A TREATISE OF THE NEW ASTM EMI SHIELDING STANDARD

ASTM has several procedures for releasing a new standard. The normal procedure requires from one to two years for release. Because of the need for such a standard, the initial release of the "Standard Test Method for Electromagnetic Shielding Effectiveness of Planar Materials" has been approved in accordance with the emergency standard release procedure. This process requires significantly less approvals, but is restricted to a life of one year with an option for one additional year. Concurrent with the emergency standard process, the permanent standard is also being processed.

The need for such a standard became evident with the advent of the capability to coat, fill and plate non-conductors, specifically plastics. These various systems were developed by many progressive companies to make possible the application of polymeric materials to component closures which are parts of an assembly subject to the FCC docket 20780. Manufacturers of electronic equipment are motivated to apply polymeric materials in the interest of design freedom, weight reduction and cost savings. But polymeric materials in themselves are "open-windows" to RF radiation; in other words, RF energy is transmitted through these materials essentially unimpeded, or with no significant attenuation. Of all the common materials used for consumer products, only metals and carbon will attenuate RF energy. Thus, a metal or carbon must be applied in some way to a polymeric material so that it will attenuate sufficient RF energy to satisfy the FCC requirements. A property of the system applied to the polymer is known as SE (Shielding Effectiveness). SE becomes very important in order to forecast whether the system (which can be coated, filled, or plated will be adequate for a specific application.

The SE of the system applied to a polymer is affected by three independent variables. These variables are: the distance between the RF source and the shield; the frequency of the RF source; and the thickness of the conductor in the case of plating, or the density and configuration of the conductor in a coating or within the plastic matrix. Manufacturers of these systems have been reporting the SE of their products using data which was developed by non-standard test procedures, many of which are unique to themselves. Manufacturers had no choice since no test standard existed. As a result, their data is not comparable with other manufacturers' and very difficult for a design engineer to relate to his specific application. ASTM recognized the need for such a standard and, in August of 1980, created a section whose charter was to develop a standard to determine the SE of electromagnetic shielding materials.

It must be emphasized that this standard is intended only for ranking the SE of materials. The data have relative significance and are not necessarily absolute. The standard recognizes that there are two types of fields: induction or near-field, and radiation or far-field. The transistion point of these two fields is the source to shield distance when it equals the wavelength divided by 2π or approximately 1/6 wavelength (See Figure 1). The standard specifies the transmission line test method for far-field determinations. In the far-field, the wave impedance is constant, and in air or free space is equal to 377 ohms. The wave impedance is defined as the ratio of the E (Electric) field to the H (Magnetic) field.

The standard specifies the dual-chamber method when near-field data is required. The near-field condition exists when the source to shield distance is less than the wavelength

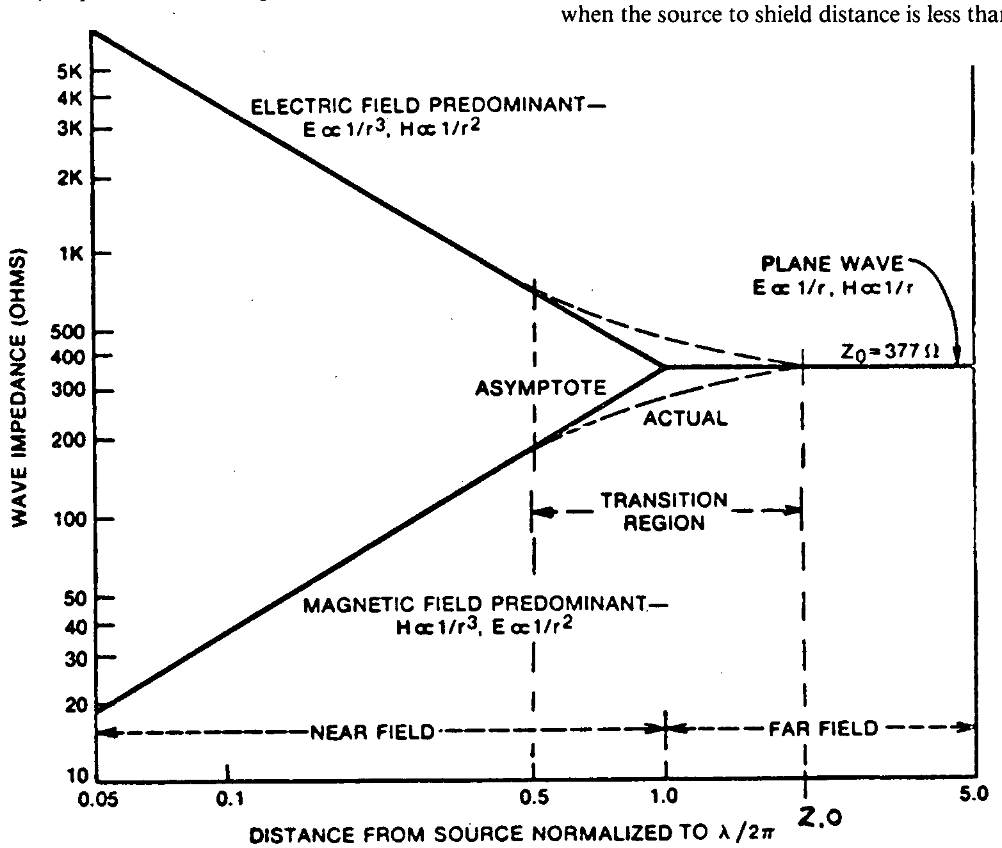

Figure 1. Far Field or Near Field.

divided by 2π (See Figure 1). In the near-field, the E and H-fields must be treated independently. The E-field impedance is extremely high near sources such as straight wire antennas, or low current, high voltage sources. The E-field impedance decreases with distance to the transition point. Conversely, the magnetic field impedance is very low near sources such as loop antennas, or high current, low voltage sources; the impedance increases with distance until it reaches 377 ohms at the transition point. Whether an H- or E-field is being measured by the dual-chamber method is therefore dependent upon the antenna design. If the specified di-pole antenna is used, the method will measure the SE of an E-field; if a loop antenna is employed, the method will measure the SE of the magnetic field.

Regardless of which method is used, all the test components contribute to establishing the DR (Dynamic Range) of the set-up. The standard defines DR as "the maximum SE measurable by the system." The DR is determined by measuring the SE of a specimen which is essentially opaque to RF, such as 1/8 inch aluminum panel. This may be compared to determining the permeability of a film to steam. Before the permeability of the film is measured, a specimen would be installed which is impervious to steam in order to measure the leakage rate. To determine the SE, components that may "leak" RF energy are used. These include the signal generator, line connectors, the coaxial cable, attenuators and the specimen fixture. The amount of RF energy escaping from these components is a function of transmitted power. Some of the energy escaping from these components finds its way to the receiver and will be indicated as power received even though it did not pass through the specimen being tested. A 1-watt signal generator can produce a DR of 80 dB (decibels) with standard coaxial cables connecting components. A higher DR is obtainable with more sophisticated shielding techniques, higher power output and a high sensitivity receiver. Equations have been developed to forecast the SE of homogeneous metals. Calculated values will always significantly exceed measured values. However, in practice, these same "leakages" occur, so that the measured values are much closer to those that will be experienced in an application than the theoretical values. The DR is therefore the maximum SE that can be measured by the particular set-up. As a result, the standard prohibits reporting any test results which is within 3 dB (decibels) of the DR.

The standard specifies a system to measure the SE that consists of 4 major components: a signal generator, two 6 dB attenuators, a receiver and a specimen fixture (See Figure 2). The specimen fixture is the only variable in the two methods, near-field or far-field. These various components are connected with standard connectors and coaxial cable. It should be remembered that the shielding quality of the connectors and cable is important since they can significantly affect the DR of the system. The standard specifies that the SE be reported at 30, 100, 300 and 1,000 MHz; therefore, the signal generator, a shelf item available from electronic suppliers, must be capable or producing signals at these frequencies. Signal generators are available which will sweep a frequency spectrum but the ASTM standard requires that a point-by-point procedure be followed.

From the signal generator, the RF is transmitted through a connector, cable, the 6 dB attenuator, more cable and a connector on the specimen fixture. In the interest of deriving the maximum DR for the minimum power, the connecting cables should be kept as short as possible. In fact, if one wished to do a high quality job, all the components would be joined with heavy wall conduit in order to maximize the DR. This design is one that only a "purist" would insist on, since it really complicates the set-up. High quality joints between the cable shield and connectors, however, are extremly important for a high DR.

From the output of this specimen fixture the signal will travel through the connectors, an attenuator and into the receiver. The receiver is also a standard shelf item with electronic suppliers. The sensitivity of the receiver is a major contributor to the DR of the system. The more sensitive the receiver, the higher the DR that can be achieved, assuming that the more sensitive receiver does not sacrifice linearity when presented with a relatively high power signal.

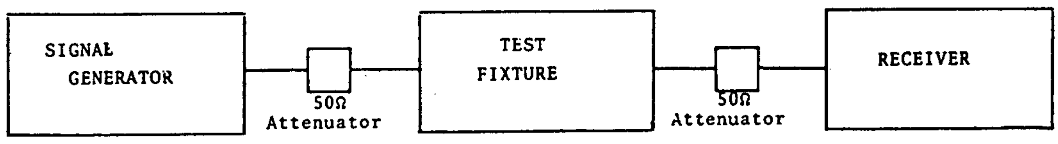

Figure 2. General Test Setup.

The selection of the specimen fixture to be used is determined by which method of the standard is to be followed, i.e., near-field or far-field. Detailed drawings of both fixtures are available from ASTM Headquarters through the Staff Manager of Committee D9. The dual-chamber specimen fixture (See Figure 3) consists of a steel box 178 mm. high by 127 mm by 178 mm. The box is hinged such that the 152 mm. dimension is interrupted at its center line allowing the box to be opened 180° for the insertion of the sample and maintenance of the antenna. An antenna is mounted in each half of the box, one transmitting and the other receiving. The specimen is held in place with beryllium copper finger-clips between the two antennas. These finger-clips must make good electrical contact with the conducting system on or in the plastic specimen. For this reason the standard requires that a silver filled coating be applied around the perimeter of the specimen. It is also imperative that the surface of the beryllium clips be perfectly clean to assure a high quality electrical contact to the specimen.

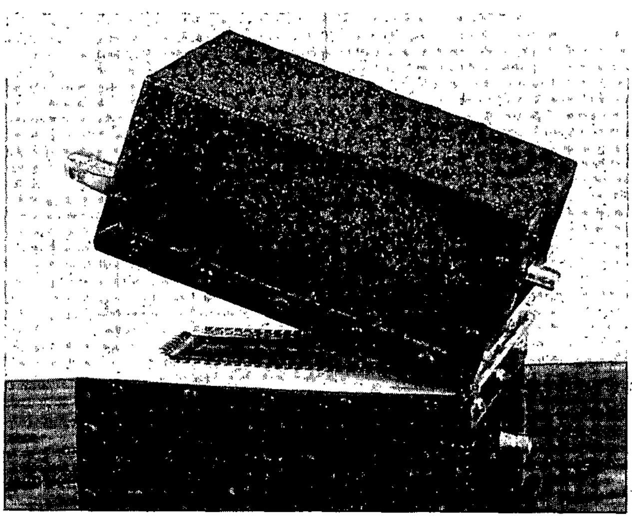

Figure 3. Dual-Chamber Specimen Fixture.

Electrical continuity between the specimen and the specimen holder is absolutely required for reliable data. It is for this reason that the standard requires that a standard test panel yields specific attenuations. If a plated or coated specimen is clean, no problems should be experienced. However, a situation can exist with filled materials which would yield very erratic results. This condition exists when very little or no conductive filler is exposed on the surface. Even though a metallic paint is applied to the periphery of the specimen, poor or no continuity will exist between the applied silver coating and the plastic filler. In this case, the perimeter of the specimen must be abraded before the silver coating is applied in order to expose the filler. The standard requires an appropriate notation if this is done. In order to gain reproducibility of results, the moisture content of the plastic material must be consistant since moisture will affect the SE of the sample. The standard specifies the specimen conditioning environment.

Figure 4. Transmission Line Specimen Fixture.

The transmission line specimen fixture, a torpedo shape, is 543 mm. long by 133 mm. maximum diameter (See Figure 4). The specimen for this test method has the configuration of a "washer" with an external diameter of 99.75 mm., and internal diameter of 43.70 mm. and 3 mm. thick. The specimen for this method must also make excellent electrical contact with the specimen holder. The same precautions apply here that were discussed above in the dual-chamber specimen paragraph. The transmission line specimen fixture utilizes all the same components as the dual-chamber fixture and all of the principles described in the dual-chamber paragraph apply with this method. The SE data developed by the transmission line fixture is only representative of a far-field condition, i.e., when the source to shield distance is greater than the wavelength divided by 2π.

The Chairman and members of ASTM Section D09.12.14, authors of the EMI Shielding Standard, have absolutely no reservations that the two test methods are representative applications of the physical laws defining the behavior of dynamic electrical and magnetic fields. The section consisted of physicists, electrical and mechanical engineers who are in current practice of these theories.

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