How to Select a Shielded Cabinet

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Optimum material selection, design and EMI/RFI shielding techniques ensure successful electronic system operation in demanding electromagnetic environments.

INTRODUCTION

Determining exactly what kind of an electronic enclosure best fits the specific needs of an electronic product or use can be fraught with unexpected consequences. A product depends on the enclosure for its durability, reliability, shielding effectiveness, and in the case of a new product, marketability. In other words, how well will this enclosure protect, maintain and shield the electronic components?

NEMA VS. EIA STANDARDS

Adding to the complications of the selection process is the fact that there are two standards that enclosure manufacturers can strive to meet: Electronics Industries Association (EIA) standards and those of the National Electrical Manufacturers Association (NEMA). Not surprisingly, these have different specifications, each having been created to meet various needs. So the first question is: "What is the difference between them and how does the cabinet buyer know which is applicable?"

NEMA enclosures were designed to answer the problem of finding an easy way to meet Underwriters Laboratories (UL) specifications for a variety of electronics. Engineers developed a fully-welded five-sided enclosure with just one opening for a door. A panel was mounted in the back and the electronics were mounted directly onto it. The doors were designed to be secured with mechanical power shut-offs to prevent both unauthorized access and access when high voltage was used. Advancements in development produced additional advantages such as protection from dust, moisture, oil spray, rain or snow, and even submersion.

EIA enclosures were developed to meet a totally different set of requirements. Focus was on meeting and incorporating various product needs and on changing requirements. Electronics manufacturers found they couldn't afford the time or cost of customized enclosures. Today's short life cycles for new electronic products and the effort to get new products to market in the least amount of time interfered with such desires.

ADVANTAGES OF EIA ENCLOSURES

The standardization by EIA manufacturers offered an effective solution. Now, even large electronic companies that can afford customizing are turning to the use of standard EIA racks in order to meet deadlines.

Using EIA standard enclosures, a manufacturer or systems engineer can often specify exact requirements. Whether the need is to mount 19"-, 24"- or 30"-wide electronics, the standards are there, and the EIA enclosure industry has cataloged products, solve these problems. Accessories, including Plexiglas doors to shelves, drawers, casters, lifting eye bolts, wired plug molds, grounding bus bars, and work shelves, are standard for most manufacturers.

VULNERABLE ELECTRONICS SYSTEMS

Another complexity presented by enclosures is the need to protect the internal and surrounding equipment from electromagnetic interference (EMI) and radio frequency interference (RFI). Not simply a nuisance, EMI/RFI can jeopardize successful operation of critical electronic communication, computer, and command/control systems. Delicate computer equipment cannot tolerate these emissions, which can be radiated from the ignition systems of gasoline engines and other electronic equipment. Received by wire and cable attached to a susceptible electronic system, or directly by the system's circuits, this radiated electromagnetic energy can cause the undesirable responses associated with EMI/RFI.

Conducted interference may also occur when heavy-duty motor switching causes transients on the power line; when spurious signals appear on the transmission line interconnecting systems; or from sources such as switching power supplies within the system.

The susceptibility of equipment, or the degree to which a system responds to electromagnetic energy in the environment, along with the source characteristics, ultimately determine whether signals in the environment are converted into harmful EMI/RFI. Some systems are less susceptible to EMI/RFI because of the nature of their circuit design or their operational parameters, such as frequency, amplitude, and sensitivity. The intended function of a system shapes how one assesses its susceptibility. Low levels of signals in the environment may be harmful for sensitive systems; for less sensitive systems, high levels of EMI/RFI may be tolerated.

It is not just the increasing sophistication and number of electronic systems in use today that impact the EMI/RFI problem, but also their density in a small space. The military has long been faced with placing a number of systems in close proximity in limited space, such as aboard aircraft or ships. Now, similar problems are arising as more electronic systems are finding their way onto the factory floor and into the automobile. EMI/RFI control in all these environments is problematic because isolating the interference source from the susceptible system is difficult in limited space.

Digital systems present a particularly tough problem by being both radiators of undesirable signals and susceptible to interference. Rapid data transfer and processing results in signals within computers and microprocessor-based equipment that have a high repetition frequency and pulse rise time, and hence are rich in high frequency harmonics. Short lengths of wire and cable as well as the conductors on the printed circuitry become efficient radiators, and small openings in metal cabinets become larger than one-half wavelength, and thus are also efficient radiators.

Whether for reduction of emissions to meet FCC rules, or for application to susceptible equipment for reduction of interference effects, methods of EMI/RFI control are similar. There are a number of EMI/RFI control options, of which shielding by the electronic system's metal cabinet is of primary interest.

When formulating options, an engineer must examine what is controllable and how much flexibility is possible in implementing EMI/RFI control techniques at those points. For instance, the designer of a factory data acquisition and control system has no influence on the design or selection of other electronic equipment which customers may use in these facilities. On the other hand, specification of interconnecting cable between subassemblies within the cabinet, the cable's shielding and its routing, and the cabinet and its shielding effectiveness, are issues which can be controlled by the designer. Additionally, these control techniques may provide a good amount of flexibility in implementation.

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CABINET SHIELDING

The ideal cabinet, from an electromagnetic shielding point of view, is thick metal, has continuous construction with no seams, and has no openings. From a practical point of view, the design of a good cabinet must be consistent with requirements for access to the interior for service or repairs, human factors, control knobs and connectors, a view of meters and visual indicators, and the facilitation of heat transfer from the electronics within.

Heavy metal material with solid construction and high electrical conductivity continuity at seams and corners provides good shielding that can be maintained under the various mechanical stresses that may occur in use. Seams separating conductive panels must not be insulating or of high resistance, such as could occur with coverings of paint, corrosion, oxides, or with inadequate fastening forces. Differing conductive materials must be galvanically compatible to preclude formation of a high-resistance mating section through electrochemical action (Table 1).

Some high reliability EMI/RFI cabinets are constructed from stainless steel. Sway-proof corners help maintain the mechanical integrity, and hence shielding effectiveness, when the unit is under mechanical stress. Panels, fitted into a recessed ledge, have electrical conductivity continuity and shielding effectiveness assured with beryllium copper spring-finger shielded gasketing. Two stainless-steel studs are sometimes located in the lower rear of the frame to assist in grounding.

Door closure on cabinets is frequently secured in an electromagnetic sense by the use of conductive gaskets. Common forms of gaskets are wire mesh, rubber or vinyl tubes with dispersions or coatings of conductive particles, and beryllium copper spring-finger strips.

Both the wire mesh and compliant tube require a design that provides force or pressure in the closure direction of the door. This compresses the gasket and assures that its shielding effectiveness is attained. Shielding along the length of the gasket is only as uniform as the closure force along its length. These gaskets tend to take a compression set after a period of time, which further reduces their effectiveness.

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Each metal group overlaps, making it possible to use materials from adjacent groups to avoid galvanic action.
GROUP 1 (METAL GROUPINGS) Gold • Platinum • Gold/Platinum Alloys • Rhodium • Graphite • Palladium • Silver • Silver Alloys • Titanium
GROUP 2 (METAL GROUPINGS) Rhodium • Graphite • Palladium • Silver • Silver Alloys • Titanium • Nickel • Monel • Cobalt • Nickel and Cobalt Alloys • Nickel Copper Alloys • AISI 300 Series Steels • A286 Steel
GROUP 3 (METAL GROUPINGS) Titanium • Nickel • Monel • Cobalt • Nickel and Cobalt Alloys • Nickel Copper Alloys • Copper • Bronze • Brass • Copper Alloys • Beryllium Copper • Silver Solder • Commercial Yellow and Bronze • Leaded Brass and Bronze • Naval Brass • 400 Series Stainless Steel • Chromium Plate • Tungsten • Molybdenum
GROUP 4 (METAL GROUPINGS) Leaded Brass and Bronze • Naval Brass • Steels AISI 431, 440, 410, 416, 420, AM 355, PH hardened • Chromium Plate • Tungsten • Molybdenum • Tin-Indium • Tin Lead Solder • Lead • Aluminum 2000 and 7000 Series • Alloy and Carbon Steel
GROUP 5 (METAL GROUPINGS) Chromium Plate Tungsten • Molybdenum • Steel AISI 410, 416, Alloy and Carbon • Tin • Indium • Tin Lead Solder • Lead • Aluminum • All Aluminum Alloys • Cadmium • Zinc • Galvanized Steel • Beryllium • Zinc Base Castings
GROUP 6 (METAL GROUPINGS) Magnesium • Tin

Table 1. *Metals Compatibility.*

Beryllium copper spring-finger gaskets, on the other hand, work with a wiping action on the door, with only low contact pressure required for effective shielding. These gaskets will not take a compression set over a period of time. Other attractive properties are that they are galvanically compatible with stainless steel, do not absorb moisture or support fungus growth, are not affected by air, ozone, ultraviolet and nuclear radiation, or solvents, and cannot flake or break into small conductive pieces that can short out electronics.

Sag-proof doors on heavy-duty cabinets can be designed to wipe across beryllium copper spring-finger shielding strips as they close into a recessed ledge. All gaskets are attached to the recessed ledge of the cabinet frame, eliminating damage when doors and panels are removed for installing electronic equipment, or are opened for service.

OTHER CONSIDERATIONS

Specifiers (whether design engineers or purchasers) should expect more than shielding integrity, multiple product lines and adherence to standards. The enclosure manufacturing company should have a full-line catalog, complete with technical information. It should offer free engineering services. On major projects, it should also include a trip to the specifier's facility by the vendor's engineers — preferably its chief or senior engineer. Custom colors, even for a single enclosure, should be available at no additional cost. On best-selling standard products, a maximum of five-day shipping, in any combination of standard colors, can be expected. A major customer should even expect special colors.

QUALITY CONTROL

Any good vendor will have an ongoing written Quality Control (QC) plan, with a strong, experienced manager aggressively taking action before a problem product arrives at the customer's shipping dock. To check how important QC is to the enclosure vendor, ask to whom the QC Manager reports. Is it the Plant Manager, VP of Operations, or the President? What was the last problem the QC Manager identified, and what was done about it? Is there a plant and office procedure to identify QC problems? Is a QC problem defined simply as bad material or workmanship, or is it anything that can affect the end customer in its application?

The best factory in the world can be made useless without knowledgeable, responsive field sales personnel. These people should be available within days (sometimes even hours) of a call. They should be able to help not only with enclosure specifications, but also in cases of freight damage or an ordering error. In the case of a problem, regardless of who caused it, the factory should be able to respond within days with replacement parts. It should never be necessary to pinpoint fault prior to corrective action.

Shipping dates should be real and honored at any cost to the manufacturer. No one can control everything. However, a good enclosure vendor should be willing to run the plant at maximum overtime and to air freight late parts when its customers' deliveries are at risk. These services should never have to be requested, nor should additional charges be expected. These are standard services from any good enclosure supplier.

If the enclosure vendor meets all of these guidelines, it is one of the best. If planning a long-term relationship (such as using the company for an OEM application), it would be a good idea to do one more thing: run a D&B report. Is the company financially stable? Is it master of its destiny (i.e., individually owned rather than owned by a larger company that may direct what and when the vendor manufactures)? Does it have the cash assets to handle needs as demand increases, and the flexibility to rapidly pull back if demand drops off? And for long-term OEM relationships, is it free from potential labor problems and plant shutdowns?

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SUMMARY

Cabinet purchasers should never settle for less than they need in terms of shielding effectiveness, product line or service. A good manufacturer designs cabinets to meet customers' special needs. On the other hand, why reinvent the wheel when the solution may already have been designed? The design staff at the enclosure vendor is a valuable resource. Their work should be free and could save the buyer significant problems, time and money.

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or 12-gauge steel, and doors are 0.063" aluminum or 16-gauge steel. Doors can be ordered with flush, paddle or slam latches (which automatically latch when the door is closed).

CONCLUSION

Given a new mid-course alternative to the either/or restrictions of standard versus custom shielded cabinets, the design engineer is now free to develop an enclosure that is uniquely functional and visually distinctive as well as economical and quickly procured.

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