The Flooring and Footwear System – An Important Part of any Electrostatic Discharge Control Program

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The human body is an electrostatic generator and as such, needs to discharge the electricity it generates or damage highly sensitive electronic components. The appropriate flooring and footwear system can dissipate electrostatic energy and contribute to a safer environment. Not all systems are created equal, however, and buyers should be aware of the capabilities of their ESD flooring and footwear systems.

Starting at the beginning: A short introduction to Electrostatic Discharge – The Invisible Enemy

Static electricity is capable of causing product damage, product malfunction, and shocking personnel when it discharges and causes other problems by attracting dust and lint. The negative impact of electrostatic discharge (ESD) can be staggering. Without proper control measures, ESD can cause poor production yields and unreliable product performance.

ESD protective flooring in combination with proper ESD control footwear is considered by many today as the first line of defense against damage from ESD.

Generating electrostatic charges

Static electricity is often generated through triboelectric interactions, that is, the separation of electric charges that occurs when two materials are brought into contact and then separated. This includes the movement of people and materials in the work environment, which is a major cause of static electricity. In fact, any relative motion and physical separation of materials can generate electrostatic charges. Examples of tribocharging include walking on a rug, exiting a car, or removing some types of plastic packaging. In all these cases, the contact and separation between two materials results in tribocharging, thus creating an accumulation of electrostatic charge and a difference in electrical potential that can lead to an ESD event.

How to minimize undesirable ESD events

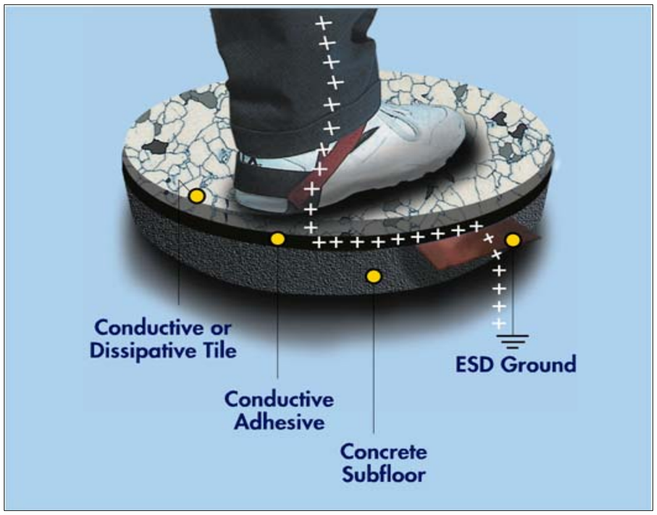
The way to minimize ESD events is by implementing an ESD Control Program. The ESD Association standard ANSI/ESD S20.20-2007 (S20.20) describes the requirements necessary to design, establish, implement and maintain an ESD Control Program for activities that manufacture, process, assemble, install, package, label, service, test, inspect, or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 Volts Human Body Model (HBM).

A key message from the document is that all personnel shall be bonded or electrically connected to a grounding/equipotential bonding system when handling unprotected Electrostatic Discharge Sensitive (ESDS) items or equipment. The personnel grounding methods described in S20.20 include a wrist strap system and a flooring/footwear system.

Most modern facilities today rely on a conductive flooring/footwear system as an essential part of an ESD Control Program. (See Photo 1.) This system provides flexibility to accommodate mobile operators as manufacturing processes and operations demand. The flooring and footwear must work together not only to discharge static electricity from people, but also to limit the charge generation by people and mobile equipment.

The use of floor materials to control personnel generated static electricity is beneficial only if adequate ESD control footwear is worn. Employees who work in areas protected with static control floor materials simply need to wear the appropriate footwear. Failure to wear ESD control footwear such as conductive heel straps or ESD protective shoes can result in excessive static charge generation, regardless of the type of ESD protective flooring installed in the facility.

Photo 1



Proper flooring and footwear contribute to a comprehensive ESD control program.

ESD protective floor materials provide a broad range of control, rather than isolating control to individual work stations. However, they do have some limitations, such as not being able to assure that personnel will maintain contact with the floor while they are seated. Therefore, according to S20.20, "when personnel are seated at ESD protective workstations, they shall be connected to the common point ground via a wrist strap system." This must be done in accordance to local safety laws and codes, of course.

The Flooring/Footwear Grounding System

Two flooring/footwear grounding methodologies are provided by S20.20. In the first method, the total resistance of the system (from the person, through the footwear and flooring to the grounding/equipotential bonding system) is required to be less than 3.5 X 10^7 ohms using the product qualification test method described in ANSI/ESD STM 97.1 – *Floor Materials and Footwear – Resistance Measurement in Combination with a Person*. The test method describes measuring the electrical resistance of floor materials in combination with a person wearing static control footwear.

If the total resistance of the system is greater than 3.5 X 10^7 ohm, but less than 1 X 10^9 ohms using ANSI/ESD STM 97.1, then the additional product qualification test method ANSI/ESD STM 97.2.-*Floor Materials and Footwear – Voltage Measurement in Combination with a Person* must be employed. In this second method, the floor/footwear system must not allow a person to generate over 100 volts.

These personnel grounding technical requirements are most easily met with a conductive floor. It is more challenging to achieve these measurements with a static dissipative floor rather than a conductive floor. A conductive floor is defined as having a resistance to ground of less than or equal to 1 X 10^6 ohms, while a static dissipative floor is defined as having a resistance to ground greater than 1 x 10^6 ohms, but less than 1 x 10^9 ohms.

One important goal of any ESD Control Program is to discharge any charge to ground that is generated by a person's or a material's motion in a controlled manner. It is important to remember that floor materials that create a ground path are dependent on the type of footwear worn by personnel and the conductivity of other items that come into contact with the floor (such as a cart wheel or caster), to function correctly. Typical street shoes with rubber soles, for example, insulate the wearer from the floor. Generated charges cannot readily flow from the body through the insulated shoe sole to the floor and then to ground.

Any individuals that work with unprotected devices or equipment that is sensitive to ESD should be included in the ESD Control Program. This program can be tailored for the area and application, but normally should include a selection of flooring and footwear that can help meet the ESD control requirements for the parts and items handled in that facility.

Testing Flooring and Footwear combinations

A recent industry study highlighted permanent resilient static control floor tile coverings made from either a vinyl or rubber composition. These types of resilient floor coverings are the most commonly used and for good reason: they offer the required static control performance, attractive appearance and resistance to many commonly used chemicals, while repairs can easily be made. Certain examples of these ESD protective tile floor coverings can retain their ESD control properties without any additional special treatments.

Not all products are created equal. One report[1] has highlighted the possibility that rubber flooring may be contaminated with silicone mold release agents that will hinder its electrical performance until it has been cleaned a few times. A sensible practice is to always evaluate performance data carefully against the required application specifications before purchase. For many electronics applications, these specifications generally will include measurements related to contamination and cleanliness.

Experimental Apparatus and Procedures

All floor samples and footwear were tested using identical test methodology. Test results should be compared side by side to evaluate differences.

Temperature and humidity were controlled during the testing (40% Relative Humidity and 75 degrees Fahrenheit). Charge generated by the personnel grounding flooring/footwear system under test was measured using a calibrated 3M Charge Plate Monitor 711. Only peak voltages were recorded. The 3M Charge Plate Monitor 711 was first grounded following manufacturers instructions. The scale range of 500 to 1000 volts was used. Before each test, the operator touched a ground point to make sure their body potential was at “0” volts. This was verified by observing a “0” value on the 3M Charge Plate Monitor 711.

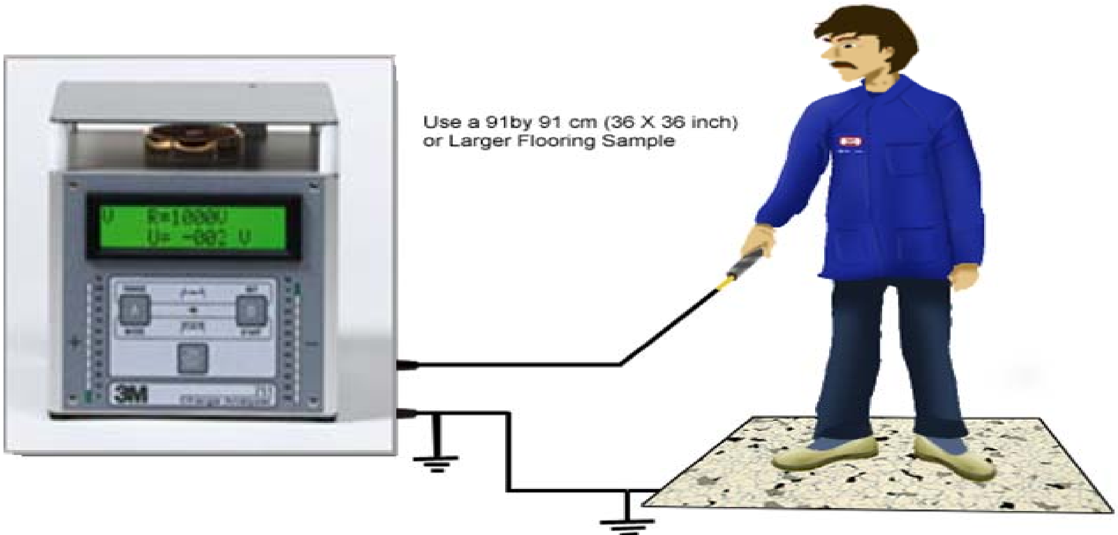


Figure 1

All floor samples were mounted on the same type of backing and grounded according to the manufacturers' instructions.

Measurements were taken during a series of movements that alternated between both feet on the ground and one foot off the ground. To minimize operator effects, the same operator was used for all of the tests. In order to properly analyze the floor's ability to dissipate a charge from a person, ESD control footwear was included in this study. The following flooring/footwear systems were tested:

	Flooring	**Footwear**
System A	Conductive Vinyl	Athletic Shoes
System B	Conductive Rubber	Athletic Shoes
System C	Conductive Vinyl	ESD Protective Shoes
System D	Conductive Rubber	ESD Protective Shoes
System E	Conductive Vinyl	Dress Shoes
System F	Conductive Rubber	Dress Shoes
System G	Conductive Vinyl	Heel grounders
System H	Conductive Rubber	Heel grounders

The soles of the athletic and dress shoes were tested using a Nicolet Nexus 670 FTIR equipped with a TGS detector. The results indicated that the sole of the athletic shoe was a non-conductive filled butadiene rubber and the sole of the dress shoe was a non-conductive filled styrene butadiene rubber.

The ESD control footwear used in the study were 3M Non-Marking Shoe Grounding Assemblies 2056 and Lehigh 5194 Static Control Shoes.

The 3M Non-Marking Shoe Grounding Assemblies 2056, or heel grounders, were worn on the heel of each shoe by forming the cup around the shoe heel and then fastening it with 3M Dual Lock Fastener Strips. A long conductive contact ribbon was placed in the shoe to fit between the inner shoe and the sock. Foot perspiration helps sustain the electric contact with conductive ribbon.

Tests were conducted by moving the feet in a simulated walking motion. The same operator was used for all tests. One operator was used to reduce the variables caused by different people, different size feet, different walking motions and other individual traits that impact the static charge generated. For example, tribocharging can be affected by the clothing worn, the walking speed, and how much perspiration is developed. Further, the size of the operator dramatically impacts the capacitance of the system which impacts the observed voltage in the test. In a pre-test warm up routine, the operator walked with each type of shoe for 10 minutes. Each test was run 15 times and the order in which the tests were conducted was randomized.

Test results

The different combinations of footwear and conductive floor tile lead to the generation of different walking body voltages, as shown in Figure 2. For example, in a previous two year study of over 20 reportedly ESD-safe floors, it was concluded that vinyl floors used in conjunction with street shoes demonstrated the lowest body voltages[2].

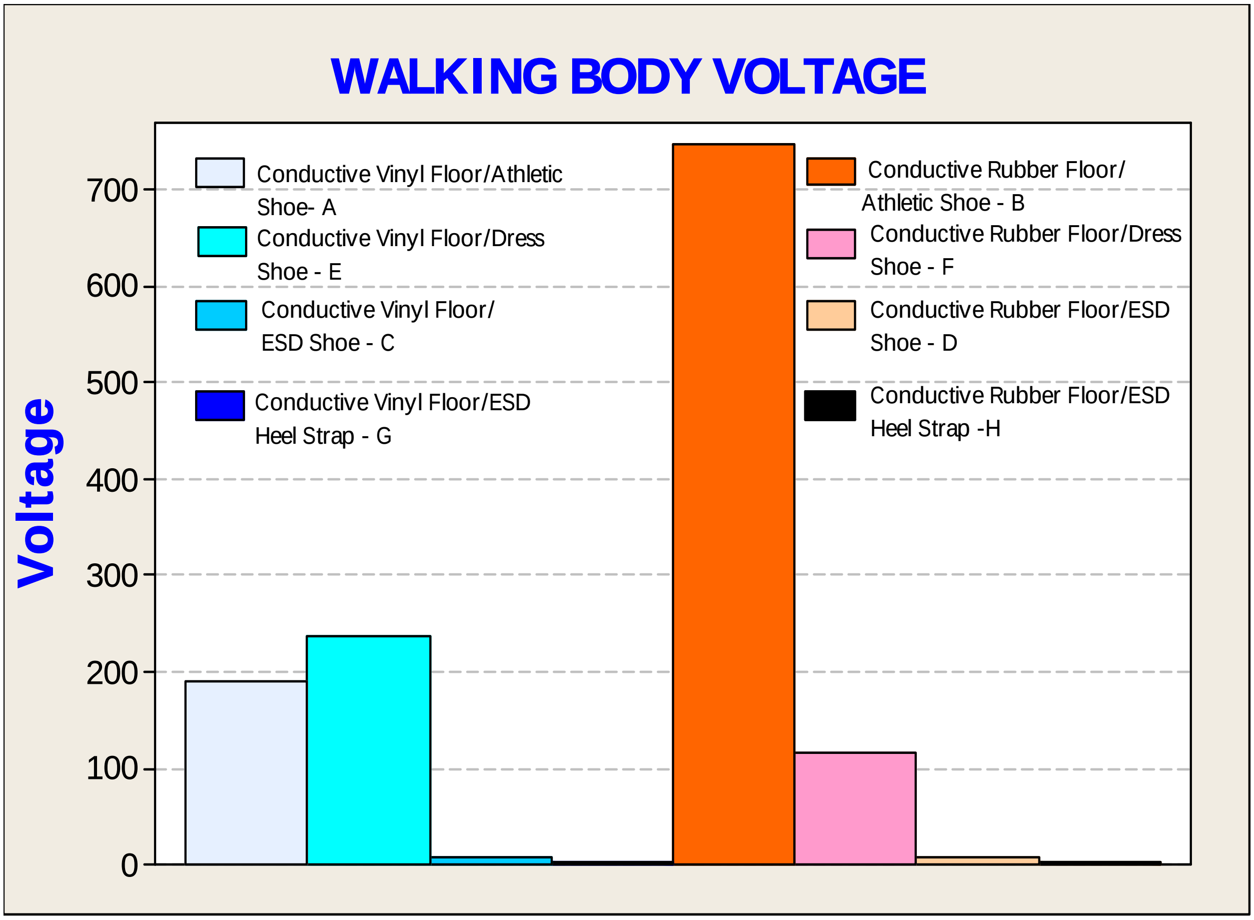


Figure 2

From the results displayed in Figure 2, it is clear that footwear selection has an important role in minimizing the walking body voltage generated on the conductive tile floors under test. When street shoes were selected, the walking body voltage was dependent on the actual street shoe selected. If static control footwear is not used, walking body voltages of many hundreds of volts can be generated. For example, the combination of athletic shoes and conductive rubber tile flooring generated walking body voltages of over 700 volts, according to this study.

When ESD control footwear was selected, Figure 2 shows that all conductive flooring/footwear test systems (C, D, G and H) generate walking body voltages of less than 20 volts. This emphasizes the importance of adhering to an ESD Control Program that includes the wearing of ESD control footwear. This ESD control footwear would include ESD protective shoes and other shoe grounding devices. While testing static control flooring systems with street shoes provides interesting data[3], we recommend that approved ESD control footwear always be used as an essential part of the static control flooring/footwear system. Compliance with grounding procedures as described in S20.20 is an essential part of any ESD Control Program.

Study Conclusions

1. The flooring/footwear system is an integral part of any Electrostatic Discharge Control Program.
2. Walking body voltages were dependent upon the footwear selected.
3. Different street shoes can generate varying walking body voltages depending upon such considerations as the material of the shoe sole, and the floor under test.
4. Conductive rubber floor tile in combination with an athletic shoe generated the highest walking body voltages of >700 volts.
5. The use of ESD approved footwear with both conductive vinyl and conductive rubber flooring resulted in walking body voltages of < 20 volts.
6. ESD control footwear must be used as a required part of the ESD protective flooring/footwear system.

When making a purchasing decision regarding a conductive tile floor, there are many items that should be considered. These include static control performance, cost, durability, maintenance, chemical resistance, cleanliness, warranty and customer support for example. A conductive tile flooring installation is a large investment that the end user should expect to last for many years. The nature of the end users' business today and what they anticipate in the future with regards to how they will use their facility should also be considered.

The electronics industry continues to scale microelectronic structures to achieve faster devices, new devices or more per unit area[4]. Along with increased device sensitivity, electronics are becoming ubiquitous in every device, with an increased customer dependence on the reliability of the end products. Therefore, the need for ESD control programs will increase. Customers will expect their suppliers to provide data that demonstrates compliance to these programs. We recommend using S20.20 as the basis for an Electrostatic Discharge Control program.

References

1. Common mistakes when selecting a static control floor, 2007 Annual Guide, Conformity P. 179, D. Long.

2. ESD Flooring: An Engineering Evaluation, 1995, EOS/ESD Symposium Proceedings, EOS-17, Phoenix, AZ, D. Robinson Hahn.

3. Choosing the right ESD floor for Laboratory and Technical Environments, May 2005, Conformity, D. Long

4. The ESD threat, 2002, Chapter 1, ESD Phenomena and the Reliability for Microelectronics White Paper, ESD Association.

ANSI/ESD S20.20 2007. A copy of this standard can be obtained from the ESD Association. www.esda.org.

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