EcoTile ESD Presentation & Training Handbook

Index

The ESD Gospel: IEC / BS EN 61340-5-1:2007
WHAT ARE YOU TRYING TO ACHIEVE?

IEC / BS EN 61340-5-1:2007 applies to activities that involve manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handling off electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 V human body model (HBM).

IEC / BS EN 61340-5-1 provides the requirements for an ESD control program. The user should refer to IEC 61340-5-2 for guidance on the implementation of this standard. This standard does not apply to electrically initiated explosive devices, flammable liquids, gases and powders. The purpose of BS EN 61340-5-1 is to provide the administrative and technical requirements for establishing, implementing and maintaining an ESD control program.

- The fundamental ESD control principles that form the basis of this Standard are as follows:
  - Avoid a discharge from any charged, conductive object (personnel and especially automated handling equipment) into the ESDS.
  - Avoid a discharge from any charged ESD sensitive device. Charging can result from direct contact and separation or it can be field induced.
  - Once outside of an electrostatic discharge protected area (hereinafter referred to as an EPA) it is often not possible to control the above items, therefore, ESD protective packaging may be required. ESD protection can be achieved by enclosing ESD sensitive products in static protective materials, although the type of material depends on the situation and destination.

Each company has different processes, and so will require a different blend of ESD prevention measures for an optimum ESD control program. It is vital that these measures are selected, based on technical necessity and carefully documented in an ESD control program plan, so that all concerned can be sure of the program requirements.

The Requirements For An ESD Flooring System

The International standards details the requirements for an ESD floor system: IEC/ BS EN / DIN 61340-5-1 standard Protection *of electronic devices from electrostatic phenomena – General Requirements.*

In order to be able to undertake the measurements in accordance with the standards and the Human Body Model (HMB) the flooring must be tested:

1. For Resistance to ground of the floor by itself - *Rgp of the flooring to earth if floor surface to be used as your primary grounding point*
2. For Resistance to ground of the SYSTEM – i.e. in combination with the person, shoes and flooring - Rg_{system} *of the system "person/shoes/flooring" against protective earth or function earth*
3. For Surface Resistance of the floor surface
4. To measure the level of charge generated whilst walking on the floor - *Walking test – Measurement of the body voltage U*

The Requirements For An ESD Flooring System

The sections Specific to Flooring & More Importantly the combination of the Individual, Footwear & Flooring are detailed within:

- **IEC / BS EN 61340-4-1 ed2.0 -** Electrostatics - Part 4-1: Standard test methods for specific applications - Electrical resistance of floor coverings and installed floors (New Version expected 04/2015)
- **IEC / BS EN 61340-4-5 ed1.0 -** Electrostatics - Part 4-5: Standard test methods for specific applications - Methods for characterizing the electrostatic protection of footwear and flooring in combination with a person

These standards can also be cross referenced with*:* IEC 60364, IEC/TS 60479-1, IEC/TS 60479-2,IEC 60749-26, IEC 61010-1, IEC 61140, IEC 61340-2-3, IEC 61340-4-1, IEC 61340-4-3, IEC 61340-4-5, IEC/TR 61340-5-2, ANSI/ESD S1.1,ANSI/ESD STM2.1, ANSI/ESD STM3.1,ANSI/ESD STM11.31, CENELEC HD 384,CENELEC HD 60364, EN 60749-26:2006, EN 61010-1:2001, EN 61010-1:2001/Corrigendum:2002, EN 61140:2002, EN 61340-2-3:2000, EN 61340-4-1:2004, EN 61340-4-3:2001, EN 61340-4-5:2004, IEC 60749-27,IEC 61340-1-2, EN 60749-27:2006

The Requirements For An ESD Flooring System

The Floor Only	**Limit according to IEC/BS/DIN EN 61340-5-1**	**Norm**	**Comment**
Resistance to ground Rgp of the flooring to earth if floor surface to be used as your primary grounding point Or If used as a secondary ground (i.e. in combination with wrist straps etc.)	**Product Limits** Rgp <$1x10^{7}\Omega$ Rgp <$1x10^{9}\Omega$ (corresponds <1GΩ)	IEC/BS/DIN EN 61340-4-1 (2004-12)	Conditioning and test climate have to be agreed between the contract parties. If not agreed or specified differently, the following is valid according to the norm IEC / BS/ DIN EN 61340-5-1 (2008-07) <u>Temperature:</u> 23 ± 2 °C / <u>Relative Humidity:</u>12 ± 3 %
The System – The Person, Footwear & Floor In Combination			
Resistance to ground Rg_{system} of the system “person/shoes/flooring” against protective earth or function earth Walking test – Measurement of the body voltage U	**Product Limits** Rg_{system} <$3.5 \times 10^{7}\Omega$ (corresponds < 35MΩ) **OR** Rg_{system} <$1 X 10^{9}\Omega$ (corresponds<1 GΩ) **<u>And</u>** Body voltage<100 Volt (mean value of the 5 highest readings)	IEC/BS/DIN EN 61340-4-5 (2005-03)	Conditioning and test climate have to be agreed between the contract parties. If not agreed or specified differently, the following is valid according to the norm DIN EN 61340-4-5: <u>Temperature:</u> 23 ± 2 °C <u>Relative humidity:</u> 12 ± 3 %

WHAT SHOULD I HAVE - STATIC DISSIPATIVE OR STATIC CONDUCTIVE FLOORING?

The answer is something that overlaps both dissipative & conductive with the ideal range being between 5 x 10 E4 and 3.5 x E7

Resistance To Low - Minimum Resistance should be 25000ohms tested at 500V / We recommend 50000ohms at 100V

Target Zone for a safe and compliant ESD Floor - See BELOW for Specific Application Guidance

*** Resistance to Low - See Note 2 Below**

Recommended Zone for Areas with High Voltage / Energized Equipment (i.e. Server Rooms / Data Centres / Flight Control Centres etc.) Target Zone - 1.0 x 10 E6 to 3.5 x 10 E7 - Protection from Lower Resistance should be provided by using footwear with a resistance no lower that 10 x E6)

Recommended Zone for Manufacturing Facilities - Target Zone - 5 x 10 E4 to 1 x 10 E6 - Protection of devices susceptible to static damage by lower resistance / Safety achieved by 1 MegΩ Resistor in grounding cord)

*** Resistance to High - See Note 1 Below**

Resistance to High - Maximum Level of Resistance = 35 million ohm

Conductive Range				Static Dissipative Range					
1k (10 x E3)	< 10k Resistance (10 x E4)	50K (5 x 10 x E4)	100k (10 x E5)	1 million (1 megΩ/ 10 x E6)	10 million (10 x E7)	35 Million (3.5 x E7)	>35 millions Ohms (3.51 x E7)	100 million (10 x E8)	1 Billion (10 x E9)

Note 1. **For Manufacturing Facilities, areas where Electronic Components & Handled & DOD Explosive Handling Requirements:** Most experts believe that floors measuring below 10 million ohms (1.0 X 10 E7) offer the best static-control performance for electronic manufacturing and handling. Floors measuring above 10 million ohms drain static more slowly (circa 20 x slower) than floors measuring in the conductive or lower end of the static-dissipative range (< 1.0 X 10 E7).

Note 2. **Non Manufacturing Facilities with High Voltage / Energised Equipment**: In the event of an electrical short circuit individuals could be exposed to high electrical currents if the floor has a surface resistance of below 1.0 x 10 E6 **AND** they are either not wearing ESD footwear with a built in resistance greater than 1.0 x 10 E6 **OR** they are wearing non ESD footwear that has low surface resistance. This is an unlikely event **BUT,** for example, if an individual is wearing leather soled shows and the floor is wet their is a potential risk. At 10,000 (10 E4) 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 E6) Ohms, people would experience 1/100th of this current.

Static Dissipative & Static Conductive Flooring Comparison Chart	Static Dissipative	Static Conductive
What flooring should I use for what application?	**1 x 10 E6 to 1 x 10 E9**	**2.5 x 10 E4 to 1 x 10 E6**
Meets Standard for use as **Primary Ground** in Electronics Manufacturing & Handling Facilities according to BS EN 61340-5-1 / ANSI20:20 / IEC BS EN 61340-5-1	**NO**	**YES**
Meets Standard for use as **Secondary Ground** in Electronics Manufacturing & Handling Facilities according to BS EN 61340-5-1 / ANSI20:20 / IEC BS EN 61340-5-1	**YES**	**YES**
Meets Motorola R56 / ATIS-0600321 / FAA STD 019e for Calls Centres, Telecommunication Facilities, Flight Control Centres etc.	**YES**	**YES**
Meets NFPA 99 for Healthcare Installations	**YES**	**NO**
Meets IBM recommendations for Data Centres	**YES**	**NO**
Lifetime Static Control Properties	**YES**	**YES**
Meets DOD Explosives Handling Requirements	**NO**	**YES**

HOW SHOULD YOU TEST YOUR FLOOR & THE SYSTEM.

- **Surface Resistance** – Using the appropriate test equipment test the floor across two or more tiles and take a minimum of 9 readings across random points. Calculate the average reading from your tests to get an accurate surface resistance reading.

- Measuring the resistance between two points on the tiles = Surface Resistance.
- In this example the surface resistance is 0.59megΩ = 5.9 x 10 E5

☒ **Wrong test method** – Do not use prong contacts to test the floor, insufficient surface contact.

☑ **Correct Test Method** – Use weights or suitable test plate to ensure good surface contact.

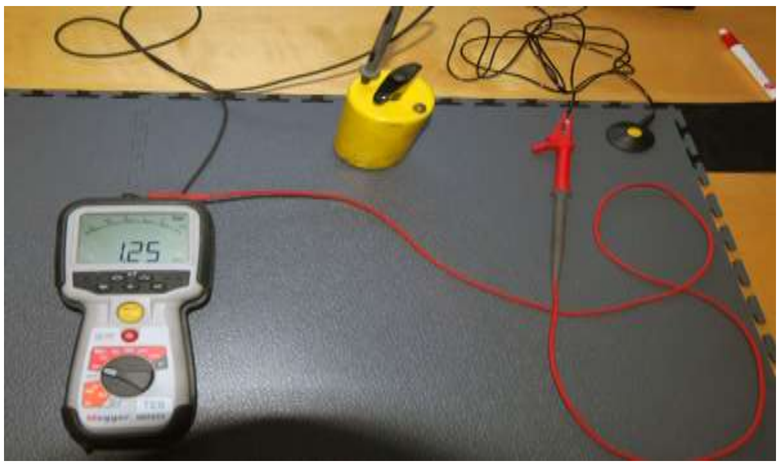
HOW SHOULD YOU TEST YOUR FLOOR & THE SYSTEM.

- **Resistance to Ground of the FLOOR**– To measure the resistance to ground of the floor tiles in isolation test from the tile to either the grounding stud or the grounding tape (not via the grounding cord because the cord includes a 1 megΩ resistor). To test the resistance to ground of the entire floor system test place one probe on the floor and connect the other connection to the end of the grounding cord.

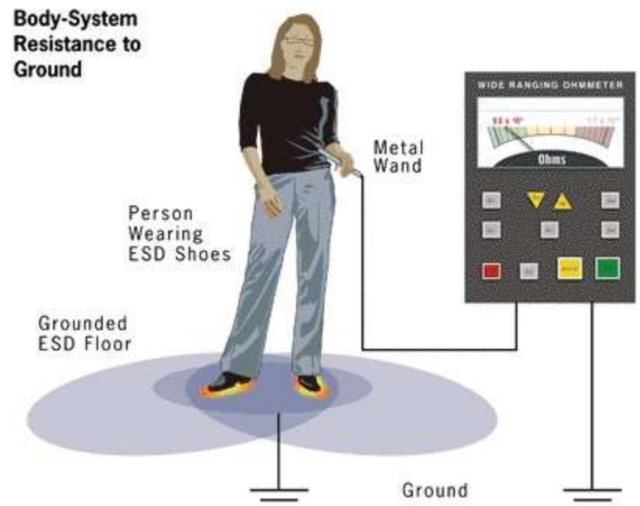
☑ Correct Test Method 1 - Test from the floor first to your grounding point to test the resistance to ground of the floor – **Target Resistance to be less than 1 x 10 E6. i.e. Suitable for use within an EPA zone / electronics manufacturing facility**

HOW SHOULD YOU TEST YOUR FLOOR & THE SYSTEM.

- **Resistance to Ground of the SYSTEM**– To measure the resistance to ground of the system (the combination of the person, footwear and floor) hold one probe in the palm of your hand, connect the other probe to your grounding point and test. The results should be from 1×10^6 or 1 MegΩ and not exceed 3.5×10^7 or 35MegΩ.



Test the resistance via the grounding cord with the 1megΩ

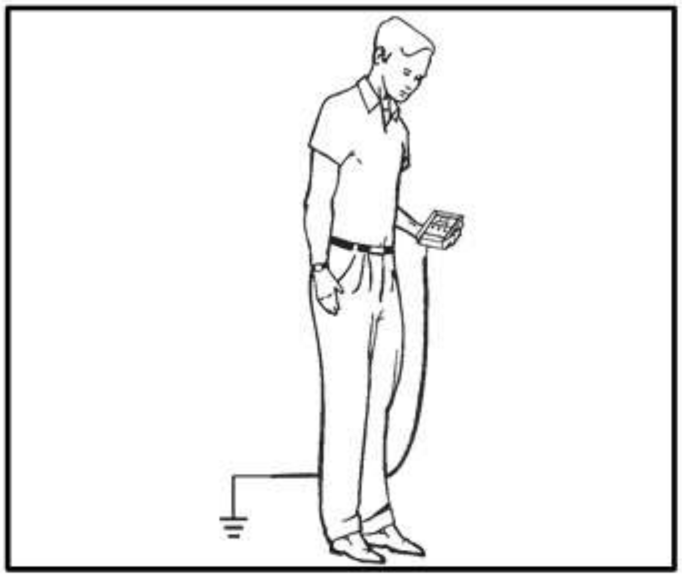


Test the resistance of the system, the individual, the footwear and the floor.

☑ Correct Test Method 2 - Test from the floor next to your grounding point to test the resistance to ground of the floor via the grounding cord with the 1megΩ resistor – **Target Resistance to be between 1 x 10 E6 and 3.5 x 10 x E7. i.e. The safety zone in the event of an electrical short circuit.**

HOW SHOULD YOU TEST YOUR FLOOR & THE SYSTEM.

- **Walking Test / Human Body Model –** Test for tribo-electric charging, to see the approximate body voltage electrical charges generated on the human body while walking or moving across floor use a static field meter whilst wearing the appropriate footwear & test what body voltage is created. The voltage should not exceed 100V



Using the Personal HBM Test Fixture to measure charges on the body

- Cradle the field meter in the palm of your hand. Once the Meter is grounded and you are standing on the floor to be tested, walk around, shuffle your feet, raise a foot or use the random walking pattern to determine if the combination of footwear and substrate produces an electrical charge. If an electrical charge is generated and induced onto the human body, the amount of the charge will be registered on the meter.
- This test can be done regardless of the type of footwear or substrate combination.
- Target – The individual should not generate a charge in excess of 100V

•The amount (or size) of the charge generated will vary from one human body to another. Other factors such as humidity, contamination between the foot and flooring surface, as well as human body capacitance will also affect the amount of charge generated.

Interpreting your Test Results - **Scientific Notation**

How to interpret your reading

Example:

0.429mΩ = 4.29 x 10^{5} - Explanation: 0.429 is between 0.1 and 1 is in the range for 10^{5} and the 0.429 represents where in the range it is located
5.9Meg = 5900kΩ = 5.9 x 10^{6} - Explanation: 5.9 between 1 and 10 is in the range for 10^{6} and the 5.9 represents where in the range it is located

Ohms (Ω)	Notation / Integer	KΩ	MΩ	GΩ	Description	Guidelines
100	10^{2}	0.1	0.0001		= CONDUCTIVE	but below recommended safety guidelines, resistance above 10^{4} recommended
1000	10^{3}	1	0.001			
10000	10^{4}	10	0.01		= CONDUCTIVE	Range for an ESD floor if it is to be used as a primary ground
100000	10^{5}	100	0.1			
1000000	10^{6}	1000	1	0.001Gig		
10000000	10^{7}	10000	10	0.01Gig	= DISSIPATIVE	Range for an ESD floor if it is to be used in addition to a secondary ground (i.e. Bench top mats and wrist straps)
100000000	10^{8}	100000	100	0.1 Gig		
1000000000	10^{9}	1000000	1000	I Gig	10^{9} to 10^{11} = Anti-static	

SUMMARY

There are multiple factors that can impact on the results that you will get, humidity, temperature, cleaning methods, dust and dirt on the floor, how well hydrated the individual undertaking the test is!!! To achieve both a floor that is safe for the manufacture of components that are susceptible to damage from electro-static discharge and that is also safe for the individual to work on you MUST view the system as an entirety:

- **The floor should have a resistance ideally between 5 x 10^4 or 50,000Ω and not exceed 1 x 10^6 or 1MegΩ. This allows a margin for error in the event of low humidity or dirt build up on the floor. This will ensure that individual working on the floor will safely discharge any electrical charge that they may build up whilst working within the area covered by your ESD floor.**
- **The floor should be grounded using a grounding cord with a 1Meg, in the event of an electrical short circuit the resistor will blow and the route to ground will be cut ensuring the safety of the individual**
- **The floor must be viewed as part of an ESD system, the floor, the footwear and the individual have to be tested in conjunction with the objective that the overall resistance of the system does not exceed 3.5 x 10^7 or 35MegΩ.**

Remember that an ESD floor will only work if used in conjunction with ESD shoes or ESD heel straps, without the appropriate footwear the floor will ensure that the individual will not generate more than 100V whilst working on the floor but it will not discharge any electrical charge that the individual has built up via other activities (i.e. handling packaging materials, walking across carpet etc.)

A Brief Explanation Of What ESD Is And The Effects It Can Have On Your Industry

What is Electrostatic discharge (ESD)

Electrostatic discharge is the sudden flow of electricity between two electrically charged objects caused by contact, an electrical short, or dielectric breakdown. A build-up of static electricity can be caused by tribocharging or by electrostatic induction. The ESD occurs when differently-charged objects are brought close together or when the dielectric between them breaks down.

ESD can cause a range of harmful effects of importance in industry, including gas, fuel vapour and coal dust explosions, as well as failure of solid state electronics components such as integrated circuits. These can suffer permanent damage when subjected to high voltages. Electronics manufacturers therefore establish electrostatic protective areas free of static, using measures to prevent charging, such as avoiding highly charging materials and measures to remove static such as grounding human workers, providing antistatic devices, and controlling humidity.

What Causes Static Electricity? - Static Electricity is caused by friction between and separation of two materials. This phenomenon is also called **Triboelectric Charging**

Definitions

- **Insulator:** A material with high resistance (> 10^{12} Ohm)
- **Electrostatic Conductor:** A material with low resistance (< 10^6 Ohm)
- **Static Dissipative:** A material with an electrical resistance between the electrostatic conductive and anti-static range (10^6 Ohm < dissipative > 10^9 Ohm)
- **Antistatic / Low Tribocharging:** Material that minimizes the generation of electrostatic charge range (10^9 Ohm <anti-static> 10^{11} Ohm)

Examples of Levels of static discharge?

- Approx. 3 000 V - You Can Feel It
- Approx. 5 000 V - You Can Hear It
- Approx. 10 000 V - You Can See It
- Electronic devices can be damaged by static discharge of **100 V** or less

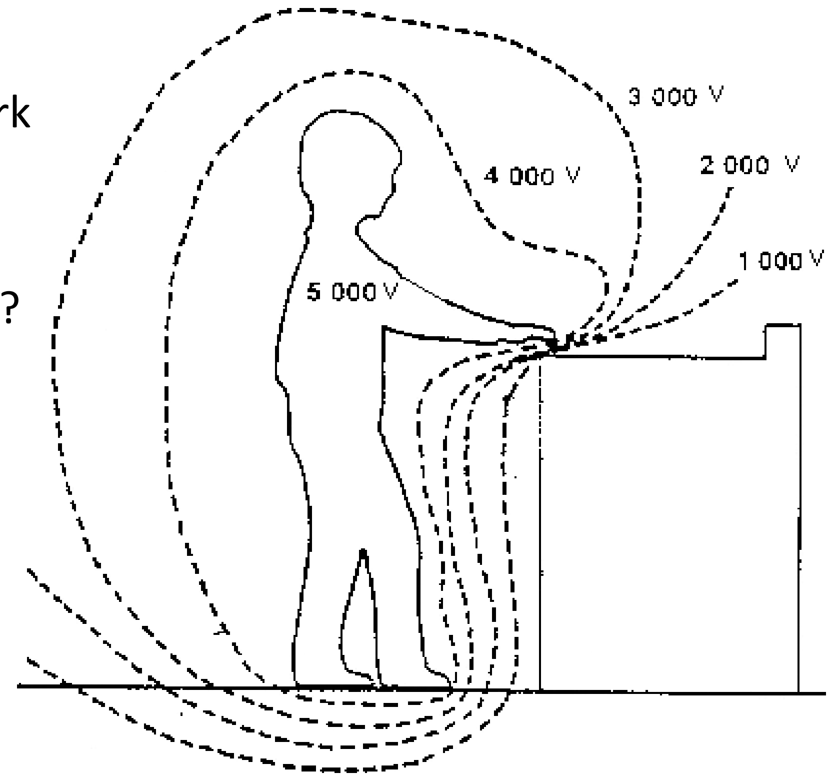
***Some Examples Of Electrostatic Charging (*Values are subject to humidity levels & temperature)**

- Working Behind A Desk (Approx. 2,000v)
- Walking On A Vinyl Floor (Approx. 8,000v)
- Walking On A Carpet (Approx. 20,000v)

What Are The Main Generators Of Static ?

The Primary Cause of Static is People

- Walking across Floor Surfaces
- Moving and creating Friction between their Chairs Work Benches
- Handling Packaging Materials?
- Handling & Contact With Containers, Tools, Machinery?



Example Of An Electrostatic Field Around A Charged Person

How Can Static Discharge Damage Components?

- By direct contact, handling, assembling or moving static sensitive components
- By Electrostatic Induction between an individual and a component

Why Should I Be Concerned about ESD / Static Discharge?

ESD precautions are often treated with cynicism but without doubt with ESD it is a fact that even when it doesn't seem to affect anything, every small discharge *does* cause *some* damage, whether it's pitting of the silicon, vaporizing a little bit of the bonding wire, removing some of the metalisation on one of the semiconductor layers, or some other effect, it will physically alter the product. ESD damage cannot be detected without removing the silicon from the package and inspecting it, or, in cases where the damage is hidden in-between layers, by slicing the silicon into very thin sheets where the damage is likely to have occurred.

In most cases, most uses of a given part won't be measurably altered by the change. Most people over engineer their designs so they aren't using them anywhere near their limit, so there's a huge margin where a pitted part will work just fine. However over time repeated use of the component or subsequent discharges will potentially change the part enough that it will behave slightly out of spec. If you are fortunate the one small discharge will cause enough damage that when you do use it or test it to full capacity, it will fail prior to shipping or installing the component. If the damage / failure happens once you've deployed it in the field the cost of repair / replacement is increased significantly or subject to the components use / application the risk could be more than just cost!

Taking appropriate ESD precautions will:

- **Save You Money by reducing your failure rates / Warranty Claims etc.**
- **Show that you are an Ethical & Responsible Manufacturer**
- **Win you Orders & Help Retain Customers**

Problems That Can Be Caused By Static Electricity

- Machinery Breakdown
- Explosions & Fires
- Staff Discomfort / Irritation From Static Shocks
- Contamination On Products - Contamination Arises Because Electrostatically Charged Products Do Attract Dust And Micro-organisms
- **Damage to Electrostatic Sensitive Devices** !!!!!

Damage That Can Be Caused By ESD

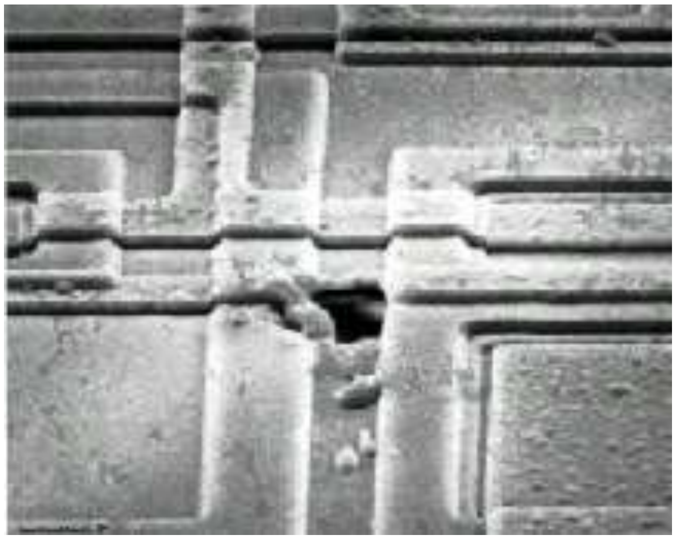
- **CATASTROPHIC DEFECT** – Product / Component Failure At Point Of Manufacture - Not All Catastrophic Defects Can Be Detected Prior To Shipping

Or Potentially Of Greater Risk and Expense

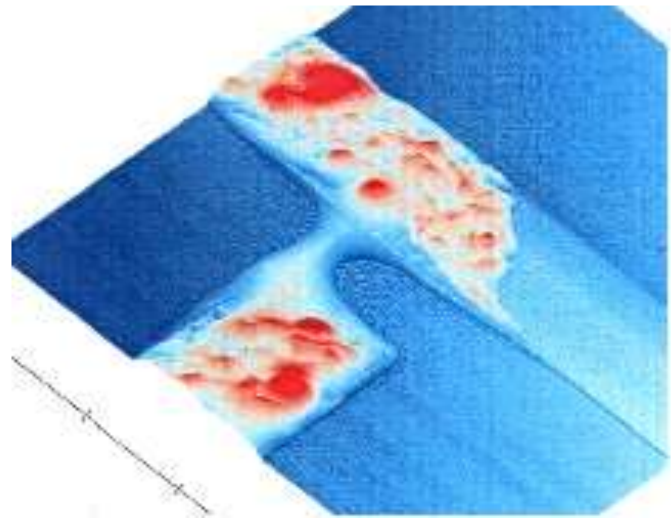
- **LATENT DEFECTS** - Latent defects such as reduced operational lifespan, product failure etc. Latent defects can occur arbitrarily at any time, in many cases latent defects are not identified as ESD damage: for example the device is damaged by ESD during manufacture but works when tested but the life span of the product is reduced dramatically.

Damage caused by ESD Events

- Damage due to electrostatic discharge is one of the most common causes of failures, malfunctioning or degradation of micro- electronic devices
- 50% - 60% of electronic defects are caused by an ESD event



Catastrophic Defect



Latent Defect

Latent defects are almost impossible to spot and usually far more expensive to rectify.

The Consequences Of ESD Failures

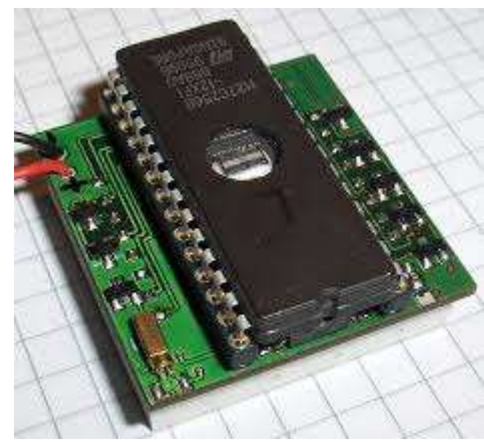
- Higher (Direct) Failure Rate
- Interruption Of Production
- Compromised Product Quality
- Higher Service Costs
- Dissatisfied Customers

The Cost of ESD Failures!

- **Damage to Component During Production:** Replacement Cost = Factor 1
- **Damage to Component In The Field (latent Defect):**
- Replacement Costs = Increase With A Factor Of 10 Per Process Level; E.G:
- Factor 10 - Replacement Of Component On Component In House
- Factor 100 - Replacement Of Component On Customer's Site
- Factor 100,000 - Replacement Of A Satellite In Space

Examples of ESD sensitivity of Typical Electronic components

- VMOS 30-1 800v
- MOSFET 100-20v
- GaAsFET 100-300v
- EPROM 100v
- JFET 140-7000v
- OP-AMP 190-500v
- CMOS 250-3000v
- SCR 680-1000v
- ECL 500v
- Schottky TTL 1000-2500v



What Are The Main Generators Of Static ?

The Primary Cause of Static is People! When they walking across the floor, move an object, shuffle on their seat, use equipment etc. they will potentially generate static.

How Can You Prevent Esd Damage?

- Minimise the generation of static electricity in areas where sensitive devices are handled - For example: do not establish an EPA close to a conveyer belt or other electrostatic generating activities
- If charge generation can not be avoided, ensure a defined path to ground is in place allowing electrostatic charge to be drained in a controlled manner.
- Make sure that materials which acquire charges are not placed close to sensitive devices - Stay away from a monitor screen and do not move your devices close to a keyboard

How do you Prevent Your People from Creating A Static Risk?

- Primary Grounding Via A Suitable **CONDUCTIV**E Floor Surface Combined With Heel Grounders / ESD Footwear And ESD Protective Garments

Or

- Secondary Grounding Via A Dissipative Floor Surface **AND** Heel Grounders / ESD Footwear, ESD Protective Garments, Wrist Straps And Bench Top Matting Connected To A Suitable Ground Point.

Setting Up An ESD Control System

- The level of ESD protection depends on the most sensitive parts used in the production process. Check the sensitivity of the components from the parts' lists and define the maximum electrical charge allowed to be generated in the EPA
- Define the boundaries of the ESD protected Area (EPA= ESD Protected Area)
- Develop an ESD Control programme
- Carry out ESD audits regularly
- Prevent contamination from plastic cups, rubbish sacks, packing tape etc. in the EPA

What are the Key Components of an ESD Control System

- Flooring (ESD protective flooring)
- Workbenches (frames and table tops)
- Chairs
- Shelves and trolleys
- EPA - boundary tape, signs
- Desk accessories (document holders/bins, ring binders, waste bins, etc.)
- Ionisation equipment

ESD – The International Industry Standards

- The **International Electrotechnical Commission**(IEC) is the world's leading organization that prepares and publishes International Standards for all electrical, electronic and related technologies.
- The IEC 61340-5-1:2007 standard Protection *of electronic devices from electrostatic phenomena – General Requirements* was developed from earlier Standards including EN100015 and ESD S20:20. It is accompanied by a User Guide IEC61340-5-2, which gives a lot of additional information to help the non-specialist implement 61340-5-1. As a IEC documents, they have world-wide applicability in IEC member countries where they have been adopted. An unofficial harmonisation with ESD S20:20:2007 has occurred, and so the requirements current versions of 61340-5-1 and 20:20 are nearly the same.
- In Europe, the 61340-5-1&2 documents have been adopted by **CENELEC** (European Committee for Electrotechnical Standardization) to replace EN 61340-5-1:2001. The 61340-5-1 *General Requirements* document contains ***requirements*** for compliance which are considered mandatory, while the contents of 61340-5-2 *User Guide* only has the status of guidance or recommendations.
- Each individual countries Standards authority has replicated the standards laid down in IEC 61340 and are listed as
- British Standard / European Norm - **BS EN 61340-5-1:2007 / BS EN 61340-5-2,** German Standard - DIN **61340-5-1:2007 / BS EN 61340-5-2: Edition 2** for example.

Myths Regarding ESD & The Protection of Static Sensitive Devices

- “Touching a grounded object gives enough ESD -protection” - *When you touch a grounded conductive object you will be discharged but electrostatic charging is an ongoing / continuous process*
- “When a component is assembled on a PCB, nothing can happen” - *Partly true: components on a PCB are less sensitive but they can still be damaged by direct ESD or induction fields.*
- “Only some PCB’s should be handled with care” - *Some PCB’s may be, but how do you know which ones? There are usually a large number of different components on a PCB with different levels of sensitivity.*
- “Components can only be damaged by direct contact” – *Not true, Induction can cause ESD damages without the need for physical contact*
- “PCB’s not handled with care during the production process, but tested successfully are ok” – *Not True, it is impossible to test for most latent defects.*
- Low Tribocharging / Antistatic flooring / bags / bench top matting will give all the ESD protection I need – Not True anti-static surfaces do not protect the components from induction (No Faraday – cage) and will not conduct or discharge any static build up already present in the individual.
- ESD is not a problem in an environment with a high relative humidity - In a high relative humidity, some charge will be drained via the surface but not a sufficient charge and not usually fast enough. Secondly, humidity in the air varies per day while most buildings are conditioned at lower relative humidity due to risk of corrosion and contamination to components.

20 YEARS

ecotile

SOLVING YOUR FLOORING PROBLEMS