Use ESD Control Products Correctly Or You Can Do More Harm Than Good

A Comprehensive Program Is Required For Effective ESD Control

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With most companies pressured by global competition, effective ESD control can be a key to improving productivity, quality, and customer satisfaction. It is a pity that many companies buy ESD protective products or equipment and then misuse them, often causing more harm than good.

Electronic components that are electrostatic discharge sensitive (ESDS) must be protected throughout the entire manufacturing cycle. According to ANSI/ESD S20.20, the ESD Association's standard for the development of an Electrostatic Discharge Control Program, safeguards are required during activities that "manufacture, process, assemble, install, package, label, service, test, inspect or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges."

If ESD latent defects occur during this manufacturing and product cycle, it can be most frustrating and costly. Latent defects in components by definition will not be detected so products will pass normal inspections. ESD damage is the hidden enemy; electrostatic charges cannot be seen, typically discharges less than 3,000 volts cannot be felt, and latent defects cannot be detected through normal quality control procedures.

Manufacturing facilities should be as diligent with their ESD control program as hospital operating rooms are in implementing sterilization procedures. Damage caused by invisible and undetectable events occurs in medicine where people can experience infection or even death from viruses or bacteria. In hospitals, the defense against this invisible threat is extensive contamination control procedures including sterilization.

The discipline required to control and minimize ESD damage can be tough to acquire, but the basics of ESD control are fairly simple:

- Ground conductors
- Remove, convert, or neutralize insulators with ionizers
- Shield ESD sensitive items when stored or transported outside the ESD protected area

Many ESD protective products have conductive, dissipative, or shielding properties added to otherwise common factory items such as packaging, floor and worksurface mats, floor finish, document holders, tape, etc. Many of these are converting the normal product that is an insulator [or non-conductor] into a conductive or dissipative version which can be grounded and charges remove. Dissipative material refers to a range of conductive material; greater than 1 x 10^4 ohms and less than 10^{11} ohms which has the ESD control benefit of more slowly removing electrostatic charges to ground. For ESD control purposes, conductive material refers to material less than 10^4 ohms resistance. In addition, special equipment can be used in ESD control such as ionizers that neutralize electrostatic charges from insulators.

However, all items have to be used as a system, and many ESD control products can be misused. It is quite wasteful to protect ESDS items

through nine of ten manufacturing steps only to damage the item at one of the other steps. The company's investment in all the ESD protective products could be for naught. To maximize value and financial return, individual products must be used properly and used together as an overall system.

Here are some examples of misused ESD control products that we have noted while conducting ESD surveys in the field:

Ionizers

Problem: Ionizers poorly maintained with emitter pins not cleaned, becoming out of balance and putting charges on ungrounded items.

Solution: Clean ionizer emitter pins and filters on a regular maintenance schedule. Consider using ionizers with "Clean Me" and/or "Balance" alarms.

Ionizers produce billions of positively and negatively charged ions. Insulators cannot be grounded, but a negative charge on an insulator or isolated conductor will attract positively charged ions while repealing negatively charged ions. The quantity of positive and negative ions cannot be perfectly balanced, but should be below the voltage threshold of the most sensitive device. However much the ionizer is out of balance (offset voltage), that amount of charge will be placed on insulators and/or ungrounded conductors in the ionizer air stream.

Companies invest in ionizing equipment for various purposes per ESD Handbook TR 20.20 paragraph 5.3.6.7 Maintenance / Cleaning: "All ionization devices will require periodic maintenance for proper operation. Maintenance intervals for ionizers vary widely depending on the type of ionization equipment and use environment. Critical clean room uses will generally require more frequent attention. It is important to set-up a routine schedule for ionizer service. Routine service is typically required to meet quality audit requirements."

Ionization test kits are available to perform periodic verification testing (ESD Handbook TR 20.20 paragraph 5.3.6.6.5). Simplified test methods for this purpose will be found in ESD SP3.3 – Periodic Verification of Air Ionizers. Ionizers should be tested for discharge time and balance after they have been installed in the use location. The time intervals for subsequent measurements will depend on the user's requirements. The ionization test kit isolates the conductive plate and positions it so charges can be measured by a static field meter. The battery operated charger can quickly place a 1,000 volt charge on the plate which, since it is isolated, will remain there for some time. The periodic verification of air ionizers test in accordance with ESD-SP3.3 is to place the charged conductive plate in the ionizer's airflow and use a stopwatch to measure the charge decay time to reduce the 1,000 volt + & - charge to 100 volts. With the kit grounded, it can then approximate balance or offset voltage.

Ionizers

Problem: Ionizer airflow cooling worker, so turned off. Ionizer with heater placed at worker's feet to warm feet.

Solution: Employee training.

Per ANSI/ESD S20.20, initial and recurrent ESD awareness and prevention training shall be provided to all personnel who handle or otherwise come into contact with any ESDS items. The training shall include an objective evaluation technique to ensure trainee comprehension and training adequacy. Printed ESD Awareness Guides including assembler level quizzes are available, as well as CD-ROM ESD training courses.

Studies by major companies quantify significant financial returns from ESD control, up to 95:1 ROI. However, efforts to improve productivity, quality, and customer satisfaction will not occur if a company purchases ESD control equipment and then does not train employees on the product or equipment's function and purpose.

ESD Garments

Problem: ESD smocks not grounded.

Solution: ESD Garments are available that can be grounded via a coil cord to snap at wrist or hip-to-cuff, allowing hands free operation. In addition, using a wrist band or a conductive cuff, charges can be removed to ground via ESD footwear in conjunction with ESD flooring.

Otherwise, one might just use regular smocks made of cotton or other low charging fabric, instead of taking a chance that the ESD garment fabric will become an isolated charged conductor that can discharge to ESD sensitive items. Per ANSI/ESD S20.20 Paragraph 6.2.3.2. Protected

Areas Guidance "All process essential insulators that have electrostatic fields that exceed 2,000 volts should be kept at a minimum distance of 12 inches from ESDS items."

Although ESD smocks are not a S20.20 requirement, with regards to workers' clothing which might be synthetic and high charging, ESD garments create "Faraday Cage" type shielding and can be a very effective means to fulfill paragraph 6.2.3.2's recommendation. ESD smock fabric includes conductive fibers, and all conductors are to be grounded. The risk is that ESD garment panels can become an isolated charged conductor.

Per ESD Handbook TR 20.20 paragraph 5.3.13.2.6 Proper Use, "after verifying that the garment has electrical conductivity through all panels, the garment should be electrically bonded to the grounding system of the wearer so as not to act as a floating [conductor]. Garments should be worn with the front properly snapped or buttoned to avoid exposure of possible charges on personal clothing worn under the garment."

ESD Garments

Problem: ESD smock loses ESD properties after many launderings and is still used.

Solution: Companies' compliance verification plans should include periodic checks so ESD garments are replaced when their ESD control properties are lost. ESD garments typically have the ESD control properties of being low charging [formerly referred to as antistatic], dissipative, and shielding. Although some companies offer warranties as long as two years or seventy-five launderings, ESD garments will eventually wear out.

ESD Handbook TR 20.20 paragraph 5.3.13.3.1.8 Periodic Testing states "to maintain process control, it is imperative that the garment be tested per ESD STM 2.1 ("recommended electrical resistance range is 1 x 10^5 ohms to 1 x 10^{11} ohms."). The point-to-point and sleeve-to-sleeve resistance test should be made. These tests can quickly be performed using a surface resistance test kit by placing the garment on an insulative test surface or isolated in the air using a wooden hanger. To measure sleeve-to-sleeve resistance top-to-top (RTT), a five pound electrode is placed on each sleeve, or "bankers clips" are attached to each sleeve.

An operation outfitted in ESD smocks conveys to all that there is ESD control program commitment and that ESD protection is being provided. However, misuse and/or poor product selection like the examples above end up being quite penny-wise and pound-foolish.

Test Equipment

Problem: No test equipment available, or the equipment is not in calibration to check ESD protective products

Solution: Comply with ANSI/ESD S20.20 Compliance Verification Plan Requirement.

Per paragraph 6.1.3.1 "A Compliance Verification Plan shall be established to ensure the organization's compliance with the requirements of the Plan. Formal audits or certifications shall be conducted in accordance with a Compliance Verification Plan that identifies the requirements to be verified, and the frequency at which those verifications must occur. Test equipment shall be selected to make measurements of appropriate properties of the technical requirements that are incorporated into the ESD program plan."

It does not make sense to make a significant expenditure on ESD protective products and then not have the test equipment to periodically verify performance results. Workstations get moved, ground cords get disconnected. Without a verification plan and the necessary test equipment, any ESD control program will deteriorate over time. ESD control must be a comprehensive system throughout the manufacturing cycle; otherwise money can be wasted by providing protection at some steps while ESD damage is occurring at others.

ESD Packaging

Problem: Conductive totes and/or ESD shielding bags used without covers for the totes, or bags not being closed.

Solution: Use conductive tote covers to close conductive totes, or labels to close ESD shielding bags to prevent ESD damage to ESDS items.

Static electricity is a surface phenomenon - Per ESD Handbook TR 20.20 Figure 2 "the normal stable structure of the atom shows that unlike charges attract and like charges repel. Therefore, a separated charge will be self-repellent and will reside only on the surface of a charged item." Using the cover on the conductive tote, and closing the ESD shielding

bag will restrict charges to the exterior surface of the packaging creating a type of "Faraday Cage." However, the shielded packaging must be closed.

A fundamental ESD control principle in ANSI/ESD S20.20 is "transportation of ESDS items outside an Electrostatic Protected Area requires enclosure in static protective materials; low charging and static discharge shielding materials are recommended." And, per paragraph 6.2.4.2. Packaging Guidance, "the objective of ESD protective packaging is to prevent a direct electrostatic discharge to the ESDS item contained within and allow for dissipation of charge from the exterior surface."

ESD Packaging

Problem: ESD shielding with holes and scratches being re-used.

Solution: It is up to the user to determine if a shielding bag is suitable for re-use or not. The testing of every bag before re-use is not practical. Many companies will discard the shielding bag once used and replace it with a new one. Others will use a system of labels to identify when the bag has gone through five (5) handling cycles. Non-reusable labels are used that requires that the label be broken to open it. The bag is resealed using a new label. When there are five broken labels, the bag is discarded.

Per ANSI/ESD S20.20 paragraph 6.2.4.2. Packaging Guidance, "users should be aware that some packaging materials may be humidity dependent and may have limited shelf life. They may also lose static shielding properties by crumpling, puncturing and folding." Per ESD Handbook TR 20.20 paragraph 5.4.3.3.1 Returnable and Reusable Packaging, "shielding bags and containers also may fall into this category as long as the metal layer may be tested for continuity, integrity, or shielding performance."

Worksurface Grounding

Problem: ESD mat or laminate not grounded, ground snap on the mat is loose, or ground cord has become disconnected.

Solution: Many companies use a daily checklist, which includes assembler verifying that ground cords are firmly connected.

ESD mats and laminate worksurfaces cost more than their regular insulative counterparts. The ESD dissipative characteristic is added so when charged conductors (conductive or dissipative) items are placed upon the surface a controlled discharge occurs and electrostatic charges are removed to ground. This occurs only if the ESD worksurface is actually connected to ground.

Best industry practice is that ESD ground connections should be firm fitting connecting devices such as metallic crimps, snaps and banana plugs that shall be connected to designated ground points. Use of alligator clips is not recommended. The company compliance verification plan should include periodic checks of worksurfaces measuring resistance top-to-ground [RTG] from worksurface's center or most worn area to third wire (green) AC equipment ground. If this overall measurement is within acceptable range (Per ESD S4.1 paragraph 8. Resistance Guidelines "Resistance-to-groundable point 1 x 10^6 to 1 x 10^9 ohms"), this one test indicates that connections are good.

ESD Floor

Problem: Dissipative floor measures high (10^{10} ohms RTT), floor is dirty, or there is an ESD floor or ESD footwear but not both.

Solution: Regular maintenance schedule needs to be followed and floor resistance measurements taken (Periodic Verification Plan). A dissipative floor finish can be used to reduce floor resistance. Periodic verification will identify how often the floor finish needs to be applied. As the layer(s) of dissipative floor

finish wear, the resistance measurements will increase. So, after some amount of data collection, a cost effective maintenance schedule can be established.

Dissipative floor finish is a versatile product able to turn almost any hard floor into an ESD protective floor. If the area is large enough, floor capacitance will provide an effective ground, and expensive grounding grids or wires are not required. In addition to being dissipative, some ESD floor finishes are low charging (antistatic), impeding the generation of electrostatic charges. The best form of ESD control is to not generate a charge in the first place. All the other ESD controls are designed to remove the charge.

Per ANSI/ESD S20.20 Paragraph 6.2.2.2 Personnel Grounding Guidance, "ESD protective flooring, used with approved footwear, may be used as an alternative to the wrist strap system for standing operations." It is wasteful to spend money on ESD footwear and have workers walking on worn out dissipative floor finish. We also see numerous situations where companies spend money on foot grounders but the floor is a regular insulative floor. This does not complete the system, and is not the way to improve productivity and quality.

ESD Cleaners

Problem: Cleaning ESD mat or laminate with a "common" cleaning product. Many of these contain silicone to help create surface "shine," or will leave a residue on the surface. In either case, the residue from common cleaning products can result in an insulative surface layer on mat, thus reducing grounding performance.

Solution: Clean ESD worksurfaces only with approved ESD surface and mat cleaners that are specifically designed for ESD Control. It is certainly a financial and ESD control shame to spend extra money on ESD mats, and then coat them with an insulative layer that interferes with the function of the ESD worksurface.

Per ESD Handbook TR 20.20 paragraph 5.3.1.14 Worksurface Maintenance, "periodic cleaning, following the manufacturer's recommendations, is required to maintain proper electrical function of all worksurfaces. Ensure that cleaners used do not leave an electrically insulative residue common with some household cleaners that contain silicone."

Wrist Straps

Problem: Wrist band loose and not making electrical contact with skin, or with worn wrist band snap causing accidental disconnects.

Solution: As discharges from people handling ESDS items cause significant ESD damage, the wrist strap is considered the first line of ESD control. The wrist strap should be effectively tested while worn on the person, and records should be kept. Wiggling the resistor strain relief portion of the coil cord during the test will help identify failures sooner. Analysis and corrective action should take place when a wrist strap tester indicates a failure.

Per ANSI/ESD S20.20 Paragraph 6.2.2.2 Personnel Grounding Guidance, "a log should be maintained which verifies that personnel have tested their personal grounding devices." Per ESD Handbook TR 20.20 paragraph 5.3.2.4.2 Additional User Wrist Strap Testing, "proper testing of the wrist strap includes the resistance of the groundable point on the end of the cord, the cord itself, the resistor, the cord-to-cuff snap connector, the resistance of the interface of the cuff, the cuff/wrist interface, and the resistance of the person between the wrist and the hand that contacts the test electrode."

To minimize accidental disconnects, the coil cord should be attached to the wrist band so a one pound force will not cause a break in the connection to ground. Periodically, wrist straps should be checked verifying meeting ESD S1.1 paragraph 5.4 Breakaway Force: "with the ground cord connected to the cuff in a normal manner, a force of >1 pound but < 5 pounds applied to the ground cord, in the normal disconnect direction, shall be required to separate the ground cord from the cuff."

Per ESD Handbook TR 20.20 paragraph 5.3.2.2.2 Wrist Strap Ground Cord, "at first glance, the ground cord appears to be a relatively simple assembly. However, the design requirements are considerable, given the wide range of user applications and the durability requirements of constant tugging, flexing, and dragging over the edge of workstation tops and equipment chassis."

Superior Solution: Use continuous monitors that will alarm if the person or worksurface is not properly grounded. Some monitors will beep if a discharge occurs or when a certain voltage level of electrostatic charge is on the person.

Per ESD Handbook TR 20.20 paragraph 5.3.2.4.4 Test Frequency, "because wrist straps have a finite life, it is important to develop a test frequency that will guarantee integrity of the system. 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 knowledge of a continuous, reliable ground is needed, and then continuous monitoring should be considered or even required." Per ESD-S1.1 paragraph 6.1.3 Frequency of Functional Testing, "daily [wrist strap] testing may be omitted if constant monitoring is used."

Insulators

Problem: Common items, which are insulators, are at the ESD protective workstation.

Solution: Remove the non-essential insulators, and neutralize with ionization those items that are process-essential insulators.

Non-essential insulators at the ESD protective workstation might include regular packaging, document holders, binders & tape. In addition, workers like to personalize their work areas so they might have high charging plastics in the form of radios, picture frames, purses, drinking cups, etc. on the bench. These should be a minimum of 12" from ESDS items.

Per ANSI/ESD S20.20 Paragraph 6.2.3.1. Protected Areas Requirement, "all nonessential insulators, such as those made of plastics and paper (e.g. coffee cups, food wrappers and personal items) must be removed from the workstation. Ionization or other charge mitigating techniques shall be used at the workstation to neutralize electrostatic fields on all process essential insulators if the electrostatic field is considered a threat.

Per ESD Handbook TR 20.20 paragraph 2.4, "it should be understood that any object, item, material or person could be a source of static electricity in the work environment. Removal of unnecessary nonconductors, replacing nonconductive materials with dissipative or conductive materials and grounding all conductors are the principle methods of controlling static electricity in the workplace, regardless of the activity."

The list of potential problems goes on:

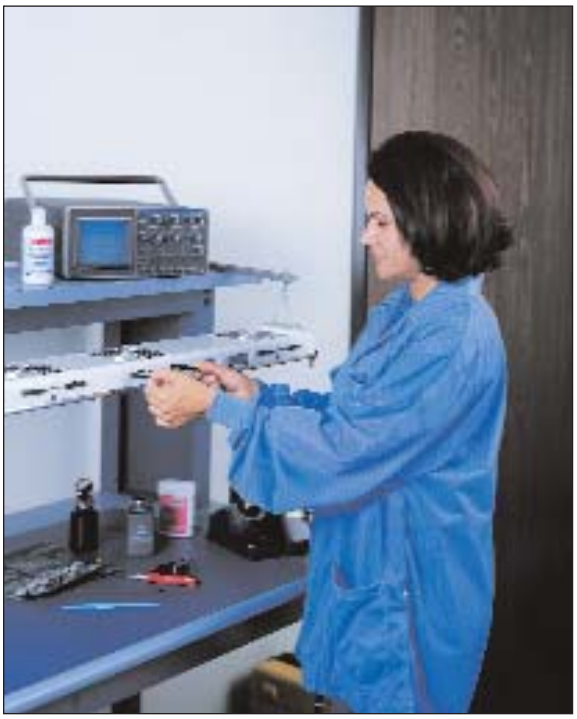
Company buys foot grounders, but the operator cuts off the grounding tab.

Shelves for storing ESD sensitive items not electrically connected.
Electrical outlet or power strip not wired correctly.
People entering ESD protected area are not using proper precautions.
People are "trained" but not tested to determine retention level.
Workers are not clear where boundaries of ESD protected area are.

Summary

It's not a pretty sight to see money thrown away, but this is the effect if ESD protective products are not used properly and not used as an overall system. It gets worse when the focus becomes reducing the pricing of items to save pennies. The real focus should be on the development of a complete ESD control program system and using ESD control products properly.

This focus can turn the ESD control program into a competitive advantage. Top companies improve productivity, quality, and customer satisfaction. They obtain financial returns of 50%, 100%, 200% ROI, and up to 1,000% ROI has been achieved and documented. An effective ESD control program is not rocket science. But it does require knowledge, discipline, periodic verification and using ESD protective products as a comprehensive system. ■



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