Understanding ESD Flooring Specifications and Standards

History of Static Dissipative and Conductive Terminology

To start, it’s important to understand how the terms “static dissipative” and “conductive” were originally developed, as well as the differences between them.

These terms were originally put in place by the packaging industry in order to simplify the selection of shielding materials. The Electronics Component Industry Association, the authors of EIA-541, developed a standard that characterized materials based on their ability to provide shielding from electrostatic fields. They defined “static dissipative” materials to fall within the range of \(1 \times 10^5 - 1 \times 10^9\), and “conductive” materials below \(1 \times 10^5\). They also determined that conductive materials provide better shielding than static dissipative materials.

This reasoning resulted in the widespread use of highly conductive materials, defining adequate shielding as possessing a resistivity of less than \(1 \times 10^5\). This was further accepted because it was aligned with specs for conductive flooring (\(2.5 \times 10^4 - 1 \times 10^6\)) in environments with explosives and flammable materials, and for hospital operating rooms handling ether in the 1950s and 60s, the first use of electrostatic discharge (ESD) flooring. This packaging specification mistakenly started spilling over to the table covering materials, tote boxes and flooring industries, which arbitrarily adopted them as the need for ESD protection grew, and the need for specifications to compare flooring materials performance outpaced the development of test data specific to flooring/personnel/environment interaction. Unfortunately, static shielding properties have no bearing on floors designed to protect against the voltage generated by people walking across the surface.

Surface Resistance Factors & Testing

Testing surface resistivity, which became the accepted test method for ESD flooring for many years, only tells part of the story. The ability of the floor to dissipate a charge on a person and limit the ability of a person to generate a charge are critical to a floor’s ability to maintain an equipotential balance between all items and personnel. Flooring should be approved and installed based on evaluation of properties that apply specifically to flooring and the industry application involved. The long-time argument of whether static dissipative or conductive material is better suited to flooring no longer applies. The most comprehensive of today’s specifications, ANSI/ESD S20.20, addresses the need for a comprehensive system approach, and not simply surface resistance. Therefore, the spec defines a surface resistance range for the floor (ANSI/ESD 7.1), a resistance range for the entire grounding system including the person, protective footwear and grounded floor (ANSI/ESD 97.1), and a requirement for walking body voltage on a moving person (ANSI/ESD 97.2).

Surface resistance tests can be performed easily and verified with inexpensive and readily available equipment. They are considered the most-favored method for monitoring ESD floors. Body voltage testing; however, requires special knowledge and elaborate testing equipment, so it’s typically only used during the qualification phase. When performing these tests, one should consider the intended choices of footwear and a sampling of individual workers since minor variables can affect the total package. Different environments within the same facility may perform differently as well, such as clean-room environments vs. manufacturing environments.
Evolution of Static Dissipative vs. Conductive Resistance Ranges

Electronics Industry Drives New Advances with Need to Limit BVG

As the electronics industry advanced in the 1980s, it moved away from conductive flooring and toward the static dissipative range of 1E6-1E9 after it became clear that a conductive floor could actually reduce a charge too quickly, causing as much damage as not limiting a charge. Additionally, it became clear that since electronics manufacturing environments can contain energized electrical equipment, potentially lethal current could be transferred to a person that came in contact with an electrical source while grounded to the floor.

A quick look at Ohm’s law brings this into perspective. Ohm’s law states I=V/R, with (I) being the current that is calculated by dividing (V) voltage by (R) resistance. To put this into perspective, a floor with a resistance range of 2.5E4 and a 220-volt power source would yield a current of 8.8 milliamps, well within the 6 - 16 milliamps range that OSHA considers is possible to inflict a painful shock and cause a person to lose muscular control, also known as the “let go range.” If this same energy source of 220 volts was introduced to a floor reading 1E6, the resulting current would only be 0.22 milliamps, below the 1 milliamp perception level determined by OSHA.

As the electronics industry continued to move forward throughout the 1990s, it determined the need to limit body voltage (BVG) to less than 100 volts. By the turn of the 21st century, it also found that the accepted range of 1E6-1E9 did not guarantee the ability to limit BVG to < 100; however, a grounded system (person/footwear/floor, etc.) with a resistance of < 3.5E7 cannot and will not generate walking voltages greater than 100 volts, hence the adoption of the ANSI/ESD spec S20.20, which does not mention “conductive” or “static dissipative” ranges.

Telecommunications Industry Further Refines ESD Flooring Requirements to Enhance Safety

The telecommunications industry, 9-1-1 call centers and data/air traffic control centers are the latest and most critical environments in need of ESD flooring as part of a static control program. These environments have their own unique requirements relating to grounding and surge protection, as well as controlling static electricity generation and protecting public safety. The proliferation of static-sensitive operational equipment for end-users, which are often publicly accessible, necessitates the need for flooring with a minimum resistance of 1E6.

 Widely Used Standards for ESD flooring and Their Original Intent

- **NFPA 99** was developed by the National Fire Protection Agency in the 1960s to address all of the safety issues and define standards for health care facilities. It contained comprehensive criteria for conductive floors used in operating rooms.

  Section 12-4.1.3.8 included the conductive range of 2.5E4 - 1E6, and it outlined specific testing using a megohmmeter with five-pound probes with an insulative rubber base wrapped in foil and placed three feet apart, tested with a 500-volt test charge.

  As one of the first detailed spec’s, it’s still widely used but has been deleted from revisions of NFPA 99 after 2005. The industry has moved away from this test method because it has been
determined that conductive rubber-based probes are more consistent and accurate than the foil-wrapped probes. More important, it has been decided that the test voltage of 500 volts is ineffective at determining the ability of the flooring system to control, limit or remove charges of less than 500 volts. Higher applied voltages cause electrical resistance to drop. In many cases floors, readings within an acceptable range at 500 volts will be much more insulative and actually out of spec at lower test voltages of 100 or 10 volts, which is the relevant data required with today’s increasingly sensitive devices and equipment. All the latest standards call for test voltages of 10 or 100 volts, not 500 volts.

- **ASTM F 150** is designed specifically for ESD-resilient flooring in tile or sheet form, and does not necessarily pertain to polymeric seamless ESD flooring. This standard also calls out the old test method utilizing 500-volt test charges and old style probes along with the inherent deficiencies mentioned above.

- **MIL-B-81705, 101C METHOD 4046** is used for testing static decay of barrier packaging materials. It has no relation to flooring and no pass/fail criteria.

- **ASTM D 257** is used for testing insulating materials.

- **MIL-B-81705, 101C METHOD 4046** is used for testing static decay of barrier packaging materials. It has no relation to flooring and no pass/fail criteria.

- **ASTM 991** is used for volume resistivity of rubbers used in conductive products. It’s not related to surface resistance of ESD rubber flooring.

- **AATCC 134/ANSI 134** is designed for measuring body voltage generation on ESD carpet.

- **EIA-541** is for electrostatic protective packaging materials.

**Current and Relevant Standards for Flooring Contractors**

*Electronics Industry*

- **ANSI/ESD S20.20-2014** is the most recognized standard for development of an ESD control program, specifically for the electronics industry. This state-of-the-art standard provides details about flooring and the interaction between flooring and personnel, with references to other specific ANSI/ESD test methods mentioned earlier. The standard calls for surface resistance ranges below 1E9, system resistance ranges (floor/ person/environment) < 3.5E7 and body voltage generation < 100 volts.

  *It should be noted this spec was the result of the Electrostatic Discharge Association working with the Department of Defense to convert MIL-STD-1686 into a commercial standard.*

*Emergency Call Centers*

- **MOTOROLA R56** is the most complete and rigorous specification for protection of communication system equipment installed at public safety and commercial wireless communication sites. Flooring requirements are 1E6 - 1E9 when measured using ANSI/ESD 7.1.
Telecommunications

- **ATIS-0600321** was developed by the Alliance for Telecommunications Industry Solutions for electrical protection of network operator equipment. Flooring requirements are $1E6 - 1E10$ when measured using ANSI/ESD 7.1.

Federal Aviation Administration

- **FAA STD 019e** is used for lightning and surge protection, grounding, bonding and shielding from section 4.1.3.4.3.5 Static Dissipative Floor Coverings. Recommended range is $1E6 - 1E9$.  

  *It should be noted that the 019e document supersedes 019d where conductive flooring was considered acceptable.*

Conclusions

ESD control is a matter every electronics and telecommunications company must confront, making a comprehensive, environment-specific static control program essential. In every case, the ESD floor represents a major capital investment and affects every aspect of the organization, from performance to image. Finding the right floor can be a challenge that involves balancing costs, durability, ergonomics, and compliance with safety standards, appearance, maintenance, and of course, ESD properties. In this day and age, specifications have been developed for many specific industries and environments within key industries. With careful research, an optimized plan can be developed for any environment requiring static control.

To address the needs of today’s marketplace, StatRez® Static Control Coatings are available in the traditional ranges of conductive and static dissipative, as well as an ANSI S 20.20 /R56 compliant version that has surface resistance and system resistance properties of $< 3.5E7$ but greater than $1E6$. Regardless of the environment or the application, there is a StatRez product to help achieve a world-class electrostatic discharge program.