Selecting EMI Shielded Cabinets and Enclosures

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INTRODUCTION

The increasing speed of computers, sophisticated electronics and demands for tighter security has changed cabinet designs dramatically in recent years. This need for greater shielding effectiveness has also resulted in a dramatic increase in cost. This article can assist users in selecting the optimum shielding system in terms of performance and cost-effectiveness.

A great deal has been written on shielding effectiveness in electronic cabinets, ranging from the types of materials used in fabricating cabinets to frame construction techniques, and from cabinet-joint designs to the types and mounting methods of conductive gaskets. Although these subjects are important, specifiers of cabinets need to know exactly how much shielding is enough, rather than relying on shielding specifications.

Knowing the environment in which a finished system will function is imperative. It also is important to understand that a cabinet can keep emissions *out* as well as *in*. Examining the noise level of components and subsystems within a system is equally beneficial.

Unfortunately, the most prominent criterion in developing the shielding parameters of a cabinet is the point most often missed by system designers and cabinet suppliers alike: *All cabinet shielding specifications are systems specifications; that is, the only way to truly confirm the effectiveness of the shielding is to test the system after it is installed in the cabinet.*

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Shielding requirements for the FCC, MIL-STD-461 and TEMPEST standards define maximum noise emission level for the entire system. This means the cabinet can only be tested after the equipment is installed and the cables attached. The equipment is turned on, the associated noise levels are recorded and the data is compared to the maximum allowable noise levels defined by the applicable specification for a pass/fail determination.

This criterion -- knowing what the real shielding requirements are in terms of effectiveness vs frequency -- can mean the difference between success and failure. A cabinet manufacturer cannot determine these requirements, because only the designers of the system are familiar with the electronics which will be installed.

Overspecification is a common error, and is usually based on the assumption of a worst case shielding level. Generally, this translates into paying too much for a cabinet.

To illustrate the magnitude of cost differences, a cabinet designed to meet the MIL-SPEC shielding levels can be expected to be two or three times more expensive than that required for compliance with FCC requirements. A TEMPEST compatible unit might be three or even four times greater than the MIL-SPEC cabinet.

An understanding of how much shielding is enough to achieve the necessary effectiveness is critical. By identifying potential noise generators with component and sub-assembly suppliers, then setting minimum shielding levels, the burden on the enclosure to meet the system level shielding requirements is reduced dramatically.

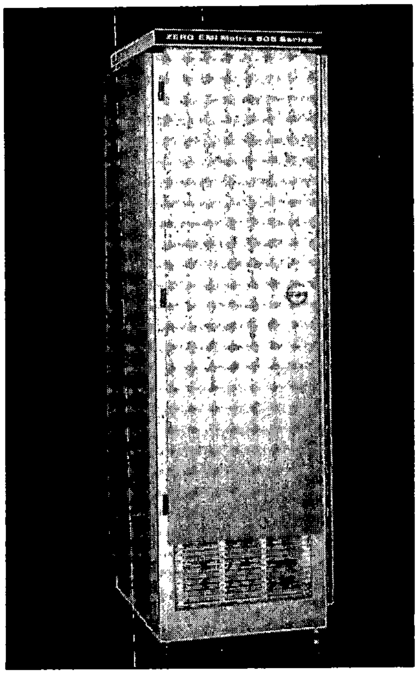


FIGURE 1. *Sixteen-gauge Steel Cabinet.*

CABINET DESIGN

Several factors drive up cost. In an effort to combat this situation, some enclosure openings can be covered with perforated screens rather than the more costly honeycomb filters.

Cabinets designed to medium (50 to 60 dB) shielding levels may require a honeycomb filter. These should be tin-plated because the honeycomb is made with nonconductive adhesive at the node points of the hexagon cell. The tin plating covers these joints, making the entire filter more conductive and eliminating inconsistencies that otherwise might cause erratic and unacceptable performance. This feature could cost $100 to $200.

In cabinets designed to meet the maximum (greater than 80 dB) shielding levels, it is not the *performance* of the filter as much as the *interface* between the cabinet and the filter that is important; the interface must be sufficiently rigid so the units will not distort when bolted together. Generally, this is accomplished by using a double gasket with approximately $1^1/_2$" spacing between the screws. To assure satisfactory performance, these filters generally are made of steel. They add approximately $200 to $400 to the cost of the cabinet.

Grinding and welding of all joints is another consideration. In minimum (20 to 30 dB) shielding requirements, joints do not have to be welded, making grinding unnecessary. For higher levels of shielding, however, welding and the cosmetically acceptable grinding of the welds is required, and adds significantly to the cost of the cabinet.

The most costly consideration is the structural stiffness of the cabinet. The higher the level of shielding, the stiffer the structure must be.

Units designed to the lowest shielding levels do not require high gasket pressure. Lighter gauge material can be used and structural reinforcement is not necessary. For comparison, the unit in Figure 1 is made with 16-gauge steel and very little reinforcement. Figure 2 illustrates the shielding effectiveness achieved by this cabinet. Figure 3 shows a cabinet made from 12-gauge steel, with reinforcement in the door, 1/2"-

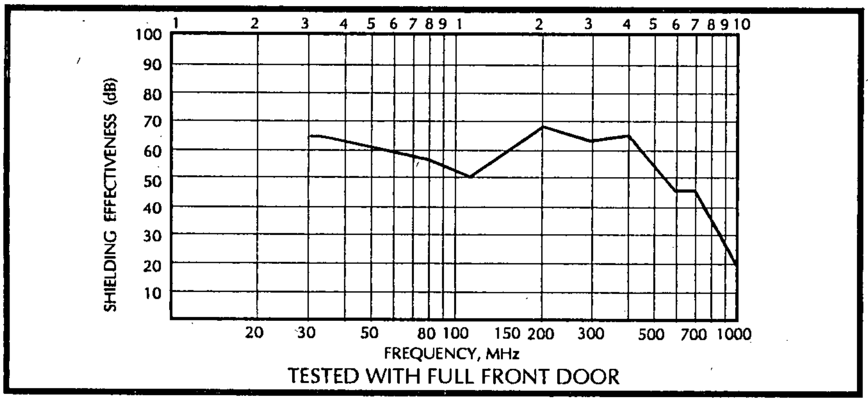


FIGURE 2. *Shielding Effectiveness of 16-gauge Steel Cabinet.*

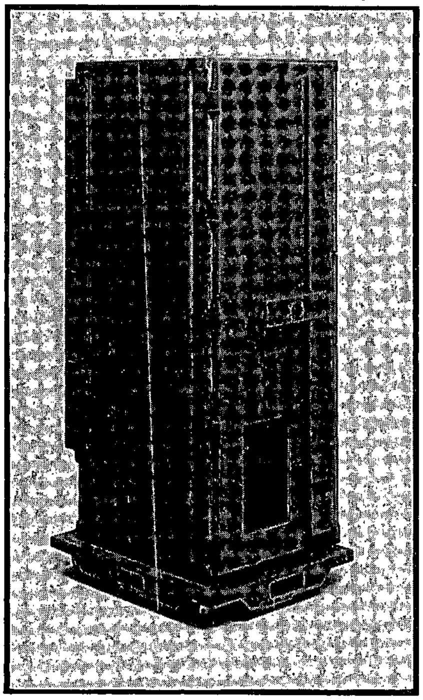


FIGURE 3. *Twelve-gauge Steel Cabinet, with Reinforced Door, Honeycomb Filters and Multiple Gaskets.*

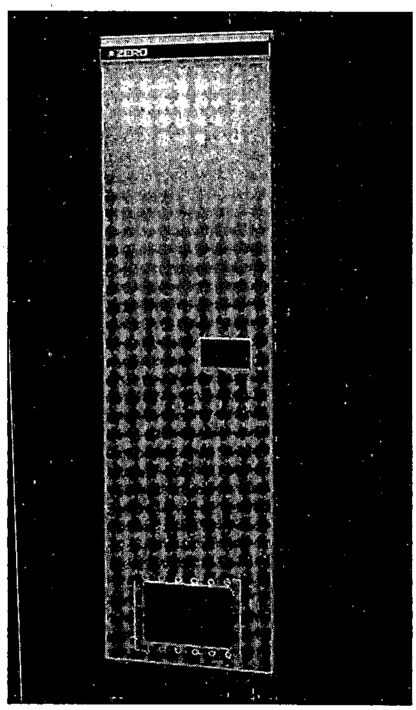
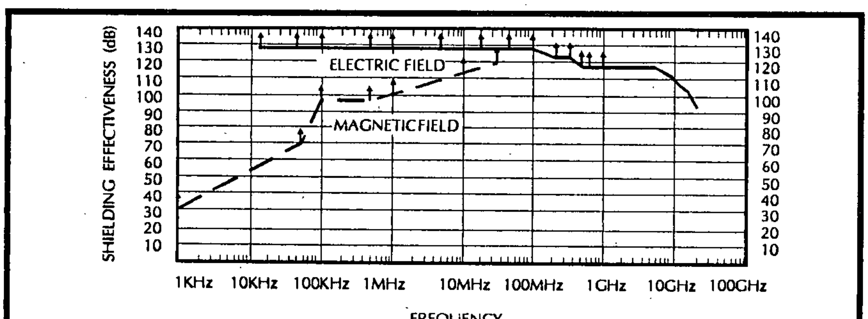


FIGURE 5. *Twelve-gauge Steel Cabinet with 2 Rows of 3/4" Wide Gaskets.*



NOTE: ↑ Indicates greater than value. Due to equipment dynamic range, exact numbers cannot be determined.

FIGURE 4. *Shielding Levels Achieved with Cabinet Illustrated in Figure 3.*

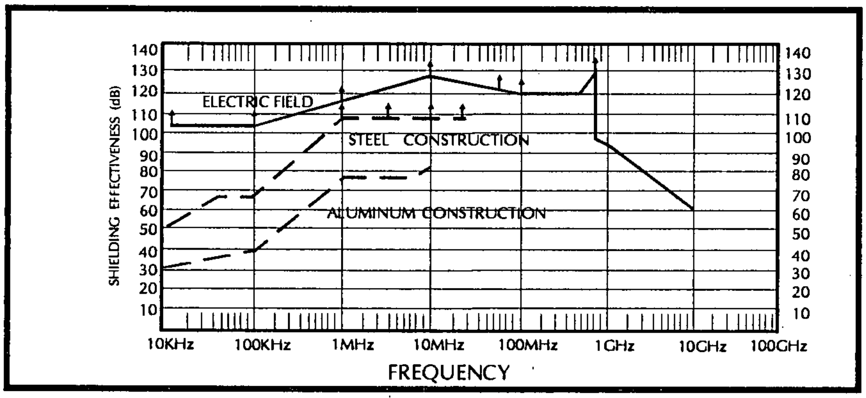


***FIGURE 6.** Shielding Effectiveness Achieved with Cabinet Illsutrated in Figure 5.*

thick honeycomb filters and multiple gaskets. Figure 4 shows the effective shielding levels achieved. The cabinet in Figure 5 has two rows of 3/4"-wide gaskets, doubling the pressure, as well as the cost, of the gasket material. The honeycomb filters in the cabinet are 1" thick.

The design of the door and latching mechanism must also be considered. In low shielding applications, such as the cabinet shown in Figure 1, a three-point latch with a standard wiping pawl is all that is required. The cabinet shown in Figure 3 utilizes a four- or five-point latching mechanism. The points utilize ball-bearing rollers, cams or other mechanical means to close the door. The highly shielded cabinet in Figure 5 employs a continuous latching mechanism down the side of the door and a special lever to close the door. This unit also has reinforcements so the door or the cabinet frame will not deflect, assuring proper pressure along the entire gasket.

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The higher the level of shielding effectiveness, the more sophisticated -- and costly -- the latching mechanism. A mechanical design must assure a tight seal while permitting the easy latching of the cabinet door. Generally, a closing torque of 90 to 95 lbs. is acceptable. Anything beyond that warrants a close look at alternatives.

Cabinets are available in many standard ranges of shielding effectiveness from FCC requirements (Figure 2), to general military specifications (Figure 4) to the specifications defining TEMPEST compatible cabinets (Figure 6). With this range of specifications comes an understandable level of confusion. No cabinet manufacturer can state with any degree of assurance that a cabinet will meet FCC, MIL-STD-461 or TEMPEST specifications. These companies can only supply shielding effectiveness data to assist a system designer in making a logical decision. The correct evaluation of this data and the method by which it is collected is critical to making a correct decision.

The only specification that covers the measurement of shielding effectiveness of an empty enclosure is MIL-STD-285. This standard outlines the generally accepted test procedure for measuring the shielding effectiveness of an enclosure. A transmitter is placed inside the cabinet and a receiving antenna is positioned outside the unit. An open reference is taken with the cabinet door open, followed by a reference with the cabinet door closed. These readings are taken at specified frequencies in the 14 kHz to 10 GHz range in the electric and plane wave fields, and from 1 kHz to 30 MHz in the magnetic field. The difference in these readings is the shielding effectiveness of the cabinet.

If the open reference is made with the transmitting and receiving antennas in open space, and the transmitting antenna is then placed inside the cabinet, the shielding effectiveness would increase an additional 10 dB. This is because the cabinet provides a certain level of shielding effectiveness even with the door open.

Knowing how the open reference was taken -- with the antenna inside or outside the cabinet -- can have an impact on whether a system will be adequately protected. If the data shows that the shielding effectiveness achieved under test is very close to the required shielding levels, the transmitting antenna must be placed inside the cabinet during every phase of the test, including the open reference stage. Otherwise, the safety margin inherent to the correct test method is eliminated and a real possibility of failure exists.

Most emission tests are performed with both a front and rear door in place, but designers must know if the tests are

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When production personnel, tool makers and other subcontractors have been included in the design loop analysis, the production of the cabinet can be expected to proceed more smoothly. Any parts that require difficult or costly production methods are redesigned early in the design process where the incurred costs are the lowest.

CONCLUSION

A well-designed knockdown cabinet can be expected to achieve a level of shielding performance close to that of a similarly designed solidly welded cabinet. One standard 38-rack unit cabinet contains about 120 feet of gasketed seams. Clearly, a welded cabinet whose only seam is the door will likely perform at a somewhat higher shielding level, particularly at higher frequencies. Despite this limitation, relatively high levels of shielding are still attainable. Figure 6 shows the attenuation levels of a prototype cabinet after five assembly/disassembly cycles. This illustrates that fairly high levels of shielding are attainable in a knockdown cabinet through multiple assembly/disassembly cycles.

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A knockdown cabinet is of little use if the assembly or disassembly of the cabinet is too complex and time consuming. The inherent complexities of a high performance shielded cabinet will always require a fair amount of assembly time; however, this time should not exceed a few hours. The designer should have realistic expectations about the abilities of personnel likely to assemble the cabinet. If an assembly operation is too complex, then it will likely be performed incorrectly, resulting in a deficient cabinet.

The cost of a knockdown cabinet should be comparable to that of a similar all-welded cabinet. The additional costs of the corners and associated gasketing are offset by avoiding any welding and grinding on the frame.

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undertaken with intake and exhaust openings in the cabinet. For accurate comparison, the designer must compare this data with the maximum noise levels generated by the equipment to determine the real shielding effectiveness of the cabinet.

Side-panel access for equipment service or installation often is taken for granted. In highly shielded cabinets, removable side panels are not available because they would allow many opportunities for a shielding failure to occur over time on an otherwise solid design. Side panels on cabinets designed for middle and low level shielding effectiveness add significantly to unit cost, due to additional fabrication of the panels and gaskets, and installation expense. For low level shielding requirements, the side panel can be hung on brackets attached at the top. A deliberate bow designed into this panel tends to draw down the panel as it is secured to a bottom flange with two externally accessible screws. When locked into place, the panel maintains a secure seal around its perimeter to assure satisfactory shielding levels for less critical applications.

CONCLUSION

Clearly defined shielding level requirements must be determined to select the proper cabinet. This information then must be compared with data (including an in-depth study of the test procedures) provided by the cabinet and enclosure manufacturer.

The greater the shielding effectiveness, the higher the cost of the cabinet. To be cost-effective as well as properly protected, the user should purchase a cabinet based on the minimum shielding level required.

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