The Role of Enclosures in Establishing EMC

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What is EMC?

Standards governing electromagnetic compatibility (EMC) also refer to the topic as shielding against electromagnetic interference/radio frequency interference (EMI/RFI or simply, EMI). Such interference is caused by stray voltages propagated through the air and/or by currents coupling between electronic systems that create undesirable effects. While shielding against EMI can occur at the component level or the subrack level, ultimately, it is the electrical or electronic enclosure that is called upon to provide functional EMC of the whole system in the field.

The undesirable effects produced by EMI can vary between just a brief annoyance, such as a vacuum cleaner disturbing family television viewing, to a more serious situation, such as a cellular phone interfering with the heart monitor of a critically ill patient. In industrial settings, EMI from a noisy power supply or arcing relay contacts may interfere with the proper operation of an industrial robot or process control signals may give erroneous results when interference exceeds a certain signal-to-noise ratio.

For most industrial applications, protecting electrical and electronic components from dust, oil and moisture is critical for both safety and long-term system integrity. But in a growing number of industrial environments, creating a line of defense against electromagnetic and radio frequency interference is becoming just as important. In other applications, like networking, telecommunications and audio/video signal processing, EMI shielding for components, subracks, cabling and enclosures has been a long-standing practice. Industrial environments can be quite "noisy," however, in terms of stray electromagnetic radiation. As more and more electronic systems find their way onto the factory floor, shielding systems from broad-spectrum interference in that environment will become even more critical.

Shielding: One of Many Functions

In practice, enclosure designers have had to add EMI protection to the list of normal protective functions enclosures must perform. Industrial enclosures perform five basic functions which are integral to the proper operation of any system:

- Provide a physical structure and support for electrical and electronic components.
- Maintain a proper operating environment based on temperature and humidity.
- Provide protection against physical damage, including seismic activity, shock and vibration, contamination, corrosion, and/or tampering.
- Provide connectivity by distributing power and accommodating input/output cabling and operator interface.
- Provide proper electromagnetic and electrostatic shielding to assure reliable operation and/or to make the device compatible with other electrical/electronic devices.

A sixth function of an enclosure might be to provide the proper level of aesthetic and ergonomic design so that it is compatible with other system components and is safe and convenient to use.

Sometimes, these functions can work at cross-purposes and interfere with component cooling or cable entry/exit, for example. The earlier the enclosure engineer can be brought into the application design, the better the chances are of meeting electromagnetic compatibility goals and normal enclosure functions without undue cost or delays.

Any enclosure made of an electrically conductive material provides a certain amount of EMI shielding by virtue of its inherent design. The ideal enclosure for electromagnetic compliance would be a seamless sphere manufactured of a highly conductive material such as copper, aluminum, silver or gold. Unfortunately, this solution is not only impractical, but also provides electromagnetic shielding at the expense of the other functions the enclosure must perform. Most enclosures are manufactured in steel or stainless steel (Figure 1).

While the principles of EMI shielding are well known and largely straightforward, the only way to know whether a packaging solution provides proper protection is to test the application in a qualified EMI laboratory. Even still, compliance under laboratory conditions is one thing, and compliance under extended field conditions is another. The solution is to create a testing situation as close to the real-world environment as possible.

Shielding Effectiveness

The measure of an enclosure's ability to prevent EMI emissions from entering or escaping is know as shielding effectiveness (SE). The SE of an enclosure at a specified frequency is expressed in decibel microvolts per meter (dBμV/m) by the

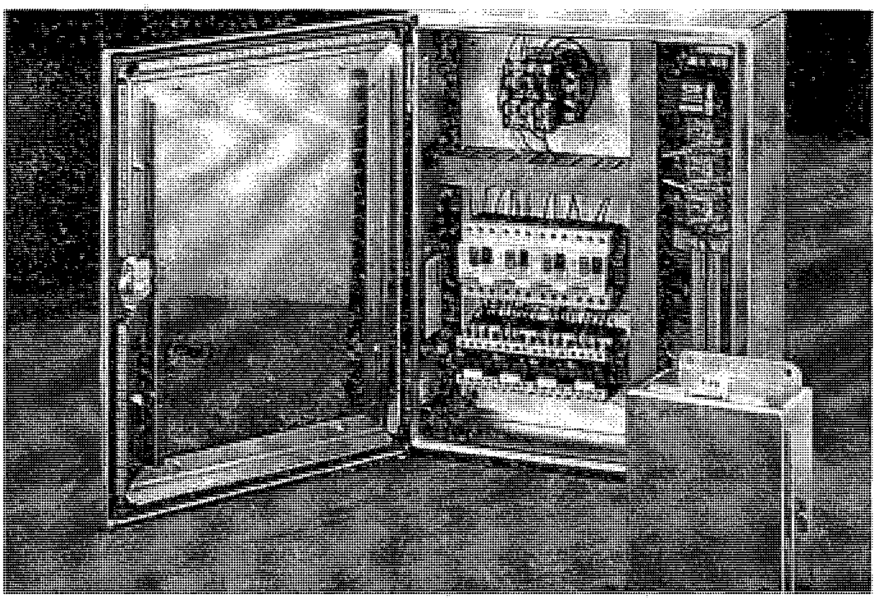

Figure 1. Enclosures and Junction Boxes are Available in Steel and Stainless Steel.

following equation:

$$SE = 20 \log_{10} (E_O/E_I)$$

where

E_O = radiated voltage measured outside the enclosure, and

E_I = radiated voltage measured inside the enclosure.

While the use of shielded enclosures does not automatically ensure EMC of a system, new EMI shielded enclosure products are available which, when correctly specified, will provide a high level of shielding effectiveness (30 dB or greater attenuation) up to frequencies of 1 GHz. Since interference can only be attenuated and not totally eliminated, the engineer specifying a shielded enclosure needs to decide what level of interference (or signal-to-noise ratio) can be tolerated by the system. For example, if 30 dB of attenuation at 1 GHz is not sufficient to protect signal integrity in a telecommunications application, then additional shielding must be employed at the component or subrack level to increase attenuation. Alternatively, steps may be taken to increase signal strength, thereby improving the signal-to-noise ratio.

For companies selling systems in Europe, the CE mark is often essential in meeting quality and operational standards, especially when it comes to EMC. In order to meet these EMC standards, system integrators must test systems in their final configuration in field-like conditions. This entails testing systems housed in an enclosure as it would finally be operated by an end-user.

Prior to the importance of EMI issues in the industrial environment, shielding was usually only encountered in various military applications. Even today, the original specification MIL-STD-285 describes the test procedure for making these SE measurements and it is still the standard test procedure that enclosure suppliers use to evaluate the SE of their products.

Other Factors Affecting Electromagnetic Emissions

EMI would not be much of a problem if an enclosure were a completely sealed conductive sphere. However, every enclosure has openings which may emit EMI from power and input/output cabling, glass or solid doors, inspection panels, various holes and cutouts for switching, lights or meters. Input, output and power cables can be shielded in a metal wireway, or arranged in twisted pairs to cancel emissions and ensure good SE. Openings need to be restricted to 1/10th of the wavelength of the highest expected frequency. In today's applications where frequencies can range up to 1 GHz, that means openings should be less than 30 mm in any dimension.

In order to create a completely conductive envelope, the surfaces of all panels, doors and modular attachments must have electrical continuity. This is typically accomplished by plating the interior surfaces of the enclosure with zinc and yellow or clear

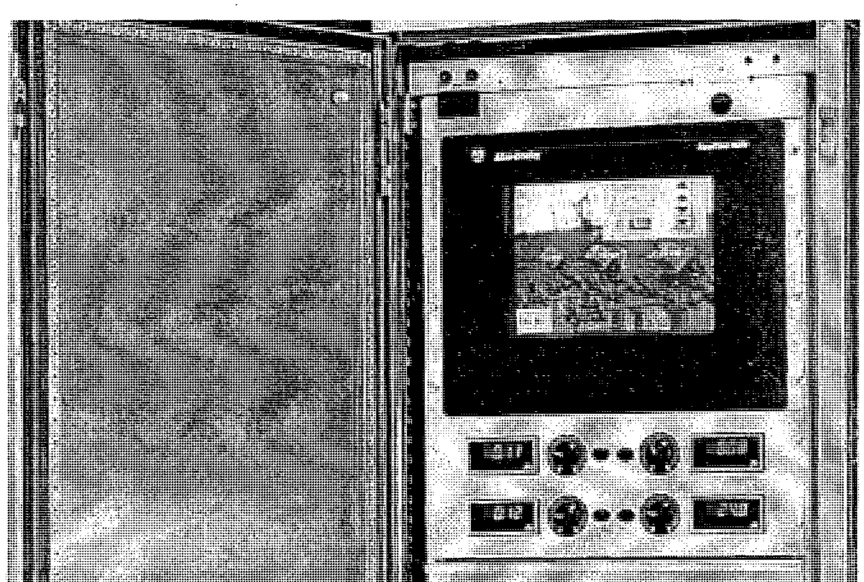

Figure 2. Modular Enclosures with EMC Options Feature Yellow Chromate Plating and Metal Fabric Gasket to Achieve a NEMA Type 12 Protection Rating.

chromate (Figure 2). With its low galvanic rating, zinc provides long-term protection against corrosion which would otherwise interfere with electrical continuity.

Doors on enclosures used in clean environments can usually be electromagnetically sealed through the use of a conductive elastomer gaskets with metal fabric or continuous metal finger style gasket such as those fabricated from stainless steel or beryllium copper. Some modular enclosures offer two levels of protection—a conductive fabric EMI gasket or a patented stainless steel finger gasket for enhanced attenuation at higher frequencies (Figure 3).

In wall-mount enclosures destined for the outdoors or harsh, industrial environments where there is dust, oil, moisture or corrosive chemicals, a foamed-in-place urethane gasket can be used in addition to the stainless steel finger gasket to achieve a NEMA 4X rating along with EMI shielding (Figure 4).

Cable entry and exit ports can be both sources of EMI emissions and places where EMI can enter an enclosure. Conductive elastomer gasketing material can be used to seal these openings. In industrial applications where exposed cables also need physical protection, continuous, metallic wireways effectively seal openings, protect cabling and provide EMI shielding.

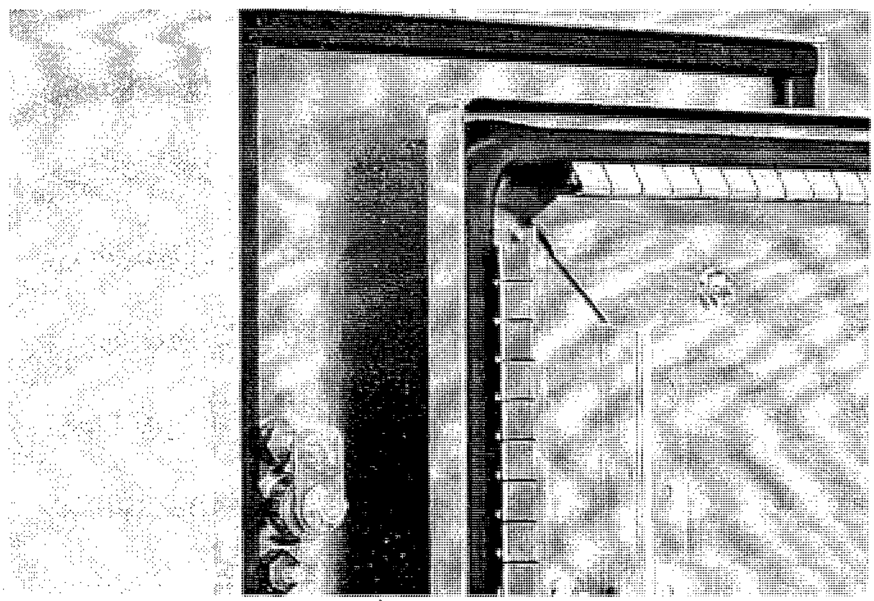

Figure 4. *Stainless Steel Finger Gasket Plus a Foam-in-place Urethane Gasket Can Provide Up to 30 dB of Attenuation at 1 GHz.*

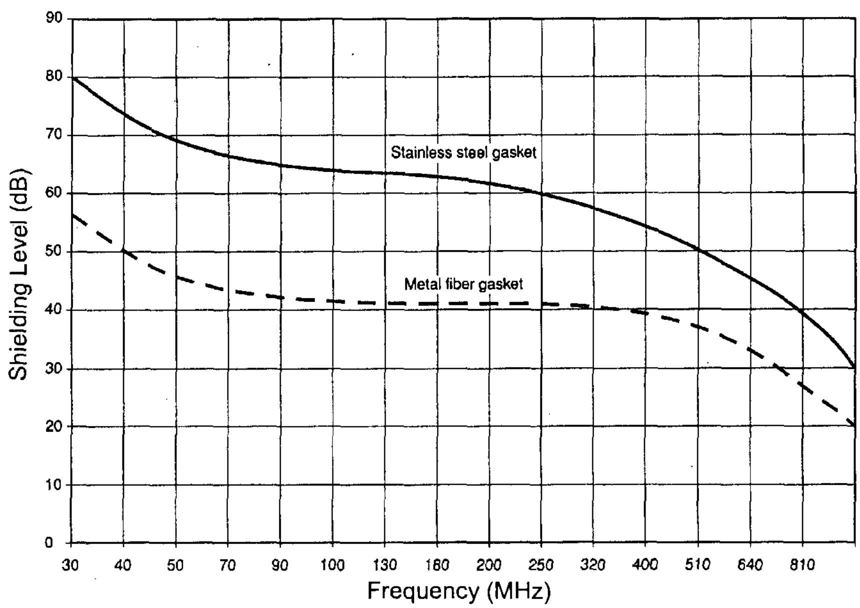

Figure 3. *Gasket Materials Compared.*

Thermal Management and EMC

Openings for cooling vents, air conditioning or heat exchangers also require treatment to prevent EMI. Often, a simple metal mesh with openings no greater than 1/10th the wavelength of the highest applicable frequency, provides adequate shielding. In general, however, EMI shielding treatments increase cooling requirements due to restricted airflow. In contaminated industrial environments, this may require the use of heat exchangers or air conditioning units.

Applicable Standards

The applicable North American and European standards for the overall assembly, including internal electronics, can vary with the application and the environment. A partial list of generic electromagnetic emissions standards is given in Table 1. For a complete list of applicable standards, contact your local testing authority.

North American Requirements

In North America, the Federal Communications Commission (FCC) regulates the amount of acceptable electromagnetic interference that products can produce. Since an empty enclosure by itself does not radiate any interference, it is not subject to the requirements of the FCC. However, a complete system (including the enclosure) may be subject to such requirements.

European Requirements

Europe has enacted legislation

which regulates the amount of EMI that products can emit and withstand while still operating properly. This legislation is called the EMC Directive, 89/336/EEC, and it became effective on January 1, 1996. Manufacturers shipping electronic/electrical products into Europe must comply with the essential requirements of this directive. In most cases, this means the OEM configured system must conform to relevant national standards that pertain to the intended purpose of the product (Table 1).

	North America	Europe	IEC
Industrial Equipment	CISPR 11	EN50082	801
Information Technology	CFR Part 2 CFR Part 15	EN55022 EN55024	
Telecommunications	CFR Part 47 CFR Part 68 GR-1089-CORE (Bellcore)	EN55022	
Test & Measurement	CISPR 11	EN50082	

***Table 1.** Applicable Standards.*

Summary

Worldwide standards have been established that require some level of EMI shielding for all electrical and electronic devices. In industrial environments, EMI shielding is growing in importance as more and more sophisticated electronic equipment finds its way onto the factory floor. In general, EMI shielding treatments tend to complicate other important enclosure functions such as environmental protection, cooling and input/output cabling requirements. While there are ample design solutions for achieving electromagnetic compatibility, it is important to involve an enclosure manufacturer early in the process in order to reduce costs, reduce design cycle time, and provide the best product for end users.

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