

A woman with curly brown hair and glasses, wearing a white lab coat, stands in a technical facility. She has a yellow ESD (Electrostatic Discharge) warning patch on her left chest. In the foreground, there are several green printed circuit boards (PCBs) mounted on a rack. The background shows industrial shelving and equipment.

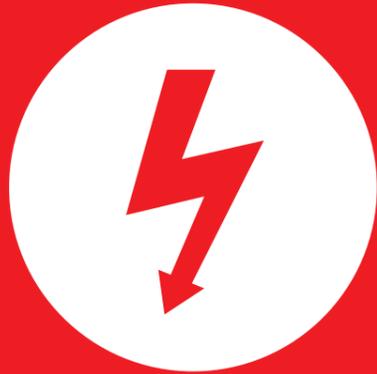
## **ESD-PROTECTION**

in technical and industrial  
workplaces

## **6-POINT CHECKLIST**

for creating and maintaining  
ESD-protected areas

**TRESTON**



**“ESD damage is typically non-visible and may even pass final product testing. However, if it occurs, it could still affect the reliability and operational life of the product.”**

## 1. INTRODUCTION



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You're running a marathon for which you have trained for quite some time. You have run 25 km when your heart rate monitor, which is just a few months old, stops working. You're very distressed but decide to continue, though it's difficult as you're so used to relying on your monitor to tell you how to run. Something similar might happen in the middle of heart surgery and then it becomes a matter of life and death. The reason for incidents like this could be ESD damage that wasn't detected during production of the heart rate monitor or heart surgery equipment.

Electrostatic discharge, commonly known as ESD, is an acronym that you cannot avoid when you work in the electronics industry. However, in today's world, sensitive electronic components are being handled in many other working environments

such as machine workshops, machine repair and lighting. Therefore, ESD protection should be taken into account to avoid potential ESD damage.

ESD damage is typically non-visible and may even pass final product testing. However, if it occurs, it could still affect the reliability and operational life of the product, which will cost both the customer and the manufacturer. But the good news is that it is not difficult to create an ESD-protected area (EPA) in your own workplace. It is actually easy and straightforward to set up. In this paper you will find a simple checklist of what to do to get ESD protection up and running in your own facility. Whether you only occasionally require ESD protection or you require a full-scale production line, this paper provides you with the information you need on how to get started.

## 2. ESD AND HOW IT AFFECTS COMPANIES

### ESD in a nutshell

We all have felt it, electrostatic discharge (= ESD) and have received, for example, an electric shock after walking on a carpet and then touching something. Actually, while we are moving and working, we continuously generate static electricity, which cannot be avoided. We are electrically charged virtually all the time.

If we touch a conductive object while being electrically charged, the charge will be discharged into the object, creating an "electric shock". As a matter of fact, ESD is a sudden discharge of static electricity and occurs when two conductive objects with opposite (+/-) charges get close to each other. If this electric charge is discharged

into components, component boards or device connectors, it often results in ESD damage.

In many cases, such ESD damage occurs without us noticing it, because humans do not sense discharges weaker than 3 000 volts; a discharge must be at least 5 000 volts to be discernible as a spark. The most sensitive components, however, can be damaged at voltages as low as 30 volts, hard drive pickup heads at less than 5 volts only, which is very little. Many commonly used components are susceptible to voltages of 100–200 volts. Hence, you can work on components without having any idea whether or not they have been damaged during the production process.

**“While we are moving and working, we continuously generate static electricity, which cannot be avoided. We are electrically charged virtually all the time.”**

### NOTICING THE ELECTROSTATIC DISCHARGE

Feeling the electrostatic discharge	3 500 V
Hearing the electrostatic discharge	4 500 V
Seeing the electrostatic discharge	5 000 V

Commonly used components can be damaged by 100-200 volts and the most sophisticated ones by as little as 5-10 volts.



### DEFECT SENSIBILITY OF COMPONENTS ON A CIRCUIT BOARD

<b>RF components</b> <small>(Radio Frequency components)</small>	< 50 V
<b>Resistor</b>	1 000 - 5 000 V
<b>Linear MOS</b> <small>(Linear metal-oxide-semiconductor)</small>	800 - 4 000 V
<b>CMOS</b> <small>(Complementary metal-oxide-semiconductor)</small>	1 000 - 5 000 V
<b>MOS VLSI</b> <small>(Metal-oxide-semiconductor Very large scale integration)</small>	400 - 3 000 V
<b>MOSFET</b> <small>(Metal-oxide semiconductor field-effect transistor)</small>	100 - 300 V

All of the above electronic components are commonly used in electronic devices and technical products.

Read more e.g.: [https://en.wikipedia.org/wiki/Electronic\\_component](https://en.wikipedia.org/wiki/Electronic_component)

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**“You can work on components without having any idea whether or not they have been damaged during the production process.”**

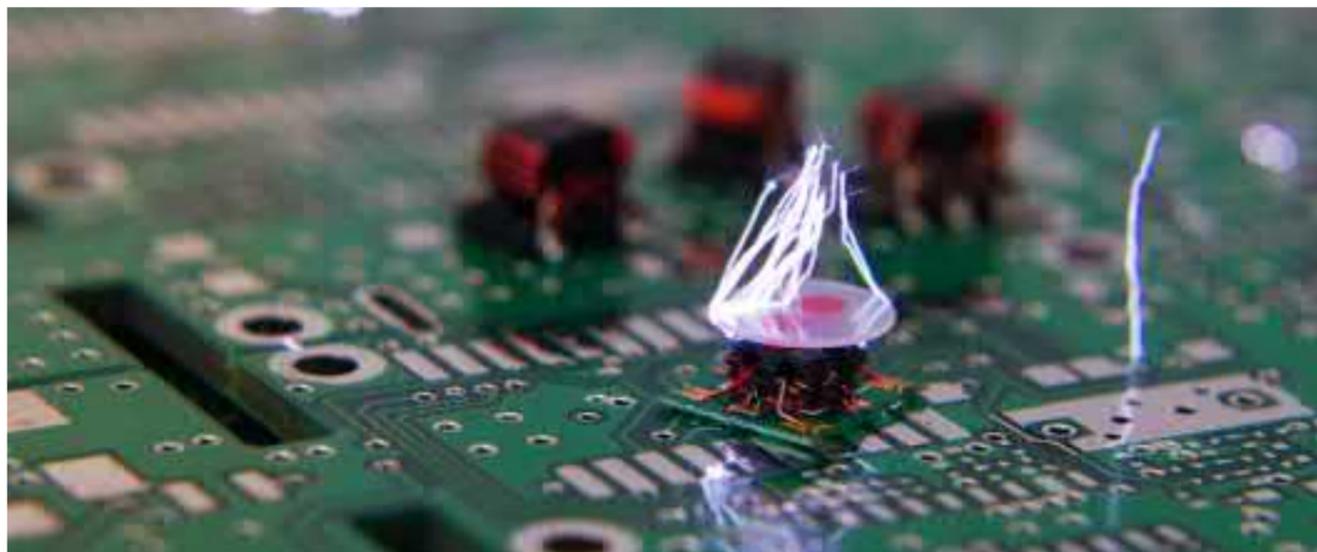
## Two types of ESD defects that cost money and weaken product quality

In industrial and technical environments there are two types of ESD defect. The first is fatal failure that can usually be detected easily as early as during the assembly or handling phase, or at the latest, during the testing phase if it is conducted properly. Such products usually won't be shipped to the customer.

The other type of ESD defect is latent defect. This is difficult to detect as the product might pass all the tests and function normally for a while. But latent defects still impact the functionality and

durability of the product and might even be one of the reasons for products of inferior quality. As explained above, problems caused by static electricity often remain hidden and cannot be detected by the naked eye. Within the electronics industry,

ESD has been found to be one of the factors that reduce product reliability<sup>(1)</sup>. Faulty products only become apparent over time. Maintaining an unbroken protective ESD chain is essential to product quality.



### CHARGES GENERATED ON DAILY WORK ACTIVITIES

Walking across a carpet	1 500 – 35 000 volts
Walking over vinyl floor	250 – 12 000 volts
Working at a bench	700 – 6 000 volts
Picking up a plastic bag from bench	1 200 – 20 000 volts
Chair with polyurethane foam	400 - 3 000 volts

The lower the relative humidity the higher the voltage. The lowest values in the table usually apply when the relative humidity is 65-90%. During a cold winter day, the relative humidity in indoor spaces can be as low as 10 %.

Source: Cisco: ESD Training program<sup>(2)</sup>.



### An ESD-protected area is worth the investment

An ESD-protected area can be anything from a workstation to a full-scale production line. But in the ESD area, no matter how large it is, the same principles apply to ensure it functions as it should. If the workstation and workstation user are grounded properly, there is no ESD risk. If a workstation has no ESD protection and the person using the workstation is not grounded, the electrical charge will be high and any type of ESD damage can and most often will happen. ESD protection is like a cold chain. To keep components ESD safe, it is necessary to ensure that the component chain from component factory to product line is ESD safe. There should be no "leakage" in the chain that could lead to

ESD damage, which would render the product useless in the future. To achieve a reliable level of ESD protection, the workstation itself must be measured on site. Acceptable measurement values, together with instructions on how to measure, are defined in the ESD standard

EN 61340-5-1 (or ANSI S20.20 or similar) and its appendices<sup>(3)</sup>. This is a good document to start with when creating your own ESD control plan.

In today's world, components are constantly getting smaller and smaller, which makes them more sensitive to ESD-type damage. Electronic components are used in many products and it is important to ensure that ESD protection is in place for any type of industrial or technical workplace that handles electrical products and components. This also applies to healthcare and clean rooms in which ESD protection can also form part of contamination control. ESD standardisation is actually in progress in the healthcare sector (March 2018).

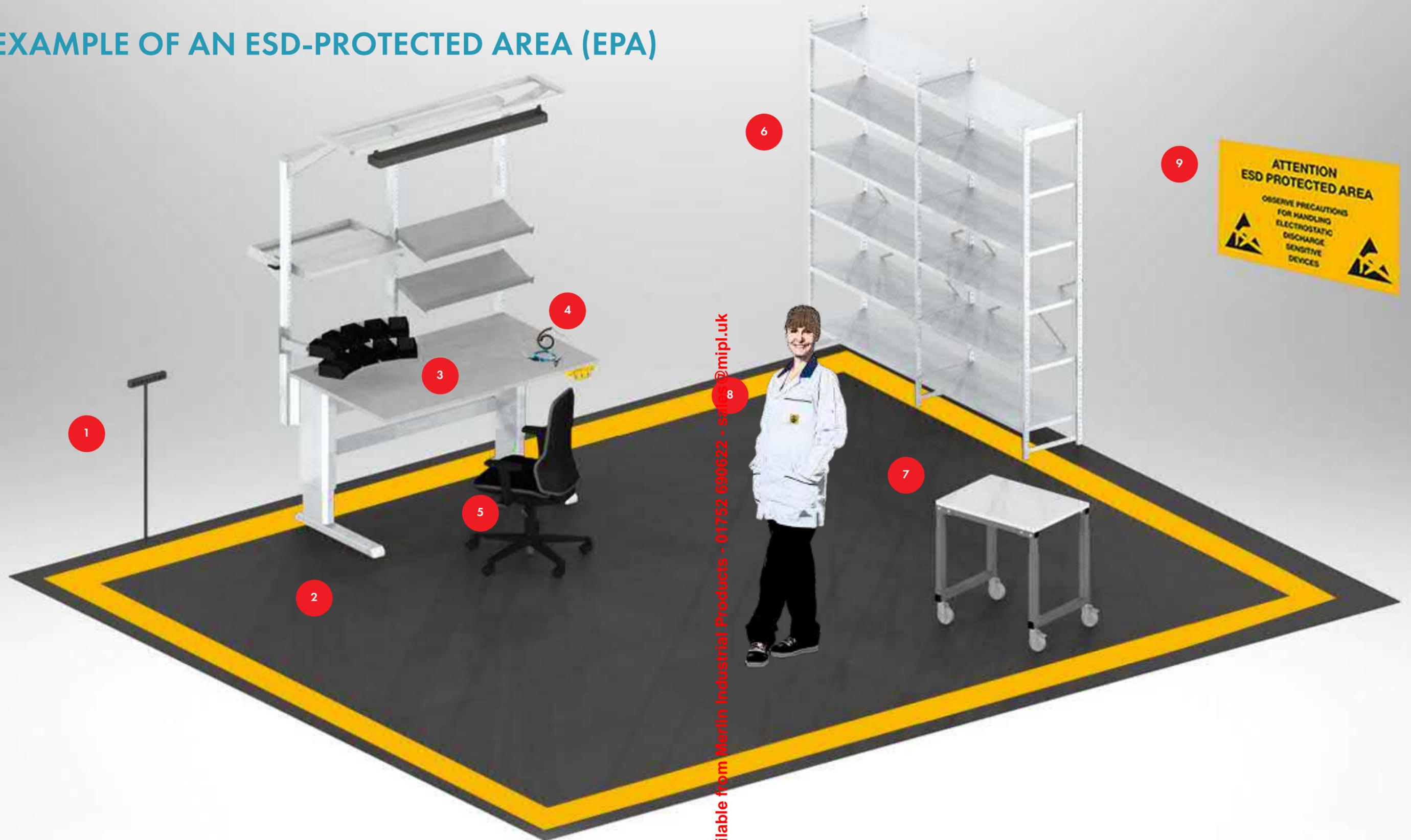
The advantages of ESD protection are numerous. It has been calculated that investing in ESD control can lead to an ROI of 10:1 or occasionally even 1000:1<sup>(4)</sup>. Besides cost savings, it maintains a positive customer perception and brand image<sup>(5)</sup>. Hence, it is important to check that ESD protection is in place.

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**"It has been calculated that investing in ESD control can lead to an ROI of 10:1 or occasionally even 1000:1"**

## EXAMPLE OF AN ESD-PROTECTED AREA (EPA)



**“ It is important to ensure that ESD protection is in place for any type of industrial or technical workplace that handles electrical products and components.”**

# CONTROL PLAN

*Includes e.g. component/product sensitivity levels, ESD protection level, daily routines and maintenance procedures.*

## CONTROL PLAN

The purpose of an ESD control plan is to define how to protect valuable and sensitive components and parts from ESD failure and, for example, set own limits for ESD levels as well as the ESD level-testing schedule. An ESD control plan is the starting point for ESD protection in a facility and is also a requirement of the IEC 61340-5-1 standard.



An ESD control plan does not require a myriad of details and be very lengthy – just a few pages listing key points and your own requirements for ESD protection. In any case, it is important to have an ESD control plan, communicate it to all relevant personnel and then apply it to daily work procedures. Preparing the plan in paper is a start but it has to be implemented in order for it to work and for you to benefit from it.

To create an effective control plan, it is vital to understand what you're trying to protect and that you familiarise yourself with the IEC 61340-5-1 standard. When you are aware of these you can set the ESD protection levels based on the standard or you can set the level above or below the standard based on the sensitivity of the components and your own needs. You can set the desired levels for permissible voltage potentials, resistance levels, protective clothing, etc.

An ESD control plan usually also includes information regarding the selected grounding system and grounding method. It describes how to identify an ESD-protected area and ESD items such as workbenches and trolleys. It is also a good idea to have a written plan on how to handle

components while they are being stored, moved and packed within your work environment. Finally, the most important thing is to properly train your employees and notify them about the ESD plan and how it is being implemented in your workplace. Everyone needs to know why it exists, what it includes and what they need to do when entering an ESD-protected area (EPA). Everyone needs to understand the importance of ESD protection with regard to product quality, cost savings and, ultimately, customer satisfaction.

Also, don't let your ESD control plan remain the same for an extended period. It is a living document that can and should be modified based on your business needs. It is also smart to make the ESD plan part of the company's quality system to give it the value it deserves among everyone in the organization.

## TERMS EXPLAINED

**ESD**

**Electrostatic discharge.** Occurs when two electrically-charged objects come together and a charge is discharged. Could result in visible or hidden damage to an electrical component.

**EPA**

**ESD-protected area.**

**ESDS**

**Electrostatic discharge sensitive.** A component that needs ESD protection.

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**"It is important to have an ESD control plan, communicate it to all relevant personnel and then apply it to daily work procedures."**

**6 POINT CHECKLIST**  
for creating and maintaining an epa

# FLOORING

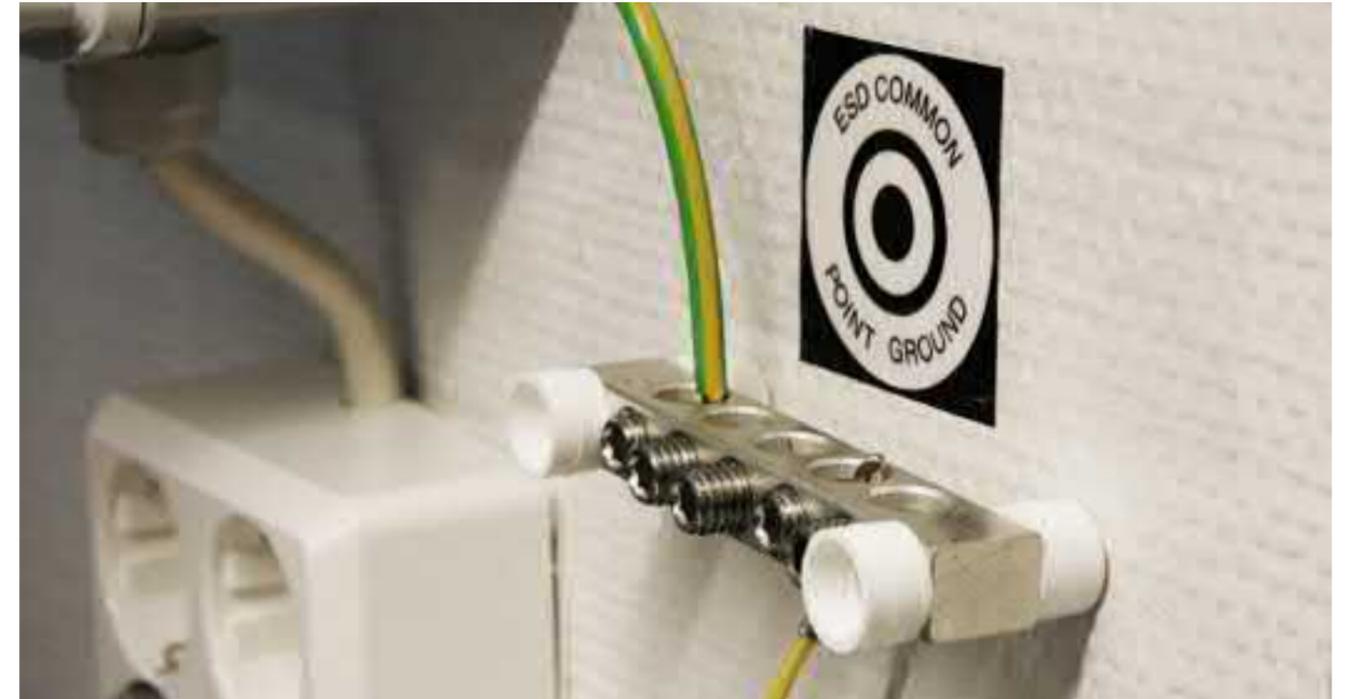
Grounded ESD floor or mat enables convenient usage of trolleys and chairs in EPA.

## FLOORING

After the plan is ready, you should look at the ground as, in most cases, an ESD floor or mat is the key to the entire ESD protection system. This is particularly important if you are using trolleys or ESD chairs. Based on the standard, it is not mandatory but really impacts ESD protection. An ESD mat or floor needs to be grounded in order for it to be ESD protected. Common point ground (CPG) is the way to connect all ESD grounding potentials together for ESD grounding and should be installed at the same time as the floor or mat.



For small ESD protected areas, an ESD floor mat a few square metres in size is a good and simple choice. There are various types of mats with different features and materials. The choice of mats might be limited but it affects everything, and, with regard to ESD, some mats work better with certain types of castors, shoes etc., although this cannot usually be ascertained before measuring ESD levels (i.e. surface conductivity) in a real environment.



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Compliance information is sometimes available but as "everything affects everything" some "trial and error" may be necessary. After the mat has been selected and assembled, it must be grounded and, depending on its size, one or more ground points are required. Refer to the mat manufacturer regarding installation.

For new buildings, larger areas or heavy loads it is smart to consider using a "cast" ESD floor. There are many different options for ESD flooring and choosing the right one might be difficult.

We recommend that you consult ESD experts such as floor and ESD mat manufacturers and resellers for details, as well as the best options for your EPA. After being set up, an ESD-protected area should also be clearly marked. People entering an ESD area should be made aware that they must not accidentally pass the area without proper protection.

For example, for a small area comprising a few square metres, it is a good idea to place yellow ESD stickers around the area to make it visible.

## MEASURING SURFACE CONDUCTIVITY

- 1 The ESD standard defines how and what to measure
- 2 Must always take place in a real environment
- 3 Special equipment needed for measurements



**"An ESD floor or mat is particularly important if you are using trolleys or ESD chairs."**

# FURNITURE

*All furniture in EPA needs to be grounded.*

## FURNITURE

When a floor or mat is in place and grounded, you must focus on workstation furniture. All furniture used in an EPA should be ESD protected, particularly furniture that is close to the working surface, i.e. the location where components or other electronics are being handled. In general, the ESD standard restrains the potentials to 5 000 volts/m and < 125 volts for "hotspots". It is essential to check the potential levels with proper measurements. Individual opinions are not reliable enough.



There are two types of ESD-protected workbenches. When a workbench is semi-conductive through its structure, ESD protection is in place as soon as the bench's feet touch an ESD floor. This is very simple and easy. Other benches always require wiring to a common point ground.

All workbench accessories that make the workbench fully functioning and ergonomic constitute potential risks to ESDS (Electrostatic discharge sensitive) components and should also be ESD protected. For example, shelves, drawers and plastic boxes.

Whether or not they are a risk, analyses of product sensitivity, manufacturing process and voltage potentials/distances to sensitive components are necessary. This is one of the important

issues to be covered in the ESD control plan. ESD-safe furniture such as trolleys and chairs can be used without extra protection if an ESD floor or mat is present. It is very smart to have

ESD-protected trolleys if you move components around. And don't forget the tools used to assemble sensitive components. They should also be ESD safe and checked and cleaned on a regular basis.



## IONIZERS

As well as conductive materials, there are also insulators in the workplace. These can be electrically charged but grounding doesn't help neutralize them. This is particularly important in low humidity, for example on cold and frosty winter days. Thus, it might be smart to consider using an ionizer to ensure ESD-protection. An ionizer is not mandatory but it helps keep components "uncharged" as it ionizes the air and ensures that insulators don't stay electrically charged but become neutral quickly.

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**"It is essential to check the potential levels with proper measurements. Individual opinions are not reliable enough."**

# PERSONNEL

*Wrist strap is the most efficient way to ground people working on EPA.*

## PERSONNEL

Objects are electrically charged when two objects rub or slide against each other. This is difficult to avoid when doing any type of task in an industrial environment. Personnel working with components tend to be charged. Therefore, whenever working with sensitive components and parts it is important to ensure ESD protection of personnel.

A wrist strap is the easiest and most effective way of ensuring a person is grounded and ESD protection is in place. It is very easy to install a wrist strap to a workbench and attach



the strap to your hand, if you simply remember to do this. With a wrist strap, it doesn't matter whether you are sitting or standing at the workbench as you are grounded all the time. Using a wrist strap could be seen as a "cheap insurance" for sensitive components and usually leads to optimal results. Two different types of wrist straps are available, metal and fabric, and there is no difference in the level of ESD protection they offer. It is important to have wrist straps available and ready for use in all work areas that have sensitive components.



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It is also important to remember that a person entering an EPA without wearing ESD clothing is always electrically charged and if that person is not grounded before starting to work the risk of ESD damage is very high. ESD shoes and jackets are also typically required in EPA areas. They will improve ESD protection in the area but do not

replace wrist straps in terms of efficiency and ESD safety. A wrist strap is like a safety belt in a car. It saves money in most cases and doesn't restrict any movement necessary to complete the task at hand. ESD jackets can be seen as a car's airbag. It can prevent injuries in certain conditions and is an important safety device.

**6 POINT CHECKLIST**  
for creating and maintaining an epa



**"A wrist strap is the easiest and most effective way of ensuring a person is grounded and ESD protection is in place."**

# STORING, MOVING AND PACKING

Store ESDS components in their original packages and minimise the transportation and movements.

6 POINT  
CHECKLIST  
for creating and  
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## STORING, MOVING AND PACKING

The components or parts you use arrive at your factory and don't usually land directly at an ESD workstation but are stored before being taken into use. It is smart to keep the components in their original ESD packaging and use ESD-protected bins to store them until they are to be used and installed. By doing so you minimize ESD damage.



Though the bags are safe havens for sensitive components, you should not totally depend on them as one of them might contain a small hole or might not have been sealed correctly, which could result in damaged components. It is therefore important that the trolleys and bins being used to transport sensitive components and parts around the factory are ESD protected, as they ensure ESD protection, enhance safety and reduce the risk of potential damage.

It is also important to check the workflow and the number of times a sensitive component is being moved from one workbench to another. The less a component is moved, the better. Minimising movement is a good strategy for reducing ESD risk. So next time, you could also look at the layout of the product line from this perspective.

Finally, packing the ESD sensitive products should be handled appropriately. For example, having a separate packing station in EPA, equipped with ESD-protected packing materials only, ensures an unbroken ESD-protection chain. After products are packed in the ESD sealed bags, they can safely be moved away from EPA to packing department for final packing and shipping.



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**“The less a component is moved,  
the better. Minimising movement is  
a good strategy for reducing ESD risk.”**

# CLEANING AND TESTING

*Regular cleaning with ESD detergent in EPA maintains the ESD protection.*

**6 POINT CHECKLIST**  
for creating and maintaining an epa

## CLEANING AND TESTING FOR MAINTENANCE

To ensure ESD protection remains at a high level, you cannot leave your EPA area uncleaned for months. You must remember to clean all flat surfaces regularly with an ESD detergent. Or, if you are not responsible for this task yourself, advise your cleaner carefully and ensure that the cleaner understands it is very important to follow the instructions.

It is also vital to clean the floor. And don't forget about the wheels on trolleys, drawer units and chairs. Please ensure that all the wheels are regularly cleaned with ESD detergent. This is an extremely important part of ESD protection, although not a particularly pleasant job. A specific ESD shoe tester will indicate the need for cleaning or replacing shoes. ESD jackets and other clothing can be washed normally.



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Regular measurement of ESD is the key to continuous success and a minimum level of ESD defects. Measurements must be carried out as planned in the ESD control plan and all values must be reported. If values rise above the set levels it is important to check that cleaning has been conducted properly and that you are measuring the right things.

For example, if a trolley has two ESD wheels, you should ensure that you measure one of them. If not, the measurement results will show incorrect values.

By following your ESD control plan, cleaning and measuring, the protection rate of your EPA area will stay at the same level for many years. But you should also train new employees and regularly remind all employees about the importance of ESD protection as people tend to forget things that become part of their daily routines. ESD damage is insidious as you can neither see it nor feel it every time so it is easy to forget such a risk. Out of sight, out of mind. But this doesn't apply to you as you have your plan and you follow it.



**“Don't forget trolley wheels, drawer units and chairs. They are the usual suspects when ESD measurements do not stay within the range.”**

# CONCLUSIONS



**“Setting up an ESD environment is simple and straightforward.”**

Setting up an ESD environment is simple and straightforward. An ESD-protected area can be small, for example, one workbench. Or it can be large, with hundreds of workbenches. However, both areas need the same procedures, only the scale is different.

Everything starts with the ESD control plan. Then you just need to roll up your sleeves and start implementing the plan, beginning with the floor and the common point ground, moving to ergonomic and ESD-protected furniture, personnel and, finally, cleaning and maintenance with measurements.

If possible, it is a good idea to optimise the EPA layout so that the movement of sensitive components from bench to bench is minimised.

Then you are ready to work on any type of ESD-sensitive components without any problems.

No matter whether you're a component producer, electronics manufacturer or only occasionally work on sensitive electronic components, it is important to have ESD protection in place. Investing in ESD protection usually pays back in terms of both money and brand. If your products are long lasting and reliable they are usually also appreciated by your customers.

If you need help or you have any questions you can always ask an ESD-protected product supplier such as Treston for further information to help find the right solution for you.

## 6-POINT CHECKLIST FOR CREATING AND MAINTAINING AN EPA

- 1 CONTROL PLAN**  
Includes e.g. component/product sensitivity levels, ESD protection level, daily routines and maintenance procedures.
- 2 FLOORING**  
Grounded ESD floor or mat enables convenient usage of trolleys and chairs in EPA.
- 3 FURNITURE**  
All furniture in EPA needs to be grounded.
- 4 PERSONNEL**  
Wrist strap is the most efficient way to ground people working on EPA.
- 5 STORING, MOVING AND PACKING**  
Store ESDS components in their original packages and minimise the transportation and movements.
- 6 CLEANING AND TESTING**  
Regular cleaning with ESD detergent in EPA maintains the ESD protection.

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**An ESD-protected area can be anything from a workstation to a full-scale production line. But no matter the size the same principles apply.**

## TERMS AND EXPLANATIONS:

<b>ESD</b>	<b>Electrostatic discharge.</b> Occurs when two electrically-charged objects come together and a charge is discharged. Could result in visible or hidden damage to an electrical component.
<b>ESDS</b>	Electrostatic discharge sensitive. A component that needs ESD protection.
<b>EPA</b>	ESD-protected area.
<b>CONDUCTIVE MATERIAL</b>	<b>Conductor</b> = material that permits the flow of electrical current in one or more directions. Metals are often conductive, e.g. copper and aluminium.
<b>INSULATING MATERIAL</b>	<b>Insulator</b> = material that does not conduct electricity. The insulator can be electrostatically charged. Insulators can be plastic or wood, for example.
<b>STANDARDS</b>	IEC 61340-5-1: ESD standard widely used in Europe and ANSI S20.20 in the Americas. Both standards have a great number of similarities.

## RESOURCES:

1. [www.esda.org/about-esd/esd-fundamentals/part-1-an-introduction-to-esd/](http://www.esda.org/about-esd/esd-fundamentals/part-1-an-introduction-to-esd/)
2. [www.cisco.com/c/en/us/training-events/esd-training-program/welcome.html](http://www.cisco.com/c/en/us/training-events/esd-training-program/welcome.html)
3. **More information about the standards (contain e.g. measuring and testing guidelines):** [www.esda.org/about-esd/esd-fundamentals/part-6-esd-standards/](http://www.esda.org/about-esd/esd-fundamentals/part-6-esd-standards/)
4. [www.electrostatics.net/ESD\\_Solutions/Cost\\_of\\_ESD.htm](http://www.electrostatics.net/ESD_Solutions/Cost_of_ESD.htm)
5. [www.esda.org/assets/Uploads/documents/RealCostofESDDamageFinal2-18-2010.pdf](http://www.esda.org/assets/Uploads/documents/RealCostofESDDamageFinal2-18-2010.pdf)

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