Anti-Static Flooring – The Lifeline of ESD Protection Programme

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ESD (electrostatic discharge) is an increasingly challenging problem for manufacturers of products containing electronics. Static electricity is generated in many ways. People, carts, and chairs generate static electricity as they walk or are rolled around. A simple touch from an operator in a nonstatic controlled environment can transfer thousands of volts of static electricity.

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 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 systems.

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.

The basic working philosophy of ESD safe flooring is as a person walks on the floor and generates a static charge, the charge is drained to ground through conductive footwear and the floor. The facility floor plays a vital role in the success of any robust ESD control program. With its comprehensive product line, technical and contracting support, Protective Industrial Polymers is dedicated to providing fully compliant, turnkey ESD safe flooring solutions that provide peace of mind both today and in the future. ESD-safe flooring, in conjunction with ESD footwear has become a reality for today's electronics industry. To meet this need, a variety of report-

Captured on film! An electrostatic spark from a person's finger to a filing cabinet.

edly ESD-safe flooring materials have become commercially available which are intended to minimize the magnitude of charge generation. Refer Figure 1.

Figure 1: ESD safe Flooring

An Insight into the ESD Problem

ESD & its Source

All experience occurrence of static electricity everywhere. For an instance, walking along a carpeted floor in a heated room during winter generates sufficient static electricity to give us a rather shocking experience when we touch the door knob. While this sudden discharge of static electricity does not result in any harm to the human body, it can be very damaging to electronic devices which are sensitive to electrostatic discharge (ESD). It is possible for electronic devices to be damaged by ESD that is imperceptible to the human body. Refer Figure 2 for the common sources of static electricity.

Object or Process	Material or Activity
Work Surfaces	Waxed, painted or plastic surfaces
Floors	Waxed, common vinyl tiles, sealed concrete
Clothes	Common smocks, non-conductive shoes, synthetic materials (e.g. nylon)
Chairs	Vinyl, fiber-glass, finished wood
Packaging	Common Plastic bags, foam, trays, tote boxes
Assembly area	Spray cleaners, heat guns, blowers, plastic tools (e.g. solder suckers, brushes), cathode ray tubes

Figure 2: Common Sources of Static Electricity

The Damaging Phenomena of ESD

When a statically charged person or object touches an electrostatic discharge sensitive (ESDS) device, there is a possibility that the electrostatic charge could be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage could occur in the device due to localized overheating. Generally, devices geometries are more susceptible to damage from ESD.

The Modes in which ESD Damage Occurs are

- Discharge to the device
- Discharge from the device
- Field-induced discharge

ESD caused Damages in electronic device

ESD damage is of two types as mentioned below

1. catastrophic failure resulting in the immediate destruction of an item
2. latent defect resulting in a reduced life expectancy of an item

Both types of damage can have serious financial impacts on businesses through increased quality-control failure rates for catastrophic events, and consumer product warranty claims for latent defects.

About ESD Protection Programme:-

It has now become increasingly more important for all semiconductor manufacturers and users of semiconductors and other electronic components to fully understand the nature of ESD, the sources of ESD, and its impact on quality and reliability, to effectively deal with this silent chip killer. Almost all these manufacturer's are now coming up with ESD Protection Programme.

The key elements of a successful ESD Protection Program include:

1. Understanding static electricity.
2. Understanding ESD related failure mechanisms.
3. ESD sensitivity testing.
4. Establishing an ESD task force to outline the requirements of the program, sell the program to management, implement the program, review progress against milestones, and follow up to ensure the program is continuously improved and upgraded. Selecting an ESD coordinator to interface with all departments affected.
5. Conducting a facility evaluation to help identify the sources of ESD and establish static control measures.
6. Setting up an audit program.
7. Selecting ESD protective materials and equipment.
8. Establishing a training and ESD awareness program.

Most Key life line of ESD protection programme is Anti Static Flooring, which is discussed in the upcoming sections. Once this flooring is put in place, all the major risk of ESD is taken care of automatically.

Typical Application Area of ESD safe Flooring

Any industry where dust can present a problem or where

stray electric currents are undesirable will have requirements for anti-static floors. Typical examples are: Electronic assembly, computers, TV tubes, Magnetic tape production, Semi-conductor production of integrated circuits, Micromechanics, Gyroscopes, Miniature bearings, CD or DVD players, Optical lenses, Photographic film, Lasers, Biotechnology, Antibiotic production, Genetic engineering, Pharmaceutical manufacture, Sterile disposables, Medical devices, Heart valves, Cardiac by-pass systems, Food & drink production, Hospitals, Immunodeficiency therapy, Operating theatres, Clean rooms generally.

Figure 3: Various Application Areas of Anti Static Flooring

A Dive into Anti Static Flooring materials:-

Some of the very commonly used ESD safe materials are as mentioned below.

"No wax" vinyl tile / sheet – This is available in "conductive" and "dissipative" ranges. The material is installed with conductive adhesive. This material is uniform in size and easy to install. No wax needed to maintain ESD properties. Because of its easy to repair, low maintenance cost and good durability makes it a very promising ESD safe flooring material. Refer Figure 4

Figure 4: "No Wax" ESD Tile Floor

Standard vinyl tile / sheet – ESD wax on vinyl composition tile gives lowest initial cost. However this is a temporary solution as it helps only in static-dissipation. This process involves a very high maintenance cost. The other drawback is its effectiveness is application dependent.

Seamless epoxy – This is available in "conductive" or "dissipative" resistance range. One important benefit is it is seamless / self-leveling. The material is excellent in terms of durability and is also ideal for heavy forklift traffic. Low maintenance cost along with chemical-resistant and abrasion-resistant makes it an ideal ESD safe flooring material. Refer Figure 5.

Figure 5: ESD Epoxy Floor

Carpet – This has following features.

- Slight noise reduction
- Sold as tiles or broadloom
- Limited ESD conductivity range
- Not typically used for heavy production traffic
- Easy to repair
- Softer walking surface
- Moderate maintenance cost
- Rubber Flooring – This has following features.
- Higher initial cost
- Matte finish
- Moderate maintenance cost
- Good durability
- "Spiked" concrete
- Metal
- Surface treatments (wax)

Available Tests for Anti Static Flooring

Standardized test specifications and procedures available for characterization of ESD flooring materials have not been developed till date. However out of the specifications available, many are ill-defined or unrelated to ESD flooring, but adapted by the ESD industry while development of specific ESD flooring procedures are being formulated. Because of this, prototype test specifications were developed in cases where none currently exist, or modifications to traditionally accepted approaches of testing made when deemed appropriate. The critical aspect of this study was consistency. All floors were tested using identical test methodology, equipment & personnel.

- Body Voltage Generation
- Surface Resistivity

- Appearance
- Odor
- Resistance to Ground
- Static Decay
- Scuff Resistance
- Wear
- Required Maintenance
- Slip-Resistance

Resistance Ranges of ESD safe Flooring and Selection Criteria

The surface-to-ground resistance range of ESD safe flooring is as mentioned below.

- Conductive: 2.5x104 to 1x106 ohms
- Dissipative: 1x106 to 1x109 ohms
- Non-ESD: Greater than 1X109 ohms

Selection Criteria for ESD safe flooring material

Terms such as conductive and dissipative should be avoided as they mean different things to different people. The exact range of acceptable resistance, test method (including test voltage) and any specific charge decay requirements should be specified by the end user before selection of resin flooring. Where a resistance value is quoted (in Ohms) it should be specified whether this refers to surface resistance (the resistance measured between two electrodes placed on the surface of a material after a given time of electrification) or resistance to ground (the resistance measured between a single electrode placed on the surface of a material and a groundable point). In this case it should be specified whether 'ground' refers to the protective earth of the power distribution system (resistance to earth) or, for example, the steel frame of a building used as a return path for electric currents and as an arbitrary zero reference point. The test voltage must be specified as the measured resistance will depend upon the applied voltage. Different industries have varying requirements and standards vary from country to country. Many industries or organizations have their own internal standards for anti-static flooring. Requirements may relate to the antistatic or conductive nature of the flooring material to be used or to the anti-static characteristics of the finished floor.

Composition of Anti-Static Floor Finish

The application and upholding procedures and equipment for applying, anti-static floor finish is basically the same as for standard floor finishes. Anti-static electro-static discharge control (ESDC) floor finishes, however, have a different chemical structure that requires that special attention be paid to certain details when they are being applied and maintained. To provide static dissipation, anti-static finishes contain a special active ingredient. This active ingredient is not readily compatible with standard floor finish polymer chemistry. Producing a quality ESD finish requires that a finely tuned balance be achieved between having a sufficient concentration of the active ingredient to provide effective ESDC properties, while avoiding an unacceptable level of the side effects inherent when incorporating anti-static compounds into finishes. These side effects can include increased water sensitivity, reduced gloss, extended drying times and slipperiness. The cause of these side effects is the active ingredient's tendency to absorb humidity present in the environment into the finish film. These hydrophilic properties help anti-static floor finishes to dissipate static charges. The consideration is that factors that inhibit regular floor finishes from drying and curing, like cool floor temperatures, high air temperatures coupled with high humidity and heavy coat application, also effect anti-static floor finishes, but to a much greater extent. This means that additional care and time must be taken when applying anti-static floor finishes.

Application Considerations of Anti-Static Floor Finish

In order to achieve effective static dissipative properties, a sufficient amount of active ingredient must be present in the floor finish film. In order to function correctly, both immediately after application and over time, the anti-static active ingredient must effectively bond to the polymer chain. Once a floor finish is applied, film formation occurs in two phases. The first stage involves the evaporation of the water from the finish. Most floor finishes, ESDC and regular, contain between 75% and 84% water, which must leave the finish film before the second curing phase can start. The second stage, sometimes referred to as the glass transition phase, occurs after the water has evaporated and the co-solvents/plasticizers have reached a high enough concentration to initiate cross-linking of the various polymers used to make up the finish. It is during this curing phase that the anti-static ingredient becomes bonded to the polymer chain. During both of these phases there are a number of environmental conditions and application factors that impact both evaporation rates and the curing of the polymer.

Air Circulation-moving air holds more moisture than stagnant air, so although positive air circulation is beneficial under any circumstance it becomes critical in higher humidity conditions.

Floor Temperature-the optimum floor temperatures for effective evaporation and curing of both regular and ESDC finishes is 65-75o F. Floor temperatures at either extreme can have a significant negative impact. At less than 50o F many polymers will never achieve the glass transition phase, never cure and will display adhesion failure, powdering, lack of gloss and streaking and mop marks. At excessively high temperatures, greater than 85o F, floor finishes can flash dry at the interface between the floor and bottom of the finish film and may not adhere properly. Whenever possible, adjustments should be made to the environmental controls to bring floor temperatures a close to optimal as possible. If adjustments can't be made, cooler floor temperatures will require additional drying and curing time.

Humidity-humidity conditions are an important factor in the drying and curing of any finish, but can have a critical impact on the performance of ESDC finishes. The ideal application humidity level for ESDC finishes is 40% relative humidity or lower. 40% relative humidity is also the level at which ESDC finishes provides optimum static dissipative properties. As previously mentioned, the second curing phase of finishes starts when sufficient water has evaporated and the co-solvent/plasticizer levels reach a high enough concentration to initiate cross-linking of the polymers. The chal-

lenge with ESDC finishes is that this is also approximately the point at which the anti-static active ingredient reaches a high enough concentration to start absorbing atmospheric humidity. This creates a conflicting set of chemical reactions which results in ESDC finishes being much more sensitive to humidity levels and drying times than standard floor finishes. At humidity levels higher than 60% ESDC finishes can take an extraordinarily long time to cure, as much as 24 hours per coat, so when possible, it is best to simply avoid applying ESDC finishes under these circumstances.

Drying Times-most standard vinyl composition tile finishes will generally dry and have cured sufficiently to allow additional coats to be applied within 20-60 minutes depending on humidity conditions. Because of their chemistry ESDC finishes take substantially longer. A minimum of 2 and preferably 4 hours drying time should be allowed between coats. Adverse drying conditions will require allowing even longer drying times between coats.

Coat Thickness-due to ESDC finish's particular chemistry they should be applied as thinly as possible. Coverage rates should be approximately 2000 ft2 to 2500 ft2 per gallon. Heavy applications will take longer to dry and cure, and will increase the potential for experiencing short and longer term performance problems.

Conclusion

Anti-static floors are made from materials that do not generate a static charge. In that sense, an ordinary linoleum floor is 'anti-static' under certain conditions, and so is bare concrete as long as the relative humidity in the floor and air are balanced correctly. But there is also a wide range of tile and sheet products specifically marketed as anti-static because they do not contribute to the build-up of static electricity, unlike many normal vinyl and carpet products. They are often used in the picking and packing areas of warehouses and around automated carousels. Although anti-static floors overcome the problem of people building up a static charge as they walk across the floor, they won't actively attract or control a charge before it has a chance to discharge somewhere else. Many industries organizations have their own internal standards for anti-static flooring. Requirements may relate to the antistatic or conductive nature of the flooring material to be used or to the anti-static characteristics of thefinished floor. However specialized care needs to be taken as per the tests and standards mentioned here to any avoid mis-application.

Reference

- http://www.minicircuits.com/app/AN40-005.pdf
- http://www.polyflor.com/jh/web.nsf/page/2292705B896281CC802574AA004C6FA0/$file/ESD%20floorcoverings%20Oct%2011.pdf
- http://www.awp-p.com/media/vloertegels/EC10%20ecotile%20esd%20range%20email.pdf
- http://www.eis-inc.com/Files/pdf/supplier_showcase_page_downloads/3mesd/Flooring_and_Footwear_Systems.pdf
- http://www.esdflooring.com/assets/pdf/AntiStatic_Maintenance_Products_White_Paper.pdf
- http://www.flooringtech.com.au/unit13_esd_floors/docs/esd_floors_learner_guide.pdf
- http://www.nifl.co.uk/pdf/Anti-static%20Flooring.pdf
- http://cds.linear.com/docs/en/quality/esdprotection.pdf
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