Stephen Halperin & Associates

Process Capability & Transitional Analysis

As presented by Stephen Halperin, Ronald Gibson & John Kinnear, Jr. at the 2008 EOS/ESD Symposium
Process Capability & Transitional Analysis

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Abstract: A new approach analyzes the manufacturing critical path, defining locations of charge generation and discharge, and types of device ESD failure mechanisms experienced in the process. The technique identifies the device sensitivities a process is capable of handling in relation to HBM, CDM, Field Induction and Machine Model failure thresholds.

I. Introduction

ESD is a dynamic problem closely enjoined with the design and flow of the manufacturing process. Traditional ESD controls such as specially designed worksurfaces, flooring, garments, footwear, production aids, etc. have long been methods for controlling ESD1, 2.

These controls are often not chosen to address specific ESD needs of the manufacturing process. Rather, they are a means to introduce ESD controls into sensitive environments with the expectation that additional controls further reduce ESD problems, i.e., “more is better”.

A Special Need

Problems become more challenging as device damage thresholds fall to new levels; additional controls, sensing systems, devices and materials are installed in anticipation of preventing losses. In many applications, the effectiveness of the controls already in place are not known. Additional traditional controls may not be sufficient or required for addressing existing or decreasing sensitivity levels.

A Possible Solution

A more suitable approach for determining ESD control is to apply systematic measurement techniques to assess the ESD protective strengths and weaknesses of the process from beginning to end. Given the measurements are effective, they will answer three critical questions:

1. What is the process capable of protecting in relation to ESDS device Human Body Model (HBM), Charged Device Model (CDM - direct charging and charging by field induction) and Machine Model (MM) failure thresholds?
2. Where are the ESD problem areas in the process, and what risk do they pose to ESDS devices?
3. How effective are any changes to the process for minimizing risk to ESD sensitive items?

Over the past 4 years, the authors have developed a series of proprietary concepts and measurement techniques for ESD analysis of the manufacturing process. As these techniques evolved, they were applied to several different manufacturing processes in consulting, problem analysis and process evaluation situations.

The techniques were refined and ultimately resulted in a means to characterize entire processes for ESD protective levels, and identify problem areas and their characteristics. This paper introduces the concepts of Process Capability & Transitional Analysis (PCTA), and the means to make process measurements. It deals with

• Failure Models & Setting ESD Control Levels
• Provides an actual case study, referred to as Illustrative Case Study
• Offers additional measurement and observation insight
• Introduces additional information from other Process Capability & Transition Analysis (PCTA) case studies.

II. Failure Models from a Process Point of View

Device designers and their manufacturing customers have different objectives when it comes to defining failure models and damage thresholds. They approach their objectives and apply information differently.

Device Design

Most device engineers have opinions and insights regarding failure models and device testing for determining damage thresholds to various models. The results of their tests and analysis are used in
developing protective circuitry and new device technology.

Manufacturing

Manufacturing personnel must understand the ESD sensitivity level of their process to develop their ESD control programs. Knowledge of device sensitivity confirms that the ESD control program can safely handle the devices. This information is often not easy to obtain from most device manufacturers. For practical reasons users of semiconductor devices must make assumptions as to device failure model sensitivity to meet their control needs. These targets are critical to the manufacturing process.

Common Ground

One bridge spanning the device design and manufacturing worlds is the ESD Association (ESDA) Technical Roadmap\(^3\). It was developed in 2005 to project ranges of probable device sensitivity to HBM, CDM and MM impact over the years until 2010. The developers included respected engineers from IBM, Intel and TI working in concert with ESDA Standards Management. Their projections are based on their industry insight regarding shrinking nanometer technology and failure models discussed in ESDA device standards series 5.0.

The authors used the ESD Association Technical Roadmap, and Device Testing Standards series 5.0 to create analysis targets, discussed below.

Manufacturing Failure Mechanisms

Process Capability & Transitional Analysis (PCTA) focuses on the essence of device failure as it occurs in the manufacturing environment. Simply stated:

1. **HBM** is caused by discharge from a charged person to an electrostatic discharge sensitive (ESDS) device or assembly.

2. **CDM** translates to a discharge from an ESDS device to a conductor or other material/object at a later time. Charging can take place by either:
   - a. Direct triboelectric charging of the ESDS device leads.
   - b. Induction from a nearby electrostatic field.

3. **MM** is discharge from manufacturing or test equipment through a conductor to an ESDS device or assembly.

4. **Hybrids** are ESD waveforms that do not resemble any of the (3) models that are used to classify devices. These waveforms may appear to be a combination of one of more models or they could be unique.

Practical manufacturing experience indicates that ESDS devices can be damaged by failure to control any one model. In reality a device has four different ESD damage thresholds; a voltage level for each of HBM, CDM, and MM. Thus, one must design and maintain a manufacturing process to prevent violating the most sensitive devices’ damage thresholds.

These failure models exist in virtually all manufacturing processes to varying degrees. Each has characteristic waveform attributes. Discharge waveforms of the models can be seen as pure HBM, CDM or MM. “Hybrids” are seen in assembly combinations and non-device items. Hybrids are not new; they have always existed and became concerns as some practitioners became aware of how discharges in high level assemblies rarely resemble the traditional waveforms.

A critical objective of PCTA is to identify where and what kind of potential ESD failure model(s) exist in the process. It does not assume that one or a combination of event types exist, it is simply an objective foundation for analyzing what is happening in a manufacturing process, and summarizing these events in a clear manner.

Failure Model Threshold Assumptions

In lieu of device sensitivity information, manufacturing personnel must make assumptions as to appropriate ESD control levels. The current ESDA Technical Roadmap is the only practical guideline presently available for industry’s consideration. For purposes of the authors’ work, the following worst case ESDS device thresholds were assumed, unless otherwise stated by the host process.

1. **HBM** at 100 volts
2. **CDM** at 50 Volts
3. **MM** at 10 Volts

These assumed ESDS failure threshold guidelines were used for PCTA project case studies with the exception of those studies involving a very ESD sensitive device where the ESD sensitivity to all models was known.

III. Analysis Concepts

Once the ESDS failure threshold limits for the process are clarified or established, fundamentals of PCTA include the following:
1. Defining the Process Critical Path
2. Making Transitional Analysis Measurements
3. Summarizing findings

1. Defining The Process Critical Path

The critical path may be defined as a series of tasks, each of which must be completed in order to finish a project, or product. In this study, the process critical path starts at Receiving and ends at Shipping. There may be a single path, or one primary path that is supported by a series of secondary paths.

Typically, each operational area has its own process path and supporting activities. In every case, the process is examined from beginning to end including all support activities.

Tasks fall into two categories:
- A process function that adds value or a conversion element to the device, subassembly or product.
- Movement, i.e., transport, from one task to another.

A task may be cleaning, screening, parts addition, testing or any one of hundreds of process steps. However, for our purposes all Tasks represent process Transition Points.

Transition elements are:
- Transport by personnel or automated equipment moving, i.e., parts from one process point to another.
- Loading or unloading process equipment
- Parts placement, either manually or by automated equipment
- Soldering & Reflow
- Test & Inspection
- Coating and cleaning operations

Transition elements can be obvious or hidden from view as part of automated equipment functions, or secondary activities.

Figure 1 illustrates a basic process that was studied for PCTA and consists of human transport and automated equipment tasks. The process basically includes:

1. A board Screening Operation
2. Parts Installation
3. Reflow

Detailed analysis of Figure 1’s Critical Path reveals the following Transition Points.

Figure 1: Characterizing the Critical Path & Identifying Transition Points

Once the Critical Path and Transition Points are identified, the next step in PCTA is preparation and planning measurements of the priority Transition Points. Every element may not be measured, but properly planned the effect of all process elements are measured and documented.

2. Transitional Analysis Measurements

The objectives of Transitional Analysis Measurements are to assess that portion of the process for conditions that would create HBM, CDM, FIM or MM events. Then quantify the potential magnitude of those ESD events as they relate to the ESDS device sensitivity thresholds.
The measurement may not reveal that an ESD event is taking place at that Transition Point. Rather, it may show that an assembly is being charged at that specific point in the process, only to discharge at some later time. It would also indicate how the assembly is being charged. Proper analysis will provide the probable type of ESD event the assembly will see when and if discharge occurs.

To this end, measurements include:

1. The electrostatic voltage or charge condition of ESDS devices or subassemblies:
   a. Prior to a transitional element
   b. After the transitional element
   c. In some cases during transitional element
2. The electrostatic voltage or charge conditions and resistance to ground of equipment, personnel, operational surfaces and materials
   a. Making direct contact with ESDS devices and assemblies, or
   b. Producing electrostatic fields near or in the process flow, and at transition points
3. Identifying the charged device or object’s discharge waveform

In this study several types of measurements were made of the manufacturing process environment, grounding, equipment, personnel and materials. In all cases the authors applied traditional ESD control measurements when “auditing” the process environment. However, traditional measurements, while important, are not the subject of this study.

1. The important elements of this study are combining traditional measurement techniques with new approaches to analyzing the process and its transition points, including Body voltage measurements of personnel:
   a. To determine probability of exceeding process ESD control point and incurring HBM events
   b. While transporting and handling ESDS devices to assess the contribution of human charging to later ESD events
2. High impedance contact voltage measurements of:
   a. Conductive product components, e.g., chassis or functional mechanical components, to assess potential MM events
   b. ESDS devices, subassemblies and their connectors to determine potential CDM events
   c. Process equipment conductive elements making direct contact with the pins/leads of devices and subassemblies, e.g., placement heads and test probes, to assess potential MM events
d. Material handling devices and aids, e.g., device trays, totes, tape and reel, etc, for potential charge transfer to ESDS devices.
3. Field measurements in the critical path and inside automated equipment for FIM assessment
4. Continuity and resistance to ground measurements of critical process elements and surfaces, including automated equipment to confirm the element’s ability to dissipate charge to ground
5. Characterizing the probable type of ESD event that may occur by oscilloscope and CT-1 current probe examinations

III. Performing Process Capability & Transitional Analysis

The Figure 1 process case study illustration consists of:

- Five personnel transport and handling transition points
- Screening solder paste onto circuit boards
- Loading the Feeder
- Placing parts on circuit boards in the Pick & Place equipment
- Reflow

The case study Process Assessment & Transition Analysis measurements are summarized and described below.

Personnel in this process wore protective footwear on an ESD controlled acrylic polished floor. Body voltage measurements of each manual transport transition were made using the following equipment:

- Charge Plate Monitor (Prostat Corporation portable fieldmeter/charge plate [CPM] system PRF-711A & CPM-720)
- Analog to Digital (A/D) Converter & Appropriate Software (Prostat PGA-710 AutoAnalysis System® with related recording and analysis software)
- Portable Computer (IBM Notebook Computers [T-41, T-42 and X61], with Windows XP operating systems)

The results indicated very little body voltage generation in the process, or charge transfer from personnel to devices. Charts in Figure 2 documented personnel measurements at 18 volts or less.
Assessing Screening Operations

Analysis of the screener process identified the following key transition points at the screener.

- The Operator loads boards by hand into the screener
- The employee removes the boards after screening for inspection
- Parts are manually transported to Pick & Place (SMT)

A high impedance contact voltmeter (Prostat CVM-780 Prototype) was used to measure voltage on the board conductors before and after the screening processes (Figure 3).

Voltage before screening was less than 20 volts. After screening approximately 441 volts were measured on the board’s conductive elements. A CT-1 current probe and TEK 2024B oscilloscope were used to assess the type of discharge the board would produce when grounded. A CDM waveform was generated as shown in Figure 4.

Screening summary indicates:

- Screening process charges board’s conductive elements to >440 volts
- The charge poses a possible ESD discharge source during handling or device placement if the charge is not removed
- In the illustration study, an ionizer was recommended to eliminate board voltage to reduce discharge risk later in the process

Pick & Place (Smt): Feeder Analysis

Analysis of the SMT process indicates several items require evaluation:

- Device trays, tape and reel supplied to placement equipment.
  - Are these parts charged by the materials or is the process creating a potential CDM event?
Does the placement equipment charge the parts prior to placement on the board?

Are there insulators in the process that may cause FIM during placement?

Consequently, this portion of the process must be broken into two parts: Analysis of the Feeder transition points and analysis of the placement equipment.

The Feeder is loaded with devices that are manually transported to, then mounted in the Feeder for delivery to the SMT equipment.

Once loaded, trays and individual devices were measured with the contact voltmeter to determine existing voltage caused by transport, that may not have dissipated after mounting in the Feeder.

If a charge existed, the type of discharge was verified with the CT-1 and oscilloscope. The CT-1 measures current, while the scope displays voltage. The CT-1 current ratio is 5 mv = 1 ma.

As Illustration a CDM discharge (Figure 5) was recorded from a device in an improperly grounded tray. The tray was charged by manual transport in another PCTA project.

**Pick & Place (Smt) Analysis**

SMT Analysis – Pick & Place process description includes:

- Screened boards placed by hand into machine.
- Conveyor moves board into position
- Machine picks up IC and other devices and places them onto the board
- Conveyor moves board to machine exit

The Pick & Place concerns include the following potential ESD issues:

- Static generators near placement (FIM)
- Isolated charged placement nozzles and other conductive objects (MM)
- Parts charged from pick up process (FIM)
  
  Note that we previously measured the Feeder process to see if parts are charged before pickup.
- Discharge from a charged device to conductive solder paste or socket (CDM)

**Equivalent Field Voltage Measurement Considerations**

To assess the SMT equipment for electrostatic fields that may emanate from machine guards, plastic windows, pneumatic lines and other auxiliary materials, a special carrier (Figure 6) was fabricated resembling a circuit board.

The carrier is approximately 8.5 x 11.0 inches and serves as transport for a portable CPM (Prostat PFM-711A/CPM-720) and battery operated recording device (Prostat PGA-710). The carrier is transported through the machine by the conveyor system, the
CPM measures the induced voltage and the recording device saves the data for later viewing (Figure 7).

The CPM plate is 15.6 pF and will see field induced voltages differently than a device. A concern is relating the measured voltages to the device sensitivity and size (capacitance) of the device. In one approach we consider the 15.6 pF plate at the midpoint of ANSI/ESD STM 5.2 CDM standard calibration references of 4 and 30 pF. However, these values do not reflect device capacitance; they are simply a reference. Another approach under consideration is to calculate equivalent device voltage based on device capacitance and CDM threshold using \( Q = CV \). However, device capacitance varies with its proximity to ground as it moves through a process. When close to ground device capacitance is high; in free space far from ground its capacitance is very small. The following illustration assumes a device capacitance of 30 pF while in the process.

- If ESDS device of 30 pF has a FIM/CDM failure threshold of 300 volts, what is the damaging charge \( (Q) \)?
  - \( Q = CV \)
  - \( Q = 3.0 \times 10^{-11} \text{ F} \times 300 \text{ V} \)
  - \( Q = 9.0 \times 10^{-9} \text{ C}, \) or 9.0 nC
- What Voltage measured on the 15.6 pF CPM plate is the equivalent to 9.0 nC?
  - \( V = Q/C \)
  - \( V = 9.0 \times 10^{-9}/1.56 \times 10^{-11} \)
  - \( V = 580 \text{ Volts} \)

Thus, if device induction threshold was 300 volts, the CPM measurement equivalent voltage limit on the 15.6 pF CPM may be 580 volts. Until device capacitance variables can be researched further, the authors document direct measurements from the 15.6 pF CPM as their PCTA reference.

Actual measurements of the internal SMT equipment fields were less than 12 volts, well below the 50 volt control point assumption. The measurement was confirmed by placing a charged material 12 inches from the machine’s critical path and transporting the field sensing carrier past the charged material (Figure 8).

Isolated Conductors in Automated Equipment

Two symptoms of isolated conductors are:
1. Measureable voltage exists on the conductor, and
2. The conductor has no continuity to ground

In PCTA, both measurements are made to identify isolated conductors. Voltage measurements were obtained using the Contact Voltmeter (Prostat CVM-780). Resistance to ground was made with a multimeter (Fluke) and a wide range resistance system (Prostat). In the illustrated case study, all conductors in the SMT critical path were properly grounded. The device position/placement head had less than 20 ohms resistance to ground and no measureable voltage.

CDM Measurement Options

Two options are apparent for measuring potential CDM problems in the SMT equipment. One is to program the equipment to pick up a critical device and...
stop the placement of the device well above board placement. Then measure the device conductors with a contact voltmeter and compare measured voltage to the ESDS device’s CDM damage threshold. This procedure was employed when assessing automated device handling equipment in other PCTA development studies.

The second procedure was used in this case study where the carrier with portable CPM and recorder was positioned at the point of device placement. Here the device is placed onto the CPM by the programed placement equipment (Figure 9). Any device voltage is shared with the CPM and stored in the recorder’s memory for later analysis (Figure 10).

CDM Equivalent Voltage Considerations
The portable CPM plate is 15.6 pF and will measure device discharge voltages differently than the voltage seen by the device. This is due to the difference in device versus CPM capacitance as discussed above. Once again the discussion arises as to what the measurement can represent:

- Consider the 15.6 pF plate at the midpoint of ANSI/ESD STM 5.2 CDM standard calibration references of 4 and 30 pF, and use the measurement as a general equipment guideline. Direct measurement from the 15.6 pF plate is employed by the authors until further capacitance variables are clarified.
- Calculate the device capacitance and related discharge voltage, an analysis that is in process at this time. Once defined, one might employ \( Q = CV \) to calculate equivalent voltage.

The Feeder and SMT equipment analysis summary indicates:

- IC Input properly grounded and parts are not charged
- Electrostatic fields are not a concern. < 50 volts were measured on the CPM
- Tribocharging or voltage induction of devices due to IC handling is not a concern < 50 volts measured on the CPM at device contact

In the illustration case study the bare circuit board was charged to >440 volts at the screener. The board was not discharged and was transported by a non-charge generating person to the SMT equipment still having >350 volts on the board. At SMT output, the board voltage was >290 volts when it was transported to Reflow. The Reflow process includes:

- Boards manually loaded onto metal conveyor
  - Note that Boards entering Reflow in the illustration study were charged >200 volts
  - The system includes a metal wire Conveyor grounded to machine frame
  - Primary Concern: Are discharges occurring between charged boards and grounded metal conveyor?
- Conveyor system collects boards after reflow is completed

Board Loading (Placement)

Measuring board voltage with a Contact Voltmeter prior to, and after placement onto a conductive surface will indicate:

- If an ESDS assembly discharges upon contact (CDM)
- If the assembly becomes charged by the conductor upon contact (MM)

In the illustration case study the charged board assembly discharged to the conveyor. To illustrate the discharge to host management, a Credance Aware™ RFI sensing unit equipped with local antenna was placed near the metal conveyor, and the board placement process was repeated with another circuit board measuring >200 volts. The Aware unit alarmed upon placement; board voltage was <10 volts after placement.

In other PCTA studies additional RFI measurements were effectively obtained (when used properly) using various practical techniques. In those studies, various antennae and oscilloscopes were employed and were easily implemented.
Reflow Accumulation Conveyor

In the illustration study the board exited Reflow with <10 volts on its conductors, then transitioned to a rotating brush conveyor (Figure 11). The board was transported to the end of the conveyor. The brush conveying system operates on an adjustable friction basis. If a board is stopped, friction increases and the brush stops turning, assuming it is properly adjusted. In the illustration study, the brushes continued to turn generating >525 volts on the boards awaiting manual transport to Cleaning and Testing.

Figure 11: Uncontrolled Brushes Generate >500 Volts on PCBs

Reflow analysis summary indicates
- Discharges registered at loading of reflow conveyor
  o Board charged to 200 volts
  o Board should be ionized prior to moving to Reflow
- Conveyor at exit of reflow charging boards to >500 volts.
  o Possible discharge to grounded operators or at next process step
  o Change conveyor system or add ionization post reflow

Summarizing Process Capability & Transition Analysis Results

A basic summary of the Illustration Process Capability Analysis Study (Table 1) indicates problem areas, voltage measurements, type of potential discharge event and whether the process is within specification

Other Process Capability & Transition Analysis Examples

Several PCTA studies have been conducted in developing the concept and measurement techniques.

Important note should be made of the following observations

Change in Type of Failure Model
In a PCTA analysis involving high losses of RFID tags (>60% loss), the analysis identified two failure models of the same device as the critical path was measured. In one portion of the process the RFID exhibited a CDM discharge waveform (Figure 12). In another portion of the process the same RFID exhibited a MM discharge waveform (Figure 13). Indicating that analysis of each process transition is necessary; each process segment can have a totally different meaning to the devices in the process.

Hybrid Waveforms
Experimenting with transition analysis measurements in various situations, the authors recorded hybrid discharge waveforms in two areas.

1. Manual device transport
2. Garments
In device transport, personnel carried ESDS devices and placed them in contact with a conductor. The resulting discharge appears as combination of HBM and CDM (Figure 14).

Figure 14: Device Transport Hybrid Waveform

Garment measurement and analysis have been sources of controversy for several years. The common design incorporates insulative fabrics having conductive threads woven through the material. The material is a charge generator; however, if the conductors are properly grounded electrostatic fields are suppressed. Problems arise when the garment conductors are not well grounded. Here, the electrostatic field from the surrounding insulative material couples with the conductor inducing a substantial voltage. Should the conductor(s) make contact with an ESDS device or subassembly a discharge waveform having characteristics of CDM and HBM occur.

In Figure 15, the garment discharged approximately 400 nJ of energy at 50% relative humidity.

Conclusions

Process Capability and Transitional Analysis are critical requirements for determining:

1. The ability of a process to protect ESDS devices and assemblies
2. Finding cause of ESD problems and
3. Identifying types of ESD issues in the process

Measuring process is critical for ultra ESD sensitive devices because all ESD models can be found in the process

- Focusing on one type limits program effectiveness
- Can lead to ineffective changes to the process to solve problems

References

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Stephen Halperin has over 30 years of industrial experience in controlling the effects of electrostatic discharge in complex applications. His background includes an undergraduate degree in Industrial Management, postgraduate work in the field of organizational communication sciences, six years of nuclear technology, and many years’ industrial manufacturing operations and management experience. Mr. Halperin formed Stephen Halperin & Associates, Limited (SH&A) in 1983, a management consulting firm specializing in electrostatic problem analysis, laboratory testing, training and static control product design. In 1992, he established Prostat Corporation for the design and manufacture of high performance electrostatic auditing instruments and ESD control materials.

Mr. Halperin is known for his work in facility and process evaluation, static control techniques for highly sensitive environments, and his many contributions to the growth of the electrostatics industry and Electrostatic Discharge Association. He has lectured and consulted on static control throughout North America, Europe and the Far East, and has provided electrostatic advisory services to major corporations in several industries including Food, Drug, Chemical, Automotive, Aerospace, Electronics and Military applications. He is a charter member of the ESD Association (ESDA), has served several terms as an elected member of the ESDA Board of Directors, and over the years, chaired Local Chapter Development, Education, Professional Certification, and Standards committees. Mr. Halperin was elected to the ESDA office of Vice President in 1999, served consecutive terms as Senior Vice President and President.

As a member of the Electronics Industries Association’s committee for Packaging Electronic Products for Shipment (PEPS) he served over 7 years on their Static Control Task Force #1, and participated in the development of the EIA-541 Packaging Standard. Mr. Halperin has been a long-term supporter of the Electrostatic Society of America (ESA), has been active in the ESD Symposium, and is the former Technical Advisor to ANSI’s USNC/IEC Committee. He is a recipient of the EOS/ESD Symposium’s Outstanding Paper Award, and was honored to receive the Association’s Outstanding Contribution Award for his work on behalf of industry. He is also the grateful recipient of the Joel P. Wiedendorf Memorial Award for his many ESDA Standards contributions. Mr. Halperin has delivered several papers on electrostatics and authored over 100 articles on related subjects. He is NARTE certified and a Certified ESD Program Manager Instructor. Today, he is one of the industry’s strongest supporters of ESD education and the implementation of S20.20 ESD program standards to enhance industry’s product reliability, productivity and profitability.

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Ron Gibson specializes in manufacturing process control, training and facility certification in accordance with ANSI/ESD S20.20. He is well known internationally as an outstanding ESD practitioner and as a major contributor to ESD technology since 1987. He is Celestica International’s Global Engineering Consultant and Corporate ESD Program Manager. He provides ESD technical guidance to all Celestica manufacturing sites, worldwide. Ron is highly experienced in manufacturing technology, packaging and all areas of ESD control in the electronic manufacturing process.

As a respected member of the standards development community Ron is active in the International Electrotechnical Commission (IEC) as the Standards Council of Canada’s (SCC) national representative. In his position as Chair for IEC Technical Committee (TC) 101, Working Group 5, the important ESD Program Standard IEC 61340-5-1 and Handbook IEC 61340-5-2 were fully redeveloped to be technically equivalent to ANSI/ESD S20.20, thus harmonizing international ESD program standards. He distinguished himself by serving as the ESD Association’s Standards Chair for 10 years and publishing more industry ESD support documents than any standards chair in the history of ESDA. A member of the ESD Association since 1988, he has been active in several Standards Development Committees, a contributor to and past General Chairman of the EOS/ESD Technical Symposium, and served in every association officer’s position, including consecutive terms as Treasurer and ESDA President. As a co-founder and developer of the Professional ESD Program Manager Certification program, Ron has lectured and taught a variety of ESD courses internationally for major corporations and professional associations.

Ron received the ESD industry’s highest award, the ESDA Outstanding Contribution Award, for his innovation and extensive list of technical contributions. In particular, he chaired the development and launched the ESD Association’s Facility ESD Certification program based on the ANSI/ESD S20.20 standard. This important benchmark is designed to confirm the effectiveness of a facility’s ESD control program and reduce losses, manufacturing costs, and enhance product reliability. ESD Program Certification is provided to electronics manufacturing facilities only through 3rd party ISO9000 registrars. Ron’s team has trained over 160 ISO9000 Lead Assessors globally, and to date over 200 electronics manufacturing facilities have been certified to the S20.20 Standard. During the past several years Ron has worked with SH&A on many projects. He presently supports SH&A’s ESD program design, training and facility certification preparation services through a representative agreement between SH&A and Celestica Corporation.

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John Kinnear is a specialist in process & system technology, and facility certification in accordance with ANSI/ESD S20.20. John is well known globally for his technical contributions to national and international ESD standards since 1990, and for innovations in facility certification program development. John is a Senior Engineer in the Classical Test department of IBM in Poughkeepsie, NY, where he has been the ESD Site Coordinator for the Poughkeepsie site since 1989. He is the past chairman of the IBM Inter-divisional Technical Liaison Committee for ESD Protection and is an important member of his company’s committee to develop and implement the ESD Corporate program for IBM.

A respected member of the ESD Association since 1990, John has served in several Standards Development Committees as well as association management positions. Based on his long-term contributions to ESD Standards development and in-depth technical qualifications, John is the appointed Technical Adviser to the United States National Committee/IEC Technical Committee 101, where he personally represents the United States to the International Electrotechnical Commission (IEC). In this important position he assisted in the evolution of international ESD standards and supports international adoption of ANSI/ESD S20.20.

As Vice Chair of the ESDA’s Facility Certification (ANSI/ESD S20.20) development program, John played major roles in the program’s development and industry launch. In particular, John coordinated the initial development of Lead Assessor training, ISO Registrar Certification and witness audits. Through his efforts ESD Program Certification is provided to electronics manufacturing facilities through these 3rd party ISO9000 registrars. John has trained approximately half of the global ESDA Certified ISO9000 Lead Assessors.

John has made many contributions to the growth of the ESD Association. He has served in every ESD Association officer’s position, including Vice President, Senior Vice President and President. He is the past Chairman of the EOS/ESD Symposium Technical Program Committee and is presently General Chairman of the 2004 EOS/ESD Symposium.

John graduated in 1979 from the State University of Buffalo where he received a Bachelor of Science Degree in Electrical Engineering. He received his Masters of Science Degree in Electrical and Computer Engineering from Syracuse University in 1986.

During the past several years John has worked with SH&A in advisory services and product design projects. He presently supports SH&A’s ESD program design and facility certification preparation services through a representative agreement between SH&A and IBM Corporation.

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SH&A CERTIFIED ESD SPECIALIST\textsuperscript{SM} PROGRAM

The SH&A Certified ESD Specialist\textsuperscript{SM} Programs prepare industry to meet the handling challenges of ultra ESD sensitive electronic devices that will be commercialized over the next 3 years. SH&A’s highly effective training curriculum provide the skills and information necessary to meet these challenges today.

LEVEL 1: PLANT AUDITOR (3 FULL DAYS)

Learning Objectives

The Level 1 Plant Auditor Course will teach the fundamentals of ESD and train technicians to make the ESD Control Measurements required by ANSI/ESD S20.20 and IEC 61340-5-1 ESD Program standards including:

- Worksurfaces
- Floors
- Chairs
- Mobile Equipment
- Garments
- Personnel Grounding (footwear, wrist straps etc…)
- Ionizers
- Gloves
- Hand Tools
- ESD Ground Verification
- Packaging

This course is 3 days of intensive study that includes the following subjects:

- Classroom Instruction
  - ESD Basics for Auditors
  - Device Failure Models and Mechanisms
  - Equipment selection and use
  - Detailed measurement practices

- Measurement Workshop
  - Individual instructions on resistance and voltage measurement techniques
  - Hands on practice using state-of-the-art auditing equipment

- Optional Certification Exam
  - Candidate demonstrates proficiency in using equipment for required audit measurements
  - Successful candidates are designated as SH&A Certified ESD Specialist\textsuperscript{SM} Level 1: Plant Auditor

DATE & COST

When: October 21 – 23, 2008, 8:30 a.m. - 5:00 p.m.
Where: Bensenville Training Facility, Illinois
Cost: $1,995. USD
5 or more: $1,595. USD

Bensenville, IL USA

Chicago looks great from every angle, whether you’re exploring the city’s astonishing architecture during a guided tour or you’re enjoying the birds-eye view from the 103rd floor Sears Tower. Our Bensenville facility is only 15 min. from O’Hare Airport and 25 to 30 min. from Downtown Chicago.

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“3 exciting days of practical ESD education!”