

CHAPTER 1

Introduction

1.1 SCOPE

The use of radio frequency shielded enclosures has become quite common in our increasingly electromagnetically crowded environment. Until recently, the design, manufacture, and installation of shielding was the province of a handful of specialty contractors. Two basic systems were developed by the shielding industry: the modular or clamp-up enclosure, and the welded structural steel enclosure, with the latter being built in place. Only a few attempts at other types of shielding have been made. The most notable was the aluminum foil system developed by the National Security Agency as described in their detailed specification NSA 73-2A. However, the need for shielding has become so widespread that a number of companies have developed a variety of single-skin shielded enclosures.

The purpose of this handbook is to provide architectural and facility engineering personnel with the necessary information which will permit them to make informed decisions on the different types of shielding and how to properly specify them sufficiently so that the constructed shield performs its intended purpose. As will become clear from the text, the completed enclosure must be properly tested to ensure compliance with the desired level of performance. A second purpose is to point out the performance differences between the various shielding systems so that intelligent choices are possible. In the past, it has been common practice by the shield-buying community to request the highest performance specifications available, thus ensuring a safe decision, but in many instances, paying excessively for protection they did not need. This handbook gives the shielding buyer a survey of the systems available, so that he can select the best system for his particular application.

The next two chapters are introductory in that they establish what shielding is and how it is used to control electromagnetic interference. The first part of the "Theory" section has been provided to help bridge the gap between the layman's knowledge of electricity and the deeper understanding necessary to appreciate how an electromagnetic

shield performs its function. It is not the purpose of this book to teach shielding design, but rather how to select from existing systems the one best suited for the job at hand.

The next three chapters deal with shielded enclosures, first those that are provided by the speciality shielding contractor, and then those that are built into the structure of a building. This is not an arbitrary selection, but is based on the current practices in the shielding industry. Currently, the most common shielding systems provided by the established shielding manufacturers are prefabricated modular or "clamped-up" rooms and welded enclosures which are built on site. These products have evolved with time, and are proven systems available from a number of large and small companies world-wide. A newer class of shielded enclosure is the one that is built into the structure, i.e., within the walls of a building. This later class has been grouped in Chapter 6 under the heading of "Architectural Shielding." Several variations of these shielding systems are described. These are usually installed by a general contractor either as described by the drawings or by subcontracting to a specialty contractor. The key to success in these installations is how well they are detailed in the building drawings. Since the shielding is built in, it must be done right the first time because retrofitting in the field is extremely costly and time consuming. If the information given in this handbook is carefully considered and implemented, it will successfully aid those who have the responsibility to implement shielding in their facilities or design/specify them for a client.

The selection of the basic enclosure is very important to the overall performance of the facility, but a shield is only as good as the treatment of the penetrations through it. The next two chapters discuss how the designer selects methods of providing doors, vents, piping, power, communications, and security to a shielded enclosure. Just how badly an improperly installed penetration can degrade an enclosure is illustrated in the theory section.

Another very important requirement is that of testing the facility while in the process of construction and finally on completion. The latter is absolutely essential. After all trades have completed their work, the shielded enclosure must be tested to the applicable shielding effectiveness specifications. Chapter 9 details the common specifications, how to use them effectively, and how to write a test plan that will ensure that the completed facility will perform its intended function. Drawing on the theory section, each type of test is described, along with the common problems encountered in field testing.

Accomplishing an acceptable grounding system for a shielded enclosure is often a problem in the field. Signal security and electrical safety requirements do not always appear to be compatible. Using MIL-HB-419A as a guide, guidelines are given on how the various types of grounds can be designed to obtain a harmonious installation, one which is safe for personnel and also meets the needs of the security community. Also refer to MIL-HB-232 for grounding information.

The last chapter provides a series of design checklists for the three types of shielded enclosures, so the A&E can draw a complete enclosure specification together for the various forms of shielding.

A number of appendices is provided for reference, such as a reference to an annual directory that details shielding manufacturers, installers, designers, and consultants.

A large part of the material for this handbook was drawn from MIL-HB-419A, which is entitled "Grounding, Bonding, and Shielding for Electronic Equipments and

Facilities.’’ This handbook is recommended reading for all who are concerned with large industrial/government facilities. It is also useful for designing or specifying a single room.

1.2 RADIO FREQUENCY SHIELDING DEFINITIONS AND TERMINOLOGY

In any technical field of knowledge, a certain amount of special terms unique to that field must be understood in order to comprehend what is being presented. Therefore, this section is placed deliberately here in the first chapter so that a working vocabulary necessary to understanding the material presented can be easily acquired by those not familiar with shielding prior to the introduction of the technical concepts. Further definitions and supporting terminology are given in Appendix A-1.

Absorber. A material which absorbs electromagnetic energy by converting the wave energy into heat.

Absorption Loss. The attenuation of an electromagnetic wave as it passes through a shield. This loss is primarily due to induced currents and the associated heat loss.

Ambient Level. Those levels of radiated and conducted energy existing at a specified location and time when a test sample is deenergized. Atmospheric noise signals, both desired and undesired, from other sources and the internal noise level of the measuring instruments all contribute to the ‘‘ambient level.’’

Antenna. A device employed as a means for radiating or receiving electromagnetic energy.

Aperture. An opening in a shield through which electromagnetic energy passes.

Attenuation. A general term used to denote a decrease in magnitude of power or field strength in transmission from one point to another caused by such factors as absorption, reflection, scattering, and dispersion. It may be expressed as a power ratio or by decibels.

Bond. The electrical connection between two metallic surfaces established to provide a low-resistance path between them.

Bonding. The process of establishing the required degree of electrical continuity between the conductive surfaces to be joined.

Conductive Interference. Undesired signals that enter or leave an equipment along a conductive (wire or metallic) path.

Coupling. Energy transfer between circuits, equipments, or systems.

Coupling, Free-Space. Energy transfer via electromagnetic fields not in a conductor.

Cutoff Frequency. The frequency below which electromagnetic energy will not propagate readily in a waveguide.

dB. Decibel, a unit of voltage or power ratio. Defined as follows:

$$\text{dB} = 10 \log P2/P1 \text{ for power or}$$

$$\text{dB} = 20 \log V2/V1 \text{ for voltage.}$$

‘‘dB’’ is commonly used to specify shielding effectiveness since very large differences in the input/output fields are generally required by the shielding specification.

Specifications on the order of 60–100 dB are typical. This means that if one watt of power impinges on the shield, then only one millionth to one ten trillionth of a watt exits on the other side.

Degradation. A decrease in the quality of a desired signal (i.e., decrease in the signal-to-noise ratio or an increase in distortion), or an undesired change in the operational performance of equipment as the result of interference.

Earth Electrode System. A network of electrically interconnected rods, plates, mats, or grids installed for the purpose of establishing a low-resistance contact with earth. The design objective for resistance to earth of this subsystem should not exceed 10 Ω .

Electric Field. A vector field about a charged body. Its strength at any point is the force which would be exerted on a unit positive charge at that point.

Electromagnetic Compatibility (EMC). The capability of equipment or systems to be operated in their intended operational environment at designed levels of efficiency without causing or receiving degradation owing to unintentional electromagnetic interference. Electromagnetic compatibility is the result of an engineering planning process applied during the life cycle of the equipment. The process involves careful considerations of frequency allocation, design, procurement, production, site selection, installation, operation, and maintenance.

Electromagnetic Interference (EMI). Any conducted, radiated, or induced voltage which degrades, obstructs, or repeatedly interrupts the desired performance of electronic equipment.

Electromagnetic Pulse (EMP). A large impulsive-type electromagnetic wave generated by nuclear or chemical explosions.

Facility. A building or other structure, either fixed or transportable in nature, with its utilities, ground networks, and electrical supporting structures.

Far Field. The region of the field of an antenna where the radiation field predominates, and where the angular field distribution is essentially independent of the distance from the antenna. A variety of guidelines is used; for some shielding calculations, 1/6th of a wavelength has been found useful.

Fault. An unintentional short circuit or partial short circuit (usually of a power circuit) between energized conductors or between an energized conductor and ground.

Field Strength. A general term that means the magnitude of the electric field vector (in volts per meter) or the magnitude of the magnetic field vector (in ampere-turns per meter). As used in the field of EMC/EMI, the term “field strength” shall be applied only to measurements made in the far field and shall be abbreviated as FS. For measurements made in the near field, the term “electric field strength” (EFS) or “magnetic field strength” (MFS) shall be used, according to whether the resultant electric or magnetic field, respectively, is measured.

Filter. A device for use on power or signal lines, specifically designed to pass only selected frequencies and to attenuate substantially all other frequencies.

Ground. The electrical connection to earth through an earth electrode subsystem. This connection is extended throughout the facility via the facility ground system, consisting of the signal reference subsystem, the fault protection subsystem, and the lightning protection subsystem. These different systems are detailed in the following chapters.

Magnetic Field. A vector field produced by a continuous flow of charge.

Multipoint Ground. More than one path to ground.

