Dual Application EMI Filters: A Case Study

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A focus on ultimate goals at the outset yields cost-effective and efficient results in EMI designs.

Enclosure Requirements

Adeptly handling EMI/RFI requirements for full CE certification can make the difference between profit and loss for electronics equipment manufacturers in the United States. Full CE certification gives manufacturers access to European markets. Without CE certification, entrance to the European market is blocked.

One of the basic EMI/RFI considerations electronics equipment designers must address is the kind of enclosure in which to place the electronics. The requirements for electronic equipment enclosures are growing. Today's boxes not only have to look good, they must also withstand heat and shock and meet tougher EMI/RFI requirements for the equipment to earn full CE certification.

Enclosure designs are complicated further by the fact that sophisticated electronics are shrinking in size so that more functional parts can be installed. A result of this higher density is a corresponding reduction in the box size, which invites further heat build-up. Even though the electronics are condensed, the heat load is not necessarily reduced. In fact, the heat load can actually increase, as a result of how much more can be packed into the enclosure. In response, enclosure ventilation systems have been developed, but they often create EMI/RFI problems which can preclude full CE certification.

The Challenge

A manufacturer of radiation measuring equipment recently faced the challenge of meeting full CE certification requirements while in the process of redesigning a major piece of equipment. One of the company's primary products is a thermoluminescence dosimetry (TLD) instrument, an appliance designed to read badges which measure human radiation exposure in environments where radioactive material is present. Nuclear power plants and DOE laboratories use the instruments to safeguard workers from radiation overexposure. Essentially, the machine processes crystal-embedded badges by heating them to 300° C. The heating process causes the crystals to emit light at detectable, measurable levels. The higher the luminescence, the greater the radiation exposure.

The goal of the redesign effort was to fully modernize the existing TLD reader, creating a new, state-of-the-art version. At the outset of the project, full CE certification was determined to be a critical goal. A major part of reaching that goal was managing potential EMI/RFI problems. Aside from the CE certification issue, the management of potential EMI/RFI problems was critical because of the equipment's need for accuracy.

The newly-designed model is a washing machine-sized piece of equipment that contains a light measurement system, a heating system, and both analog and digital electronics. To ventilate the enclosure, three fans are built into the instrument's rear panel. Two of the fans are for intake, and the third serves as an outlet. These fans represent three large openings which could make the instrument vulnerable to EMI/RFI problems and make RF radiated emissions and susceptibility testing difficult to pass.

EMI/RFI Shielding

The answer to the potential EMI/RFI problems came from a mechanical engineer who assisted the project leader on the TLD project. The engineer specified the use of dual-application EMI air filters, 6" x 6" in a 0.43-inch thick frame, to be placed behind each ventilation enclosure hole. Alternatives to the dual EMI filter, honeycomb or perforated metal panels, would have been more expensive in this application.

The aluminum-framed EMI filters feature a shield that is integrated into the air filter assembly and an open cell polyurethane foam filter media specially coated to provide improved flame retardation. The all-aluminum components can be coated with a clear chromate conversion finish to make them conductive. In addition to providing the desired shielding, the air filters meet UL 94 HF-1 flame retardancy requirements.

MIL-STD-285 Testing

An independent testing agency tested the filter according to MIL-STD-285, modified for testing shielding effectiveness. In accordance with the standard, the EMI measurements were taken through a test fixture designed according to the MIL-G-83528 test specification for gaskets. The fixture was located between two adjacent shielded enclosures. The receive chamber and the control (transmit) chamber met the applicable requirements of NSA 65-6. AC power was supplied to each enclosure from a dedicated isolation transformer through low-pass line filters which provided a minimum of 120 dB of attenuation from 10 kHz to 1 GHz.

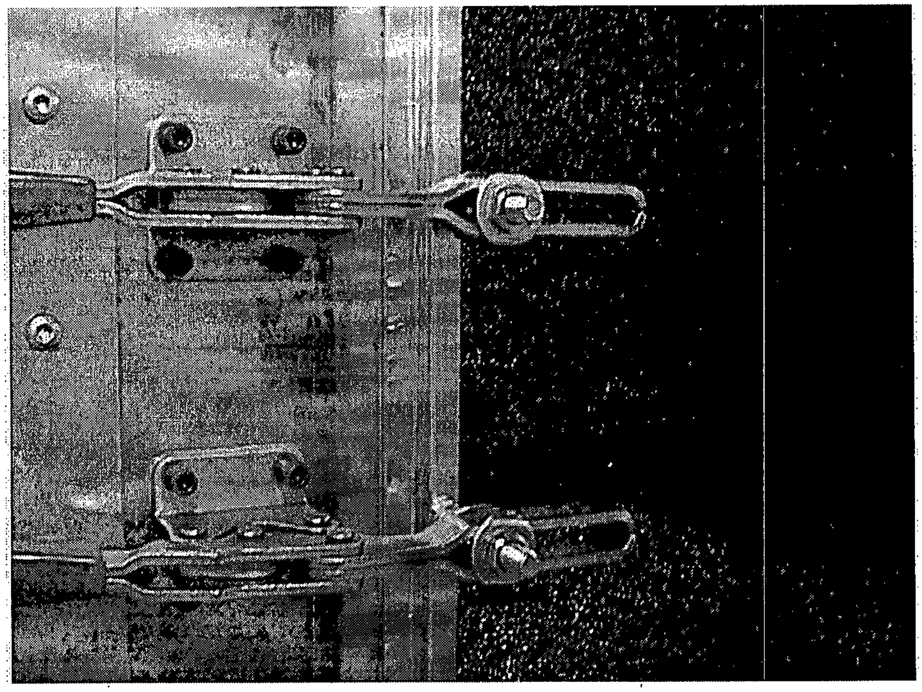

Figure 1. *Compression Clamps Used to Mount Filter Panels.*

The modified specification involved using a spectrum analyzer and a signal generator in conjunction with designated power amplifiers and antennas. The transmitting antenna was located inside a shielded control chamber located adjacent to the receiving chamber. Reference levels were measured through the 22" x 22" opening in the shielded enclosure without the test sample in place. The filter panels were mounted into the fixture using 22 compression clamps located around the perimeter of the sample (Figure 1). The edge of the test sample was also bonded to the test fixture using conductive tape around the entire perimeter in order to eliminate the test fixture or mounting method from contributing to the shielding effectiveness measurements. The antenna positions for the test references were as follows:

- For the test frequency range of 10 kHz to 30 MHz, the antennas were positioned in the vertical polarity separated by 1 meter (Figure 2).
- For the test frequency range of 30 MHz to 200 MHz, the antennas were positioned in the vertical polarity separated by 2 meters (Figure 3).
- For the frequency range of 200 MHz to 1000 MHz, a spiral polarized antenna was used separated by 2 meters (Figure 4).

The test levels were recorded at each frequency and attenuation values were determined by calculating the difference between the reference level and the test level. The dual EMI filters were certified to deliver 30 dB minimum attenuation over a commercial frequency plane wave range of 10 kHz to 1 GHz.

CE Testing

The TLD manufacturer then employed the same independent EMI test laboratory to evaluate the unit. The unit was subjected to tests required for CE certification, specifically tests involving RF emissions and susceptibility, fast transients (spikes), magnetic fields, and voltage dips of various durations.

Radiated field testing typically involved placing the equipment under test (EUT) in a large anechoic enclosure. While inside the enclosure, equipment was subjected to radiated fields to determine any performance effects they might have on the equipment's operation.

Emission testing involved placing the test equipment in an Open Area Test Site (OATS) where no reflective objects are present. A spectrum analyzer was used to measure

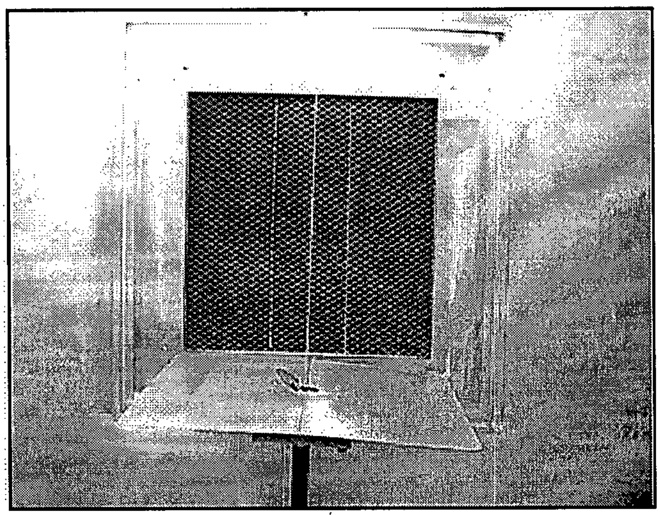

Figure 2. *Antennas Positioned in the Vertical Polarity Separated by 1 m.*

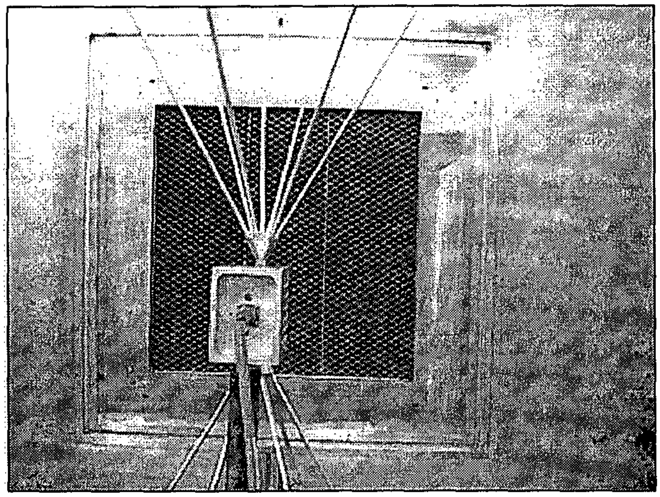

Figure 3. Antennas Positioned in the Vertical Polarity Separated by 2 m.

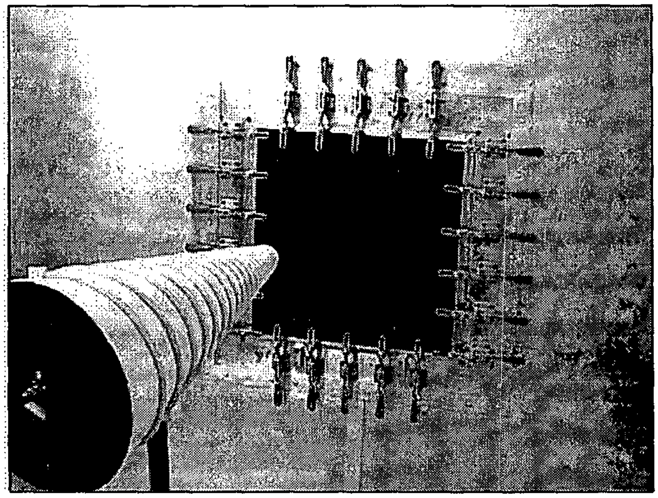

Figure 4. Spiral Polarized Antenna Separated by 2 m.

emissions. The results were then used to determine that the unit met CISPR 11 requirements.

Conclusion

By designing with EMI/RFI shielding in mind at the outset, the challenge of earning CE certification can be adeptly managed. One of the major certification obstacles, critical ventilation enclosure holes, can be overcome with the use of dual application EMI filters that, in addition to EMI/RFI shielding, provide UL 94 HF-1 flame retardancy protection.

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