CHARLESWATER ESD AWARENESS BOOKLET

PLEASE READ THOROUGHLY BEFORE WORKING ON OR HANDLING ESD SUSCEPTIBLE COMPONENTS OR ASSEMBLIES

Use as part of Training Plan required by EN 61340-5-1

ESD CONTROL PROGRAMME PLAN PER EN 61340-5-1

“The Organization shall prepare an ESD Control Program Plan that addresses each of the requirements of the Program. Those requirements include:

- training
- compliance verification
- grounding / equipotential bonding systems
- personnel grounding
- EPA requirements
- packaging systems
- marking”

[EN 61340-5-1 Edition 1.0 2007-08 clause 5.2.1]

“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.” [EN 61340-5-1 Edition 1.0 2007-08 Introduction]

TRAINING PLAN

“The training plan shall define all personnel that are required to have ESD awareness and prevention training. At a minimum, initial and recurrent ESD awareness and prevention training shall be provided to all personnel who handle or otherwise come into contact with any ESDS [ESD sensitive] items. Initial training shall be provided before personnel handle ESD sensitive devices. The type and frequency of ESD training for personnel shall be defined in the training plan. The training plan shall include a requirement for maintaining employee training records and shall document where the records are stored. Training methods and the use of specific techniques are at the organization’s discretion. The training plan shall include methods used by the organization to ensure trainee comprehension and training adequacy.” [EN 61340-5-1 Edition 1.0 2007-08 clause 5.2.2 Training Plan]

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“When the requirements of this technical report are applied, they will provide a low risk of damage to the vast majority of components and assemblies used in the electronics industry, particularly for devices which have a damage threshold of greater than 100 V (human body model). Where ultra-sensitive devices are used,additional specialist precautions will need to be applied.” [EN 61340-5-1 Introduction] For more sensitive items such as HBM (Human Body Model) Class 0, see page 15 for suggested practices.

“This version of IEC 61340-5-1 focuses on the requirements for an ESD control program. In addition, this version of IEC 61340-5-1 has been aligned with other major ESD control program standards used throughout the world.” [EN61340-5-1 Edition 1.0 2007-08 Foreword]

ESD BASICS FOR ESD PROGRAMS PER EN61340-5-1

Electrostatic Discharge [ESD] can damage components and products containing electronics. It is the hidden enemy in many high-tech factories. Often this damage cannot be detected by quality control inspections, and can be very frustrating; adversely impacting productivity, quality, product reliability and thus a company's reputation and profitability.

The prerequisites of ESD control are:
- Identify ESD Protected Area [EPA]
- Identify ESD sensitive items [ESDS]
- Provide ESD control training

The ESD protected area should have signage, often including aisle tape, to clearly identify where it is. You need to understand and follow the basics of ESD control to limit the generation of ElectroStatic charges, limit and slow discharges in the EPA.

ESD BASICS

Protect your work following these guidelines:
- Only handle unpackaged ESD sensitive items [ESDS] in the ESD protected area [EPA] when grounded
- Only allow trained or escorted people in the EPA
- Ground all conductors including people in the EPA
- Use continuous monitors or test wrist straps at least daily
- If ESD footwear is used, test at least daily
- Visually check that grounding cords are connected
- Keep wristband snug, foot grounder grounding tab in shoe, and ESD smocks covering all clothing on torso
- Keep work area clean and clear of all non essential insulators, or neutralize essential insulators with ionizers with the airflow directed towards the work area
- Use packaging with shielding properties to store or transport ESDS outside the EPA

GROUNDING AND PERSONNEL SAFETY

This booklet will deal with ESD basics. ElectroStatic charges or static electricity can be everywhere, however conductors can be effectively grounded and charges removed to ground. A fundamental rule in ESD control is to ground all conductors, including people.

However, while ESD control is important, it is of secondary importance to employee safety. Personnel should not be grounded in situations where they could come into contact with voltage over 250 volts AC.

UL Caution, Underwriters Laboratories states regarding listed personnel grounding items:
"Note: This product is not recommended for use on equipment with operating voltage exceeding 250 VAC.
CAUTION: The ESD Series is for electrostatic control. It will not reduce or increase your risk of receiving electric shock when using or working on electrical equipment. Follow the same precautions you would use without [the personnel grounding item], including:
- Make certain that equipment having a grounding type plug is properly grounded.
- Make certain that you are not in contact with grounded objects other than through the ESD Series."

STATIC ELECTRICITY, ELECTROSTATIC CHARGE

All materials can tribocharge or generate ElectroStatic charges. This is static electricity which is an electrical charge at rest. When an electrical charge is not at rest, but discharges, problems can occur and we will discuss ESD [ElectroStatic Discharge] in some detail later.

Static electricity can be a very hair-raising event.

Remember that ElectroStatic charges and ElectroStatic discharges are different.

All matter is constructed from atoms which have negatively charged electrons circling the atom's nucleus which includes positively charged protons. The atom having an equal number of electrons and protons balances out having no charge.

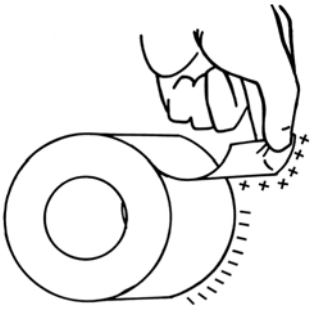
ElectroStatic charges are most commonly created by contact and separation:

- When two surfaces contact then separate
- Some atom electrons move from one surface to the other, causing imbalance

One surface has a positive charge and one surface has a negative charge.

CHARGE GENERATION OR TRIBOCHARGING EXAMPLES

The simple separation of two surfaces, as when tape is pulled off a roll, can cause the transfer of electrons between surfaces, generating an ElectroStatic charge.



- Unwinding a roll of tape
- Gas or liquid moving through a hose or pipe
- A person walking across a floor with heels and soles contacting and separating from the floor

The amount of static electricity generated varies,and is affected by materials,friction, area of contact, and the relative humidity of the

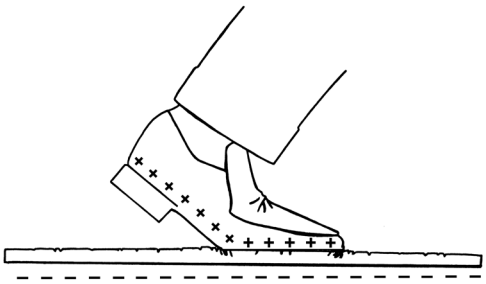
"For most people, static electricity is represented by the noise or crackle heard on a radio that interferes with good reception or the shock experienced when touching a metal object after walking across a carpeted room or sliding across a car seat. Static electricity is also observed as static cling when clothes are stuck together after coming out of a clothes dryer. Most of the time, people observe static electricity when the weather is cold and dry. While many people tend to think of static electricity as being at rest or not moving, static electricity causes the most concern when it ceases to be stationary." [ESD Handbook ESD TR20.20 section 2.1 Basics of Static Electricity, Introduction]

"Tribo-electric charging electrical charging process in which charge is generated by the contact and separation of two surfaces which may be solid, liquid or particulate-carrying gases." [EN61340-5-1 clause 3.19 Definitions]

environment. At lower relative humidity, charge generation will increase as the environment is drier. Common plastics generally create the greatest static charges.

Typical Electrostatic Voltages
Many common activities may generate charges on a person's body that are potentially harmful to electronics components. (A higher charge is generated at low humidity, in a dry environment)

- Walking across carpet, 1,500 to 35,000 volts



- Walking over untreated vinyl floor, 250 to 12,500 volts
- Vinyl envelope used for work instructions, 600 to 7,000 volts
- Worker at bench, 700 to 6,000 volts
- Picking up a common plastic bag from a bench, 1,200 to 20,000 volts

ELECTROSTATIC DISCHARGE (ESD)

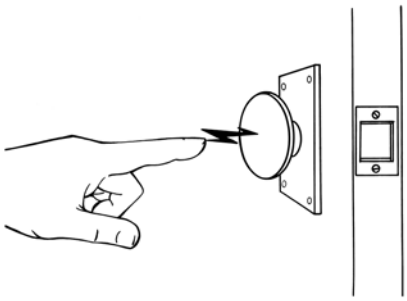
If two items are at the same electrostatic charge or equipotential, no discharge will occur.

However if two items are at different levels of ElectroStatic charge, they will want to come into balance. If they are in close enough proximity, there can be a rapid, spontaneous transfer of electrostatic charge. This is called discharge or ElectroStatic Discharge (ESD).

Examples in daily life:

- Lightning, creating lots of heat and light

- The occasional zap felt when reaching for a door knob



- The occasional zap felt when sliding out of an automobile and touching the door handle

"Triboelectric charging and inductive charging are the two primary methods of generating static electricity." "The most common electrostatic generator is triboelectric charging. This is caused when two materials come into contact or are rubbed together and then separated. Such actions allow electrons to move from one surface to another, creating a charge imbalance between the materials." [IEC 61340-5-2 Annex DD Generation of static electricity DD.2.1 and Triboelectric charging DD.2.2.1]

"Electrostatic discharge (ESD) transfer of charge between bodies at different electrostatic potentials caused by direct contact or induced by electrostatic field." [EN61340-5-1 clause 3.1 Definitions]

In a normal environment like your home, there are innumerable ESD events occurring, most of which you do not see or feel. It takes a discharge of about 2,000 volts for a person to feel the “zap”. It requires a much larger ESD event to arc and be seen. While a discharge may be a nuisance in the home, ESD is the hidden enemy in a high tech manufacturing environment. Modern electronic circuitry can be literally burned or melted from these miniature lightning bolts. ESD control is necessary to reduce and limit these ESD events.

TYPES OF ESD DEVICE DAMAGE

ESD damage to electronic components can be:

- Catastrophic Failures
- Latent Defects

EVEN LESS THAN 100 VOLTS MIGHT DAMAGE A COMPONENT

Catastrophic failure causes a failure in an ESD sensitive item that is permanent. The ESD event may have caused a metal melt, junction breakdown or oxide failure. Normal inspection is able to detect a catastrophic failure.

Direct catastrophic failures, meaning completely failed or dead components.

A latent defect can occur when an ESD sensitive item is exposed to an ESD event and is partially degraded. It may continue to perform its intended function, so may not be detected by normal inspection. However, intermittent or permanent failures may occur at a later time.

Latent defects, meaning degraded or wounded components.

COSTLY EFFECTS OF ESD

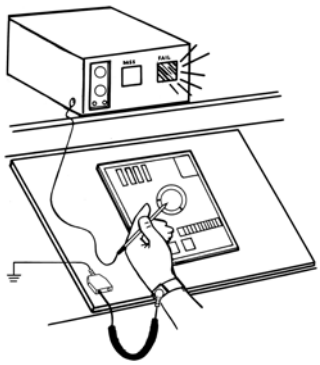
A catastrophic failure of an electronic component can be the least costly type of ESD damage as it may be detected and repaired at an early manufacturing stage.

“Failure mechanisms can include the following. Dielectric breakdown is a predominant failure mechanism on MOS devices when the voltage across the oxide excedes the dielectric breakdown strength. This failure mechanism is basically voltage dependent. The thinner the oxide, the higher the susceptibility to ESD. This failure mechanism can occur on MOS or bipolar devices, ... With bipolar devices, resistive leakage paths may occur where metallization runs over insulation which is above active semiconductor regions. Thermal breakdown occurs when the bonding materials melt, particularly in the case of eutectic alloy of silicon contact material, or of silicon. This is mainly an energy-dependent failure mechanism, namely the ESD pulse shape, duration and energy can produce power levels resulting in localized heating and eventually junction or lead melting, even though the voltage level is below that required to cause device degradation as well as functional failures. This can effect both performance and reliability. When this has taken place, then the “walking wounded” devicemay be more susceptible to both further ESD damage and also to damage by voltage surges and thermal degradation.” [IEC 61340-5-2 User guide Annex DD clauses DD.2.2.1, DD.2.2.2 and DD.2.3]

Latent damage caused by ESD is potentially more costly since damage occurs that cannot be felt, seen, or detected through normal inspection procedures. Latent defects can be very expensive as the product passes all inspection steps, and the product is completed and shipped. Latent defects can severely impact the reputation of a company's product. Intermittent failures after shipping a product can be frustrating, particularly when the customer returns a product, reporting a problem which the factory again fails to detect. It consequently passes inspection and the product is returned to the customer with the problem unresolved.

The worst event is when the product is installed in a customer's system, and performs for a while and then performs erratically. It can be very expensive to troubleshoot and provide repairs in this situation.

Catastrophic failures are detected during inspection but components with latent defects pass as good.



One study indicated the cost to be:

- £7 Device
- £7 Device in board - £700
- £7 Device in board and in system - £7,000
- £7 Device and system fails - £70,000

Industry experts have estimated average electronics product losses due to static discharge to range from 8 to 33%. Others estimate the actual cost of ESD damage to the electronics industry as running into the billions of dollars annually.

ESD CONTROL

Many organizations consider all electronic components ESD sensitive. It is critical to be aware of the most sensitive item being handled in your factory. As electronic technology advances,electronic circuitry gets progressively smaller. As the size of components is reduced, so is the microscopic spacing of insulators and circuits within them, increasing their sensitivity to ESD. As you can predict, the need for proper ESD protection increases every day.

Any ESD sensitive item should be identified with the ESD sensitivity symbol, either on itself or its container.

The ESD Sensitivity Symbol (also called Susceptibility or Warning Symbol) identifies items that can be damaged by ESD and should be unpackaged and handled while grounded at an ESD protected workstation.

"IEC 61340-5-1 requires that the Organization mark ESDS assemblies and equipement in accordance with customer requirements. When marking is not specifically required the Organization shall determine whether a marking strategy is required. Markings on ESDS and ESD packaging materials exist to inform users that that the device or the devices within packages are susceptible to ESD. Marking of hardware items (assemblies and equipment) can be accomplished by using the [ESD sensitivity] symbol. .Marking of hardware is dependent on space available on the item itself as well as the enviroment the item will operate in and whether the marking will hinder the operation of the item. Some hardware labels might contain nomenclature along with the symbol." [CLC/TR 61340-5-2:2008 clause 4.9 Marking and 4.9.1 Marking of assemblies and equipment]

Most firms use the EN61340-5-1 standard to construct their ESD control plan which is based on handling ESD sensitive items having a Human Body Model withstand voltage of 100 volts or greater. The Human Body Model simulates discharges from a person and increasingly tests an electronic device at higher and higher discharges until it fails, thus establishing the device's withstand voltage.

OHM'S LAW

At this point we should consider some basic physics:

Ohm's law is an extremely useful equation in the field of electrical/electronic engineering because it describes how voltage, current and resistance are interrelated.

Ohm's law states that, in an electrical circuit, the current passing through a conductor between two points is directly proportional to the potential difference (i.e. voltage drop or voltage) across the two points, and inversely proportional to the resistance between them.

Resistance determines how much current will flow through a component. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in ohms.

Resistance to ground (Rg) is a measurement that indicates the capability of an item to conduct an electrical charge (current flow) to an attached ground connection.

The measurement may be shown in various ways. Most commonly:

- 1 kilohm
- 1 kΩ
- 1 x 10^3 ohm
- 1 x 10E3 ohm
- 10^3 ohm

Prefix	Symbol	Scientific Notation	Common Usage
kilo-	K	1 x 10^3 or 10E3	1,000 or one thousand
mega-	M	1 x 10^6 or 10E6	1,000,000 or one million
giga-	G	1 x 10^9 or 10E9	1,000,000,000 or one billion

TYPES OF MATERIALS

Conductors

- Electrical current flows easily
- Can be grounded

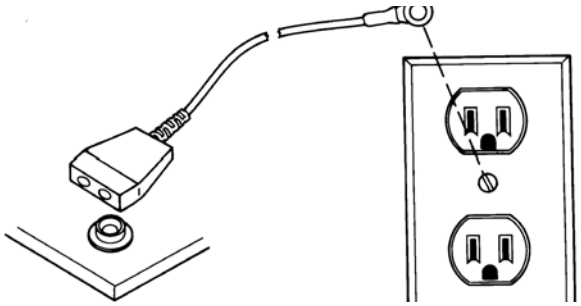
Materials that easily transfer electrons (or charge) are called conductors and are said to have "free" electrons. Some examples of conductors are metals, carbon, and the human body's sweat layer.

Grounding works effectively to remove ElectroStatic charges from conductors to ground. However, the item grounded must be

"In the electronics industry, smaller device geometries have resulted in higher density devices. ESD events can cause device damage such as metal vaporization, punch-through of thin oxide layers, or other failure modes. As mentioned earlier ESD events may or may not weaken devices so that they still pass production testing, but fail when installed in a customer's equipment." [ESD Handbook ESD TR20.20-2008 section 5.3.6.1.2 ESD Effects]

"The next step in developing an ESD control program plan is to determine the part, assembly or equipment sensitivity level under which the plan is to be developed. The organization can use various methods to determine the ESD sensitivity of the products that are to be handled. Some of the methods include: assumption that all ESD products have an HBM sensitivity of 100 V; actual testing of ESD sensitive devices to establish the ESD sensitivity threshold using IEC 60749-26; referencing ESD sensitivity data in published documents such as manufacturer's published data sheets."." [CLC/TR 61340-5-2:2008 clause 4.1.2 Determination of part ESD sensitivity]

conductive. The other term often used in ESD control is dissipative which is 1 x 10E4 to less than 1 x 10E11 ohms and is sufficiently conductive to remove ElectroStatic charges when grounded.



When a conductor is charged, the ability to transfer electrons gives it the ability to be grounded.

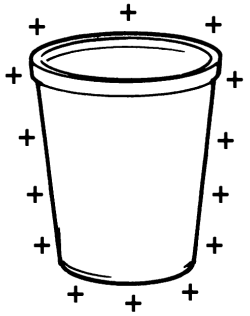
Insulators

- Electrical current does not flow easily
- Cannot be grounded

Materials that do not easily transfer electrons are called insulators, by definition non-conductors. Some well known insulators are common plastics, and glass. An insulator will hold the charge and cannot be grounded and “conduct” the charge away.

Both conductors and insulators may become charged with static electricity and discharge.

Grounding is a very effective ESD control tool, however, only conductors (conductive or dissipative) can be grounded.



Insulators like this plastic cup will hold the charge and cannot be grounded and “conduct” the charge away.

THINK OF STATIC ELECTRICITY AS GERMS AND CONTAMINATION!

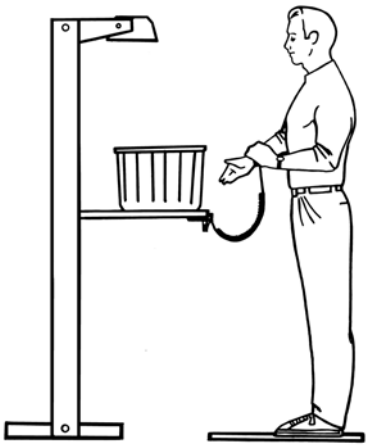
Daily life has other examples of hidden enemies where careful procedures must be followed to regularly obtain positive results. One example is sterilization, which combats germs and contamination in hospitals.

Damage caused by invisible and undetectable events can be understood by comparing ESD damage to medical contamination of the human body by viruses or bacteria. Although invisible, they can cause severe damage. In hospitals, the defense against this invisble threat is extensive contamination control procedures including sterilization.

“Dissipative materials provide charge dissipation. They also reduce areas of high charge concentration by allowing charges to sread out over the entire surface. Dissipative materials are not necessarily low charging. Insulative materials have a very high resistance and this limits the ability of the material to conduct current. In general, insulative materials can become highly charged through contact and separation with other materials. The dissipation of charge from insualtive materials via grounding may take a long time (i.e. hours or weeks depending on the enviromental conditions). This makes insulative materials generally unacceptable for use near ESD sensitive products.” [CLC/TR 61340-5-2:2008 User guide clause 4.8.2.3 and 4.8.2.5]

“ESD protective packaging ... when required, shall be defined for all material movement within protected areas, between protected areas, between job sites, field service operations and to the customer.” Per Table 4, static dissipative packaging required range is 1x10E5 to less than 1x10E11 ohms, conductive required range is 1x10E2 to less than 1x10E5 ohms, insulator is equal or greater than 1x10E11 ohms tested per IEC 61340-2-3. Bag discharge shielding required range is less than 50 nanojoules tested per ANSI/ESD S11.31. [EN 61340-5-1 Edition 1.0 2007-08 clause 5.3.4 Packaging and Table 4]

Just as you would never consider having surgery in a contaminated operating room, you should never handle, assemble, or repair electronic assemblies without taking adequate protective measures against ESD.



We are aware of the benefits of sterilization in medicine. We must develop the same attitude towards ESD control and “sterilize” against its contamination. Just as you would never consider having surgery in a contaminated operating room, you should never handle, assemble, or repair electronic assemblies without taking adequate measures against ESD.

For the hospital to sterilize most of the instruments is not acceptable; actually it may waste money. Each and every instrument needs to be sterilized. Likewise, it is not acceptable to protect the ESDS most of the time. Effective ESD control must occur at each and every step where ESDS is manufactured, processed, assembled, installed, packaged, labeled, serviced, tested, inspected, transported, or otherwise handled.

OPERATOR’S PART IN ESD CONTROL

As an employee, the invisible threat of ESD should be of great concern to you. ESD damage can significantly reduce your company’s profitability. This may affect your company’s ability to compete in the marketplace, your profit sharing, and even your employment. Everyone likes to take pride in their work, but without proper ESD controls, your best efforts may be destroyed by ElectroStatic discharges that you can neither feel nor see.

People in the high-tech manufacturing environment are still a major source of ElectroStatic charges and discharges. Operators need training and to be vigilant that ESD control procedures are followed. In order for the ESD control program to be effective, operators must be aware of the threat of ESD, and understand and adhere to the rules of controlling static electricity, and how to properly use EPA ESD control items.

EPA ESD control items are ESD protective products that have been specially formulated to possess at least one of the ESD control properties:

1) low charging (antistatic)
2) resistance (conductive or dissipative, able to be grounded)
3) shielding.

These products should be identified by the ESD Protective Symbol. Note: the ESD Protective Symbol has an arc which the ESD Susceptibility Symbol does not.

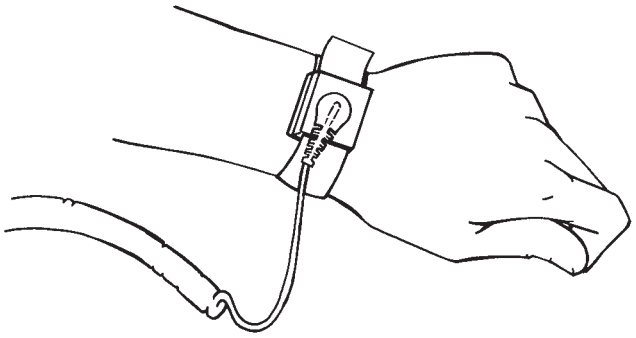
The ESD Protective Symbol identifies products designed to provide ESD control protection.

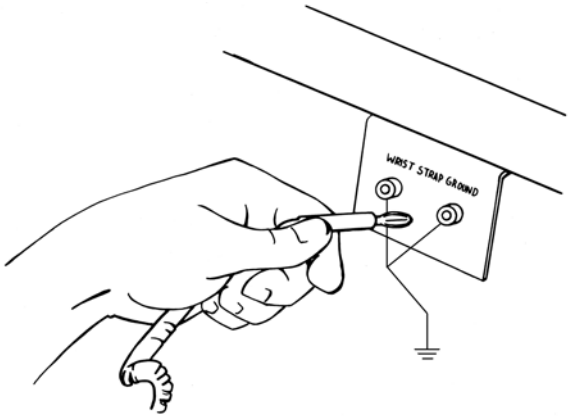
FUNDAMENTAL ESD CONTROL PRINCIPLES

- Ground all conductors including people
- Remove insulators, substitute with ESD protective versions, or neutralize with ionizers
- ESDS outside the EPA to be in packaging having ESD shielding property

PERSONNEL GROUNDING

A fundamental principle of ESD control is to ground conductors including people at ESD protected workstations. Wrist straps are the first line of defense against ESD, the most common personnel grounding device used, and are required to be used if the operator is sitting. The wristband should be worn snug to the skin with its coil cord connected to a common point ground which is connected to ground, preferably equipment ground.



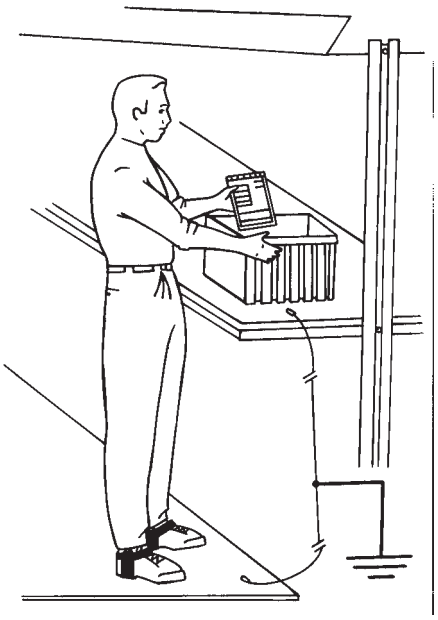


If you are not using a continuous or a constant monitor, a wrist strap should be tested while being worn at least daily. This quick check can determine that no break in the path-to-ground has occurred. Part of the path-to-groud is the perspiration layer on the person; an operator with dry skin may inhibit the removal of static charges and may cause a test failure.

Specially formulated lotion can solve this problem. Failures may also be caused by dirty or loose wristbands which should be cleaned or tightened. When a wrist strap fails a test, the supervisor should be contacted, and the failure effectively addressed or the wrist strap replaced.

A Flooring / Footwear system is an alternative for personnel grounding for standing or mobile workers. Foot grounders or other types of ESD footwear are worn while standing or walking on an ESD floor. ESD footwear is to be worn on both feet and should be tested independently at least daily while being worn. Unless the tester has a split footplate, each foot should be tested independently, typically with the other foot raised in the air.

The fundamental ESD control principles that form the basis of IEC 61340-5-1 are:
“electrically connecting all conductors in the enviroment, including personnel, to a known ground”
“Necessary insulators in the enviroment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charges on these necessary insulators (circuit board materials and some device packages are examples of necessary insulators).”
“ESD protection can be achieved by enclosing ESD sensitive products in static protective materials, ... Outside an EPA, low charging and static discharge shielding materials are recommended.” [CLC/TR 61340-5-2:2008 User guide Introduction]



Both ESD footwear and ESD floor are required. Wearing ESD footwear on a regular, insulative floor is a waste of time and money.

Part of the path-to-ground is the perspiration in the person's shoes. Foot grounder conductive tabs or ribbons should be placed inside the shoe under the foot with the excess length tucked into the shoe. Thanks to the perspiration in the shoe, direct contact with the skin is normally not necessary.

If an operator leaves the EPA and walks outside wearing ESD footwear, care should be taken not to get the ESD footwear soiled. Dirt is typically insulative, and the best practice is to re-test the ESD footwear while being worn each time when re-entering the EPA.

WORKSTATION GROUNDING DEVICES

ESD worksurfaces, such as mats, are typically an integral part of the ESD workstation, particularly in areas where hand assembly occurs. The purpose of the ESD worksurface is two-fold. (1) To provide a surface with little to no charge on it. (2) To provide a surface that will remove ElectroStatic charges from conductors (including ESDS devices and assemblies) that are placed on the surface.

ESD mats need to be grounded. A ground wire from the mat should connect to the common point ground which is connected to ground, preferably equipment ground. For electronics manufacturing a worksurface resistance to ground (Rg) of 1 x 10E4 to less than 1 x 10E9 ohms is recommended. Best practice is that ground connections use firm fitting

"Wrist straps should be tested periodically. The frequency of testing, however, is driven by the amount of usage, wear and ESD risk exposure that can occur between tests. For, example, what is the quantity of product handled between test periods? Typical test programs recommend that wrist straps that are used daily should be tested daily. However, if the products that are being produced are of such value that a guarantee of a continuous, reliable ground is needed then continuous monitoring should be considered or even required." [CLC/TR 61340-5-2:2008 User guide Wrist Strap clause 4.7.2.4.4 Test frequency]

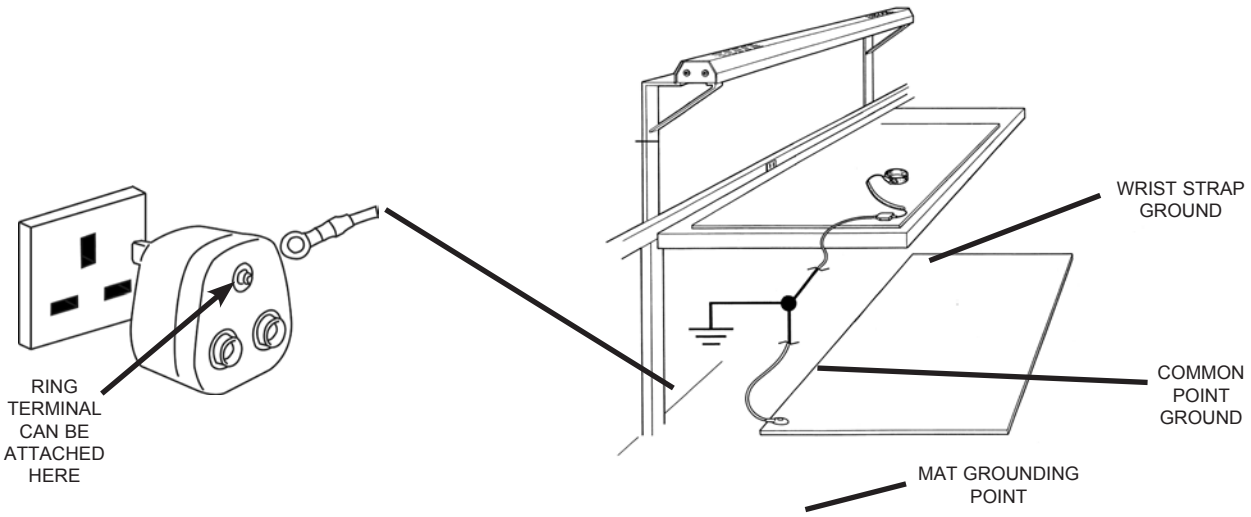
"ESD control footwear is designed to reduce body charge levels by supplying a conductive path from the body to the floor material. Heel or toe grounders should be worn on both feet to ensure effective use. Care should be taken to evaluate not only the footwear, but also the footwear/floor combination." [CLC/TR 61340-5-2:2008 User guide Footwear clause 4.7.4.3 Proper usage]

connecting devices such as metallic crimps, snaps and banana plugs to connect to designated ground points. Use of alligator clips is not recommended.

Operators should ensure that the worksurface is organized to perform work, and that all unnecessary insulators and personal items are removed. Regular plastics, polystyrene foam drink cups nad packaging materials, etc. are typically high charging and have no place at an ESD protective workstation.

Insulators can be a considerable threat to your products. Remember that an insulator cannot be grounded so it will retain its charge for a long time. Removing all non-essential insulators from the ESD protective workstation is an important rule. If not, the company's investment in the grounded ESD work surface may be wasted. If you do not believe so, please read the following paragraph.

The biggest threat is Field Induced Discharges, which can occur even at a properly grounded ESD worksurface. If an ESDS is grounded in the presence of an ElectroStatic charge, instead of the ESDS having charges removed from it, the ESDS may become charged with a voltage induced on it. Then, when placed on the grounded ESD work surface, a discharge occurs.



"The protection of ESDS is accomplished by providing a ground path to bring ESD protective materials and personnel to the same electrical potential. All conductor and dissipative items in the enviroment, including personnel, shall be bonded or electrically connected to a known ground or common connection point [EBP earth bonding point]. This connection results in sharing of charge which equalizes the voltage across all items and personnel and eliminates the chances of an ESD event to ESD sensitive devices. Electrostatic protection can be maintained at a potential different from a "zero" voltage ground reference as long as all items in the system are at the same potential." [CLC/TR 61340-5-2:2008 User guide clause 4.4.1 Grounding/bonding systems Introduction]

"The first and preferred ESD ground is protective earth if available" [EN 61340-5-1 Edition 1.0 2007-08 clause 5.3.1 Grounding/equipotential bonding systems]

"The most important functional consideration for work surfaces is the resistance from the top of the surface to the groundable point [Rgp]. This establishes the resistance of the primary path to ground for items placed on the surface. IEC 61340-5-1 has set a resistance to ground range for work surfaces of less than 1.0 x 10E9 ohms. However, it is sometimes necessary to use work surfaces that are much more conductive. This is allowed under IEC 61340-5-1 but the reason for using a more conductive work surface shall be documented in the ESD control program plan." [CLC/TR 61340-5-2:2008 User guide clause 4.7.1.2.5 Electrical considerations - Work Surfaces]

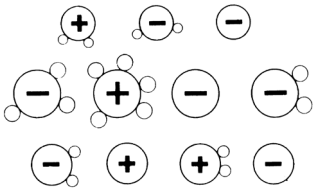
Per EN 61340-5-1 Edition 1.0 2007-08 "Table 3 EPA requirements the limit for Working surfaces, storage racks and trolleys is <1x10E9 ohms tested per IEC 61340-2-3" and per NOTE 6 "In situations where charged device model (CDM) damage is a concern a lower point to point resistance limit of 1x10E4 ohms is recommended."

If the ESDS is removed from the presence of the ElectroStatic charge and grounded again, a second discharge may occur. (Ref. ESD Handbook, ESD TR20.20, section 2.7.5).

The worksurface must be maintained and should be cleaned with an ESD cleaner. Regular cleaners typically contain silicone, and should never be used on an ESD worksurface. The ESD control plan should require testing the resistance to ground periodically. However, the operator should be on guard every day and check visually that the ground wire is attached.

IONIZERS AND NEUTRALIZATION

An ionizer creates great numbers of positively and negatively charged ions. Fans help the ions flow over the work area. Ionization can neutralize static charges on an insulator in a matter of seconds, thereby reducing their potential to cause ESD damage.



A fundamental principle of ESD control is to neutralize process essential insulators with ionizers. In addition, if a conductor is not grounded, it is an isolated conductor, and an ionizer is the only means to neutralize ElectroStatic charges on it.

Insulators, by definition, are non-conductors and therefore cannot be grounded. Besides neutralization using ionizers, insulators can be controlled by doing the following:

- Keep insulators a minimum of 12” from ESDS items at all times, or
- Replace regular insulative items with an ESD protective version, or
- Periodically apply a coat of topical antistat

When none of the above is possible, the insulator is termed “process essential” and therefore neutralization using an ionizer should become a necessary part of the ESD control program.

Examples of some common process essential insulators are a PC board substrate, insulative test fixtures, and product plastic housings. An example of isolated conductors can be conductive traces or components loaded on a PC board that is not in contact with the ESD worksurface.
Reduction of charges on insulators does occur naturally by a process called neutralization. Ions are charged particles that are normally present in the air, and as opposite charges attract, charges will be neutralized over time

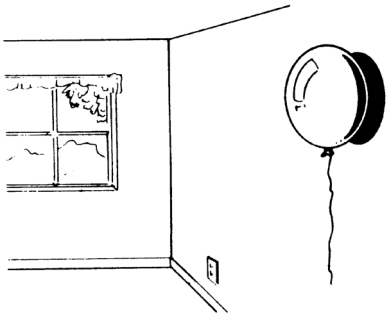
A common example is a balloon rubbed against clothing and “stuck” on a wall by static charge. The balloon will eventually drop. After a day or so natural ions of the opposite charge

“Necessary insulators in the enviroment cannot lose their electrostatic charge by attachment to ground. Ionization systems provide neutralization of charges on these necessary insulators (circuit board materials and some device packages are examples of necessary insulators). Assessment of the ESD hazard created by electrostatic charges on the necessary insulators in the work place is required to ensure that appropiate actions are implemented, according to the risk”. [EN 61340-5-1 Edition 1.0 2007-08 Introduction]

“All non-essential insulators (plastics and paper) such as coffee cups, food wrappers and personal items shall be removed from the workstation or any operation where unprotected ESDS [ESD sensitive items] are handled.
The ESD threat associated with process essential Insulators shall be evaluated to ensure that:
- the electrostatic field at the position where the ESDS are handled shall not exceed 10,000V/m;
- if the electrostatic potential measured at the surface of the process required insulator exceeds 2000 V, the item shall be kept a minimum of 30 cm from the ESDS.

If the measured electrostatic field or the surface potential exceeds the stated limits, ionization or other charge mitigating techniques shall be used.” [EN 61340-5-1 Edition 1 2007-08 clause 5.3.3 ESD protected areas (EPA)]

that are in the air will be attracted to the balloon and will eventually neutralize the charge. An ionizer greatly speeds up this process.



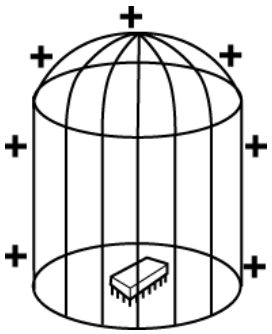
Note: Ionizers require periodic cleaning of emitter pins and the offset voltage must be kept in balance. Otherwise, instead of neutralizing charges, if it is producing primarily positive or negative ions, the ionizer will place an electrostatic charge on items that are not grounded.

SHIELDING

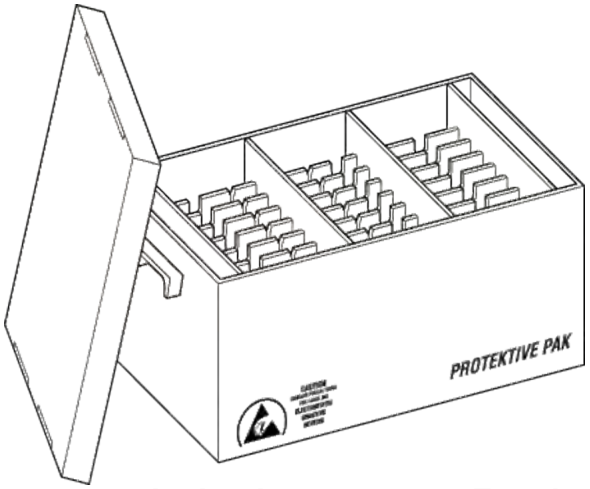
The third fundamental principle of the ESD control system is to package ESD sensitive components and assemblies during storage or transportation outside the EPA enclosed in packaging that possesses the ESD control property of shielding. In shielding, we utilize the fact that electrostatic charges and discharges take the path of least resistance. The charge will be either positive or negative; otherwise the charge would balance out and be no charge. Like charges repel and so the electrostatic charge will reside on the outer surface.

A Faraday Cage effect can protect ESDS contents in a shielding bag, or other container with a shielding layer. This Faraday Cage effect protects people in real life when a lightning bolt strikes an airplane or automobile with the charge residing on the outer metal fuselage or car body.

The Faraday cage effect causes charges to be conducted around the outside the surface of the conductor. Since like charges repel, charges will rest on the exterior.



To complete the enclosure, make sure to place lids on boxes or containers, and close shielding bags. Packaging with holes, tears, or gaps should not be used as the contents may be able to extend outside the enclosure and lose their shielding as well as mechanical protection.



Cover must be in place to create Faraday Cage and shield contents.

"The normal stable structure of the atom shows that unlike charges attract and like charges repel. Therefore, a separated charge will be self-repellant and will reside only on the surface of a charged item. If the item were a perfect insulator or perfectly insulated, a separated charge would remain indefinitely. Since there are no perfect insulators and it is impossible to have perfect isolation, charges tend to leak away to join opposite charges in the immediate enviroment thus returning the item to an electrically balanced state.
Taking all of the above into account, static electricity is the set phenomena associated with electrical charges on the surface of an insulator or insulated conductive body." [ESD Handbook ESD TR20.20-2008 section 2.3 Nature of Static Electricity]

"Electrostatic discharge shielding barrier or enclosure that limits the passage of current and attenuates the energy resulting from an electrostatic discharge such that the maximum energy from the 100 V human body model discharge is less than or equal to 50 nJ [nanojoules]." [EN 61340-5-1 clause 3.18.2 Definitions]

When ESD sensitive items are unpackaged from shielding bags or other containers, they should be handled by a grounded operator at an ESD workstation.

ESD WORKSTATIONS

An EPA might be one ESD workstation, an area that has been established to effectively control ESD. At an ESD workstation, we attempt to limit electrostatic charges by grounding all conductors (including people), removing all insulators (or substituting with ESD protective versions), or neutralizing process essential insulators with an ionizer.

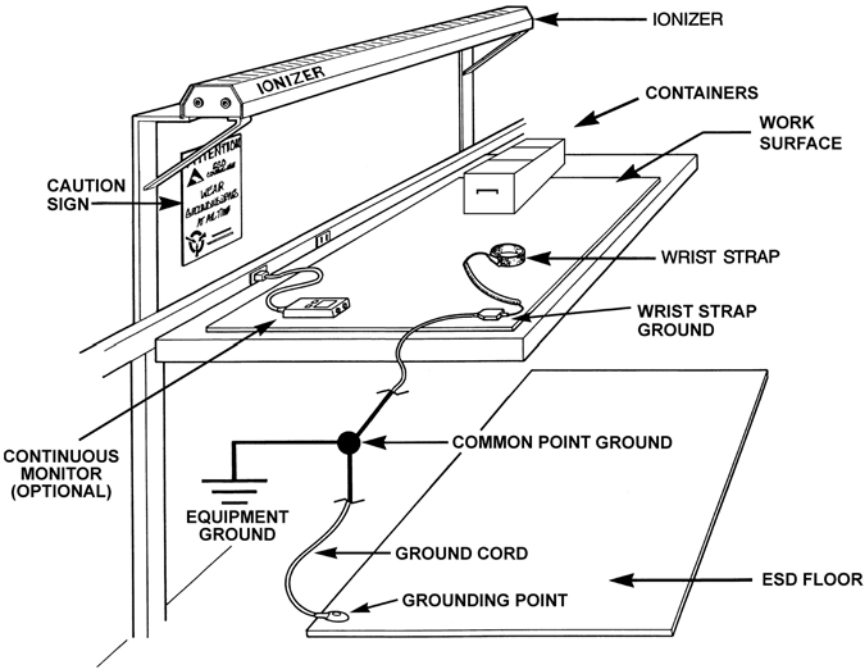
ADDITIONAL EPA ESD CONTROL ITEMS

In addition to conductive and dissipative worksurfaces, personnel grounding devices and ionizers, your company may provide a variety of additional ESD control materials.

The proper use of these materials will enhance your company's ESD control program.

Regular versions of these products have been changed to be low charging and/or groundable:

- ESD smocks and gloves
- ESD packaging, bags and boxes
- Conductive foam and shunt bars
- Antistatic or low charging tape
- ESD cleaners and topical antistat
- Dissipative bottles and cups
- Dissipative binders
- Dissipative document and badge holders
- Dissipative floor finishes
- Conductive paint and epoxy
- Conductive and dissipative flooring
- ESD hand lotion



"An ESD protected area (EPA) is an area that is equipped with the ESD control items required to minimize the chance of damaging ESD sensitive devices. In the broad sense, a protected area is capable of of controlling static electricity on all items that enter that work area. Personnel and other conductive or dissipative items shall be electrically bonded together and connected to ground (or a common connection point when a ground is not available) to equalize electrical potential anong the items. The size of an EPA can vary greatly. A protected area may be a permanent workstation within a room or an entire factory floor encompassing thousands of workstations. A protected area may also be a portable worksurface or mat used in a field service situation." [CLC/TR 61340-5-2:2008 Use guide clause 4.6 Protected areas (EPA)]

HANDLING CLASS 0 ESD SENSITIVE ITEMS

CLASS ZERO

ANSI/ESD S20.20 guides a user to enact an ESD Control Program to handle ESD sensitive items with a withstand voltage of 100 volts Human Body Model (HBM) or greater. Per ANSI/ESD STM5.1 Table1 - HBM ESDS Component Classification Class 0 has a Voltage Range less than 250 volts.

If you handle Class 0 ESDS items, to decrease the probability of ESD damage, additional precautions may be required including additional and/or more stringent technical requirements for EPA ESD control products, increasing redundancies, and more frequent periodic verifications or audits. Additionally, ESD control process systems should be evaluated as to their performance as a system. You will need to understand how the technical elements in use perform relative to the sensitivity of the devices being handled. Thus, tailoring the process to handle the more sensitive parts.

For example: If the footwear/flooring allows a person's body voltage to reach say 80 volts and a 50 withstand voltage item gets introduced into the process, you will either have to allow only handling via wrist straps or would have to find a way to modify the footwear/flooring performance to get peak voltages below the 50 volt threshold. Class Zero Workstations may be identified, and additional measures may include:

IONIZATION

- More stringent removal of non essential items from the workstation
- Ionization to reduce charges on isolated conductors like devices on PCB's
- Ionization to reduce induction charging from process essential insulators
- More stringent Offset Voltage (Balance) and/or faster Discharge times
- Use of Ionizers with feed-back mechanisms and out of balance alarms

GROUNDING

- Use Continuous Monitors to verify proper grounding of operator and worksurface
- Specify more stringent resistance technical requirements such as 10^6 - 10^8 ohm dissipative worksurface
- Require conductive ESD Floor (Per ANSI/ESD S7.1 < 1 x 10E6 ohms)
- Require more reliable ESD footwear such as full coverage foot grounders (as opposed to heel grounders)
- Require improved grounding (using positive mechanical attachments) of carts, shelves, and equipment to ground
- Require dissipative material for all fixtures

SHIELDING

- Use ESD Smocks to shield ESD sensitive items from charges on operator clothing
- Use ESD packaging with shielding properties to store and transport ESDS both within and outside the ESD protected area

Other steps may include minimizing electrostatic charge generation, converting production supplies to ESD protective versions, or treating with topical antistat, requiring dissipative material, increasing training, and frequency of periodic checks per Compliance Verification ESD TR 53.

ESD BASIC (Supervisor Level) QUIZ - True or False

1		An example of Electro Static Discharge or ESD is the zap one sometimes feels after walking across carpeting and touching a metal doorknob.
2		Static Charges are generated when two surfaces contact and separate. Electrons move from one surface to another causing an imbalance. The surface with a deficiency of electrons has a positive charge and the surface with an excess of electrons has a negative charge.
3		ElectroStatic charges eventually will come into balance, but when this occurs suddenly an ESD or ElectroStatic Discharge event occurs. However, this event cannot melt electronic circuitry.
4		A powerful example of an ESD event, creating lots of heat and light, is lightning.
5		Conductors are a type of material where electrical current flows easily so it can be grounded. Examples of conductors include plastics and Styrofoam cups.
6		Insulators are a type of material where electrical current does not flow easily that cannot be grounded. Examples of insulators include metals and people.
7		A person walking across a carpeted floor can generate a voltage, but not greater than 100 volts of electrostatic charge on their body.
8		Charges on a person frequently discharge, but for the person to feel the zap, a discharge must be about 2,000 volts.
9		In manufacturing handling electronic components, ESD is the hidden enemy as there can easily be damaging ElectroStatic discharges that a person cannot see or feel.
10		Passing an inspection test means that the ESD sensitive item (ESDS) has experienced a catastrophic ESD failure.
11		Passing an inspection test means that the ESD sensitive item (ESDS) has not experienced a latent ESD defect.
12		Although passing all inspections in the factory, ESDS items having latent defects and failing in the field can be very expensive in warranty expense, field service repairs, and loss of customer satisfaction.
13		Manufacturing ESD sensitive items without proper ESD control is like a physician conducting surgery on you without following sterilization procedures.
14		A person can be charged, and as a conductor, should be grounded at the ESD protective workstation. Always be grounded when handling unpackaged ESD sensitive items; and always wear a wrist strap when seated at an ESD protected workstation.
15		Make sure to always ground insulators.
16		Even if it adversely effects the quality of the products you are working on, allow strangers into the work area and handle products as they please.
17		If the air flow of the ionizer bothers you, it's OK to direct it away from the products you are working on.
18		Regular plastic bags are high charging insulators and should not be permitted in an ESD protected area.
19		ESD Shielding Bags, if closed, will keep electrostatic charges on the exterior of the bag, and being dissipative, the charge will be removed when handled by a grounded person or placed upon a properly grounded ESD Worksurface.
20		Wrist Straps and ESD footwear should be tested at least daily, and while wearing them. You should notify your supervisor if a failure occurs.
21		ESD Foot Grounder grounding tabs should be cut off.
22		ESD Smocks shield ESDS items from charges on your clothing. Most clothing is insulative and these charges cannot be removed via your wrist strap. Make sure to button up ESD Smock covering all clothing.
23		The ESD Association understands that high charging personal items should be allowed in an ESD protected area, even if they might damage products.
24		Only trained or escorted people should be allowed in an ESD protected area.
25		Use ESD packaging having shielding property to store or transport ESD sensitive items outside an ESD protected area.

ESD BASICS (Assembler Level) QUIZ

Please answer the following questions by circling the correct letter.

1. Electrostatic charges are generated:
A. By heat
B. By high humidity
C. When 2 surfaces contact then separate

2. When a "zap" is felt by a person, the voltage of the ElectroStatic Discharge (ESD) has to be about:
A. 200 volts
B. 2,000 volts
C. 20,000 volts

3. The first line of defense against ESD is:
A. The Ionizer
B. The foot grounder
C. The wrist strap

4. Some of today's ESD sensitive devices can be damage by as little as:
A. 100 volts
B. 800 volts
C. 3,000 volts

5. If not using continuous monitors, wrist straps should be tested at least:
A. Daily
B. Weekly
C. Monthly

6. When transporting or storing ESD sensitive devices outside the ESD protected area, the devices should be in packaging that includes:
A. Grounding
B. Shielding
C. Ionizing

7. Materials that are non-conductors cannot be grounded; they are also called:
A. Dissipative
B. Conductors
C. Insulators

8. To neutralize ElectroStatic charges on insulators, use:
A. Ground cords
B. Conductive mats
C. Ionizers

9. An ESD protective worksurface mat should be:
A. Grounded
B. Clear of nonessential insulators
C. Cleaned only with an ESD cleaner
D. All of the above

10. Wrist Strap Band should be:
A. Snug on skin around the wrist
B. Removed if a nuisance
C. Placed over shirt sleeve

11. Foot Grounders, if used, should be tested at least daily; the grounding tab should be:
A. Cut off
B. Placed in shoe under your foot
C. Tied around your finger

12. An ESD smock shields product you are working on from charges on your clothing. Front panels should be:
A. Closed covering all clothing on torso
B. Left wide open
C. Tied calypso style

13. In the workplace, ESD is an hidden enemy, you may want to think of it as a form of:
A. Combustion, like where there's smoke there's fire
B. Corruption, like money and politicians
C. Contamination, like germs in an hospital operating room

14. Insulators, not needed to do your job, such as drinking cups, regular tape, picture frames, radio enclosures, etc. should be:
A. Allowed to induce charges on ESD sensitive products
B. Color coded for identification
C. Removed from the ESD protective workstation

15. ESD control products are often regular products that have at least one ESD control property added. Examples are:
A. ESD smocks
B. ESD packaging, bags and boxes
C. Dissipative document holders
D. All of the above

For quiz answers go to:

www.DescoIndustries.com/pdf/assembler.pdf

www.DescoIndustries.com/pdf/leadperson.pdf

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"Process monitoring (measurements) shall be conducted in accordance with a compliance verification plan that identifies the technical requirements to be verified, the measurement limits and the frequency at which those verifications must occur. The compliance verification plan must document the test methods used for process monitoring and measurements… Compliance verification records shall be established and maintained to provide evidence of conformity to the technical requirements. The test equipment selected shall be capable of making the measurements defined in the compliance verification plan." [IEC 61340-5-1 Edition 1 2007-08 clause 5.2.3 Compliance verification plan]

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