DVD-75C
Ray's ESD Prevention Secrets

Below is a copy of the narration for DVD-75C. The contents for this script were developed by a review group of industry experts and were based on the best available knowledge at the time of development. The narration may be helpful for translation and technical reference.

Introduction

Before we let you in on Ray's ESD prevention secrets, let's review what we know about ESD. ESD stands for Electro Static Discharge. ESD is the sudden transfer, or discharge of electricity from one object to another. Lightning discharging from a thundercloud into the earth is an extreme example of electrostatic discharge. Another example is the electric shock we sometimes feel after walking across a carpet and touching a doorknob.

These examples of ESD – which we can see and feel – last for a fraction of a second and contain anywhere from about 2,000 volts – the lowest level most people can feel – to over 25,000 volts. However, even below 2,000 volts there is still enough static electricity to cause static discharge and damage electronic circuits even when we don't feel it. The point is that we're generating ESD all the time. And a lot of common objects around us can be sources of static electricity too. In fact, static zaps under 20 volts are capable of damaging, or destroying some of the sensitive electronic components we handle every day.

So we can better understand what we're dealing with, let's examine the basic physics of ESD. When there is an *imbalance* of electrons on the surface of a material, an *electrical field* is produced. This field can be measured and can influence other objects in the near vicinity. Whenever two materials, such as nylon and polyester, are brought into contact with each other and are then *separated*, the two materials become electrically charged. The charge is evident in that it may cause the hair on your arm to stand up.

When two corks are charged by these nylon stockings, the corks will repel each other. On the other hand, when one cork is charged by the nylon and the other cork is charged by polyester, the corks will attract each other. In other words, we can see that like charges repel while opposite charges attract. These charges are referred to as "static" or static electricity. The word static means "at rest" – so we can say the electrical charge is just sitting on the item – waiting for an opportunity to move.

Creating electrostatic charge by contact and separation of materials is known as *triboelectric charging*. It involves the transfer of electrons between materials. The charge may be positive, negative or neutral. In the atomic model, protons are positive and reside in the nucleus. Electrons are negative and orbit the nucleus. When the two materials are placed in contact and then separated, negatively charged electrons are transferred from the surface of one material to the surface of the other material.

Which material loses electrons and which gains electrons will depend on the nature of the two materials. The material that loses electrons becomes positively charged, while the material that gains electrons is negatively charged. A charge is neutral when there are an equal number of protons and electrons. An example of a material that is usually positively charged is *nylon*. A material that is usually negatively charged is *polyester*. *Cotton* is an example of a *neutral* material.

Now, let's return to our discussion of ESD. Whenever two objects with different charges come close together, static electricity may rapidly move from one object to another. This rapid movement of the electrical charge changes it from static electricity to ESD.

It is important to understand how certain materials behave with these electrostatic charges. We'll separate them into three categories. The first material we'll talk about is a *conductor*. Conductors are typically some type of metal, like a piece of wire. The term *conductor* means that this material will conduct electricity. It will freely allow the movement of electrons through it. This will enable us to use *grounding* techniques to eliminate charges. *Grounding* means providing a path for the extra charges to flow into the earth, leaving the material with a neutral charge.

The second material is called an *insulator*. Insulators *prevent* the flow of electricity. The third material is called partially conductive. Materials that are partially conductive fall somewhere in between conductors and insulators. They are conductors, but not very *good* conductors. For example, static dissipative materials are classed as partially conductive. They will allow grounding techniques to be used, but electrical charges are drained slowly. This is actually a *desired feature* in many cases since draining charges *slowly* minimizes the chances of damaging electronic components.

People are one of the biggest causes of ESD. That's because our bodies easily pick up static electricity. In fact, our skin can store relatively large amounts of this electric charge. When you're working in electronics assembly, ESD is one of the most serious problems you'll be facing. If it isn't controlled, the results are higher costs and dissatisfied customers – especially if a product fails at a critical time. On the other hand, controlling ESD means fewer repairs – so expenses can be kept down. This usually leads to increased customer satisfaction and sales – which is a win-win situation for everyone.

Now that we've reviewed ESD, it's time to let you in on some important secrets for preventing ESD. These come straight from the lips of our good friend Ray. Now that we've reviewed ESD, it's time to let you in on some important secrets for preventing ESD. These come straight from the lips of our good friend Ray.

We'll be discussing Ray's ESD prevention secrets by category – including personal grounding, clothing, packaging, ESD safe areas, static generating materials, static producing activities, handling and ESD training.

Personal Grounding

Let's begin with personal grounding. Everyone who works in electronics assembly knows how important wrist straps and shoe grounders are for controlling ESD. Operators and technicians are also aware of the need to test personal grounding equipment often. The idea behind personal grounding is to drain off charges in a controlled manner before they reach sensitive devices. To do that, all conductive surfaces *and* our bodies need to be connected to a common grounding point. If a static charge comes into contact with any partially conductive surface, this contact safely channels the charge away from ESD sensitive devices and neutralizes them into the earth, or "ground."

Wrist straps are very effective for any operation where people are seated at workstations. Shoe grounders are not as effective when seated because we may raise our feet and lose contact with the conductive floor. On the other hand, when we're engaged in stand up operations, the long cord from the wrist strap becomes cumbersome, or even impossible to use if we must move around a lot.

Wrist straps should be worn snugly against bare skin. They should be attached securely to a ground wire with a current limiting resistor and some form of quick connect/disconnect. Shoe grounders should be worn so that one end is in contact with your sock and the other end is in contact with the floor. The moisture from your sock aids in completing the electrical connection from your body to ground.

It's also very important to follow your company's policy for testing shoe grounders and wrist straps at regular intervals. With some testers, you'll need to test each foot separately. That's because they only have a single foot plate – and testing both feet at the same time will not cause a failure in one strap unless both straps fail. Some testers have the capability of testing both feet at the same time.

While testing wrist straps, it's important to shake your wrist to check for intermittent failures. Intermittent failures may indicate that the strap is not fitted or sized correctly – or that there is a problem with the attachment point.

Wearing defective personal grounding equipment will cause ESD problems – and we won't even know it. If we're lucky, the circuit board assembly will fail electrical test – and the component can be replaced. The biggest problem occurs when the component is weakened and *passes* electrical test. The circuit board assembly is then installed in the final product – and the product is sold. At some point the ESD damage causes the component to fail – resulting in an unhappy and frustrated customer.

Now that we've reviewed what you've been taught about personal grounding equipment, we'll let you in on a couple of secrets. Sometimes when we check our grounding equipment, the tester indicates a failure, but the wrist or heel strap may not actually be defective. Ray's first secret involves finding out the truth of the situation. Try rubbing some ESD hand lotion on the bottom of your foot, or on the grounding strap and then test the shoe grounders again.

Aha! They're suddenly working. That's because the grounding straps need a little moisture to work properly. This can be especially true at the beginning of your shift – before your feet or wrists have accumulated moisture. You can also use this secret if your wrist strap fails.

Now, we'll tell you about Ray's second personal grounding secret – *continuous monitoring*. Unfortunately, wrist straps typically don't fail just *before* you test them. That means that they can fail *while* you are working with ESD sensitive devices. The solution to this problem is the use of *continuous monitoring*. The continuous monitoring device contains an alarm that immediately notifies an operator when either the wrist strap or workbench does not comply. Continuous monitors do not work for shoe grounders.

Clothing

Now, let's discuss static generating clothing. As you know, one obvious remedy to charge producing clothing is to wear a conductive smock. Conductive smocks not only cover static generating clothing, but also help drain any charges harmlessly to ground. It's important to completely button the smock so that it will be more effective at reducing any charges from your clothing. Rolled up sleeves look cool, but clothing on your arms will normally get closer to the product than other areas of your clothing.

Occasionally, ESD garments can become worn or soiled. Make sure that your smock is maintained and cleaned in accordance with your company's specific guidelines.

Not all companies require that conductive smocks be worn in ESD protected areas. When conductive smocks are worn, they are very effective at reducing or eliminating the ESD risk that clothing may create. When conductive smocks are *not* used, more care should be given to the type of clothing worn in the work area. Ray's secret is that some clothing, and especially some combinations of clothing, can generate large static charges that can increase the risk of damage to assemblies.

For example, clothes made out of synthetic materials, leathers, furs and wool generate static charges that can damage ESD sensitive devices. That's why selecting your work clothing should not be based on making a fashion statement.

For example, a leather coat and a teflon shirt should not be worn together. If we review the triboelectric table, we can see that these items are at opposite ends of the spectrum and can generate very large static charges when brought into contact and then separated. A good choice is clothing made of *cotton* – which is a more neutral material – and won't generate the large static charges.

Packaging

At this point, let's turn our attention to packaging secrets. We'll start by taking a look at ESD packaging. All ESD sensitive items need to be stored and transported in static dissipative or static shielding containers. These bags or boxes will provide some level of ESD protection around the device.

One of Ray's packaging secrets is that not all packaging provides the same level of protection. For example, *anti-static*, or *static dissipative* packaging – such as this anti-static cushioning material – does not generate or hold a charge. But it won't protect the enclosed product from a charge that comes from another source.

On the other hand, *static shielding* packaging actually protects the ESD sensitive device from static discharge. The charge will not be able to penetrate the packaging. Static shielding materials can be quite expensive. This is why many companies use a combination of static shielding materials and anti-static, or static dissipative materials for both protection against ESD and physical cushioning.

Another secret is that static shielding packaging doesn't work unless it is closed and properly sealed. Carrying a circuit board assembly on top of ESD packaging, or using the ESD bag the way you'd use a potholder are not safe practices. That's because the assembly is still exposed to ESD hazards.

The point is that bags or other types of packaging have to form a Faraday cage – meaning the product must be fully enclosed – with absolutely no openings.

ESD Safe Work Areas

Next, let's reveal some ESD safe work area secrets. What characterizes an ESD safe work area is the use of static dissipative materials – such as work surfaces, floors and containers – that conduct electricity slowly enough to leave ESD sensitive devices undamaged – even when the devices have become charged.

Inside the boundaries of the ESD safe work area, you are responsible for following and enforcing your company's policy on ESD control. This is the basis of our first secret – that not everybody who visits your area knows what they are doing. That's why it's important to make sure that only authorized and trained personnel are allowed into your area.

Our other secret has to do with leaving the ESD protected area. When you go into a non-ESD protected area, your shoe grounders stop working as intended. What this means is that product should only come out of its packaging when it arrives at an ESD safe area.

For example, you may be carrying a tote with ESD sensitive assemblies and components and you realize you forgot to plug a component into a socket. You stop at the first available location, set

the assembly on a clean surface and plug in the component. There should be no problem. After all, you're wearing shoe grounders.

But the shoe grounders only work with conductive flooring – and because this is a non-ESD safe work area, your body probably has a static charge that can now discharge rapidly. This rapid transfer of a charge to a conductive surface may cause damage to the ESD sensitive components and assemblies.

Static Producing Materials

Many common office materials might appear harmless, but they can cause an ESD event. These materials can generate and hold static charges -- thereby creating charged fields. For example, when a charged object, such as these plastic safety glasses, is brought close to an ESD sensitive device, the electric field causes *charge separation* in the ESD sensitive device. If the ESD sensitive device then comes in contact with a conductive item while exposed to the field, the device can be damaged.

The best remedy for this problem is to completely eliminate these types of non-conductive materials from the workstation. This includes common plastics such as hairbrushes and tape dispensers; styrofoam food and beverage containers; vinyl binders; post-it notes and other paper products; plastic pens; bubble wrap; and equipment with plastic housings. This also includes items you may bring in to decorate your work area – like family photos in plastic frames and balloons. Even plants and flowers.

One secret is that routing sheets and other important paperwork that travels with the job may cause ESD problems. The paper itself may be a static generating source. But what's worse is that many plastic document protectors can generate significant static charges. Documents in their plastic protectors may be placed directly on top of the product, creating a significant hazard. The solution is to substitute the normal plastic document protector with an ESD safe document protector. Similarly, depending on the level of protection required, it may be beneficial to replace many frequently used items such as water bottles, flux bottles and tool boxes with ESD safe versions of the same items. Many vendors will be able to advise you on ESD safe alternatives. And when it comes to post-it notes, they are *never* acceptable – no matter what color you're using.

In addition, tape and other adhesive backed materials such as labels are very common and may put our electronics assemblies at risk. Some of these tapes create enormous static charges when used. Another of Ray's secrets is that just because your supervisor gives you some tape doesn't mean that it is ESD safe. Traditional cellophane tape creates large static charges when it is pulled from the dispenser or reel, but many people think that high temperature tape, such as polyimide/Kapton, is ESD safe. Not at all – as you can see. There *are* tapes that are specifically designed to be used in an electronics manufacturing environment and they do not create static charges when used.

When static generating materials are necessary for your job, we have some secrets for reducing the effect that these items might have at the workstation. For example, anti-static solution may be applied to tools and plastic housings on equipment. Air ionizers can also help neutralize charges. This machine blows ionized air into the work area to help neutralize any positive or negative charges that accumulate on non-conductive items, or items that are not connected to ground.

Your company may also use a humidity control system in the manufacturing area. These systems work by ensuring that the humidity does not drop to a low enough percentage to increase the risk of an ESD occurrence. As the humidity decreases and the air gets dryer, it becomes much easier to generate a static charge.

But, as we mentioned earlier, the *real* secret to dealing with static producing materials is to *eliminate* as many of these materials from your work area as possible.

Static Producing Activities

The way we work can also have an impact on how ESD is controlled. Many of our habitual activities can generate static charges that can damage ESD sensitive devices. For example, sometimes we get so busy that we leave clutter around our workstations. But this clutter can lead to conditions that cause an ESD event. Ray's secret for minimizing this potential problem is to do some housekeeping every day.

Another secret for controlling ESD involves being aware of how we move as we work. Ray suggests that we not rub our hands together, raise our arms, shift our feet or legs and put on or take off smocks around ESD sensitive devices. These movements generate charges that can damage sensitive components and assemblies. Ray likes to tell a story about an inspector whose dream was to be a ballerina. She'd be listening to the Nutcracker on her i-pod and her arms and feet would be moving all over the place.

Our final secret has to do with grooming. The desire to comb your hair is a good one – but not at your workstation. Combing hair is a generator of static electricity and should be avoided. Another story involves a test technician who was in a reggae band. He'd be constantly experimenting with different hairstyles while working on assemblies. Definitely not a safe practice.

Handling

It's important to realize that improper handling of ESD sensitive items – even *when* you're properly grounded and doing your job at an ESD safe workstation – can cause damage to components and assemblies. The first secret for proper handling of components and assemblies is to minimize handling as much as possible. Whenever possible, use a vacuum pick to move a component from one location to another.

If you have to move a component with your hand, never slide it across a work surface. This movement generates static charges and can damage the component. The secret to moving a component is to pick up the component, move it, then set it down. You should always set it down on a *static dissipative* surface – which allows any built up charge to discharge slowly.

Another secret involves *how* you pick up the component. It's important to handle the body of the component rather than the leads. The leads are the most conductive pathway for an ESD zap. In terms of circuit board assemblies, it's important to handle them only by the edges – minimizing contact with any conductive surface. Because all the components are connected, ESD damage to one component can spread to others.

ESD Training

Ray made sure he saved his favorite ESD secret for last. As you probably know, every company's approach to ESD control is different. Management may put up signs for ESD safe areas; may put labels on ESD sensitive devices; and may provide training to its employees. Engineering may monitor the humidity in a facility; use air ionizers and other charge controlling methods; install static dissipative floors and work surfaces; and provide state-of-the-art personal grounding equipment.

Ray's secret is that employee training is at the top of the list because controlling ESD won't really work without the complete participation and cooperation of every employee. Again, that's because the most common type of ESD damage is related to human contact. One person not following ESD procedures can cause extensive damage.

That's why it's important that employees receive continuing education so that they thoroughly understand the concept of ESD; how ESD can affect sensitive items; and the various techniques that are used to control ESD.

Summary

This program has provided a refresher course on ESD safe practices. Ray let us in on lots of useful secrets for controlling ESD. We discussed personal grounding; static producing clothing; packaging; ESD safe work areas; static generating materials; static producing activities; handling; and the need for regularly scheduled ESD training.
The point is that ESD is *our* responsibility. We need to *wear* the appropriate equipment and to *follow* the proper procedures for handling, storing and transporting ESD sensitive items. And we need to *report* any problems or ESD hazards promptly. In this way, we can make a difference.