Fundamentals of Electrostatic Discharge

Part Two—Principles of ESD Control

In Part One of this series, Introduction to Electrostatic Discharge, we discussed the basics of electrostatic charge, discharge, types of failures, ESD events, and device sensitivity. We concluded our discussion with the following summary:

1. Virtually all materials, even conductors, can be triboelectrically charged.
2. The level of charge is affected by material type, speed of contact and separation, humidity, and several other factors.
3. Electrostatic fields are associated with charged objects.
4. Electrostatic discharge can damage devices so they fail immediately, or ESD may result in latent damage that may escape immediate attention, but cause the device to fail prematurely once in service.
5. Electrostatic discharge can occur throughout the manufacturing, test, shipping, handling, or operational processes.
6. Component damage can occur as the result of a discharge **to** the device, **from** the device, or from charge transfers resulting from electrostatic fields. Devices vary significantly in their sensitivity to ESD.

Understanding these key concepts is crucial to protecting your products from the effects of static damage. Armed with this information, you can then begin to develop an effective ESD control program. In Part Two we will focus on some basic concepts of ESD control.

Basic Principles of Static Control

Sometimes, controlling electrostatic discharge (ESD) in the electronics environment seems to be a formidable challenge. However, the task of designing and implementing ESD control programs becomes less complex if we focus on just six basic principles of control. In doing so, we also need to keep in mind the ESD corollary to Murphy's law, "no matter what we do, static charge will try to find a way to discharge."

1. Design In Protection

The first principle is to *design products and assemblies to be as resistant as reasonable* from the effects of ESD. This involves such steps as using less static sensitive devices or providing appropriate input protection on devices, boards, assemblies, and equipment. For engineers and designers, the paradox is that advancing product technology requires smaller and more complex geometries that often are more susceptible to ESD. Recent (2009) published work by the Industry Council on ESD Targets and the ESDA Technology Roadmap suggest that designers will have less ability to provide the protection levels that were available in the past.

When very sensitive devices must be used and handled, application-specific controls beyond the principles described here may be required.

2. Define the level of control needed in your environment.

What is the sensitivity level of the parts you are using and the products that you are manufacturing and shipping? In order to have complete picture of what is required, it is best to know the Human-Body Model (HBM) and Charged-Device Model (CDM) sensitivity levels for all devices that will be handled in the environment. ANSI/ESD S20.20 defines a control program for items that are sensitive to 100 volts Human Body Model HBM. The procedures in ANSI/ESD S20.20 may need to be tailored or expanded in specific situations.

3. Identify and define the electrostatic protected areas (EPA).

These are the areas in which you will be handling sensitive parts and the areas in which you will need to implement the basic ESD control procedures including bonding or electrically connecting all conductive and dissipative materials, including personnel, to a known ground.

4. Eliminate and Reduce Generation

Obviously, product design will be increasingly less effective in minimizing ESD losses. The fourth Principle of control is to *eliminate or reduce the generation and accumulation of electrostatic charge* in the first place. It's fairly basic: no charge — no discharge. We begin by reducing as many static generating processes or materials, such as the contact and separation of dissimilar materials and common plastics, as possible from the work environment. We keep other processes and materials at the same electrostatic potential. Electrostatic discharge does not occur between materials kept at the same potential or at zero potential. We provide ground paths, such as wrist straps, flooring and work surfaces, to reduce charge generation and accumulation. While the basic principle of reasonable minimization of charging should be followed, complete removal of charge generation is not achievable.

5. Dissipate and Neutralize

Because we simply can't eliminate all generation of static in the environment, our fifth Principle is to *safely dissipate or neutralize those electrostatic charges* that do occur. Proper grounding and the use of conductive or dissipative materials play major roles. For example, workers who "carry" a charge into the work environment can rid themselves of that charge when they attach a wrist strap or when they step on an ESD floor mat while wearing ESD control footwear. The charge goes to ground rather than being discharged into a sensitive part. To prevent damaging a charged device, the rate of discharge can be controlled with static dissipative materials.

For some objects, such as common plastics and other insulators, grounding does not remove an electrostatic charge because there is no conductive pathway. Typically, ionization is used to neutralize charges on these insulating materials. The ionization process generates

negative and positive ions that are attracted to the surface of a charged object, thereby effectively neutralizing the charge.

6. Protect Products

Our final ESD control Principle is to *prevent discharges that do occur from reaching susceptible parts and assemblies*. One way is to provide our parts and assemblies with proper grounding or shunting that will "dissipate" any discharge away from the product. A second method is to package and transport susceptible devices in proper packaging and materials handling products. These materials may effectively shield the product from charge, as well as reduce the generation of charge caused by any movement of product within the container.

Elements of an Effective ESD Control Program

While these six principles may seem rather basic, they can guide us in the selection of appropriate materials and procedures to use in effectively controlling ESD. In most circumstances, effective programs will involve all of these principles. No single procedure or product will do the whole job; rather effective static control requires a full ESD control program.

How to we develop and maintain a program that puts these basic principles into practice? How do we start? What is the process? What do we do first? Ask a dozen experts and you may get a dozen different answers. But, if you dig a little deeper, you will find that most of the answers center on similar key elements. You will also find that starting and maintaining an ESD control program is similar to many other business activities and projects. Although each company is unique in terms of its ESD control needs, there are at least 6 critical elements to successfully developing and implementing an effective ESD control program.

1. Establish an ESD Coordinator and ESD Teams.

A team approach particularly applies to ESD because the problems and the solutions cross various functions, departments, divisions and even suppliers in most companies. Team composition includes line employees as well as department heads or other management personnel. The team may also cut across functions such as incoming inspection, quality, training, automation, packaging, and test. ESD teams or committees help assure a variety of viewpoints, the availability of the needed expertise, and commitment to success. An active ESD committee helps unify the effort and brings additional expertise to the project.

Heading this team effort is an ESD Program Coordinator. Ideally this responsibility should be a full-time job. However, we seldom operate in an ideal environment and you may have to settle for the function to be a major responsibility of an individual. The ESD coordinator is responsible for developing, budgeting, and administering the program. The coordinator also serves as the company's internal ESD consultant to all areas.

2. Assess Your Organization, Facility, Processes and Losses

Your next step is to gain a thorough understanding of your environment and its impact on ESD. Armed with your loss and sensitivity data, you can evaluate your facility, looking for areas and procedures that may be contributing to your defined ESD problems. Be on the lookout for things such as static generating materials and personnel handling procedures for ESD-sensitive items.

Document your processes. Observe the movement of people and materials through the areas. Note those areas that would appear to have the greatest potential for ESD problems. Remember, that ESD can occur in the warehouse just as it can in the assembly areas. Then conduct a thorough facility survey or audit. Measure personnel, equipment, and materials to identify the presence of electrostatic fields in your environment.

Before seeking solutions to your problems, you will need to determine the extent of your losses to ESD. These losses may be reflected in receiving reports, QA and QC records, customer returns, in-plant yields, failure analysis reports, and other data that you may already have or that you need to gather. This information not only identifies the magnitude of the problem, but also helps to pinpoint and prioritize areas that need attention. Where available, the potential for future problems as a result of technology roadmaps and internal product evolution should be considered.

Document your actual and potential ESD losses in terms of DOA components, rework, customer returns, and failures during final test and inspection. Use data from outside sources or the results of your pilot program for additional support. Develop estimates of the savings to be realized from implementing an ESD control program.

You will also want to identify those items (components, assemblies, and finished products) that are sensitive to ESD and the level of their sensitivity. You can test these items yourself, use data from suppliers, or rely on published data for similar items. However, estimates can be wrong when the person making the estimate doesn't have enough information. In general, two functionally identical items from two different suppliers may *not* have similar ESD ratings.

3. Establish and Document Your ESD Control Program Plan

After completing your assessment, you can begin to develop and document your ESD control program plan. The plan should cover the scope of the program and include the tasks, activities and procedures necessary to protect the ESD sensitive items at or above the ESD sensitivity level chosen for the plan. Prepare and distribute written procedures and specifications so that everyone has a clear understanding of what is to be done. Fully documented procedures will help you meet the administrative and technical elements of ANSI/ESD S20.20, help you with ISO 9000 certification as well.

4. Build Justification to Get the Management Support Top Management

To be successful, an ESD program requires the support of your top management, at the highest level possible. What level of commitment is required? To obtain commitment, you will need to build justification for the plan. You will need to emphasize quality and reliability, the costs of ESD damage, the impact of ESD on customer service and product performance. It may

be useful to conduct a pilot program if the experience of other companies is not sufficient and you have an expectation that you can show meaningful results in the pilot.

Prepare a short corporate policy statement on ESD control. Have top management co-sign it with the ESD coordinator. Periodically, reaffirm the policy statement and management's commitment to it.

5. Define A Training Plan

Train and retrain your personnel in ESD and your company's ESD control program and procedures. Training should include testing to verify comprehension. Proper training for line personnel is especially important. They are often the ones who have to live with the procedures on a day-to-day basis. A sustained commitment and mindset among all employees that ESD prevention is a valuable, on-going effort by everyone is one of the primary goals of training.

6. Develop and Implement a Compliance Verification Plan

Developing and implementing the program itself is obvious. What might not be so obvious is the need to continually review, audit, analyze, feedback and improve. Auditing is essential to ensure that the ESD control program is successful. You will be asked to continually identify the return on investment of the program and to justify the savings realized. Technological changes will dictate improvements and modifications. Feedback to employees and top management is essential. Management commitment will need reinforcement.

Include both reporting and feedback to management, the ESD team, and other employees as part of your plan. Management will want to know that their investment in time and money is yielding a return in terms of quality, reliability and profits. Team members need a pat on the back for a job well done. Other employees will want to know that the procedures you have asked them to follow are indeed worthwhile. It is helpful to integrate the process improvement process into the overall quality system and use the existing root cause analysis and corrective action infrastructure.

Conduct periodic evaluations of your program and audits of your facility. You will find out if your program is successful and is giving you the expected return. You will spot weaknesses in the program and shore them up. You will discover whether the procedures are being followed. As you find areas that need work, be sure to make the necessary adjustments to keep the program on track.

Conclusion

Six principles of static control and six key elements to program development and implementation are your guideposts for effective ESD control programs. In Part Three, we'll take a close look at specific procedures and materials that become part of your program.

For Additional Information

ANSI/ESD S20.20—Standard for the Development of Electrostatic Discharge Control Program, ESD Association, Rome, NY

Dangelmayer, Theodore, *ESD Program Management: A Realistic Approach to Continuous, Measurable Improvement in Static Control*, 1999, Kluwer Academic Publishers, Boston, MA

ESD TR20.20, ESD Control Handbook, ESD Association, Rome, NY.

ESD TR53, Compliance Verification of ESD Protective Equipment and Materials

Industry Council White Papers I & II

ESDA Technology Roadmap