Product Focus on

# ESD Design

by Dave Long

# 7 Mandatory Considerations Before Handling Class 0 ESDS Devices

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# Seven Mandatory Considerations Before Handling Class 0 ESDS Devices

From the late 1980s through the 1990s, damage to electronic devices from electrostatic discharge (ESD) declined steadily. Many companies had invested heavily in ESD programs with handling precautions and process monitoring, and their investments paid dividends. Additionally, design changes—the inclusion of protective structures on the circuits themselves—created more robust circuitry that was less vulnerable to ESD.

The early design changes, however, diminished the performance of the electronic circuitry. To meet the demand for small, faster components, manufacturers eliminated those circuit-protection schemes, reversing the trend of declining ESD sensitivity. Older model electronic components were vulnerable to human body model (HBM) discharges of 100 V or greater; today's ultra-sensitive devices are vulnerable to charges as low as 20 V. According to the Electrostatic Discharge Association's Technology Roadmap, ESD sensitivity will continue increasing, by some estimates at least through 2010.

Ted Dangelmayer, an ESD consultant and president of Dangelmayer Associates, describes this new class of vulnerable electronic parts as "class 0 ESDS devices." The emergence of these class 0 devices has exposed the loopholes in many ESD prevention programs and created challenges for all users of state-of-the-art electronics—from chip manufacturers through server room and data center managers.

According to Dangelmayer, class 0 components require much more stringent ESD controls and procedures, beginning with a complete reassessment of root causes of ESD failures. As Dangelmayer and other industry experts are quick to point out, most ESD programs are predicated on protecting electronics from human body model failures at or above 100 volts. This tactic does not protect class 0 devices from exposure to < 100 volt HBM discharges, nor does it even come close to addressing the far more deleterious effects of other ESD failure models.

**Class 0 Handling Is Inevitable**

By 2010, virtually all factories will be handling some number of class 0 devices. It has taken those companies that have already made the transition two years to bring their facilities up to the standards necessary to protect their class 0 devices from ESD failure. The decline in ESD failures during the late 1990s had lulled many companies into an attitude of false security.

As they made the transition to class 0 handling, many companies, even those that had long-standing ESD programs in place, were faced with a lack of ESD expertise. Naturally, program managers, who themselves were often unsure about how or even why to upgrade their ESD protection program, had difficulty getting buy-in from management.

Proactive response to the arrival of class 0 devices is an absolute must. The companies that will fare the best will be the ones that make the transition before they actually begin working with ultra-sensitive components. And that can only happen if they begin re-educating themselves immediately.

Fortunately, interest in ESD has been increasing over the past couple years. Internet searches on engines like www.google.com indicate a significant rise in ESD-related searches. Attendance at ESD-related events and conferences is up. Both indicate a growing need for technical information and advice. The following seven issues are only the tip of the iceberg. They are however the place to begin.

**1st Consideration: Understand the Limitations of ANSI/ESD S20.20-2007**

Today, technological advances are outpacing the human ability to respond. It could take years for standards to be modified and new standards to be generated by volunteer-led organizations. It is imprudent to rely solely on industry standards and benchmark recommendations that neither fully anticipate nor adequately prescribe solutions to problems specific to state-of-the-art technology. The responsibility to do things right— which may mean exceeding the recommendations of generally accepted methods—always falls on the implementer. In the case of ANSI/ESD S20.20-2007, two limitations are clearly identified by the document's authors.

First, as stated in the forward to ANSI//ESD S20.20-2007, "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)."***

By design, the standard does not offer a prescription for handling sensitive components with HBM thresholds below 100 volts. S20.20 also fails to address applications where the use of ESD controlled footwear is impractical—such as in server rooms, data centers or call centers. In applications where static protective footwear will not be used, buyers should consider the recommended specifications in S20.20, and also analyze any unusual performance parameters that apply to their specific application. In the case of flooring, a buyer should look at the antistatic properties of the floor not only when it's used in conjunction with conductive footwear, but also when it's used with conventional nonconductive footwear.

Second, this standard does not cover the handling of electrically initiated explosive devices. The handling of explosives is obviously of greater concern than the handling of ESDS components, since there is little margin for error where safety is concerned. The fact that S20.20 does not address these concerns does not diminish its applicability to the industry it was written to serve. It merely points out that there are situations and applications where static must be controlled at different levels and possibly in a more rigorous manner. As with explosives, the handling of class 0 devices requires redundant process controls and the use of better performing static preventive materials.

Readers can download a free copy of ANSI/ESD S20.20-2007 at http://esda.org/documents/S20.20-2007FINAL_000.pdf.

**2nd Consideration: Understand the Charge Device Model**

Most ESD program managers understand the human body discharge model. We encounter this model everyday, whether we realize it or not. When humans move, slide in chairs, remove or put on items of clothing, they generate some amount of static electricity. When they touch another object, that static electricity discharges; this is called the human body model discharge. While discharges below 3500 volts are dangerous to components, they cannot be felt by humans.

HBM threats can usually be addressed by implementing a continuous system of grounding and electrical bonding. The three most common examples of HBM precautions are wrist straps, conductive footwear and ESD flooring. Properly selected and monitored, these three precautions will eliminate almost all HBM threats. threats. (This may require educating skeptical personnel who, because they cannot see  or feel static electricity, question its existence.)

A less understood but potentially more destructive threat to components is a failure model called the Charged Device Model (CDM). *Assembly Magazine*, an industry journal covering manufacturing and assembly, defines CDM as follows: "a failure model where the part in question holds an electrostatic charge and rapidly discharges to another object when they are brought into contact. The discharge could cause a device failure." An expanded technical explanation of CDM can be found at this ESD Association link:
http://www.esda.org/esdbasics5.htm

The CDM model is not a newly recognized failure model. B. Unger et. al. from Bell Labs identified CDM problems in the early 1980s. In an ESD Symposium paper, they identified at least two scenarios where a CDM event could occur: 1) when a charged device is placed on a work surface that is too conductive; and 2) when a charged device is placed in highly conductive packaging. This early work is the reason companies today use static dissipative and not conductive table covering.

One of the best examples of the CDM threat is on automated placement equipment. If a circuit board or individual device is picked up and placed down by a nonconductive fixture, a static charge and discharge may occur. This is a particularly risky problem in a high volume factory, as every part is subjected to the same threat, and the extent of the damage cannot be determined until final test. If the electronic parts have low CDM thresholds, the fallout could be catastrophic to a company's bottom line or reputation.

CDM And HBM Thresholds Will Decrease To Class Zero Levels by 20010

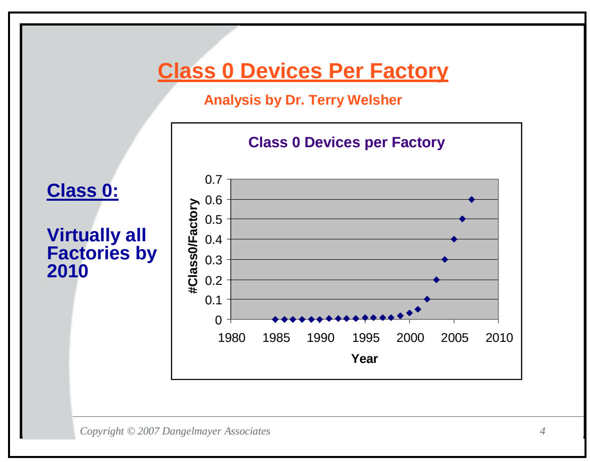


Figure 1:

ANSI/ESD S.20.20 does not mention CDM failures or offer prescriptions for reducing them. CDM failures are discussed, however, in the Association's ESD

Technology Roadmap (available at www.esda.org). In 2005, as shown on their graph (Figure 1), minimum device sensitivity was just below 500 volts; by 2010 the value is expected to drop to just above zero. This increased sensitivity to CDM failure presents a major problem for any program manager dealing with new technology in an electronics manufacturing, test, or repair application that is not equipped to handle an HBM threshold below 100 volts.

(Note that a common misunderstanding of the Bell Labs study led to the false belief that dissipative flooring is better than conductive flooring. In fact, flooring should not be evaluated in the same manner as table covering. The recognized standard for ESD flooring is a flooring-footwear system that will not exceed 35 megohms.)

**3rd Consideration: Understand Induction and Voltage Suppression**

While electrostatic physics can become quite complicated when the problems involve electrets, the effects of corona treating or the theory behind why certain materials become charged in the first place, there are two basic principles that every ESD program manager should understand. They are electrostatic induction and voltage suppression.

**Electrostatic Induction**

Electrostatic induction occurs when one object picks up a charge from the electrostatic field of a second object. When a grounded conductor is placed in the vicinity of an electrostatic field, because the conductor is grounded, its voltage is zero. When it breaks from ground while still in the presence of the electrostatic field, induction occurs—i.e., a charge opposite that of the electrostatic field is trapped on the conductive object.

Induction occurs when an aircraft is parked directly below a thunder cloud and its ground connection is removed. If the aircraft fuel intake were to reunite with ground while still charged, a CDM event would occur, potentially causing an explosion. In a factory, an ESDS device touches a grounded table mat; lying on or near the mat is a charged insulative object such as plastic bag or roll of tape. When the ESDS device is lifted from the mat, it picks up or loses electrons from the electrostatic field around the bag or tape. If the charged device now touches a grounded person's finger, a circuit board or any other conductor, the ensuing discharge could destroy the device.

It is a common misconception that the electrostatic field around a charged insulator will cause the failure of static-sensitive devices.

Although this is possible if the device is one of the rare field-sensitive ones, it is more likely that a problem will result from a CDM model. Like the cloud in the aircraft example, the fields on charged insulators can and will charge electronic devices. If the devices are discharged to the wrong surface, the results could be catastrophic ESD damage.

***Voltage Suppression***

Voltage suppression is the product of the equation relating charge, capacitance and voltage or Q = C X V; Q is charge, V is voltage and C is capacitance. When the capacitance of a charged object is raised, its voltage decreases. The easiest way to understand voltage suppression is by performing a simple experiment. This requires two items: a static field meter and a small sheet of clear plastic like the ones used to hold paper in a 3-ring binder.

**Directions:**

Place the plastic flat against a wall while rubbing it vigorously with the back of your hand. Static electricity will cause the plastic to stick to the wall.

1. While the plastic is stuck to the wall, measure it with the static meter. Unless the wall is plastic, the static meter will read at or close to zero.
2. Maintaining a constant distance between plastic and meter, slowly pull the plastic off the wall. The meter will suddenly register thousands of volts.
3. Gently allow the plastic sheet to reattach to the wall. The plastic will once again measure at or near zero. Where did the charge go?

Although this may seem like an aberrant situation, it is not, since static meters do not actually measure charge. Instead, static meters measure voltage. When the plastic is stuck to the wall, the capacitance—ratio of charge to potential on an electrically charged, isolated conductor—is high, so the voltage is low. When the plastic is in free space, because it is no longer sharing space with the wall, the capacitance is low, so the voltage is high. In both cases, the charge was and is the same. It did not appear that way because of what we call voltage suppression.

Voltage suppression can cause serious problems for ESD program managers. For example, troublesome insulators like sheet protectors could be highly charged; but, if they are resting on a flat surface, even if the static meter is placed directly over them, their charge cannot be detected. To ensure a correct reading with a static meter, suspicious objects should be lifted, frictioned and measured in free space to determine if they are potential problems.

When evaluating ESD work and flooring surfaces, particularly those with a buried conductive layer, it is important to determine whether the material pulls static away from charged objects or merely suppresses their electrostatic field. ESD table laminates, for instance, suppress but do not actually discharge items that are placed on them. Because of design flaws and contact resistance issues, it is very difficult for any hard surface table covering to bleed off voltages below 50 volts. Resilient, lower durometer work surfaces should be installed in lieu of or on top of ESD laminates.

ESD floors are routinely tested for HBM discharge by attaching a person to a charge plate monitor with a wire or a wrist strap. To test the floor properly, the person standing on the flooring material should move his or her feet, periodically breaking ground. If the subject retains a static charge when the feet are lifted, the ESD control material is merely suppressing the charge. A properly functioning ESD floor should bleed accumulated charges away from the person; when his or her feet are lifted, the voltage should remain at or close to zero. The full method for performing body voltage measurements is described in ANSI/ESD STM97.2.

**4th Consideration: Prevention Usually Trumps the Cure**

Many ESD program managers implement safety nets and redundant precautions such as ionizers, expensive ground monitors and cumbersome packaging techniques. These precautions are often unnecessary and could actually threaten rather than protect class 0 sensitive devices.

One good example of an over-prescribed cure is the use of bench-top air ionizers. Air ionizers produce positive and negative ions that neutralize charged objects if the charged object has an electrostatic field. Air ionizers effectively eliminate static *only on stationary or slow-moving, low-capacitance, charged objects at close range*. Air ionizers will not reduce static on fast-moving pick and place equipment if the air curtain is obstructed or if the ions must travel into a small space surrounded by grounded metal. Air ionizers also do not reduce static on human beings or on charged objects such as sheet protectors that are resting on a flat surface (capacitance is too high; there is no field to neutralize).

Worse, when they malfunction, air ionizers can pose unanticipated threats to class 0 devices. Contamination or mechanical problems can cause air ionizers to become unbalanced. An unbalanced air ionizer can deposit a charge equal to the amount of the imbalance, causing a CDM failure. A 20 volt imbalance that had no impact on older ESD-hardened components would be unacceptable in a class 0 ESD environment.

Ninety percent of all ionizers are installed to neutralize charged objects that find their way into the workplace. A solution that's better than neutralizing charged insulators is not to use them.

Before buying ionizers, ESD program managers should consider eliminating specific static generators, such as plastic tweezers, masking tapes and the interfaces on certain placement equipment. Most insulative production aids are available in antistatic or dissipative form. Plastics and other non-essential insulative items should be removed or banned from places where ESD-sensitive devices are being handled, used or repaired. Ionizers should be purchased only after all other preventive alternatives have been exhausted.

**5th Consideration: When Buying, Look Beyond Spec Sheets**

Often, specifications are derived from test methods that do not predict performance for a particular application. Reliance on inappropriate test methods can lead buyers in the wrong direction. For example, carpet manufactures use the AATCC134 test method to specify the antistatic properties of their product. This standard textile industry test method, designed for conventional carpet, is irrelevant for applications involving electronic components. The test evaluates newly manufactured carpet (one time) for walking body voltage, and tests voltage generation only on a person wearing leather or neolite shoes. This test does not measure conductivity, evaluate the longevity of a carpet's antistatic properties, or test the static generated by the soles of more popular footwear, such as athletic shoes, hiking boots or flip-flops.

Most standard ESD testing is done with static control footwear. These tests, conducted under perfect conditions, do not predict what will happen if a visitor or an employee wanders into an area with standard footwear, or if heel or sole straps are worn improperly. In a class 0 application, people should *always* wear ESD protective footwear, and the only ESD flooring materials that should be used are those that, with ESD footwear, keep charges below 20 volts.

Obviously, it is not always possible to monitor or control the use of static control footwear. For this reason, ESD program managers should also evaluate the static generating potential of the floor under various real-world conditions—e.g., with conventional footwear, by asking the subject to lift his or her feet or to wear one heel strap instead of two, etc. Having a full picture may enable a buyer to justify investing in an ultra low-voltage generating conductive rubber floor instead of a less-effective epoxy or urethane floor.

This same scrutiny should be used when purchasing air ionizers. Most ionizer manufacturers use ANSI/ESD STM 3.1-2006 to provide data on charge decay based on discharge times of a stationary charged plate of a known low capacitance. If the ionizer will be used to neutralize charges on moving placement heads on automated equipment, exposure time should also be considered. The ionizer may be "best of class," but that does not mean it can neutralize a small object moving at high speeds.

**6th Consideration: Buy the Right Instruments to Evaluate New Purchases and to Audit the Program**

Most ESD program managers use test equipment to audit the performance of ESD controls. Because there are numerous instruments on the market, these purchases are almost always cost-driven. This low-cost equipment is described as portable or easy-to-use. Portable, easy-to-use instruments frequently do not store data and are often inadequate for testing and evaluating materials in a class 0 environment.

The single most important use of test data is in tracking trends and making corrections before problems arise. For example, ESD wax is a temporary static control flooring solution, and traffic and washing eventually diminish its electrical performance. If ESD wax is used as the primary floor ground plane, it should be tested in multiple areas on a constant basis. Does it really make sense to measure something as important as the facility's primary ground plane without collecting, storing and evaluating multiple data points over time?

Because there is a direct correlation between body voltages (measured per ANSI/ESD 97.2-1999) over 40 volts and flooring/footwear system resistances (measured per ANSI/ESD STM97.1-2006) above 10 megohms, tracking performance trends of flooring as well as other key components is mandatory in order to safely handle class 0 components. Class 0 is not the same as "class 100," and materials that were good enough to meet ANSI/ESD S20.20 could put class 0 components in jeopardy.


Ideal Resistance to Ground of Person Wearing Static Control Footwear in Combination with ESD Flooring Per ANSI/ESD STM97.1-2006


For class 0 applications, it makes sense to invest in quality instruments. After all, data is only as reliable as the instrument used to do the testing. The pricier instruments accurately measure, store and download data. Used correctly, this longitudinal information can prevent a critical breach in the ESD prevention program. The collection and use of quality data could help justify investment in long-term solutions instead of band-aids like ESD waxes, floor mats and paints.

**7th Consideration: Involve an Expert**

In the 1980s many electronics companies employed in-house ESD experts. These individuals were usually members of the quality department and theirs was the final word on whether or not ESD controls were implemented, modified or eliminated. Outsourcing in combination with the high tech slowdown of the 1990s eliminated this position in many companies. Because management believed their ESD programs to be self-maintaining, ESD coordinators were looked upon as unnecessary overhead. This line of thinking was reinforced by the success of on-chip ESD protection and declining ESD sensitivity.

One of the fallouts from this trend is a general lack of knowledge about static at even the most prestigious electronics corporations. One particular large telecom manufacturer had been using static dissipative flooring for an application that would have been far better served by a conductive material. When their supplier installed a more conductive version of their flooring in a new area, an auditor noticed that the new floor's resistance to ground was now reading in the red zone on her analog resistance meter. Her concerns prompted an investigation, the auditor insisting that their new floor was "no good." The issue was settled only after an independent consultant was brought in to help the client understand why conductive flooring was actually better for their application.

The vast amount of competing information on the web has further confused buyers about which ESD protective materials to buy and what criteria to use when selecting them. Before the Internet, very little information was published without first being vetted by an editorial board. Today, anyone can become his or her own publisher—with or without technical qualifications. ESD program managers should consider only information gleaned from reliable sources such as industry associations, technical publications and independent consultants.

If all the ESD specialists, physicists and device manufacturers are correct, class 0 environments will soon be commonplace in high-technology environments. In a class 0 environment, marginally performing ESD solutions—a dysfunctional ionizer or static dissipative floor—cannot be trusted to eliminate the ESD threat and may even contribute to the problem they were once able to solve.

With class 0, it can no longer be business as usual. State-of-the-art components are expensive and often in short supply. A failure to properly confront the threat posed by class 0 device sensitivity will show up very quickly on the bottom line. It makes no sense to ignore an inevitable problem that can and should be eliminated by implementing logical practices. The good news is that those companies that take the threat seriously and address it preemptively will have the upper hand in today's—and tomorrow's—high tech marketplace.

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