

Potential Conflicts When Evaluating ESD Flooring

The sensitivity of today's state of the art, class zero electronic devices is forcing companies to take a closer look at their ESD programs. To prevent component failure, most electronics manufacturing and test facilities use some type of electrostatic discharge (ESD) control flooring. Options range from small conductive mats and runners, used in isolated applications, to floor coverings such as conductive tiles, carpet and coatings, used in ESD-sensitive areas throughout the facility. This static control flooring is described by many different names: conductive, anti-static, dissipative, ESD, grounded, static-free and static resistant.

Static control flooring is installed under the assumption that it will both prevent static build-up and allow the safe discharge of pre-existing static charges on people, mobile carts, equipment, chassis and conductive seating. When proper due diligence has been performed, a static control floor fulfills the expectations of the buyer. If the flooring has not been properly evaluated—as part of an entire ESD system, with all environmental factors considered—it is possible that the floor will contribute to the very problems it is designed to eliminate.

ESD Controls Must Be Evaluated As Part of a System

The most common trap buyers fall into when choosing an ESD floor is failing to recognize that flooring is only one part of a comprehensive, multifaceted static prevention system. Unlike conventional flooring, ESD flooring cannot be evaluated in isolation. To ensure proper functionality, ESD flooring must be tested in conjunction with other ESD prevention components, including but not limited to controlled footwear. If the ESD floor and the controlled footwear are not fully compatible, the floor will not comply with current ESD standards, which limit body voltage generation to a maximum of 100 volts. Many conductive epoxies, for example, generate more than 100 volts of static on people wearing conductive heel straps. For certain conductive epoxy floors to dissipate static properly, every person who walks across the floor must wear either

full-shoe sole straps or special types of conductive shoes. Conductive rubber flooring, on the other hand, maintains thresholds below 50 volts without regard to the type of controlled footwear.

All scenarios can and should be identified prior to selecting the flooring and the controlled footwear. If the footwear is not evaluated at the same time as a new ESD floor, it is quite possible for mobile workers to generate and accumulate five to six hundred volts of static electricity on the new floor and never even realize it. (Remember: people cannot sense a static zap until the discharge reaches magnitudes exceeding 3500 volts.)

Before any footwear or flooring is purchased or installed, systems tests that measure both resistance and body voltage generation should be performed on site, under normal conditions. This is

An ESD floor should not be specified as needing to be either conductive or static dissipative. Calling a floor conductive or dissipative falsely implies that the electrical properties of the material fall within a narrow set of parameters. In fact, with their extremely wide ranges of electrical resistance, the terms are about as precise as the descriptors hard and soft.

According to ANSI/ESD S7.1, a conductive floor is any floor with a resistance to ground of between 25,000 ohms and 1,000,000 ohms—in population, roughly the difference between an average U.S. suburban town and the city of Dallas. A static dissipative floor is defined as having a resistance to ground of between 1 million and 1 billion ohms—in population, the difference between New York city and the entire country of India.

Basing a flooring spec solely on a classification with such broad variation is imprudent. A particular conductive floor may be hazardous in applications involving electrical equipment, exposing personnel to harmful electrical shock, while another conductive material poses no risk at all. Materials that measure within the static dissipative range are equally variable. A highly resistive dissipative floor may not bleed off static charges adequately to protect ESD-sensitive parts, rendering it useless for static control.

The terms conductive and dissipative should be used for descriptive purposes only, never as rigid specification criteria. A flooring specification should always include actual electrical parameters expressed in arithmetical terms.

The ideal safe resistance to ground is between 100,000 ohms and 10,000,000 ohms—meaning it rides the line between conductive and dissipative. This electrical range is the same as a properly functioning wrist strap. Keep in mind that a functional wrist strap resistance encompasses the lower range of static dissipative (<10,000,000) and the upper range of conductive (>500,000 ohms). It stands to reason that an ESD floor should meet the same parameters. The proper selection criteria should evaluate whether or not a floor can safely duplicate the grounding properties of a wrist strap – not whether the floor happens to meet a broad and imprecise definition.

particularly important for systems involving dissipative and resinous (epoxy or seamless coatings) floor coverings. Because the range used to define dissipative materials is so broad (ranging from one million to one billion ohms), a highly resistive dissipative floor should not be viewed the same as a less resistive dissipative floor (less than 10 million ohms). High resistance dissipative floors (over 100 million ohms) often generate human body voltages that exceed several hundred volts. In the case of resinous flooring, buyers should conduct ESD tests on site, rather than relying on the results of independent lab tests. Resinous floors are “manufactured” while they are installed, which means that the floor installed in a building will always be different from the floor that was tested in the lab.

The ESD floor and controlled footwear may be extremely high quality products, but if the components are tested individually, using conventional pass/fail resistance testing, a systemic problem could exist with no possibility of detection. This fact should be kept in mind when reviewing the electrical properties of any ESD flooring option. Almost all manufacturers state that their flooring products meet or exceed certain ESD Association standards. A prudent buyer should always ask: Using what kind of footwear, and in what sort of environment? (For an expanded discussion of this topic, see “Choosing The Right ESD Flooring For Laboratory and Technical Environments,” Conformity, May 2005.)

Which Test Method Will Reveal Possible Deficiencies?

Before the 1990s, engineers and facilities managers evaluated a floor’s ESD properties using the predecessors of test methods such as ANSI/ESD STM S7.1 to test the floor’s electrical resistance to ground. Other electrical properties were rarely evaluated. The floor was almost never tested as part of an overall system, and the environment in which the floor was expected to perform was completely ignored. All too often, this lack of scrutiny led to the implementation of deficient ESD prevention programs—usually unbeknownst to the user.

Fortunately, ESD standards have evolved. Today, using three highly reliable and valid test methods, buyers can easily identify the best solution for their particular environment.

As mentioned above, according to the ESD Association, based in Rome, New York, a best practice ESD prevention program must prevent human body model (HBM) voltages from exceeding

100 volts. The process and test methods for creating such a program are outlined in ESD standard ANSI/ESD S20.20-1999, downloadable at no cost from the association’s website: <http://www.esda.org/>.

To be understood properly, this document must be read and analyzed carefully. Like most standards written by “insiders,” its terms can be confusing and its recommendations may even seem contradictory. For instance, a quick review of the chart on page 7 could lead an uneducated buyer to believe that a floor’s resistance to ground (RTG) can test as high as 1.0×10^9 and therefore comply with the full intention of S20.20. This is simply not the case. A static dissipative measurement of 1.0×10^9 is the highest resistance a material can have and still possibly bleed off static charges, so merely the starting point in evaluating the performance of an ESD floor. In addition, the floor must meet system resistance and body voltage generation parameters. Essentially, the floor must provide the same degree of static protection that occurs when all personnel wear wrist straps. Wrist straps provide a one meg-ohm path to ground or almost three orders of magnitude below 1.0×10^9 . It would be a significant oversight to assume that a floor resistance of one billion ohms would possibly offer the same level of ESD protection as a one-ten megohm wrist strap.

In addition to simple resistance testing, the ESD Association cites two different methods with correspondent recommendations for analyzing ESD flooring-footwear systems. Both tests should be performed and their recommendations followed.

The first, ANSI/ESD STM97.1-2006, evaluates the resistance properties of the flooring and footwear in combination with a person. According to S20.20, the aggregate resistance measurement of all three components (person, footwear and floor) should not exceed 35 megohms (3.5×10^7). Used alone, resistance tests are an unreliable means of judging a floor’s ESD properties: The aggregate, or system, resistance can be influenced by too many variables, including the hardness of the floor, its composition, the type of controlled footwear used in the testing, and the contact resistance between the footwear and the floor. Environmental conditions such as relative humidity can also influence the tests. Rather, resistance tests should be considered part one in the ESD testing equation.

Part two, as outlined in ANSI/ESD STM 97.2-1999, measures the voltage generated on the body of a person wearing controlled footwear while moving on the ESD floor. The body voltage test often contradicts the results of resistance testing. Resistance tests, including those outlined in STM 97.1, are performed while the subject is still, with his or her feet in constant contact with the same spot on the floor. They strictly measure the electrical

path to ground. The methods in STM 97.2 test the floor dynamically, requiring the test subject to move and break contact with the floor. The controlled footwear may be conductive, but regular shoes—running or tennis shoes, for example—are often made of static generating plastic or rubber. If the contact area of the controlled footwear is small, say if the test subject is wearing a conductive heel or toe strap, when the subject moves both the protected and unprotected parts of his or her shoe contact and separate from the floor. This contact and separation between surfaces generates what is called a triboelectric charge on the subject's body.

Because the test introduces the real-world factor of triboelectric generation, the results of 97.2 are more telling than those of simple resistance testing. No matter what its resistance measurements, a floor should never be installed if the walking body voltage generation exceeds 100 volts.

Which Tests Should Be Performed During Regular Audits?

Most companies cannot afford an in-house ESD expert as part of their regular staff and rely on untrained technicians to test their ESD floor. To accurately test body voltage or to measure the resistance properties of materials that might test in the upper dissipative range (over 1.0×10^8), technicians must use laboratory-grade instruments. These sophisticated instruments can be difficult to operate and the test results hard to interpret. They are also expensive. Depending on quality and options, the investment for body voltage measurement equipment can exceed two to three thousand dollars. The same is true for high reliability meg-ohm meters with constant voltage power supplies like those recommended in ANSI/ESD STM 7.1. Small and mid-sized electronics manufacturers often feel they cannot justify the cost of expensive instruments for non-revenue producing departments. In this case, buyers should consider avoiding the purchase of flooring materials that cannot be certified on a regular basis without the

use of laboratory-grade instruments. How can a company defend the use of a dissipative rubber floor, for example, if their technicians cannot verify those properties during a quality-control audit by their most important customer?

Keep in mind that a floor can pass the recommended body voltage recommendations of S20.20 and not meet the recommended maximum system resistance of 3.5×10^7 . As long as regular audits verify consistently low (<100 volts) body voltage characteristics, any ESD engineer would consider the floor compliant with ANSI/ESD S20.20. Without the right test equipment, however, proving compliance is difficult. An electronics manufacturer may have purchased a high quality ESD floor that, in combination with their footwear, is incapable of generating over 20 volts, but if they cannot prove its performance or if the customer insists on basing its pass or fail only on system resistance measurements, in all likelihood the company will fail the audit.

What ESD Flooring Meets the Recommendations of All Three Tests?

Ideally, a floor should ride the line between conductive and dissipative, with a resistance to ground of between 100,000 ohms and 10,000,000 ohms. Most ESD experts agree that more conductive flooring provides more value than highly resistant dissipative flooring ($1.0 \times 10^7 < RTG < 1.0 \times 10^9$). Less resistant floors discharge preexisting static charges on people and material

handling carts faster than marginally dissipative materials. Because they bleed off static charges faster, floors that measure in the less resistant range are less likely to produce sudden spikes of static. Less resistant floors are also easier to audit. That said, rather than relying on the loosely defined terms "conductive" and "dissipative," specifications should always be created with the particular application in mind and should include actual electrical parameters expressed in arithmetical terms.

As previously stated, before the purchase of any static control flooring, body voltage testing should be performed. In tests done with a human subject, most conductive tiles and ESD carpet tiles measure

CREATING VALID ESD FLOORING SPECIFICATIONS

- The flooring material alone should not measure over 1.0×10^9 . This criterion is easy to meet. To ensure adequate performance, the floor must also meet the recommendations of the next 2 criteria.
- Together, the floor and the person walking across the floor must not measure above 3.5×10^7 —the same as the standard for wrist straps. ANSI/ESD 97.1
- A moving person must never generate over 100 volts of body voltage. Higher body voltage generation means the floor/footwear combination is not correct. ANSI/ESD 97.2
- The flooring/footwear combination should duplicate the performance of a wrist strap. A wrist strap has a one meg-ohm resistor inside the snap. A one meg-ohm resistor protects the wearer from electrical shock.
- The ideal floor measures between dissipative and conductive—i.e. above 1.0×10^5 and under 1.0×10^7 . A floor that measures slightly below 1.0×10^6 should be viewed the same way as one that measures slightly above 1.0×10^6 .
- Specifications should always be created with the particular application in mind and should include actual electrical parameters expressed in arithmetical terms.

well below 5 meg-ohms resistance to ground. By nature, lower system resistances prohibit the generation of voltages over 100 V, precluding the necessity of ongoing body voltage auditing. For this reason, after initial certification, as long as the other test parameters fall below the recommended maximums, body voltage testing need not be done as part of a company's regular ESD audits.

In this age of increasingly sophisticated, increasingly sensitive electronics, many companies are specifying floors with greater conductivity as insurance against component failure. There is no cost penalty for making this choice. Unless there are compelling reasons involving high voltages that compromise safety, it makes no sense to intentionally choose a floor that may be incapable of protecting the next generation of components from something as simple as an ESD event—especially one that could have been easily prevented.

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