Taking The Mystery Out Of Selecting ESD Flooring

Choices Abound, But Careful Planning Is Essential In Making The Right Choice

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Often, the most challenging and anxiety-inducing decisions buyers encounter in the course of creating a world-class electrostatic discharge (ESD) program involve the selection of the ESD floor. Unlike other components in the program, the installation of static control flooring represents a permanent capital investment, with costs of 1 1/2 to 2 times those of a standard non-ESD floor. Because the static control floor affects every aspect of the organization—from performance to image—in most cases, finding the right floor involves a marriage of competing interests, including cost, durability, ergonomics, compliance with safety standards, appearance, company image, maintenance, total cost of ownership and, of course, ESD properties.

When buyers and specifiers contemplate this higher cost of ESD flooring in conjunction with the usual mountain of architectural considerations, it quickly becomes evident that someone involved with the decision-making process needs to understand both static control specifications and the long-term impact that installing an ESD floor will have on the business. To answer their ESD flooring questions, architects and specifiers typically turn to their general contractor or flooring specialist who, in most cases, has meager ESD knowledge and no expertise. Alternately, a buyer might call a supplier of ionizers, grounding mats and heel straps to ask for advice on sub-floor preparation or installation, help which is just as obviously outside that particular supplier's scope of competency.

Unfortunately, failing to understand the whole picture can yield disastrous results, ranging from a confusion of ESD-industry vocabulary and misapplication of standards to a compromised ESD floor installation. The good news is that the selection of static control flooring needs not be a mystery.

Static Dissipative Versus Conductive

In selecting an ESD floor, understanding the relationship between a floor's long-term electrical performance and its ability to protect expensive and increasingly vulnerable static-sensitive components and equipment is almost always the biggest problem faced by architects, specifiers and buyers. Several excellent ESD standards, readily available on the ESD Association's website (www.esda.org), along with a copy of the official ESD Association glossary, should eliminate much of the confusion over electrical criteria.

While these easily accessible documents certainly provide answers to most ESD questions, there is still ongoing and unnecessary confusion over a seemingly basic consideration, that is, the difference between static dissipative and conductive materials and the reasons why one might be more appropriate for use in ESD floors than the other. In the past, the majority of companies selected their particular ESD floor based on the misconception that static dissipative materials were safer than, while still equal in effectiveness to, conductive materials. This widespread fallacy led to the installation of millions of square feet of dissipative flooring that may or may not meet the recommended range of less than 35 megohms for system resistance, as documented in ANSI/ESD-20.20-1999.

It's important to understand that the definitions of and differentiation between the terms "static dissipative" and "conductive" were originally conceived not for flooring but for the packaging industry. The authors of EIA-541, a standard used by the packaging industry, used sweeping definitions based primarily on surface resistivity in order to simplify the selection and identification of static shielding materials. These standards characterized static protective materials based on their ability to provide shielding from *electrostatic fields*. Static dissipative materials (1x10E^5 to 1x10E^9) inhibit the generation of static, but they do not sufficiently dampen the penetration of static fields onto enclosed parts. According to the standard, more conductive materials (less than 1x10^5 ohms) provide better shielding than do less conductive materials. This reasoning proliferated the use of metallized static shielding bags and “faraday cage” tote boxes for the safer packaging of ESD-sensitive circuit boards.

EIA-541 recommended a resistivity cut-off point of 100,000 ohms (<1 x 10E^5) for defining adequate shielding. This recommendation effectively drew a line in the sand, which was subsequently “borrowed’ and reapplied to the selection criteria for table covering materials, tote boxes, garments and flooring. However, the unfortunate fallout from these misappropriated definitions is the false belief that materials which are “conductive and capable of providing shielding” are too conductive for safe personnel grounding. The correspondent fallacy holds that, despite their significantly higher resistance to ground, static dissipative materials will inherently prevent the generation of static electricity on mobile workers and moving carts.

In fact, static shielding properties have absolutely no bearing on floors, which are designed to protect sensitive electronic components against *walking body voltage*, the voltage generated by people walking across their surface. Thus, the consideration of electrical parameters for shielding materials involves entirely different criteria from the parameters that define a functional and long-term effective ESD floor. According to John Kinnear, past president of the ESD Association, *one should not choose flooring materials based on their fit into so-called categories of “ static dissipative” and ” conductive.” Flooring materials should be approved and installed based on evaluations of properties that apply specifically to flooring*.

Test Against Multiple Criteria

A close reading of ANSI/ESD 20.20 should eliminate, once and for all, the argument over whether “static dissipative” or “conductive” material is better suited for static control flooring. The requirements summary section, on pages 7 and 8 in S20.20, sensibly encourages material selection based upon multiple variables and several test standards, and not on a particular range of resistance designated as conductive or static dissipative. To that end, the terms conductive and dissipative have been omitted from any section involving flooring or grounding. In section 6.2.3, under “Flooring,” the standard recommends a resistance below 1x 10E^9 for the floor by itself. Obviously, the floor cannot be used in a vacuum, and so the standard includes a recommended resistance value for the entire grounding system, which encompasses the person, protective footwear and grounded floor. In section 6.2.2, under “Personnel Grounding,” the recommended System resistance is less than 35 megohms RTC (<35 x 10E^6). Since the main purpose of a grounded floor is grounding the *personnel*, the upper parameter of the System threshold (less than 35 megohms) ought clearly to take precedence over the recommended Flooring (6.2.3) resistance threshold of 1000 megohms. With today’s footwear options, it would be difficult for a person to stand on a floor with resistance values over 1x 10E^8 and consistently achieve system resistance values one to two orders of magnitudes lower. Anyone installing an ESD floor should carefully weigh these factors before choosing a particular range of conductivity.

In testing and comparing ESD flooring materials, one should also consider the intended choices of footwear and should include in the testing a representative statistical sampling of individual workers, since these sometimes overlooked variables often play a key role in determining the integrity and effectiveness of the ESD flooring solution. Certain ESD shoes, for example, used in conjunction with specific flooring materials, will outperform others. Similarly, weather conditions or the choice of stockings an employee wears can impact the effectiveness of heel straps.

Furthermore, individual components that work well in one scenario might be totally inappropriate for a different application. For instance, the combination of a particular floor and heel strap might perform well in the lab, while in a class-10 clean-room carbon sloughing from the black rubber composite heel strap would render this same tandem unacceptable. Likewise, one particular combination might outperform another at 40% RH, while the low relative humidity of the actual manufacturing environment could present unanticipated problems for that same winning combination.

No matter which system appears most suitable, it is wise to test that combination under the full range of conditions that do or might exist in the factory situation and, as always, to utilize a broad statistical sampling before finalizing any selection.

Understanding Body Voltage

As is usually the case with far-reaching industry specifications or standards, ESD S20.20 offers options and latitude. In section 6.2.2, the standard recommends an upper limit of 35 megohms in the system resistance range. If we wish to steer clear of resistance parameters, we can design our own system around a body voltage generation limit of 100 volts. Many architects and engineers are confounded by the seemingly irreconcilable options of defining grounding parameters based on either resistance measurements or on controlling voltage to limits <100. It’s easy to see why they might be confused.

Bear in mind that the authors of this standard did not intend to create a document that automatically prevents certain manufacturers of ESD materials from selling their products. Certain less conductive materials, such as rubber, might read over 100 megohms resistance to ground (RTG), yet still control walking voltages to levels below 100 or even 50 volts. Remember that the sole purpose of grounding in any ESD program is the inhibition of harmful static voltages. The idea is to control electrostatic discharge, not ohms! It just so happens that a grounded system below 35 megohms (person, footwear and floor) cannot and will not generate walking voltages greater than 100 volts.

While this fact does not preclude the consideration of other less conductive combinations, testing for body voltage does require complicated and expensive testing equipment. To maintain the integrity of the ESD program, program managers must periodically monitor and verify performance of their ESD floor. Because of the limited number of variables and the simplicity of performing the tests, resistance testing can be easily verified with inexpensive and readily available equipment. Body voltage testing, on the other hand, requires special knowledge and elaborate equipment. For this reason, most program coordinators utilize body voltage testing only during the qualification phase of the program. In the factory, most coordinators favor flooring materials that can be monitored by resistance measuring equipment so that any engineer, technician, operator or customer can easily and comfortably test and verify the performance of their floor, the foundation of any effective ESD program.

Ergonomics

Most high-technology manufacturing involves clean manufacturing procedures. PCB assembly is no longer synonymous with the use of environmentally unfriendly chemicals like freon and trychloroethylene. Messy procedures such as wave soldering, conformal coating and paste screening comprise very little of the square footage in modern PCB assembly operations. Today, most OEMs in the computer and telecom industries assemble and test prefabricated parts in workspaces that more closely resemble office environments than the factories they once occupied. As the word "factory" has become euphemistically replaced by names like Raytheon's "agile manufacturing operation," so has the need for heavy-duty chemical and spill resistant floors. The advent of clean manufacturing has enabled a shift in the emphasis on flooring considerations from pure durability to ergonomic issues and employee comfort.

The most common ergonomic concerns architects and health and safety experts involve air quality, sound absorption, anti-fatigue properties and slip resistance. Slip resistance is a major growing concern and can hit companies hard in the pocketbook. Last year, according to Joe Visintin, the director of marketing for Johnsonite Rubber Company in Chagrin Falls, Ohio, the American insurance industry spent over 10 billion dollars on claims stemming from accidents involving slips and falls on floors. The industry forecast anticipates a doubling or tripling of that number over the next 10 to 20 years. Any flooring selection should consider slip resistance in wet and dry conditions and the floor must meet the coefficient of friction parameters of the Americans With Disabilities Act (ADA). In addition to slip resistance, some companies require anti-skid surfaces for wet areas, incline ramps and locations where heavy loads are pushed or pulled.

Many of today's manufacturing operations are actually large-scale test and burn-in facilities. Despite the obvious absence of loud assembly and automation equipment, these environments can become extremely noisy from the monotonous hum of cooling fans in both test equipment and the final product itself. Telecom manufactures like Lucent Technologies, Nortel Networks and Cisco have reduced noise problems by installing softer floors, such as carpet or rubber, that offer both sound absorption and anti-fatigue properties.

Another ergonomic consideration involves the unnecessary separation of manufacturing areas from so-called offices. Traditionally, the floors in offices were carpeted, while manufacturing areas were outfitted with tile or coatings. These flooring differentiators further segregated the hourly workers from salaried employees, diminishing teamwork and distorting or prolonging what should have been streamlined communication between departments. Hewlett Packard, Phillips Medical and many other companies have integrated engineering offices and SMT manufacturing by installing floors that adequately absorb sound, despite the rattle and hum of conveyors and automatic assembly equipment. Lucent Technologies in Mount Olive, New Jersey actually won an architectural award for creating a more egalitarian environment that placed accounting, engineering and management within the same workspace as assembly and final testing.

Maintenance Considerations

In choosing an ESD flooring material, it's important to consider the relationship between long-term ESD performance and special maintenance considerations. Some floors require only periodic vacuuming or wet-mopping, while others, to even perform, require the installation of one to three coats of a special ESD floor finish. As any experienced plant manager knows, because of the sheer size of the area in question, maintenance and maintenance costs of a floor can quickly get out of hand, driving up the actual cost of ownership of a floor to far in excess of initial promises or expectations. For this reason, *no* decision regarding specific materials should *ever* be made without fully assessing its care and cleaning requirements.

If special floor finishes are required, the estimated cost of ownership should include the additional cost of the finish, the cost of verifying the performance of the finish, as well as the hidden costs associated with furniture moving and other activities that cause inevitable "downtime" during maintenance procedures. Certain resilient flooring manufacturers claim that, with only occasional high-speed buffing, their floors will shine and perform. While this may be true, it's important to calculate the real cost, by assessing the lesser effectiveness of this "occasional" dry-buffing as compared, for example, with the monthly application of ESD finishes to vinyl or with the annual steam-cleaning of carpet tiles.

In considering maintenance requirements, the function of the facility, traffic patterns, the proximity of the floor to entrances, local climate and weather conditions, as well as subjective factors such as desired appearance and company image all should be taken into account. The spotless, shiny vinyl floor in a class-100 clean-room can be an eyesore and also a maintenance nightmare around a loading dock. Super-hard, robust epoxy coatings might address the punishment and rolling load considerations in "box-build" operations, but in a factory where layouts frequently change, the inherent dulling that chair casters cause will affect the appearance of the floor, deterring a buyer who cares about company image. The same ESD carpet tile that's stained by spilled solder paste might, except around the screening process, be the ideal choice for every area in a 50,000 square foot facility.

When time permits, it's always a good idea to setup a beta installation or to visit another company with the same type of floor in use in a similar application. There is no substitute for due diligence. The pictures on flooring brochures all look beautiful, but remember that they're almost always taken immediately after maintenance and certainly always before the floor has sustained any significant abuse.

Repairs And Replacement

One of the most frequently overlooked considerations during the process of evaluating floors concerns the ease and impact of repairs. No matter what kind of floor is installed, future repairs of one sort or another should always both be anticipated and expected. I've seen cases where movers and riggers have damaged brand new floors, even before the tenants had moved into their new facility.

As with maintenance issues, the best protection against costly and time-consuming mistakes is to take into account the various scenarios within the facility where the floor will be used. To the extent possible, a savvy buyer should also consider all of the variables surrounding the use and abuse of the floor. Repairs that can be done easily in an open area, for instance, can be nearly impossible to perform in a crowded, three-shift factory.

Here is a sampling of issues, relating to maintenance and repair, that bear consideration when choosing among the various floors, whether static control *or* standard:

- If a vapor mitigation membrane was used in the original installation of a permanently bonded floor, the vapor membrane can be compromised during stripping and repair;

- Will a repaired area match the original area surrounding it?
- How much time is required to both perform repairs and then wait for the repaired area to dry or cure before normal plant operations can resume?
- Would a combination of materials address the application better than trying to service the entire facility with one solution?

Again, regardless of the material you choose, at some point in the future you'll be faced with damage, or even just wear and tear, that requires the repair or replacement of parts of your floor. Careful planning today will eliminate problems tomorrow.

Choosing A Supplier

The task of finding a good installer might actually be more critical than identifying which floor will be used. Although some installers can provide advice about materials and performance, their real value lies in their years of experience and familiarity with floor preparation, removal of old floors, concrete protection and installation coordination. Even the best and most durable material, improperly installed, is subject to problems like delamination, oozing adhesive and moisture vapor problems, which can create a never-ending nightmare for their owner. In extreme situations, problems from a poor installation can halt operations in an entire facility. Imagine, for example, the cost of shutting down a clean-room in order to remove and replace tiles or the impact of moving a surface-mount line because a coating is blistering and peeling from hydrostatic pressure.

A top-notch installer anticipates and prevents the auxiliary costs, which can actually exceed the initial investment, associated with repairing a bad installation. Many flooring manufacturers can provide a list of recommended installer/suppliers. These suppliers are usually regional companies with professional mechanics who install a host of other flooring materials, such as ceramic tile, VCT, hardwood and different types of carpeting. Often, these full-service companies are already doing work in the same buildings requiring ESD flooring. With adequate technical support from a reputable manufacturer, these local installers can provide great value and critical ongoing service.

In the quest for competitive edge, some ESD flooring manufacturers have started providing turnkey installation services. Factory installation teams employed by the flooring manufacturer are usually more familiar with the idiosyncrasies of ESD flooring than their local counterparts. The one downside to a factory installation is the handling of inevitable repairs and expansion. It is cost-prohibitive to send factory installers to a job site thousands of miles away to perform cleanup and repair. It is equally unrealistic to assume that a local professional will eagerly come in and repair a job done by someone else when they feel they should have gotten the original job in the first place.

Anyone who has ever observed a flooring demolition in an operational factory would describe the scene as an ugly one. Dust, chemicals and odors from demolition adversely affect the air quality in the plant. The grinders and blastrac equipment are noisy. The entire process, which is extremely disruptive, adversely affects the appearance of the plant during repairs. Depending upon the type of floor, some demolitions expose old sub-floors containing small percentages of asbestos, which must be removed in a contained environment by properly protected professionals. Because of space constraints, reinstallation of the floor may be much more difficult and time consuming than the original job. In some cases, it is even possible that the floor cannot be replaced without irreparably affecting a mission-critical manufacturing schedule. The best way to avoid these problems is to address them upfront. It's always best, before starting any project of this magnitude, to do all of your homework.

Final Thoughts

Today, companies have a wider than ever variety of flooring materials from which to choose. The plethora of ESD flooring options includes waxes and finishes, vinyl and rubber tile, epoxies and urethane coatings, and broadloom carpet and carpet tiles. Since almost any traditional flooring material can be manufactured with some level of static protection, buyers rarely need to compromise on ergonomics, durability or appearance. And, no matter what the application, there's always more than one option.

When a contract manufacturer in Massachusetts was contemplating an ESD floor for their new addition, they had several needs to address. The new floor plan located a major office area in an open mezzanine directly above the manufacturing floor. The floor had to have sound absorption properties, so their office workers wouldn't be distracted by the manufacturing noise. But they also needed tough, durable aisle-ways that could withstand punishment from forklifts and pallet jacks.

At first, their needs seemed mutually exclusive. With input from their architect and a suggestion from an ESD flooring specialist, they decided to explore the possibility of using two different materials. The building owner visited the EMC factory in Franklin, Massachusetts and saw the perfect solution to their problem: a combination of ESD carpet tiles transitioning to a shiny textured conductive quartz coating.

The key to success is forming an unbiased partnership that incorporates strong ESD fundamentals with a background in sub-floor and concrete protection, maintenance and flooring installation. Whether the application calls for the hardness and abrasion-resistance of epoxy-type coatings or the comfort and sound-deadening advantages of carpet, the right supplier and solution are out there. ■

About The Author

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