DVD-54C
ESD Control

Below is a copy of the narration for the DVD-54C video.. 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.

ESD – the sudden transfer, or discharge of electricity from one object to another.

With lightning -- each flash is an immense discharge of static electricity – from a thundercloud where it has built up, into the earth below. Think about the crackling and sparks that occur when you remove clothes from a dryer. How about the shock you sometimes feel when you walk across a carpet and touch 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, 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. Still -- 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 the sensitive electronic components we handle every day. That transfer of static electricity – whether visible or not – is called electrostatic discharge, or ESD.

This video is about controlling ESD. You'll be introduced to ESD and see how it affects the world of electronics and electronics assembly. Then we'll take a look at how ESD can be controlled in a manufacturing facility – both in the work area and during the handling, storing and transporting of ESD sensitive devices.

Let's begin by looking at how electrostatic charges are generated. Every object has the ability to take on an electrostatic charge. The charge may be positive, negative or neutral. A positive charge means there are more protons than electrons. A negative charge means there are more electrons than protons. A charge is neutral when there are equal numbers of protons and electrons.

Positive or negative charges are usually developed when two objects are separated or moved against each other because the protons and electrons don't transfer equally. When an item has a charge, this charge is called static electricity. The word "static" means "at rest" so we can say that the charge is just sitting on the item – waiting for an opportunity to move.

When two conductive objects with different levels or polarity of charge come close together or in contact with each other, the charge rapidly moves from one object to the other. 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. As with conductors, these materials can also become charged, but grounding techniques will have little to no effect of charge neutralization.

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. The human body, most electronic components and static dissipative materials are classed as partially conductive. They will allow grounding techniques to be used, but electrical charges are drained in a slowly. This is actually a desired feature in many cases since draining charges slowly minimizes the chance of damaging electronic components.

People are the biggest cause 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. Door knobs probably don't mind the spark. But when ESD passes through an electronic device such as an integrated circuit, it can cause serious internal damage to that component – resulting in a scrapped component.

The tiny circuit paths in these sensitive devices can be burned up, or severed by an ESD voltage so small that our sense of touch can't even detect it. Remember, we can only feel discharges above about 2,000 volts, but some ESD sensitive components can be damaged by contact from voltages less than 20 volts. And you won't even know the damage has occurred – but the destruction will exist inside the component.

Even when the device is soldered onto a printed circuit board, it's still not safe. It can be damaged by a discharge that passes through the board's conductive pattern to the ESD sensitive component. The amount of voltage needed to damage or destroy varies from component to component, but as these devices become smaller and more complex, their sensitivity to ESD generally increases.

Sometimes the damage caused by ESD doesn't mean the component will immediately fail. Instead, the assembly passes inspection, gets shipped to a customer – and then fails later on, creating a very unhappy customer. ESD is one of the most serious problems facing the electronics industry today. If it isn't controlled, the results are higher costs, lower product quality and angry customers – especially if a product fails at a critical time.

On the other hand, controlling ESD means product quality can be improved and costs can be kept down. This usually leads to increased customer satisfaction and sales – which is a win-win situation for everyone. Let's stop for a moment to review the information we just covered.

Now that we know what ESD is, and what it can do to the electronic devices we handle, let's look at how ESD can be controlled in the work area. The most important thing we can learn about ESD control is that *we* are the most important part of ESD control.

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 control humidity; utilize air ionizers; and install static dissipative floors and work surfaces. But none of these methods of ESD control really work without the complete participation and cooperation of every employee.

So – since *we* are the main culprits in the destruction of ESD sensitive devices, let's begin by taking a look at what equipment is available to reduce the risk of ESD damage from people. The idea is to drain off charges in a controlled manner before they reach the 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."

There are several methods used to drain off charges that we might carry into an ESD safe area, or that we may generate while doing our jobs. The most common are the wrist strap and heel strap – also known as the shoe grounder. We'll look at the wrist strap first.

Wrist straps are very effective for any operation where people are seated at their workstations. Shoe grounders are not as effective when seated because people may raise their feet when seated and lose contact with the conductive floor. The wrist strap needs to be worn snugly against bare skin. It should be attached securely to a ground wire with a current limiting resistor – and some form of quick connect/disconnect. The current limiting resistor provides a slow controlled drain of any charges to limit the current level and prevent damage when the charge is drained to ground.

Shoe grounders are designed to connect your body through your sock to a conductive floor or mat. Shoe grounders are very effective for stand up operations. This eliminates the problem of a long cord from the wrist strap. Most companies may require the use of two shoe grounders for standing activities and a wrist strap for seated operations.

The strap is adjusted so that one end is in contact with your sock and the other end is in contact with the floor. There is enough moisture in your sock to provide a complete electrical connection from your body to ground. Visitors to ESD safe areas may be provided with disposable shoe grounders – which are worn once, then discarded.

Shoe grounders and wrist straps should be tested at regular intervals to make sure they are working properly. Your company will let you know where and how often you should do this.

When testing shoe grounders, place the foot with the strap on the metal plate and press the test button. The pass light indicates that the device is functioning properly. If wearing straps on both feet, test each foot individually. Testing both feet at the same time will not indicate a failure unless both straps fail.

When testing the wrist strap, remove both feet from the metal plate and use the opposite hand to press the test button. Shake your wrist to check for intermittent failures. If the test results in a "fail high" light, that means that there is not a good ground connection and we may cause ESD damage to the parts. If the test results in a "fail low" light, that means that the ground connection

is too good and may result in electrical shock. If you experience any problem with personal grounding devices, let your supervisor know immediately.

There are other ways of passing charges harmlessly to the ground. Conductive shoes function like heel straps – they provide a conductive path from your body through your sock and shoe to a grounded floor surface. Conductive smocks may be used to cover static generating clothing and drain any charges to ground. It's important to completely button the smock so no part of your clothing is exposed. Similarly, the sleeves should never be rolled up to the point where underlying clothing is exposed..

When conductive smocks are not provided, you'll need to be aware of what you're wearing. Clothing made of cotton, rather than wool or synthetic materials, will help control ESD. Also, you should avoid wearing loose clothing that drapes down and may come into contact with ESD sensitive devices. Let's stop and review the material we just covered.

Now we'll take a closer look at our ESD safe work area. Inside the boundaries of this area, you are responsible for following and enforcing company policies on ESD control. One way of controlling ESD in your work area is to eliminate or reduce the number of static generating materials. What we're talking about here are common plastics such as hairbrushes and tape dispensers; paper products; and styrofoam food and beverage containers. These types of non-conductive materials tend to generate and hold static charges – thereby creating electric fields.

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.

Here are some examples of non-conductive materials that should be eliminated from your work area whenever possible. If static generating materials are essential for your job, the workstation should be arranged so that static sensitive assemblies are never closer than 12 inches to the static generating materials. There are several methods available for reducing the effect these items will have at the workstation.

For example, you may be required to apply an anti-static solution to these hand tools at regular intervals. Air ionizers can also be used to 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.

In addition, humidity control can be used to help limit charge build-up. Not only do ESD problems become much worse when the relative humidity drops to 30% or less, but some anti-static materials become ineffective at low relative humidity. Again, the best ESD control solution is to eliminate the materials that generate and hold static charges.

In spite of all precautions, ESD sensitive devices will sometimes become charged. Therefore, it's important that they are not allowed to discharge rapidly – since the rapid transfer of a charge to a conductive surface may cause damage. The material used to eliminate those harmful discharges is called *static dissipative* and may be found in various work surfaces, floors and containers. These materials conduct electricity – but do it slowly enough to leave the ESD sensitive device undamaged.

The static dissipative work surface is most commonly used in this type of ESD control. If an ESD sensitive device becomes charged and is placed on this surface, the charge will flow between the device and the surface at a rate that will not harm the component. On the other hand, this metal work surface is a good conductor of electricity – meaning that the electrostatic discharge will happen too quickly and may damage the device.

We've just looked at a number of ways to control ESD in our work area. ESD control works most effectively when you *assume* that all the components and assemblies that you handle are ESD sensitive – even when they're not. ESD sensitive devices should be properly labeled, but sometimes someone forgets. That's why it's important to get in the habit of performing all activities with ESD safe practices.

Another way to control ESD in the work area is to avoid activities that generate charges. These include shuffling our feet when walking, combing hair or touching static generating materials. And don't allow anyone who isn't properly grounded into your work area. Let's stop again to review the material we just covered.

Our last section deals with protecting ESD sensitive devices during handling and when we transport them from one ESD safe area to another. We've already learned how to protect these devices from the static fields and uncontrolled discharges in the work area.

Whether you're performing incoming inspection, storing items in the stockroom, kitting, doing assembly operations or testing and troubleshooting, here are some tips for the safe handling of ESD sensitive devices.

Handle components, such as integrated circuits, by a non-conductive portion of the body rather than the leads. The leads are the most conductive pathway for an ESD event. The body of the component is less likely to provide a pathway for an ESD zap.

Place the device with the leads down on a static dissipative surface. This way the component leads are all at the same electrical potential. Don't slide the device over any surface. Sliding can also generate static charges. And avoid any extra movements when handling the device. Again, this repeated touching and separating can generate charges.

When handling electronic assemblies, it's important to hold them only by the edges – minimizing contact with any conductive surface. Because components are connected, ESD damage to one component can easily spread to others. The key point for handling is to minimize handling of ESD sensitive items as much as possible.

All ESD sensitive items should be stored and transported in static dissipative, or static shielding containers. These special bags or boxes will provide some level of ESD protection around the device. Anti-static, or "pink poly" packaging only serves to reduce charge generation, and does not provide static shielding. These materials depend on humidity in the air and are not considered protective unless used along with static shielding packaging. The highest level of protection can be obtained by a combination of the different materials.

It's important to use clean containers that are the proper size for the device and is clearly marked for ESD sensitive items. Use only approved packaging materials. Also, make sure the device is completely inside the container and that the container is closed. Make it a habit to not leave the item on top of, or next to the container. When transporting the ESD sensitive items, use push carts

or racks that are designed for ESD sensitive devices. Again, your company will explain its policy regarding handling, storing and transporting ESD sensitive devices.

This program has presented the details of controlling ESD during electronics assembly. First, we discussed static electricity and took a look at how poor ESD practices can affect electronic components. Then we examined the ways of controlling ESD in our work area. This included wearing and testing our ESD personal equipment; removing unnecessary materials; using static dissipative materials; and avoiding activities that cause ESD. We know that the best way to control static charges is to prevent their formation whenever possible. We concluded with a discussion on the proper handling, storage and transport of ESD sensitive devices.

ESD is your responsibility. You need to wear the appropriate equipment and to follow the proper procedures for handling, storing and transporting ESD sensitive devices. And you need to report any problems or ESD hazards promptly. In this way, you can make the difference.