Manufacturing EMI Shielded Cabinetry: An Alternative to Electroplating

Ever-increasing system frequencies and strict regulations on emissions (and soon immunity) require innovative, cost-effective shielding solutions at the enclosure level.

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INTRODUCTION

Packaging for today's electronics is changing rapidly to keep pace with the demands of electromagnetic interference (EMI) control. Ever-increasing system frequencies and strict regulations on emissions (and soon immunity) require innovative, cost-effective shielding solutions at the enclosure level. The technology now used to shield metal cabinets employs a number of proven techniques, all working in conjunction with the metal panels, doors and frame of the enclosure. Products include conductive wire mesh and elastomer gasketing, shielded vent panels, conductive windows, cable shielding, conductive caulks and epoxies and source suppression at the circuit board level.

Cabinet frames and panels are normally electroplated to provide a corrosion-resistant, electrically conductive path for proper grounding of conductive gaskets and/or mating cabinet members. The high cost and often difficult process controls associated with electroplating (or conductive painting) have caused packaging engineers to look for alternate solutions. This article describes an effective, low cost substitute for plating/painting.

Most commercial electronics cabinets are made from steel or aluminum. Because of its low cost and ease of manufacture, steel is by far the most popular material. Steel cabinet frames are typically welded together, electro-deposited with cadmium or zinc, then overcoated with a clear chromate conversion coat. To prepare for painting, a high temperature masking tape is applied to all frame and panel surfaces where electrical conductivity is required. An industrial grade urethane, acrylic, enamel or powder paint is then applied (spray or dip process) and baked in a curing oven, usually up to 400°F (204°C) for an hour or more. After the cure cycle, the mask is removed, exposing a clean plated surface ready for mating with conductive gaskets.

PLATING AND CONDUCTIVE PAINTS

Although plating followed by conversion coating is a long-proven process, its drawbacks include process controls and waste disposal costs. Most plating houses will certify that their conversion coat meets the military standard MIL-C-5541, Class 3, which requires the thickness of the chromate to be .0002" (.005mm) or less. Depending on how the nonconductive chromate is applied, it can be difficult to control and accurately measure its thickness. This is important, because as thickness exceeds .0002", a corresponding increase in surface resistivity results, which can have a negative effect on overall shielding performance.

The typical cost for plating a steel cabinet frame (approximately 3' x 3' x 5') can range from $120 to $170, not including the side panels. Plating costs have risen and continue to rise due to strict regulations governing disposal of toxic chemical wastes associated with the process.

Some manufacturers have opted for conductive paints instead of plating/conversion coating. Conductive paints are usually filled with particles of nickel, copper, carbon, or silver (or combinations thereof). Costs for these paints can also be very high ($30 to $1,000 per gallon). Functionally, silver-filled paints are the most stable and conductive of the group, but are at the high end of the price range. Carbon-filled paints are typically used for low shielding or static discharge applications due to their high surface resistivity. Nickel and Copper paints are used more often for commercial shielding applications. Like conversion coating, maintaining a consistent, uniform coating (typical resistivity values range from 1 ohm/sq. and up) can be difficult. An additional drawback to the use of conductive paints is apparent when a screwdriver or other sharp object breaks through the paint and exposes bare steel beneath: galvanic corrosion. The galvanic (electromotive) series predicts a high driving force for corrosion (in the presence of an electrolyte) between the anodic steel and the cathodic (more noble) paint. In this case the steel will corrode, rendering the surface unsightly and nonconductive.

AN ALTERNATE SOLUTION

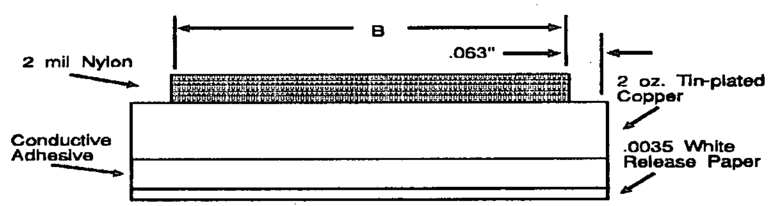
Despite their drawbacks, plating and conductive paints have been used almost exclusively by the shielded metal enclosure industry. After extensive discussions with cabinet manufacturers, one company has developed an alternate solution in the form of a premasked conductive foil tape, which obviates the need for plating or conductive paints altogether. The tape consists of tin-plated, 2 oz. (2.8 mil, .07mm) copper foil with a conductive, pressure sensitive adhesive for mounting. The adhesive is filled with highly stable metallic particles, which produce through-resistance values of .003 ohms/sq. in. The surface of the tape is covered with a high temperature nylon mask which is recessed slightly from both edges to allow paint overlap (Figure 1). This feature provides excellent resistance to corrosion. The premasked tape is easily applied to clean, bare metal surfaces where conductive interfaces are required. The cabinet is then run through its normal paint and bake cycle. Finally, the nylon mask is removed, leaving a clean, highly electrically conductive, corrosion-resistant interface for mating surfaces or gaskets. (The mask can be removed at any time, with or without a bake cycle.)

PRODUCT PERFORMANCE

Tests performed on the premasked tape indicate a high degree of durability and reliability, and savings potential for manufacturers of 30 percent or more over typical plating costs.*

Shielding performance is shown in Table 1. Testing to MIL-STD-

**Note: Example from a 3'x3'x5' welded frame, comparing zinc plating plus chromate conversion to use of .625" wide premasked tape, applied on 85 linear feet of frame interfaces.*



Dimensions	
If "A" is...	Then "B" is...
.430"	.305"
.500"	.375"
.625"	.500"
.750"	.625"
1.000"	.875"

Figure 1. Tape Construction.

Conductive Elastomers

Gasket Type	Frequency (MHz)				
Description	100	200	500	1000	2000
Silver-plated glass-filled silicone elastomer EMI gasket	97	90	110	112	120*
Silver-plated copper-filled silicone elastomer EMI gasket	85	90	110	107	120*
Silver-plated aluminum-filled silicone elastomer EMI gasket	85	90	110	112	120*

* Above Instrumentation

Wire Mesh Gaskets

Gasket Type	Frequency (MHz)				
Description	100	200	500	1000	2000
Knitted wire mesh with urethane foam core EMI gasket	85	88	82	72	60
Knited wire mesh EMI gasket	98	90	106	110	120*
Knitted wire mesh EMI gasket	99	89	110	112	120*
Knitted wire mesh EMI gasket	95	90	110	110	120*

* Above Instrumentation

Note: Results according to Test Report #3128R, Chomerics, Inc. Radiation Test Service

Table 1. Shielding Effectiveness dB (E-Field) with Various EMI Shielding Gaskets.

285 with a typical monel mesh gasket, for example, indicates shielding in excess of 90 dB from 100 MHz to 1 GHz.

Due to its tin-plated surface, corrosion resistance of the product is exceptional, making it useful for outdoor as well as indoor applications. The pre-masked tape has passed MIL-STD-810 salt spray testing for 144 hours. It has also been tested for 500 hours (21 days) fully submersed in a 5-percent saline bath, with little or no degradation in performance or aesthetic appearance. In fact, the tape performed far better than the paint, which was severely pitted.

The pre-masked tape endures harsh pre-cleaning operations, including caustic rinses and phosphatizing baths, and withstands dip and spray painting processes. Test samples on steel and aluminum panels were also subjected to chemical spray testing per ASTM D896-84 using isopropyl alcohol, MEK, acetone, ethanol, 1-1-1-trichloroethane and iron phosphate solution. None of the solvent systems cause any degradation of the tape or adhesive.

The pre-masked tape can withstand typical paint cure cycles of up to 400°F (204°C) for 2 hours. Heat aging tests have confirmed no change in through-resistance (.003 ohm/sq. in.) even after a 48-hour 400°F exposure. Other tests performed include adhesion, flame resistance and a 10,000 cycle door closure test (no visible wear through the tin plating).

TYPICAL APPLICATIONS

Applications for the conductive tape can be found in virtually all areas of the commercial shielded cabinet industry, as well as some military enclosures. Computers and telecommunications equipment are obvious examples where the tape can be employed as part of a shielded enclosure system. Even cabinet manufacturers who had not previously participated in the shielded market because of high costs/capital investment are using the pre-masked tape system as a means to enter the market. Further applications include field retrofitting damaged or corroded cabinets.

CONCLUSION

A new method of shielded enclosure flange treatment which renders surfaces conductive for EMI gasket grounding now exists. The new treatment, which uses a conductive foil tape and high temperature mask system, precludes the need for electroplating (and its associated toxic waste disposal problems) or conductive paints. The tape offers savings over conventional plating and meets or exceeds industry standards for shielding, corrosion resistance, abrasion resistance and long-term reliability.

Theresa Farrell received a B.S. in Chemistry from the University of Illinois, Urbana, IL. She held the position of Polymer Chemist at Echlin, Inc. followed by a position at United Technologies Corp. as a Materials Engineer. Currently, Theresa is employed by Chomerics, Inc. as an Applications Engineer where she is responsible for developing new products for the EMI shielding industry. Theresa, along with other inventors at Chomerics, has applied for a patent for ChoMask II EMI masking tape. (603) 880-4807.

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