ESD “Best Practices”

By Carl Newberg
ESD Association

What does “Best Practice” mean? It boils down to having a quality system that results in having the highest yield and shipping the highest quality product to your customer. In the case of ESD control, it means not only having high yields, but also having no hard or latent defects in the parts that are shipped to customers.

So what does the “best” ESD control program look like?

An excellent first place to start for protecting ESD sensitive devices is to implement a good ANSI/ESD S20.20 static control program. ANSI/ESD S20.20 (hereafter called S20.20) requires that two main areas be specified; Administrative Requirements and Technical Requirements. A careful review of S20.20 will reveal that there is some overlap in the Administrative and Technical Requirements; however they support each other well. The Administrative Requirements define the program and many of its necessary “non-technical” elements (items 1-4 in the list below); the rest (items 5 – 9) are documentation of the technical requirements that make up the program.

The Administrative Requirements as defined in S20.20 start with a definition of an ESD control “Plan.” The “Plan” must have several items documented in it. These are outlined below, with more explanation given in each of them later in the article.

1. Determine the sensitivity of the devices to be protected by the control program
2. Assignment of a program manager or coordinator
3. A Training Plan
4. A Compliance Verification Program
5. A definition of the grounding / equipotential bonding system
6. Documentation of the EPA (Electrostatic Protected Area) elements
7. A definition of the packaging system to be used by the organization
8. A definition of “marking”
9. A tailoring statement if necessary

Device Sensitivity Determination

One of the first steps in developing a high quality ESD control program is to understand how sensitive your products are to electrostatic discharges. It is important to have some idea of both Human Body Model (HBM) and Charged Device Model (CDM) sensitivities because in most cases, these will be very different. While knowing the exact withstand voltage of every device is not necessary, you should know the general sensitivity of the parts being handled. For instance, if one is manufacturing boards with standard CMOS-like components, the typical HBM withstand voltage will usually be in the 1000’s of volts range, and the CDM values will usually be in the 500 - 1500 volt range. This ESD control program would look very different than one in the hard disk drive industry, for example, where handling of parts with reportedly less than 1-volt CDM ESD thresholds is becoming commonplace. The current HBM and CDM test methods loosely classify device sensitivities into categories such as those seen in Table 1. Everyone in the industry has realized that all devices have become more sensitive over the past 20 years, yet the classifications as seen in Table 1 haven't changed. Most ESD practitioners realize that many of the most sensitive parts fit into a sub-set of the most sensitive classifications (HBM Class 0 and CDM Class C1). It is especially important to know if you have any of these more sensitive devices. As far back as the mid-1980's, researchers at AT&T realized they were manufacturing and handling parts well below the lower threshold of the most sensitive ESD classifications used at that time and adopted the phrase "Class 0", which referred mostly to CDM values (even though CDM was a barely heard of ESD failure mechanism at the time). They did this to highlight that these devices needed some extraordinary protection beyond the standard ESD control programs at the time. More recently, this "Class 0" term has been used in various areas of the industry. While some ESD Control practitioners have objected to the use of the term, most who do use the term realize that it simply means "a very sensitive device." While further discussion of the "Class 0" classification is beyond the scope of this article, suffice it to say that if you believe you are handling what the industry has been calling "Class 0" ESDS parts, you will need to, at a minimum, develop a robust ESD control program or you will see yield and reliability issues.

Table 1
Device Thresholds as Specified in ANSI/ESD/JEDEC J1-1 and ANSI/ESD S5.3.1

Voltage Range	HBM Classification	CDM Classification
<125	- -	C1
125 to < 250	0	C2
250 to < 500	1A	C3
500 to < 1000	1B	C4
1000 to < 1500	1C	C5
1500 to < 2000	1C	C6
2000 to < 4000	2	C7
4000 to < 8000	3A	C7
≥ 8000	3B	C7

Assignment of an ESD Program Manager/Coordinator

The organization must document the appointment of a coordinator or manager of the ESD Control program. The purpose of this is to require management to take the ESD control program seriously enough to assign a person to this role. This is similar to the ISO 9001 requirement to assign a quality manager responsible for maintaining the quality system of an organization. The ESD coordinator is the focal point for the management of the ESD control program. This person is not required to have any certain level of training or certification, however additional training in the technical details of ESD and ESD program management would benefit this person and the organization.

Training Plan

The organization must have, and properly document, an ESD Training Program. The method of training, frequency of recurrent training, and location of training records must be documented. In addition, a method of measuring the employee's comprehension of the training material must also be documented. This "test" can be a written test on the job observation or another measurable method. The results of each employees "test" must be recorded and stored along with the training records. The "Training Plan" portion of S20.20 is the most common cause of formal assessment failures during an S20.20 assessment.

Compliance Verification Program

There must also be a documented compliance verification program for the organization. It is well recognized in the industry that ESD control items and procedures lose their effectiveness if they aren't continuously maintained. A well defined and implemented compliance verification program ensures that the ESD control program elements stay working during the life of the program. Some companies have chosen to have the compliance verification done by their own employees, while others have chosen to use outside vendors (such as a calibration test company). In any case, the more complicated the ESD control program, the more attention needs to be paid to the compliance verification program. For instance, a well-known disk drive manufacturer has 4 levels of compliance verification. The first lines of defense are the manufacturing operators. They are trained to do a visual check of their ESD controls at the beginning of each shift. They check not only their own wrist strap, footwear and garment systems, but they also do a visual check of their workstation, looking for ground wires, ionization discrepancies, and non-ESD approved materials. The second level of compliance verification is a department technician that does a daily, weekly, or monthly check of all of the ESD controls. An AQL-type of audit (statistical sampling) may be done on a frequent basis. However, enough items are inspected on a regular basis so that in a specified time frame all of the items are checked. The third level is an audit performed by the ESD Coordinator ensuring that the inspections done by the department technician are being completed, and then spot checking the ESD controls in each area. The fourth and final level is done by a third party auditor on an annual basis. The compliance verification methods must be technically equivalent to those documented in ESD TR53, and the equipment used for the testing must be documented properly. Finally, it is important to note that the most successful Compliance Verification Programs are those that are regularly reviewed by management through reports that are made available to them, with subsequent follow-up to close corrective actions.

Grounding System

The grounding system used by the organization to ground all conductive elements must also be defined. S20.20 describes three grounding systems: Equipment (AC) ground, Auxiliary Ground, or Equipotential Bonding system. One or more of these systems must be defined as the grounding system in the "Plan." This is followed by implementation of the grounding system that was defined. Many companies use more than one of the grounding systems. For instance, they may define the Equipment (AC) ground as the primary method, but they may also define areas that use Equipotential Bonding for areas where the equipment ground is not available.

The second issue that must be documented as well is how personnel are to be grounded. Most companies simply state that all personnel wear a grounding wrist strap whenever working on ESDS items. Some allow the use of footwear/flooring if the operators are standing. S20.20 requires seated operators to always be wearing a grounding wrist strap - any deviation from this requires a tailoring statement (see below for “tailoring”).

Documentation of the EPA (Electrostatic Protected Area) Elements
This can be the largest section of the “Plan”, as it defines the balance of the technical elements of the ESD Control Program. However, it can also simply refer to the S20.20 elements. It is important to note that not all elements specified in S20.20 are required elements. However, if an element is documented in the “Plan”, it then becomes an auditable requirement by an S20.20 assessor. An example of this would be the use of garments. Many companies like to use garments in their factory for a variety of reasons. However, many don’t want to do compliance verification of the garments. If garments are formally documented in the ESD Control “Plan” then compliance verification must be performed. An option would be to require the use of garments somewhere besides the “Plan”, which would avoid them being audited by an assessor. Another element that is typically addressed here is the flooring/footwear system. Table 3 in S20.20 specifies that the total resistance of an operator must be below 35M-ohms whenever they are not using a wrist strap system. If the resistance is above 35M-ohms then more testing must be done to verify that they do not generate more than 100 volts when walking. This is one of the most misunderstood sections of S20.20.

Packaging
The organization must specify packaging requirements for parts moving or stored inside and outside of the EPA. The safest way to do this is to specify packaging that meets the requirement in ANSI/ESD S541. It is important to address packaging in the compliance verification program as well.

Marking
Marking is another one of the misunderstood sections of S20.20. It is included mostly due to demands by the military that it be addressed. “Marking” includes both the signage used to identify the EPA, but it also is applied to the marking of packaging and actual devices that are ESD sensitive. Many commercial companies either make a simple statement that they mark packages containing ESDS components with a commercially available mark, or they state that no marking is required.

Tailoring
One of the greatest strengths of S20.20 is the ability of the user to tailor the specification if necessary. It is important to note that tailoring is not necessary if you choose to make requirements more stringent than those specified in S20.20. However, if you want to make a required element optional, or if you want to make a specified value less stringent, tailoring is required. For instance, if you want to specify a lower resistance limit for your worksurfaces, no tailoring is necessary. However, if you wanted to allow operators to not wear wrist straps when seated, or if you want to allow

worksurfaces that have a higher resistance-to-ground than 1×10^9 ohms, you would need a tailoring statement. The tailoring statement must have technical justification and data to support your assertion that using the specification as-is is not necessary or deleterious to your product.

Additional Thoughts

For products that fall into that “super-sensitive” range you may need to do some things beyond the standard S20.20 program. For instance, if you have devices that are sensitive to charged device model damage, you may need to specify a minimum surface resistance value for worksurfaces and/or anywhere else ESDS parts may touch, and/or you may need to limit metal-to-metal contact (say from tweezers or other tools). You may also need to determine if more critical ionization is necessary to remove charge from product before it is handled or touched. Some companies are finding that they must also beef up the compliance verification program with more frequent or more stringent testing. You also might benefit from beefing up training, highlighting the critical items needed for the most sensitive products. Many companies dealing with these ultrasensitive devices are finding that standard measurement tools are not enough. These companies are finding that the use of more robust process assessment tools, such as an electrostatic voltmeter and ESD event detectors, are necessary. Some are also using constant monitors for wrist strap, grounding and ionization verification, to ensure these elements work continuously. Some companies have even implemented computer-based factory monitoring of these elements.

The “best” ESD control program is one that prevents any ESD damage to the components being manufactured or handled, without overkill, resulting in expensive controls that may not be necessary. Certainly, an excellent place to start is to have a well documented and implemented S20.20 ESD control program. Additional controls may be necessary depending on the sensitivity of the components being handled and the complexity of the manufacturing process.

Carl Newberg is the President of MicroStat Laboratories and is a Director of S20.20 Manufacturing Programs for Dangelmayer Associates, L.L.C. He has a B.S. degree in Metallurgical Engineering, a M.S. Degree in Materials Science, and a professional engineer’s license (Met. Eng.). He is also an iNARTE Certified ESD Engineer, and is one of the first to test and receive certification from the ESDA as a Certified ESD Program Manager. He is pursuing ISO 9000 Lead Registrar certification from RABQSA. He has held positions as the ESD Program Manager for Western Digital Corporation, and has been actively involved in the corporate ESD program at Seagate Technology and IBM Corporation. Currently he works for Magnecomp Precision Technology as a Senior Scientist – Contamination Control. Carl has been a member of the ESD Association since 1995. He has been a Board member since January, 2005, and was the Technical Program Committee Chairman for the 2004 EOS/ESD Symposium, Vice Chairman for the 2005 Symposium, and General Chairman for the 2006 Symposium. Currently, Carl is the Standards Business Unit Manager, overseeing standards development for the ESD Association. Carl was the 2009 recipient of the David F. Barber Sr. Memorial award from the ESD Association.