Companies having products that include electronics have to deal with ElectroStatic Discharge (ESD) that cause serious and costly damage to electric circuitry. If failures occur intermittently, it can be quite frustrating. The solution is to develop a quality ESD control program. Best practice is to have the program be in accordance with an international standard such as the ESD Association ANSI/ESD S20.20 “For the Development of an Electrostatic Discharge Control Program for – Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)” which focuses on the requirements for an ESD control program.

Guidance should be obtained from the ESD Handbook ESD TR20.20 particularly section 4.1.3 “Initial Process and Organizational Assessment”. Per section 5.3.4.1 “The principal cause of static electricity is frequently cited as the movement of people and materials in the work environment. This routine movement, particularly the contact and separation of shoe from floor, generates charges as high as several thousand volts. Similarly, the movement of mobile carts or other equipment will generate electrostatic charge.” This is static electricity at rest, but a rapid, spontaneous transfer of electrostatic charge can occur between two bodies at different electrostatic potentials as they approach one another. This is ElectroStatic Discharge or ESD which can damage electronic circuitry designated as ESD sensitive (ESDS) items.

According to ANSI/ESD S20.20 Foreword: “Any relative motion and physical separation of materials or flow of solids, liquids, or particle-laden gases can generate electrostatic charges. Common sources of ESD include personnel, items made common polymeric materials, and processing equipment. ESD damage can occur when:

- a charged object comes into contact with an ESDS device, or
- An ESDS device is grounded while exposed to an electrostatic field.

The ESD control program should be sufficiently robust to eliminate ESD related latent defects which by definition cannot be detected by normal inspection. Like germs and sterilization in a hospital operating room, factories handling electronic components have to deal with a hidden enemy. Typically, ESD events cannot be seen or felt. The discharge, literally a small lightning bolt, happens quickly often in less than a nanosecond, but can have a peak current of several amperes. Its heat can damage an electronic component’s microelectronic structure. Each of us have felt a “zap” which typically requires an ESD event of about 2,000 or 3,000 volts. ESD events that you cannot see or feel can damage many electronic components which can have ESD susceptibility or withstand-voltage rating of 50 volts HBM (human body model) or even lower.

According to the ESD Association’s “Electrostatic Discharge (ESD) Technology Roadmap – Revised April 2010” “With devices becoming more sensitive through 2010-2015 and beyond, it is imperative that companies begin to scrutinize the ESD capabilities of their handling processes. Factory ESD control is expected to play an ever-increasing critical role as the industry is flooded with even more HBM (Human Body Model) and CDM (Charged Device Model) sensitive designs.”

ANSI/ESD S20.20
A must is to download at no charge from www.ESDA.org a copy of the ANSI/ESD S20.20 standard. It is also recommended to download at no charge “Compliance Verification of ESD Protective Equipment and Materials” ESD TR53, and to purchase the ESD Handbook ESD TR20.20.

According to the ANSI/ESD S20.20 Foreword “This standard covers the requirements necessary to design, establish, implement and maintain an Electrostatic Discharge (ESD) Control Program for 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 greater than or equal to 100 volts Human Body Model (HBM). This document covers the ESD Control Program requirements”.

Circuit Protection Using ESD Control Program per ANSI/ESD S20.20
by Gene Felder Desco Industries, Inc.
ESD Coordinator and Management

The ESD control plan should be a numbered company controlled written document having configuration management revisions controlling changes, and being approved by senior management.

Per ANSI/ESD S20.20 section 6.2 “An ESD Control Program Manager or Coordinator shall be assigned by the Organization to verify the compliance of the Program in accordance with the requirements of this document.” A good idea is to form an ESD committee with representatives from other departments to improve and make changes to the ESD control program.

An effective ESD control program requires the support of senior management. In order to be effective the ESD coordinator needs access to measuring equipment for the purposes of performing compliance verification audits as well as testing new ESD products and materials for use in the ESD program. Management must provide the ESD coordinator with the authority and funding necessary to ensure that the ESD control program is maintained and enforced.

Withstand Voltages – ESD Sensitivity

An ESD control plan should be based on the withstand voltage of the most susceptible components used in the facility or work cell. Examples of ESD susceptible parts are microcircuits, discrete semiconductors, thick and thin film resistors, hybrid devices, and piezoelectric crystals. Many users assume all semiconductor electronic devices to be ESD sensitive. ANSI/ESD S20.20 is based upon handling items susceptible to damage by ESD greater than or equal to 100 volt human body model (HBM). If more sensitive items are to be handled, the program may require additional control elements or adjusted limits. Per section 6.1 “the most sensitive level of the items to be handled, in accordance with the Program, shall be documented.”

Writing the Program

Write an ESD control program plan per ANSI/ESD S20.20 ESD Control Program Requirements section 6.1 “the Program shall include both administrative and technical requirements as described herein. … The Organization shall establish, document, implement, maintain and verify the compliance of the Program in accordance with the requirements of this document.”

The plan is to include personnel ESD control training, both initial and refresher training, compliance verification that the plan is being followed, and a list of the ESD protected area ESD control items to be used along with their technical required limits. It is best practice to list the ESD control products approved for use in the program such as Qualified Products Listing (QPL).

Per ANSI/ESD S20.20 ESD Control Program Plan section 7.1 “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”

The ESD control program is an ongoing effort to identify and eliminate defects, and prevent their introduction to reduce the cost and risk associated with ESD damage.

Training Plan

The written ESD control Training Plan is to include initial and recurrent personnel training having a means to ensure trainee comprehension and training adequacy.

Compliance Verification Plan

The written Compliance Verification Plan specifying frequency and sampling of the auditing of ESD control items. It should require personnel to test grounding devices while worn before starting work each day and should detail the method of maintaining records of the test results.
Grounding
The preferred ground is AC electrical equipment grounding conductor, although if not available, equipotential bonding may be used.

Personnel Grounding
Personnel should be at equipotential when handling ESDS. When seated, they must wear a wrist strap fitting snugly on the skin and have it plugged into a common point ground. An ESD garment may be part of the wrist strap system path-to-ground. Standing personnel may be grounded via a flooring-footwear system which requires ESD flooring and ESD footwear on both feet.

Per ANSI/ESD S20.20 Personnel Safety section 5.0 “The procedures and equipment described in this document may expose personnel to hazardous electrical conditions. Users of this document are responsible for selecting equipment that complies with applicable laws, regulatory codes and both external and internal policy. Users are cautioned that this document cannot replace or supersede any requirements for personnel safety. Ground fault circuit interrupters (GFCI) and other safety protection should be considered wherever personnel might come into contact with electrical sources. Electrical hazard reduction practices should be exercised and proper grounding instructions for equipment shall be followed.”

Although personnel grounding items are to include a minimum of 1 megohm of resistance to limit current to less than 0.25 mA, personnel grounding should not be used if inadvertent contact with voltages greater than 250 VAC is possible.

ESD Protected Area (EPA) Requirements
Signage must make clear where the EPA is. Inside the EPA, all conductors including people are to be grounded. Unnecessary non-conductors or insulators are to be removed from the EPA. Essential non-conductors and isolated conductors are to have charges neutralized using ionizers. It is necessary to test and clean ionizer emitter pins periodically to ensure meeting offset voltage (balance) and discharge times. ESDS should be opened or removed from ESD protective packaging only at an ESD workstation. ESD mats and conductive/dissipative surfaces should be cleaned regularly and only with ESD cleaners that do not leave an insulative residue. Worksurfaces including storage racks and carts are to be grounded and not daisy-chaining should not be permitted.

Packaging Systems
Packaging is to be per ANSI/ESD S541. The requirement is that packaging in the EPA is to be low charging and conductive or dissipative. However the additional ESD control property of discharge shielding is required for ESDS stored or transported outside the EPA.

Marking
Consider requiring marking identifying ESDS using the ESD sensitivity symbol, and consider requiring ESD control items to be marked with the ESD protective symbol.

EPA ESD Control Items Technical Requirements
Each company has flexibility designing its program as ANSI/ESD S20.20 Annex B states “The selection of specific ESD control procedures or materials is at the option of the ESD Control Program Plan preparer and should be based on risk assessment and the established electrostatic discharge sensitivities of parts, assemblies, and equipment.” The written plan is to specify ESD control items to be included in the program such as grounding hardware, wrist straps, worksurfaces, flooring, footwear, packaging, garments, seating, and ionizers.
An ESD control program typically will adopt the required limits listed in the tables of ANSI/ESD S20.20:

<table>
<thead>
<tr>
<th>ESD Control Item</th>
<th>Product Qualification</th>
<th>Compliance Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Groundable points</strong> to Equipment Grounding Conductor</td>
<td>ANSI/ESD S6.1 &lt; 1.0 ohm impedance</td>
<td>ESD TR53 Wrist Strap Section &lt; 1.0 ohm impedance</td>
</tr>
<tr>
<td><strong>Wrist strap system</strong></td>
<td>ANSI/ESD S1.1 &lt; 3.5 x 10E7 ohms</td>
<td>ESD TR53 Flooring Section &lt; 3.5 x 10E7 ohms</td>
</tr>
<tr>
<td><strong>Flooring / Footwear System - Method 1</strong></td>
<td>ANSI/ESD STM97.1 &lt; 100 volts</td>
<td>ESD TR53 Footwear Section &lt; 1 x 10E9 ohms</td>
</tr>
<tr>
<td><strong>Flooring / Footwear System - Method 2</strong></td>
<td>ANSI/ESD STM97.2 &lt; 1 x 10E9 ohms</td>
<td>ESD TR53 Worksurface Section &lt; 1 x 10E9 ohms resistance to ground</td>
</tr>
<tr>
<td><strong>Flooring</strong></td>
<td>ANSI/ESD STM97.1 &lt; 1 x 10E9 ohms</td>
<td></td>
</tr>
<tr>
<td><strong>Flooring / Footwear System - Method 1</strong></td>
<td>ANSI/ESD STM97.1 &lt; 1 x 10E9 ohms</td>
<td></td>
</tr>
<tr>
<td><strong>Flooring / Footwear System - Method 2</strong></td>
<td>ANSI/ESD STM97.2 &lt; 1 x 10E9 ohms</td>
<td></td>
</tr>
<tr>
<td><strong>Footwear</strong></td>
<td>ANSI/ESD STM9.1 &lt; 1 x 10E9 ohms</td>
<td></td>
</tr>
<tr>
<td><strong>Foot Grounders</strong></td>
<td>ESD SP9.2 &lt; 1 x 10E9 ohms</td>
<td></td>
</tr>
<tr>
<td><strong>Flooring</strong></td>
<td>ANSI/ESD STM7.1 &lt; 1 x 10E9 ohms</td>
<td></td>
</tr>
<tr>
<td><strong>Seating</strong></td>
<td>ANSI/ESD STM12.1 &lt; 1 x 10E9 ohms</td>
<td>ESD TR53 Seating Section &lt; 1 x 10E9 ohms resistance to ground</td>
</tr>
<tr>
<td><strong>Ionization other than Room Systems</strong></td>
<td>ANSI/ESD STM3.1 &lt; 10E9 ohms and/or User defined &lt; +/- 50 volts</td>
<td>ESD TR53 - Discharge time &lt; +/- 50 volts</td>
</tr>
<tr>
<td><strong>Ionization (Room Systems)</strong></td>
<td>ANSI/ESD STM3.1 &lt; 1 x 10E9 ohms and/or User defined &lt; +/- 150 volts</td>
<td>ESD TR53 - Discharge time &lt; +/- 150 volts</td>
</tr>
<tr>
<td><strong>Shelving</strong></td>
<td>ANSI/ESD S4.1 &lt; 1 x 10E9 ohms</td>
<td>ESD TR53 Worksurface Section &lt; 1 x 10E9 ohms resistance to ground</td>
</tr>
<tr>
<td><strong>Continuous Monitors</strong></td>
<td>User defined &lt; 1 x 10E11 ohms</td>
<td>ESD TR53 Continuous Monitor Section &lt; 1 x 10E11 ohms</td>
</tr>
<tr>
<td><strong>Garments</strong></td>
<td>Static Control Garment (ANSI/ESD STM2.1) &lt; 1 x 10E11 ohms</td>
<td>ESD TR53 Garments Section &lt; 1 x 10E9 ohms</td>
</tr>
<tr>
<td><strong>Garments</strong></td>
<td>Groundable Static Control Garment (ANSI/ESD STM2.1) &lt; 1 x 10E9 ohms</td>
<td>ESD TR53 Garments Section &lt; 1 x 10E9 ohms</td>
</tr>
<tr>
<td><strong>Garments</strong></td>
<td>Groundable Static Control Garment System (ANSI/ESD STM2.1) &lt; 3.5 x 10E7 ohms</td>
<td>ESD TR53 Garments Section &lt; 3.5 x 10E7 ohms</td>
</tr>
</tbody>
</table>

Product qualification can be based upon product specification review.
Wrist Strap Compliance Verification testing is to be per ESD TR53 which can be a typical wrist strap tester. Alternately, a continuous monitoring system can be used in lieu of the daily testing. Flooring / Footwear System Compliance Verification testing is to be per ESD TR53 which can be a typical footwear tester.

When personnel are grounded via a Flooring / Footwear system, conductive flooring less than $1 \times 10^6$ ohms should be considered to reliably meet the Flooring / Footwear system Method 1 required limit of less than $3.5 \times 10^7$ ohms.

If the garment is used as part of the wrist strap grounding path, a Groundable Static Control Garment System, the total system resistance including the person, garment and grounding cord is to be less than $3.5 \times 10^7$ ohms. Compliance Verification per ESD TR53 can be a typical wrist strap tester.

Electrostatic generating sources, often insulators, should be eliminated if possible. Best practice is to require that nonessential and personal items not be placed on the ESD worksurfaces. All items that generate static voltages of greater than ±2,000 volts need to be kept at least 12 inches away from ESD sensitive items at all times.

**Tailoring**

Per ANSI/ESD Tailoring section 6.3 “This document, or portions thereof, may not apply to all applications. Tailoring is accomplished by evaluating the applicability of each requirement for the specific application. Upon completion of the evaluation, requirements may be added, modified or deleted. Tailoring decisions, including rationale and technical justifications, shall be documented in the ESD Control Program Plan.”

Section 2.0 states “Activities that handle items that are susceptible to less than 100 volts HBM may require additional control elements or adjusted limits.”

**Conclusion**

Electronic component circuitry can be damaged by ESD. To be effective, an ESD control program must be comprehensive and over time be improved. The written plan must be adjusted to suit each company’s specific needs, but is to follow the requirements of ANSI/ESD S20.20. Management support, ongoing personnel training, and periodic compliance verification audits are essential, and then the benefits of optimizing an ESD control program can be considerable. For example, a properly designed and successfully implemented ESD control program can provide a return on investment of up to 1,000% per year. If handling ESDS, companies can turn ESD control programs into a competitive advantage—a strategic tool focused on quality, productivity, reliability and customer satisfaction improvement. A good suggestion is to obtain a second pair of eyes and a review of a current ESD control program, a third party assessment. Desco factory trained sales representatives can perform an ESD Survey to verify program compliance and to make suggestions for improvement.

**References**

5. ESD Association “*Electrostatic Discharge (ESD) Technology Roadmap – Revised April 2010*”

**About the Author**

Gene Felder is the Corporate Product Manager at Desco Industries. Before joining Desco, he was general manager of BW/IP International SR Engineering. Mr. Felder graduated from California State University with a B.A. in business administration and earned an M.B.A. from the UCLA Anderson School of Management. He is a member of the ESD Association serving on a number of Standards Committee working groups. Gene can be reached at Gene.Felder@Desco.com.