

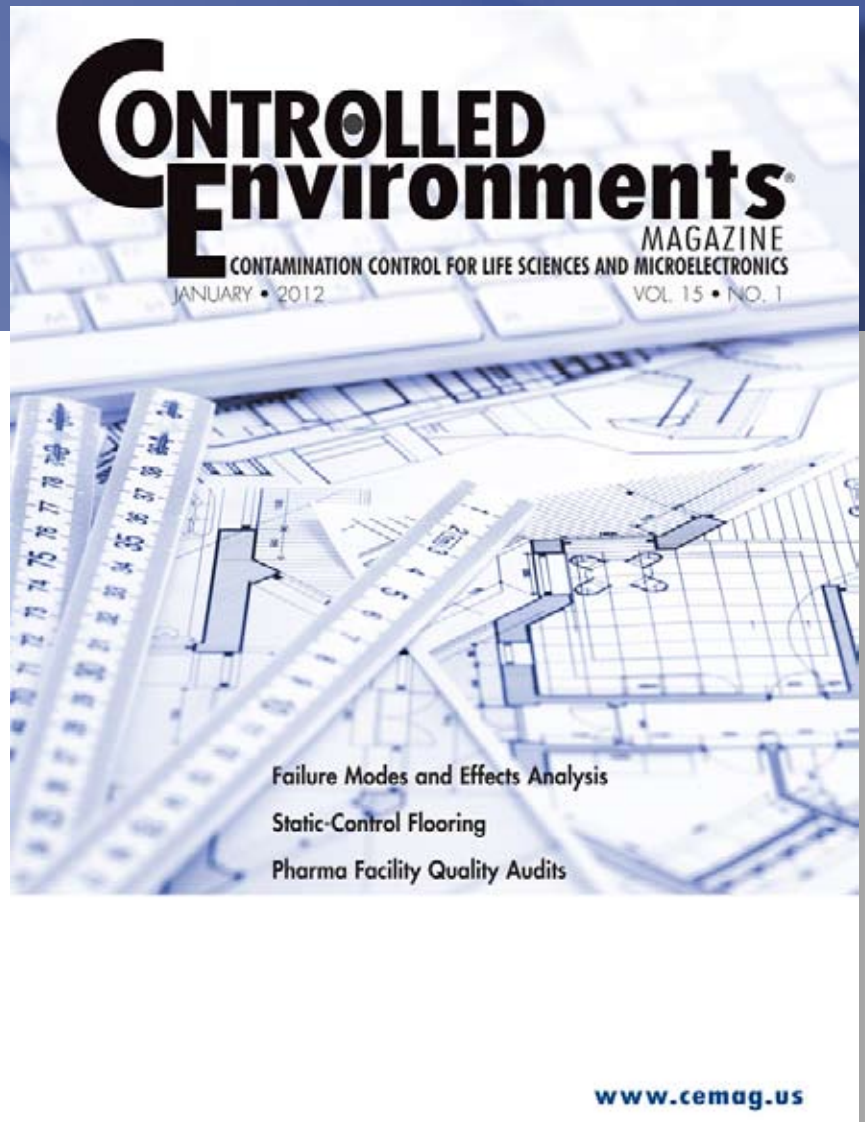
Published Articles

Why Static-Control Flooring Is So Important — And How to Find Solutions to Keep You Grounded

Selecting the right kind of ESD (electrostatic discharge) flooring is always a challenge, and in controlled environments, the stakes are particularly high.

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Why Static-Control Flooring Is So Important — And How to Find Solutions to Keep You Grounded

Selecting the right kind of ESD (electrostatic discharge) flooring is always a challenge, and in controlled environments, the stakes are particularly high.

While cleanroom environments are known for the exacting standards used to control contaminants, it's ironic that their anti-static flooring doesn't always meet industry specifications. This is a critical concern on several levels:

- First, the ESD problem is intensifying as electronic devices continue to become smaller and more powerful. Miniaturization, also known as device scaling, reduces the room for on-chip protection, increasing vulnerability to ESD and accenting the need for static-control, fault tolerant flooring.
- In addition, recent and proposed changes to ESD standards, including ANSI (American National Standards Institute), increases challenges to manufacturing facilities seeking ISO certification. These changes address the need to comply with revised static-prevention performance parameters, with failure to do so exposing companies to potential lost business due to non-compliance.
- Floors installed in cleanrooms have enormous bottom-line implications if you consider the potential costs of installing a new, correctly specified, floor after your facility is operational.

In other words, it is paramount to get your ESD flooring right the first time, and there should be no room for compromising within the precious real estate of cleanrooms. Yet, problems persist. Why?

INITIAL CONSIDERATIONS

Understandably, many engineers and facility managers are frustrated and confused when it comes to selecting static-control floors for their factories. They typically don't have the time nor the expertise needed to deal with electrical specifications and standards. Selecting a floor includes considerations like maintenance, durability, ergonomics, safety, installation procedures, and, most importantly, how the floor controls static charges on people based on their footwear.

In cleanroom environments, the process often requires the assistance of outside experts who specialize in ESD, contamination control, ion chromatography, material out-gassing tests, and particle analysis.

Overall, depending on the application and site considerations, ESD floors can be installed over old floors, over bare concrete, or on top of raised access-flooring panels. However, due to contamination and particle control considerations, only three forms of ESD flooring are generally considered suitable for cleanroom environments: rubber, vinyl, and epoxy.

With this as the backdrop, the following will focus on key factors to consider in the evaluation and selection process, including electrical resistance, footwear, cleanliness, mechanical properties, and ergonomics.

ELECTRICAL RESISTANCE

Rubber, vinyl, and epoxy floors can be produced in either the conductive or the static-dissipative ohms range. According to the ESD Association, a conductive floor measures below one million ohms (1.0×10^6) when using test method ANSI/ESD S7.1-2005. Using the same test, a floor measuring between one million ohms and one billion ohms (1.0×10^9) is defined as static dissipative. As a general rule, most experts believe that floors measuring below 10 million ohms (1.0×10^7) offer the best static-control performance for electronic manufacturing and handling. Floors measuring above 10 million ohms drain static more slowly than floors measuring in the conductive or lower end of the static-dissipative range ($< 1.0 \times 10^7$).

Also, ESD floors that are too conductive may not be considered safe. Most safety engineers refer to NFPA 99 to define the minimum resistance of conductive floors. According to the 2005 version of NFPA 99, a floor should not measure below 25,000 ohms (2.5×10^4). There is a caveat when referencing NFPA 99, however: This test requires measuring a floor's resistance using an ohmmeter with a 500 volt output, and most of the meters used for testing conductive floors operate at 10 volts. Unfortunately, this creates a potential safety dilemma for specifiers because a floor measuring 25,000 ohms at 10 volts will measure far below the NFPA minimum of 25,000 ohms when tested at 500 volts. For this reason, we recommend setting the resistance minimum above 50,000 ohms to address the discrepancy caused by the two different test methods.

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Why Static-Control Flooring Is So Important — (continued)

Upshot: Recommended floor range: greater than 50,000 ohms and less than 10,000,000 ohms (5.0×10^4 – 1.0×10^7).

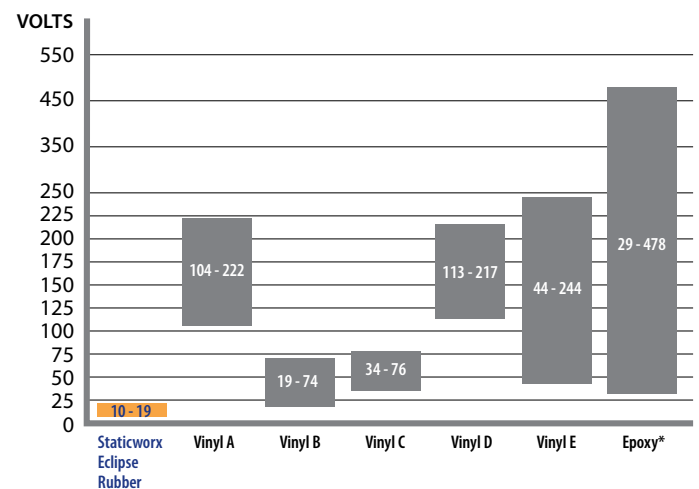
FOOTWEAR

ESD floors should never be evaluated solely on electrical resistance parameters, since that is only part of the story. ESD standards like ANSI/ESD S20.20-2007 require testing of both the resistive properties (ohms) and the charge-generation properties (volts) of the floor. The ESD Association requires that the floor's performance be evaluated in combination with static-control footwear. The first requirement in S20.20 evaluates a property called "system resistance," which is determined using the ANSI/ESD S97.1 test method. In this test, the ohms resistance is measured from a person's hand to the ground—through the body, the footwear, the floor itself, and the ground. As of November 2011, an acceptable reading requires a system resistance below 35 million ohms (3.5×10^7). (Note that before writing this article, we interviewed several members of the ANSI/ESD S20.20 committee about possible changes in the system resistance requirement. We were informed that the requirement might be raised to a maximum of 1 billion ohms (1.0×10^9). However, if this system resistance is increased, requiring body voltage testing at the same time will likely offset it.)

Body voltage generation is determined by measuring static charges using test method ANSI/ESD S97.2. With this method, subjects wearing special static-control footwear walk on ESD flooring while connected to an instrument that measures the amount of static charge the subject generates from the interaction of the footwear and grounded floor. To meet ANSI/ESD S20.20, a person wearing approved, grounded footwear cannot generate over 100 volts. Achieving this parameter may be difficult in cleanrooms, however, depending on the contamination-control footwear requirements. Standard cleanroom shoe covers generate static voltages in excess of 1,000 volts. Several suppliers offer disposable and permanent static-control shoe covers with conductive or static-dissipative material on the bottom side.

Regardless of the shoe cover specifications, they should always be tested with the grounded floor. Testing has shown that many conductive and static-dissipative vinyl and epoxy floors will generate well over the 100 volt maximum on test

Body Voltage Generation in Combination with a Person per ESD STM 97.2**



* Epoxy flooring was tested with conductive footwear.

** The tests were performed by an independent test company.

fig. a.

Disposable shoe cover. Specialized footwear like this is required in controlled environments; unlike the booties, these shoe covers are typically used in less stringent environments.

fig. b.

Shoe cover or bootie. This is a common shoe cover, or bootie, worn in cleanrooms. To meet the ANSI/ESD S20.20 standard, people wearing approved footwear cannot generate over 100 volts. Anti-static rubber flooring works best with this footwear, generating well under 100 volts.



subjects wearing these types of booties and shoe covers. The same testing has proven that conductive rubber flooring will generate well under 100 volts combined with most static-control cleanroom footwear. This is because conductive rubber flooring generates significantly less static than vinyl

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Why Static-Control Flooring Is So Important — (continued)

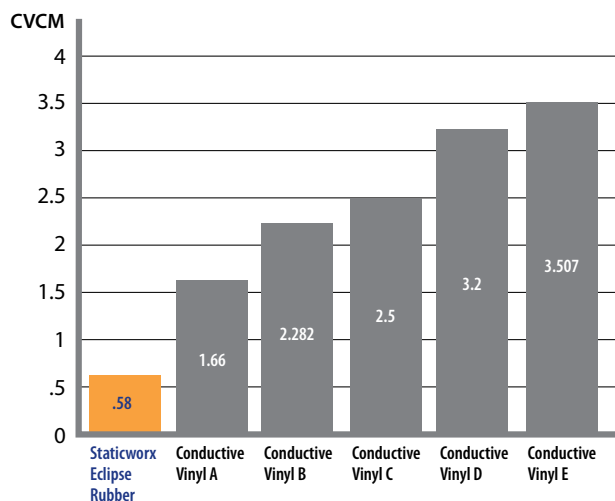
or epoxy flooring, regardless of footwear.

Upshot: Current system resistance requirement: < 35 million ohms (3.5×10^7). Proposed requirements: system resistance < 25 million ohms and body voltage < 100 volts.

CLEANLINESS

When determining the compatibility between construction materials like flooring and cleanroom processes, there are numerous considerations. Here, we will touch on the main factors: out-gassing and particle transfer. According to ESD and contamination-control consultant Carl Newburg, president of Microstat Laboratories and River's Edge Technical Services in Rochester, Minnesota, "Out-gassing is a measurement of the quantity of volatile chemicals released from a material while it is heated. Condensable volatile residue (CVR), Static Headspace, and Dynamic Headspace

Outgassing comparison according to ASTM-E-595 (CVCVM)*



* Tests performed by an independent testing company.

Definition of CVCVM: Collected volatile condensable material – the quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time. CVCVM is expressed as a percentage of the initial specimen mass and is calculated from the condensate mass determined from the difference in mass of the collector plate before and after the test.

Out-gassing. Conductive rubber flooring and conductive epoxy flooring perform the best i elevated temperature out-gassing tests because, unlike vinyl, rubber and epoxy are made without plasticizers.

are typical tests used to measure out-gassed materials. Test results offer an indication of the material's tendency to contaminate surfaces in a controlled environment with airborne molecular compounds."

Most vinyl flooring materials fail stringent, elevated temperature outgassing testing due to the inclusion of plasticizers in the flooring material. Plasticizers are problematic because they can migrate out of the flooring material and create significant contamination problems in cleanroom applications like optics and MR head manufacturing. We have all experienced plasticizer migration through what we refer to as "new car smell." This smell is the result of airborne plasticizer out-gassing from all of the various plastics used in an automobile's interior. Without thorough testing, this plasticizer migration would be difficult to identify and quantify. Many flooring manufacturers will state that their flooring will meet all out-gassing requirements at ambient temperature, but most contamination-control experts do not believe that ambient testing is adequate.

Before specifying any flooring for installation, we recommend discussing the application with an expert in contamination control and ESD. As a rule of thumb, conductive rubber flooring and conductive epoxy flooring will perform the best in elevated temperature out-gassing tests. Unlike vinyl, rubber and epoxy are made without plasticizers.

Upshot: Floors that pass elevated temperature outgassing tests: conductive rubber and conductive epoxy.

MECHANICAL PROPERTIES

Most cleanroom floors are installed using methods that create a seamless floor, which can be achieved with epoxy coatings because the material is coated onto the floor in liquid form and allowed to flow across the surface. The downside to seamless epoxy coatings involves the difficulty and time required to make repairs in the event of damage from scratches or cracking. A typical cure time for an ESD epoxy floor is between 24 and 72 hours, depending on the number of layers. If a repair is performed in an operational cleanroom, the epoxy could create contamination or odor problems during the time it takes to harden from its liquid state. Additionally, epoxy repairs usually require some form of abrasive floor preparation to make the surface fit

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Why Static-Control Flooring Is So Important — (continued)

for recoating. Abrasive floor preparation could generate particles that contaminate fixtures and HEPA filters.

Rubber and vinyl can also be installed without seams using a technique called seam welding, which fills in and fuses gaps resulting from the interactions of sheet floor flooring or adjacent tiles. Both tiles and sheet floors can be seam welded (similar to caulking), but most specifiers prefer sheet flooring since there are fewer seams to weld. The welds in rubber sheet flooring are less visible compared with vinyl welds because, unlike vinyl, rubber does not shrink. Rubber and vinyl floors can be repaired more easily than epoxy using simple techniques that don't require abrasive floor preparation techniques. Conductive rubber sheet flooring can be installed with fast-drying, pressure-sensitive adhesives that can usually be applied in an operational cleanroom. Pressure-sensitive adhesives allow for foot traffic within an hour of the repair.

ERGONOMICS

Of the three most common cleanroom flooring options, rubber offers the most slip-resistant walking surface, wet or dry. Rubber is also softer underfoot, and it absorbs ambient noise better than hard epoxy and vinyl surfaces. Even though it is much harder than generic rubber used in forms like anti-fatigue matting, rubber can become damaged from rolling heavy loads over it. Compared with epoxy, it is also more difficult to roll heavy racks weighing thousands of pounds over rubber. In some cases, epoxy may be the only practical flooring option due to its toughness and ability to handle rolling loads and chemical spills.

Upshot: Rubber offers the most ergonomically friendly solution.

SIMPLIFYING THE SELECTION PROCESS

Indeed, there is a vast amount of technical information to consider when selecting static-free flooring in controlled environments—and it would be short-sighted to look for shortcuts in the process. In the final analysis, the key concepts are prevention and protection.

To prevent ESD problems, select the flooring option that best meets current and anticipated industry specifications.

While there are different variables, here is what industry sources recommend for cleanrooms and electronic manufacturing facilities:

- Conductive Rubber the only ESD flooring certified as Class-0 Qualified is rated "ideal;" it also has low body voltage generation.
- Conductive Vinyl Tile and Conductive Epoxy may also be suitable.
- Other flooring options are not recommended.

As far as protection, if you plan wisely from the get-go, you can avoid costly liability issues later on. We encourage installation floor audits to determine if you are ground safe.

In short, when it comes to ESD flooring in controlled environments, it makes sense to exercise maximum control.

Dave Long is CEO and founder of Staticworx, Inc., in Watertown, Mass., Staticworx offers comprehensive flooring options including rubber, vinyl tile, carpet, epoxy, and adhesives. All products meet international standards, are environmentally friendly, and come with lifetime warranties. For more information, visit www.staticworx.com or e-mail dave@staticworx.com.