

# Walking Body Voltage Generation Between Conductive and Static-Dissipative Carpet Tile

## NEW INDUSTRY ESD STANDARDS ADDRESS SAFETY ISSUES

### Abstract

Previous studies of ESD floors have exposed little correlation between the resistive properties of floors measuring below 100 megohms and the amount of body voltage a given floor might generate on a person walking on the floor. Given the safety liabilities associated with excessively conductive carpet, we examined the possible advantages of using a static-dissipative carpet over excessively conductive carpet in various applications requiring a low static-generating floor. As in previous studies, our data revealed no disadvantage to using a carpet tile measuring in the lower end of the static-dissipative range.

The fact is that highly conductive carpet has come under fire due to revisions in grounding safety standards. Many standards organizations now prohibit the use of highly conductive floors in applications involving powered equipment like those used in mission-critical environments such as server rooms, 911 call centers, and telecommunications areas.

ShadowFX was developed to address personal safety concerns without compromising static-control effectiveness in end-user sites as well as electronics manufacturing ESD-Protected Areas (EPAs).

### Industry Studies

In an ESD Symposium paper, *Procedures for the Design, Analysis, and Auditing of Static-Control Flooring/Footwear Systems*, Fowler, Klein, and Fromm showed that the electrical properties of shoe soles play a role equal to the electrical properties of the flooring. Their data also

demonstrated that effective static mitigation was achievable with flooring that was not excessively conductive. Accordingly, with heightened concerns about electrical safety in situations where operational electrical equipment is used, there is a documented, great need for less conductive flooring that prevents static electricity as effectively as highly conductive flooring.

Also, in other independent lab studies, we compared the charge generation properties of highly conductive carpet tiles with those of more resistant, static-dissipative carpet. The purpose was to quantify a middle ground or “sweet spot” of carpet-resistive properties that would effectively mitigate static without exposing people to potentially unsafe electrical currents due to flooring measuring in the low OHMs resistance range (see Figure 1).

The lab compared electrical properties of static-control carpet to determine suitability in

end-user environments and EPAs. Specifically, we compared three different carpet designs produced with 44 denier conductive fibers wrapped around 100% of the yarn ends:

- **Specimen 1:** Highly conductive, 22-ounce carpet tile with mill branded type 6 nylon and a conductive, recycled thermoplastic backing. Identified as “EL Black Back.”
- **Specimen 2:** Static-dissipative, 20-ounce carpet tile constructed with Universal-type 6.6 nylon yarn and static-dissipative PVC backing. Identified as “SD Pattern Style.”
- **Specimen 3:** Static-dissipative, 24-ounce carpet tile constructed with Aquafil-type 6 nylon and PVC backing. Identified as “SD Solid Style.”

Multiple tests utilized ANSI/ESD and AATCC standards and modified methods. Tests were performed at 12% relative humidity to produce worst-case outcomes. We determined resistive properties using ANSI/ESD S7.1-2005. We measured the OHMs resistance properties between two test points on the surfaces as well as the OHMs resistance to ground properties of an actual 4 tile installation of each of the designs. The EL Black-Back carpet tiles measured extremely low in the conductive range (< 50,000 OHMs). The SD Solid and the SD Pattern tiles measured slightly over 1 megohm (1 million OHMs) in both tests.

**Electronics Manufacturing EPA Results:** We utilized ANSI/ESD test method S97.1 in which a subject walks a repeatable pattern on carpet tiles wearing static-control footwear (Hytest ESD shoes) while attached to a voltmeter. Peak voltages are logged. An acceptable measurement for meeting ANSI/ESD S20.20 is fewer than 100 volts. All three carpet tiles generated well below 100 volts despite the two to three orders of magnitude differential in resistive properties between the SD and EL designs.

**End-User, Mission-Critical Results:** Using the same test equipment, we measured body voltage generation using two different methods on the subject wearing two different types of ordinary footwear. The AATCC-134 test measured voltage on a person wearing the prescribed neolite shoe sole covers. In this real-world scenario, both SD carpet tiles generated less voltage than the EL Black-Back tiles. The second test, using a modified version of S97.1, required the subject to wear a pair of aged Adidas sneakers while walking. The old shoes were chosen because previous studies identified a strong correlation between increased voltage generation and shoes that have less plasticizer content due to plasticizer migration from aging: Old shoes are likely to generate more static than newer ones. Again, the SD carpet tiles generated almost 10% lower peak voltage, even though they are less conductive than the EL Black-Back tiles.

To view test results, see Figure 2.

## Overall Findings

- Different spaces present different static-control challenges. Floors should be qualified based on the needs of the environments where they will be installed. Floors in real-world, mission-critical environments should be evaluated based on voltage generation on subjects wearing ordinary footwear. Floors in EPAs should be tested for voltage generation on subjects wearing ordinary as well as static-control footwear.
- Data indicates that highly conductive carpet tile (<10 E5) does not offer static-control advantages over a more resistive (10 E6 to 10 E8 OHMs) carpet tile for either mission-critical spaces or EPAs.
- Safety concerns should be carefully reviewed before a conductive carpet is installed around powered electrical equipment. As demonstrated,

highly conductive carpet poses an unnecessary safety risk. It is less safe than more resistant carpet because electrical currents increase as resistance decreases by a factor of 10 times for each exponential drop in resistance. A person grounded through a floor measuring  $10^4$  would be exposed to 100 times more electrical current than a person grounded through a floor measuring  $10^6$ .

- In the event of an electrical short circuit on a carpet tile installation in a school, lab, call center, etc., people could be exposed to high electrical currents if the floor is too conductive. At 10,000 ( $10^4$ ) OHMs, people could be exposed to 12 milliamps of current, enough to cause them to not let go of the voltage source. At 1 million ( $10^6$ ) OHMs, people would experience 1/100th of this current.
- Overall, highly conductive carpet should not be used when an equally effective, less conductive alternative is available.

### Recommendations for Specifiers

Specifiers should always refer to applicable standards, safety laws, and electrical codes when specifying and installing grounded flooring, as noted below:

- **For electronics device handling.** The floor must provide a system resistance of less than  $3.5 \times 10^7$  in combination with static-control footwear to meet ANSI/ESD S20.20-2007. If this cannot be achieved, the floor must generate fewer than 100 volts using standard test method ANSI/ESD S97.2 ANSI/ESD S97.2 (Floor Materials and Footwear–Voltage Measurement in Combination with a Person).

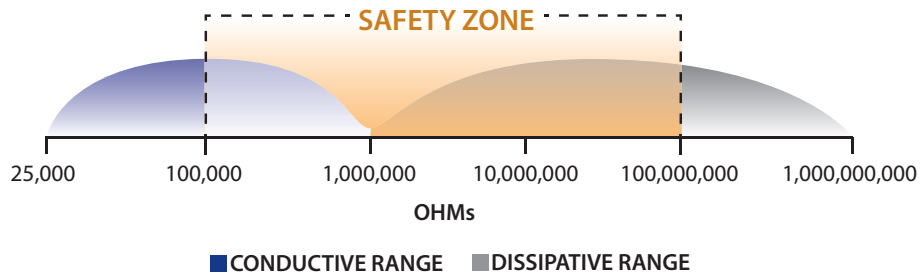
- **For mission-critical applications.** The floor should measure no less than  $1.0 \times 10^6$  and no greater than  $1.0 \times 10^9$ , according to Motorola R56, ATIS-0600321, and FAA STD 019e. *These documents do not recommend carpeting measuring between  $2.5 \times 10^4$  and some greater value because any measurement below  $1.0 \times 10^6$  violates these standards.*

### Conclusion

Static-control floors are often incorrectly evaluated as having to be either conductive or static dissipative. This thought process can create problems downstream. Floors should be specified quantitatively—not qualitatively (see Figure 1). Our study determined that carpet tiles measuring in the lower end of the static-dissipative range performed as well as carpet tiles measuring in the highly conductive range. The resistance of the SD carpet tiles measured less than  $1.2 \times 10^7$  OHMs, which is very low in the static-dissipative range; the SD range extends to 1 billion OHMs ( $1.0 \times 10^9$ ). Floors measuring in the upper end of the SD range would not meet the same performance parameters or the levels of effectiveness we revealed, even though those floors are still classifiable as “static dissipative.”

Therefore, to prevent problems due to semantic interpretations, we recommend that specifiers not describe carpet as conductive or static dissipative and instead use a quantitative range from 1 million OHMs to less than 100 million OHMs. This will eliminate the possibility of ineffective static-control materials becoming specified in static-sensitive environments, and it will prevent liability exposure.

**Figure 1: Your “Sweet Spot” for Safe Conductivity**



All Staticworx flooring is within the safe range shown here.

**Figure 2: Independent Lab Study for Carpet Tile\***

	EL Black Back	ShadowFX Solids	ShadowFX Patterns
ESD S7.1 Resistance Point to Ground	1.29 X 10 E4	3.57 X 10 E6	6.1 X 10 E6
ESD S97.1 System Resistance to Ground	7.25 X 10 E6	1.16 X 10 E7	1.76 X 10 E7
Voltage on Person Wearing Adidas Shoes	1122 Volts	885 Volts	398 Volts
	Walk Test	Walk Test	Walk Test
	1476 Volts	1033 Volts	1210 Volts
AATCC-134 Voltage Neolite (Static-Generation Test)	Scuff Test	Scuff Test	Scuff Test
	> .9 kV	< .4 kV	< .4 kV
ESD STM S97.2 Voltage on Person with Static-Control Footwear	17 Volts	25 Volts	46 Volts

\* All samples were pre-conditioned at 12% relative humidity for 48 hours.



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**StaticWorx®**  
 Waterbury-Stowe  
 Road  
 Waterbury Center  
 VT 05677  
 t: 617-923-2000  
 f: 617-467-5871

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