Design and Construction of a Modular Shielded Enclosure

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INTRODUCTION

This article discusses the design and construction of a modular shielded enclosure using a material which belongs to a new family of coated textiles. Based on shielding effectiveness (SE) values measured on small samples, a prediction was made for the SE value on the modular enclosure. A simple test setup for characterizing the behavior of the joining technique was used. Finally, an enclosure was constructed. The obtained SE of the enclosure, measured according to MIL-STD-285, was found to be consistent with the predicted value.

MATERIAL CHARACTERIZATION

Due to the increased use of high speed electronic circuitry in different environments and applications, a real need exists for medium class shielded rooms, or rooms which offer a shielding level of about 50 - 60 dB (far-field conditions) for a reasonable price.

Predicting shielding effectiveness performance in MIL-STD-285 conditions from small samples is possible.

Applications for this shielding level exist in laboratories, small computer rooms and medical facilities.

Several new conductive textiles are available for use in medium class shielded rooms. Some of them are textiles actually woven with conductive fibers or wires. Others are made from a non-conductive substrate and coated with a conductive layer.

A new deposition technique was recently developed which results in a high quality conductive layer, a nickel-coated nonwoven nylon substrate. Now, conductivity levels ten times greater than were possible with traditional coating techniques are achieved for the same metal layer thickness.

Coated textiles can be characterized in small samples. One method involves the use of the ASTM D4935/89 measuring cell for the evaluation of the SE of small samples under far-field conditions.[1] However, using this cell is very time consuming. Therefore, other measuring cells were developed, the results of which have been reported earlier.[2-6] Figure 1 shows SE values for near-field (magnetic) conditions, measured with an H-t cell, and far-field conditions, measured with a TEM-t cell.[6] Typical SE values for the material were determined based on this research.

MIL-STD-285 PREDICTION

A well-known standard for characterizing shielded enclosures is MIL-STD-285. This test applies to shielded enclosures of approximately 2 x 2 x 2 m, or a metal box of at least this size with a window of about 0.6 x 0.6 m up to 1 x 1 m. The window should be

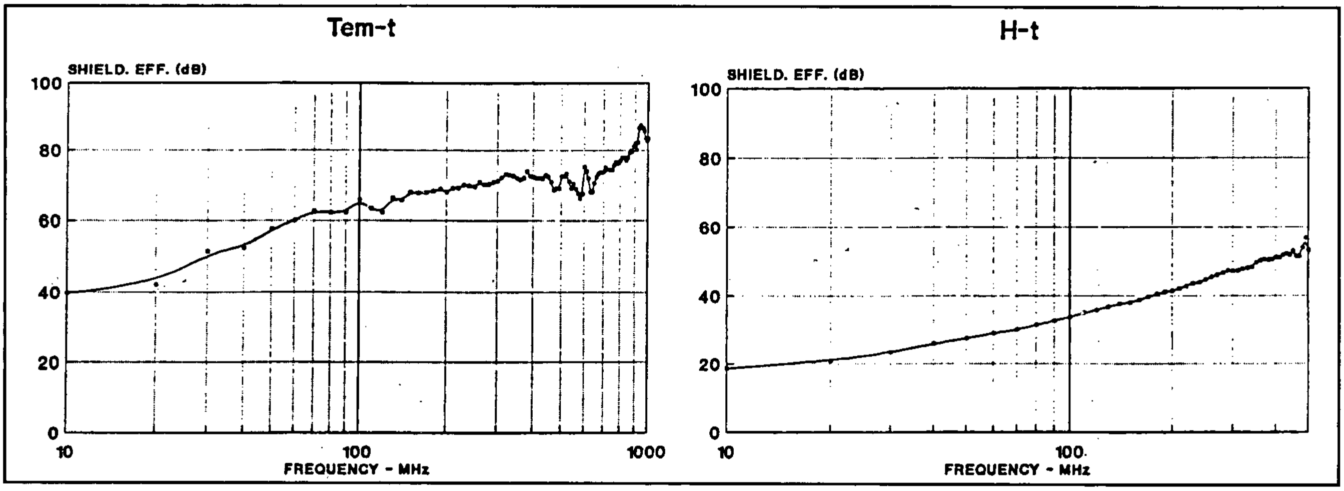

Figure 1. *SE Values of Material Measured with TEM-t and H-t cells.*

covered with the material under test.

In an early stage of product development, only small samples are available. Therefore, the expected MIL-STD-285 SE value must be predicted from a small sample. Some tables and formulas are useful for correcting MIL-STD-285 measurements (reference distance 30 cm) to other measuring distances.[7] These methods have been changed to accommodate the aforementioned TEM-t and H-t cells.[8]

An example of small sample MIL-STD-285 prediction is given in Figure 2, using the material under test. The material used was expected to offer a shielding effectiveness of 35 dB H-field at 1 MHz, 58 dB H-field at 10 MHz, and more than 70 dB for far-field conditions.

Because of the expected performance of the material itself, a modular enclosure of 2 x 2 x 2 m was constructed. Due to the modular construction, joining the panels was necessary. A characterization of the joint was first done on a small box of about 0.3 x 0.3 x 0.3 m.

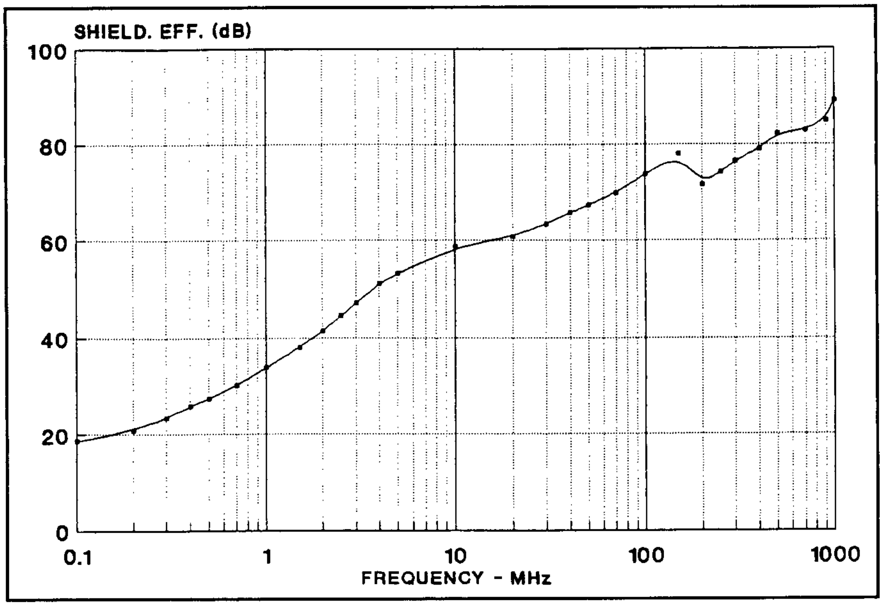

Figure 2. *Predicted MIL-STD-285 SE Values.*

CHARACTERIZATION OF THE JOINT

The first measurement performed to characterize the joint was a dc resistance measurement, where two small wooden panels covered with the substrate were connected and bolted together. The basic setup is shown in Figure 3. After an injected current of 1 A, voltages over the entire frame (dV1) and voltages over only the joints (dV2) were measured.

$$dV1 = 88.1 \text{ mV}$$
$$dV2 = 1.7 \text{ mV}$$

These results indicate that the contact between the two panels was very good. An appropriate conclusion is that the dominant resistance value stems from the surfaces covered by the material, rather than from the joining structure.

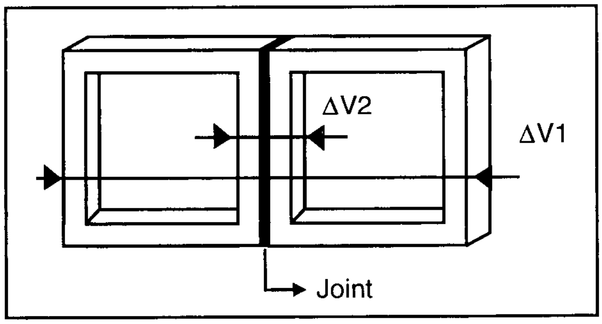

Figure 3. *DC Resistance of Joint.*

Next the box was placed in an open stripline, which was used to generate an ambient EM field. A small loop antenna was used as the receiving antenna. Measurements were done for three configurations of the box. One configuration used no gaskets while the second and third used two different types of gaskets for joining the panels. Results indicated that use of a gasket created extra contacting impedance and a higher joint resistance.

CONSTRUCTION OF A LARGE MODULAR ENCLOSURE

A modular enclosure was designed, based on a wooden frame of panels of 1 x 2 m. Each panel has an open structure, based on a 0.3 x 0.3 m matrix. The wooden laths used for this construction measured 4 x 4 cm. Each panel was covered with the nonwoven textile and bolted together. Details are illustrated in Figure 4 and a general view of the enclosure is given in Figure 5.

Other features of the enclosure were a main power line filter with a penetration panel, a honeycomb panel and a low-cost flush door. This auxiliary equipment was mounted on one of the walls in order to isolate possible leakages due to the contacting impedances and non-ideal joints between this equipment and the conductive panels.

MEASUREMENTS AND CONCLUSIONS

Measurements were performed according to MIL-STD-285 for both magnetic and electric/plane wave conditions. For the low frequency magnetic measurements, two identical loop an-

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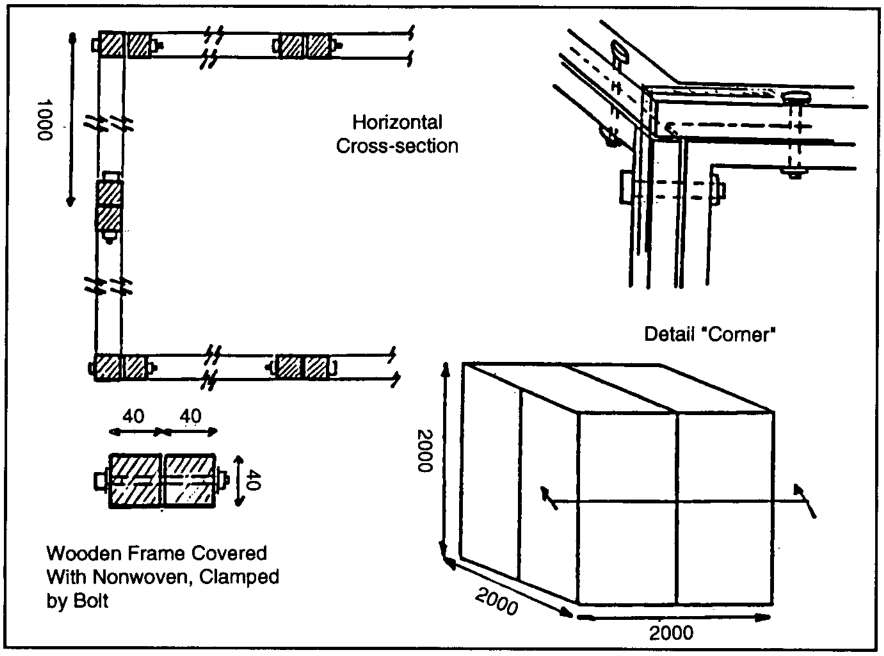

Figure 4. *Schematic of Panel Assembly.*

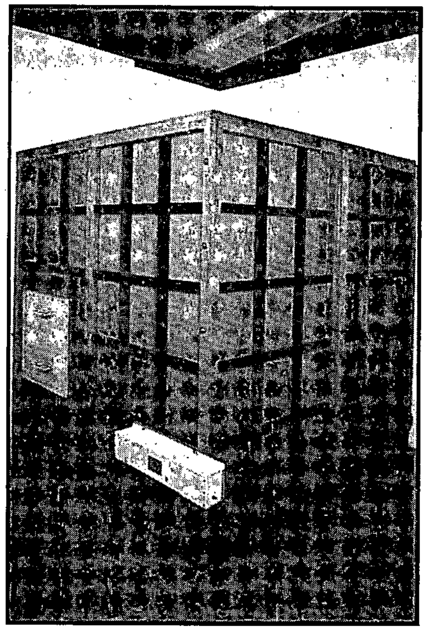

Figure 5. *Shielded Modular Enclosure (2 x 2 x 2 m).*

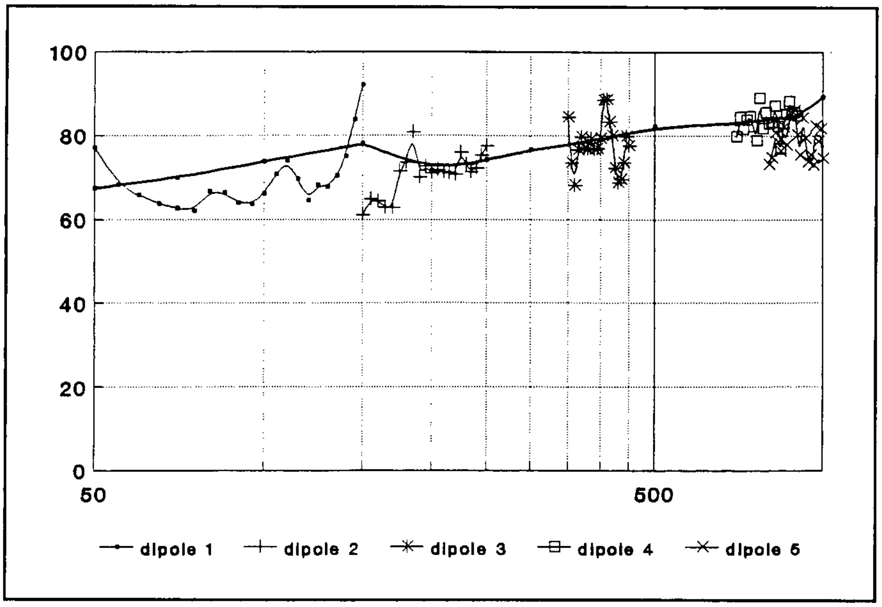

Figure 6. *Predicted and Measured Plane Wave SE Values.*

tennas were used, each at a distance of 30 cm from the conductive layer. The other measurements were performed using tuned dipole antennas in accordance with the reference distance of the standard. The antennas were tuned by a balun to match the impedance to the RF generator, and to measure a half-wavelength size. The measuring frequencies were 50 MHz (not tuned in size), 100 MHz, 200 MHz, 400 MHz, 800 MHz and 950 MHz.

Due to the larger sizes of some antennas, only one measuring position was used, in the middle of a side wall. Therefore, the effect of joining two modular panels was also averaged in these measurements.

Predicted and measured SE values for the far-field/plane wave conditions (tuned dipole measurements) are given in Figure 6.

A low-cost flush door was used for easy access to the enclosure. A nonconductive seam was glued onto the door panel, and the conductive layer covered the seam. In this way, a good conductive contact was established between the door panel and the frame of the enclosure. Figure 7 shows this construction. The resultant shielding values are given in Figure 8.

Figure 9 gives predicted and measured values for LF magnetic fields and HF plane waves. Predicted values and actual measurements correspond. It should be noted that the prediction is based on small samples of the material used, and that the measurements are done on a modular enclosure, taking into account average values of larger surfaces and joining effects.

CONCLUSIONS

Predicting shielding effectiveness performance in MIL-STD-285 conditions from small samples is possible, and is a very useful technique during new product development. The predicted SE values and the measured SE values correspond.

The modular enclosure featuring this new family of conductive textiles performed very well with respect to shielding. SE values of more than 70 dB were obtained for far-field (plane wave) conditions.

For joining the panels, no gaskets were needed in order to obtain good performance and no leakages were observed. Also, the application of other equipment such as power line filters and honeycomb ventilation structures did not present any leakage problems.

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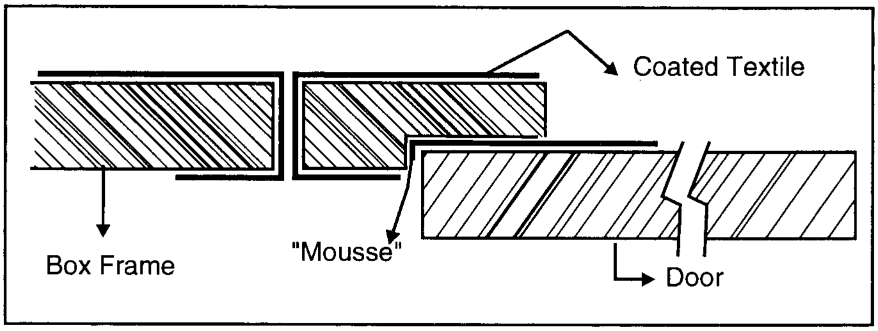

Figure 7. *Construction of Door Panel.*

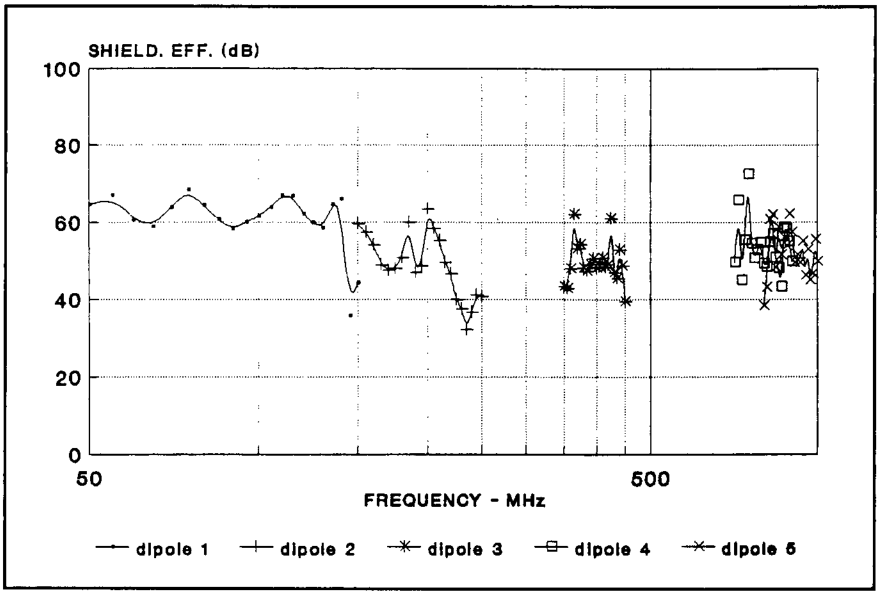

Figure 8. *Measured SE Values at Door.*

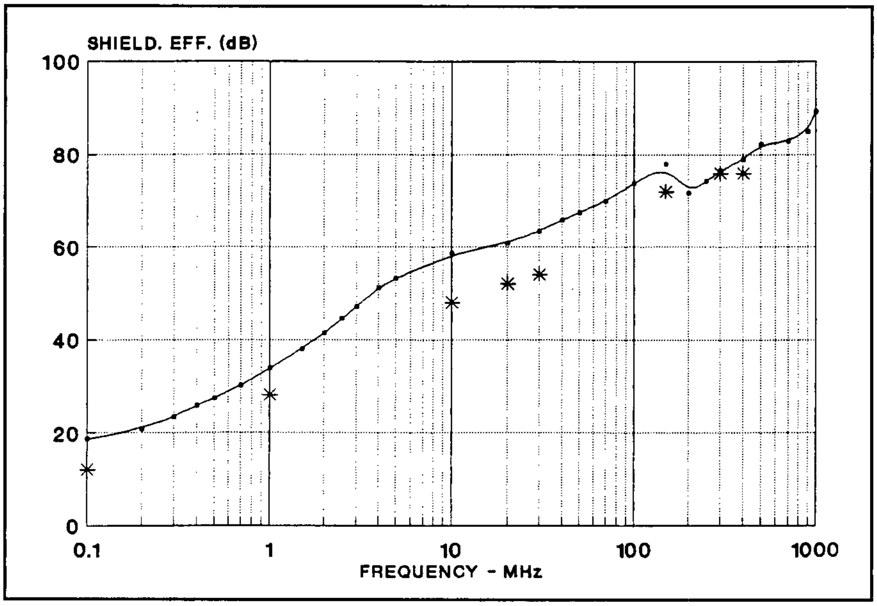

Figure 9. *Overall Predicted and Measured Shielding of Enclosure.*