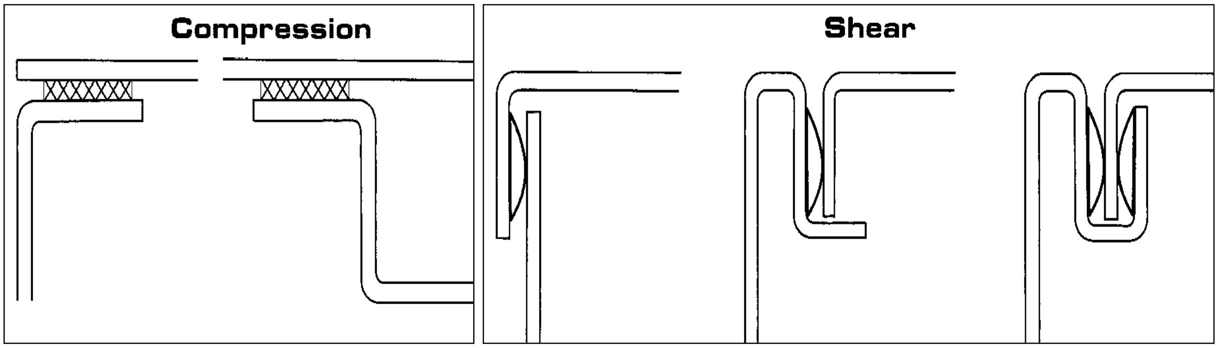


***Figure 2:*** *Gasket application: compression configuration vs. shear application.*

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

**Beryllium copper gaskets:** Beryllium copper gaskets (Fig. 3) offer the highest level of attenuation over the widest frequency range and are useable in both compression and shear type 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. A potential problem area, depending upon the frequency range of concern, is due to the slots between the fingers. At sufficiently high frequencies, the slots between the fingers begin to permit RF energy transmission through the bounded slot configuration.

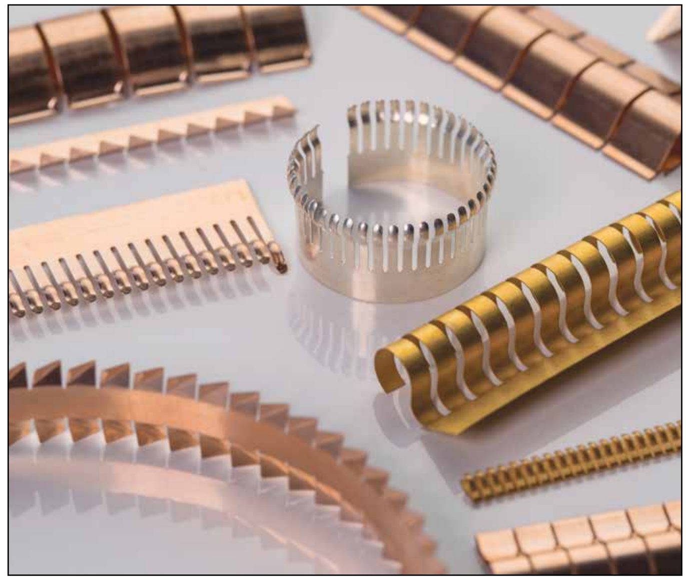

***Figure 3:** High-performance beryllium copper gaskets from Orbel deliver the industry's highest EMI shielding effectiveness and are available in a variety of finishes.*

**Metalized fabric gaskets:** These types of gaskets (Fig. 4) are composed of conductive fabric material over foam. The conductivity can be very low and hence offer very high attenuation. The amount of attenuation is determined by the level or amount and matrix of the conductive particles used, and the compression force. These gaskets come in different styles and shapes (i.e., hollow core, D-shaped, etc.) that allow various compression ranges down to low values.

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

**Gasket design guidelines:** Generally, any of these gasket types will provide effective shielding. Except for high-frequency applications requiring high attenuation, almost any gasket will work electrically. It is the mechanical characteristics and cost that determine the choice of gasket. The effectiveness of the gasket is dependent upon the use of proper design guidelines. Regardless of gasket type, important factors that must be considered during the selection process are RF impedance, shielding effectiveness, 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 (beryllium copper) has the highest conductivity.

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Corrosion is also a concern because it leads 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 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 where the environment is controlled, galvanic compatible materials are those that are within 0.5 to 0.6 volts. Typical galvanic activity is shown in Figure 5.

The height or diameter of the gasket must be sufficiently 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 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 (different from gasket material conductivity or volume resistivity of the gasket material) and good shielding. Minimum closure force is that pressure required to break through corrosive and oxide films to make a low resistance contact. Therefore, if insufficient pressure is applied to the seam, then a high contact resistivity will exist and reduced shielding effectiveness will result. So, for a good joint seal, there needs to be a low surface contact resistivity as well as a low gasket resistivity (i.e., high gasket conductivity).

There are many varieties of gasketing and shielding methods available and it can be very daunting to an engineer as to which type is best for a particular application. Consult with a shielding design engineer to select the material appropriate for the intended application.

| **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:*** *Galvanic activity table.*

### 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**.