

# Fundamentals of Electrostatic Discharge

## Part Four – Training and Compliance Verification Auditing

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Your static control program is up and running. How do you determine whether it is effective? How do you make sure your employees follow it? In Part Three, we covered basic static control procedures and materials of your ESD control program. In *Part Four*, we will focus on two ESD control program plan requirements: training and compliance verification auditing. Per ANSI/ESD S20.20 and IEC 61340-5-1 the written ESD control plan is to include a training plan and a compliance verification plan.

### Personnel Training

The procedures are in place. The materials are in use. But, your ESD control program just does not seem to yield the expected results. Failures declined initially, but they have begun reversing direction. Or perhaps there was little improvement. The solutions might not be apparent in inspection reports of incoming ESD protective materials. Nor in the wrist strap log of test results. In large companies or small, it is hard to overestimate the role of training in an ESD control program. ANSI/ESD S20.20 and IEC 61340-5-1 ESD Control Program standards cite training as a basic administrative requirement within an ESD control program.

There is significant evidence to support the contribution of training to the success of the program. We would not send employees to the factory floor without the proper soldering skills or the knowledge to operate the automated insertion equipment. We should provide them with the same skill level regarding ESD control procedures.

### Elements of Effective Training Programs

Although individual requirements cause training programs to vary from company to company, there are several common threads that run through the successful programs.

#### 1. Successful training programs cover all affected employees.

Obviously we train the line employees who handle ESD sensitive devices and typically test their wrist straps or place finished products in static protective packaging. But we also include department heads, upper management, and executive personnel in the process. Typically they are responsible for the day-to-day supervision and administration of the program or they provide leadership and support. Even subcontractors and suppliers should be considered for inclusion in the training program if they are directly involved in handling your ESD sensitive components, sub-assemblies or products.

Because ESD control programs cover such a variety of job disciplines and educational levels, it may be necessary to develop special training modules for each organizational entity. For example, the modules developed for management, engineering, assembly technicians and field service could differ significantly from one another because

their day-to-day concerns and responsibilities are much different. Also the different education and skills should be considered.

## **2. Effective training is comprehensive and consistent.**

Training not only covers specific procedures, but also the physics of the problem and the benefits of the program as well. Consistent content across various groups, facilities, and even countries (adjusted for cultural differences) reduces confusion and helps assure conformance. The training content should include topics such as the fundamentals of static electricity and electrostatic discharges, the details of the organization's ESD Control Program plan, and each person's role in the plan.

## **3. Use a variety of training tools and techniques.**

Choose the methods that will work best for your organization. Combine live instruction with training videos or interactive computer-based programs. You may have in-house instructors available, or you may need to go outside the company to find instructors or training materials. You can also integrate industry symposia, tutorials, and workshops into your program. Consider using this "Fundamentals of ESD" series of articles.

Effective training involves employees in the process. Reinforce the message with demonstrations of ESD events and their impact. Bulletin boards, newsletters, and posters provide additional reminders and reinforcement.

Maintaining a central repository for educational ESD control materials will help your employees keep current or answer questions that may occur outside the formal training sessions. Materials in such a repository might include

- Material from initial and recurring training sessions
- ESD Association or internal bulletins or newsletters
- DVDs or CDs
- Computer based training materials
- Technical papers, studies, standards (e.g. ESD Association, IEC, JEDEC), test methods and technical reports
- ESD control material and equipment product technical data sheets

In addition, a knowledgeable person in the organization should be available to answer trainee questions once they have begun working.

## **4. Test, certify and retrain**

Your training should assure comprehension, material retention and emphasize the importance of the effort. If properly implemented, testing and certification motivates and builds employee pride. Retraining or refresher training is an ongoing process that reinforces, reminds, and provides opportunities for implementing new or improved

procedures. Establish a system to highlight when employees are due for retraining, retesting, or recertification.

## **5. Feedback, compliance verification, and measurement**

Motivate and provide the mechanism for program improvement. Sharing yield or productivity, quality, and reliability data with employees demonstrates the effectiveness of the program and of their efforts. Tracking these same numbers can indicate that it's time for retraining or whether modifications are required in the training program.

Design and delivery of an effective ESD training program can be just as important as the procedures and materials used in your ESD control program. Without an effective personnel training program, investments in ESD materials can be wasted. A training program that is built on identifiable and measurable performance goals helps assure employee understanding, implementation and success.

A key method of training effectiveness is observation of the operator in the EPA following ESD control procedures and precautions. Non-compliance with required ESD control program practices should be treated in the same manner of other impermissible actions that are handled through the company's disciplinary process. This includes verbal warnings, re-training, written warnings, and eventually re-assignment or termination.

### **Compliance Verification Auditing**

Developing and implementing an ESD control program itself is obvious. What might not be so obvious is the need to continually review, verify, analyze, feedback and improve. You will be asked to continually identify the program's financial return on investment and to justify expenditures with the cost savings realized. Technological changes will dictate improvements and modifications. Feedback to employees and top management is essential. Management commitment will need continuous reinforcement.

Like training, regular program compliance verification and auditing becomes a key factor in the successful management of ESD control programs. The mere presence of the auditing process spurs compliance with program procedures. It helps strengthen management's commitment. Program compliance verification reports should trigger required corrective action and help foster continuous improvement.

The benefits to be gained from regular compliance verification of ESD control procedures are numerous.

- Prevent problems before they occur rather than always fighting fires.
- Identify problems and take corrective action.
- Identify areas in which our programs may be weak and provide us with information required for continuous improvement.
- Leverage limited resources effectively.
- Determine when our employees need to be retrained.
- Improve yields, productivity, and reliability.
- Bind our ESD program together into a successful effort.

An ESD control program compliance verification audit measures performance to the ESD Control Program Plan's required limits. Typically, we think of the ESD program compliance verification as a periodic review and inspection of the ESD protective area (EPA) verifying the correct use of packaging materials, wearing of wrist straps, following defined procedures, and similar items. Auditing can range from informal surveys of the processes and facilities to the more formal third-party audits for ISO 9000 or ANSI/ESD S20.20 certification.

## Requirements for Effective Compliance Verification

Regardless of the structure, effective compliance verification revolves around several factors. First, the *existence of a written and well-defined ESD Control Program Plan* with defined required limits for each EPA ESD control item. It is difficult to measure performance if you do not have anything to measure against. Yet, you quite frequently hear an auditor ask, "Some people say you should measure less than 500 volts in an EPA, but others say you should measure less than 100 volts. What's acceptable when I audit the factory floor?" Obviously, this question indicates a lack of a formal ESD Control Program Plan defined required limits and test procedures, and the audit will be relatively ineffective.

Second, the *taking of some measurements* – typically measuring resistance and detecting the presence of charge or fields. Therefore, you will need *test equipment* to conduct EPA compliance verification. As a minimum, you will need an *electrostatic field meter*, a *high range resistance meter*, a *ground AC outlet tester*, and appropriate electrodes and accessories.

Third, *include all areas in which ESD control is required* to protect electrostatic discharge sensitive (ESDS) items. Typically included are receiving, inspection, stores and warehouses, assembly, test and inspection, research and development, packaging, field service repair, offices and laboratories, and cleanrooms. All of the areas listed in the ESD Control Program Plan are subject to compliance verification. Even the areas that are excluded from the plan need to be reviewed to ensure that unprotected ESDS devices are not handled in those areas. In the event that devices do enter those areas (e.g. Engineering and Design), mechanisms must be put in place to ensure that the devices are handled as non-conforming product. Similarly, we need to audit all of the various processes, materials, and procedures that are used in our ESD control programs – personnel, equipment, wrist straps, floors, clothing, worksurfaces, continuous monitors, seating, training, and grounding.

Fourth, we need to conduct compliance verification audits *frequently and regularly*. However, the user must determine the frequency (and if sampling is appropriate). Per Compliance Verification ESD TR53 ANNEX A Test Frequency "The objective of the periodic test procedures listed in this document is to identify if significant changes in ESD equipment and materials performance have occurred over time. Test frequency limits are not listed in this document, as each user will need to develop their own set of test frequencies based on the critical nature of those ESD sensitive items handled and the risk of failure for the ESD protective equipment and materials. Examples of how test frequencies are considered:

Daily wrist strap checks are sufficient in some applications, where in other operations constant wrist strap monitoring may be used for added operator grounding reliability. Packaging checks may depend on the composition of the packaging and its use. Some packaging may have static control properties that deteriorate more quickly with time and use and some packaging may be humidity dependent and may have limited shelf life. Some materials, such as ESD floor finishes, may require more frequent monitoring because of their lack of permanency. Other materials, such as ESD vinyl floor covering, may require less monitoring. The testing of a floor should also be considered after maintenance on the floor has been performed.”

The actual frequency of compliance verification audits depends upon your facility and the ESD problems that you have. Following an ESD Control Program initial audit, some experts recommend auditing each department once a month if possible and probably a minimum of six times per year. If this seems like a high frequency level, remember that these regular verification audits are based upon a *sampling* of work areas in each department, not necessarily *every* workstation. Once you have gotten your program underway, your frequency of audit will be based on your experience. If your audits regularly show acceptable levels of conformance and performance, you can reduce the frequency and the sampling. If, on the other hand, your audits regularly uncover continuing problems, you will want to increase the frequency and the sampling.

Fifth, we need to *maintain trend charts and detailed records and prepare reports*. They help assure that specified procedures are followed on a regular basis. The records are essential for quality control purposes, corrective action and compliance with ISO-9000.

Finally, upon completion of the compliance verification audit, it is essential to *implement corrective action* if deficiencies are discovered. Trends need to be tracked and analyzed to help establish corrective action, which may include retraining of personnel, revision of requirement documents or processes, or modification of the existing facility.

## **Types of Audits**

There are three types of ESD audits: *program management* audits, *quality process* checking, and *ESD Control Program compliance verification (work place)* audits. Each type is distinctively different and each is vitally important to the success of the ESD program

*Program management* audits measure how well a program is managed and the strength of the management commitment. The program management audit emphasizes factors such as the existence of an effective implementation plan, realistic program requirements, ESD training programs, regular compliance verification audits, and other critical factors of program management. The program management audit typically is conducted by a survey specifically tailored to the factors being reviewed. Because it's a survey, the audit could be conducted without actually visiting the site. The results of this audit indirectly measure work place compliance and are particularly effective as a means of self-assessment for small companies as well as large global corporations.

*Quality process* checking applies statistical quality control techniques to the ESD process and is performed by operations personnel. This is not a periodic verification

audit, but rather tracking daily effectiveness of the program. Visual and electrical checks of the procedures and materials, wrist strap testing for example, are used to monitor the quality of the ESD control process. Checking is done on a daily, weekly or monthly basis.

Trend charts and detailed records trigger process adjustments and corrective action. They help assure that specified procedures are followed on a regular basis. The records are essential for quality control purposes, corrective action and compliance with ISO-9000.

*ESD Control Program Compliance Verification* audits verify that program procedures are followed and that ESD control materials and equipment are within required limits or are functioning properly. Compliance Verification audits are performed on a regular basis, often monthly, and utilize sampling techniques and statistical analysis of the results. The use of detailed checklists and a single auditor assures that all items are covered and that the audits are performed consistently over time.

## **Basic Auditing Instrumentation**

Special test equipment will be required to conduct EPA compliance verification. The specific test equipment will depend on what you are trying to measure, the precision you require and the sophistication of your static control and material evaluation program. However, as a minimum, you will need an *electrostatic field meter*, a *high range resistance meter*, a *ground/AC outlet tester*, and appropriate electrodes and accessories. Additional test equipment might include a charged plate monitor, footwear and wrist strap testers, chart recorders/data acquisition systems and timing devices, discharge simulators, and ESD event detectors.

Although this equipment must be accurate and calibrated according to the vendor's recommendations, it needs not be as sophisticated as laboratory instruments. The compliance verification audit is intended to verify basic functions and not for product qualification of ESD control equipment or materials. The compliance verification audit is intended to verify basic functions and not as a product qualification of ESD control items or materials. You want the right tool for the job. Just as you would not buy a hammer if you are were planning to saw wood, you would not purchase an electrometer to measure static voltages on a production line. Remember, many of the test equipment you might choose for compliance verification are good indicators, but not suitable for precise evaluation of materials. However, be sure that you can correlate the measurements obtained on the factory floor with those obtained in the laboratory. If you are making measurements according to specific standards or test methods, be sure the instrumentation meets the requirements of those documents.

With a hand-held **electrostatic field meter**, you can measure the presence of electrostatic fields in your environment allowing you to identify problems and monitor your ESD control program. These instruments measure the electrostatic field associated with a charged object. Many electrostatic field meters simply measure the gross level of the electrostatic field and should be used as general indicators of the presence of a charge and the approximate level of electrical potential of the charge. Others will provide more precise measurement for material evaluation and comparison.

For greater precision in facility measurements or for laboratory evaluation, a **charged plate monitor** is a useful instrument that can be used in many different ways; for example to evaluate the performance of flooring materials or measuring the offset voltage (balance) and discharge times of ionizers.

Because grounding is so important, resistance is one of the key factors in evaluating ESD control materials. A high range **resistance meter** becomes a crucial instrument. Most resistance measurements are made using a 100 volt or 10 volt test voltage. The resistance meter you choose should be capable of applying these voltages to the materials being tested. In addition, the meter should be capable of measuring resistance ranges of  $10^3$  to  $10^{12}$  ohms. With the proper electrodes and cables, you will be able to measure the resistance of flooring materials, worksurfaces, equipment, furniture, garments, and some packaging materials.

The final instrument is a **ground/AC outlet tester**. With this device you can measure the continuity of your ESD grounds, check the impedance of the equipment grounding conductor (3<sup>rd</sup> wire AC ground) as well as verify that the wiring of power outlets in the EPA is correct.

### Areas, Processes, and Materials to be Audited

Previously we stated that ESD protection was required “wherever unprotected ESD sensitive devices are handled.” Obviously, our audits need to include these same areas. Table 1 indicates some of the physical areas that may be part of the ESD Control Program Plan and therefore will be involved in Compliance Verification Audits. Remember, some areas may be excluded from the Plan depending on the Scope of the Plan.

As noted in Part 3 Table 1 Typical Facility Areas Requiring ESD Protection

| Table 1<br>Typical Facility Areas Requiring ESD Protection |
|--|
| Receiving  |
| Inspection   |
| Stores and Warehouses                                      |
| Assembly   |
| Test and Inspection  |
| Research and Development                                   |
| Packaging  |
| Field Service Repair                                       |
| Offices and Laboratories                                   |
| Cleanrooms   |

Similarly, we need to conduct Compliance Verification audits of all the various requirements that are used in our ESD Control Program Plan. Some of these are shown in Table 2.

| <b>Table 2<br/>Typical Processes, Materials and Procedures</b> |
|--|
| Personnel  |
| Wrist Straps   |
| Floors, Floor Mats, Floor Finishes                             |
| Shoes, Foot Grounders, Casters                                 |
| Garments   |
| Mobile Equipment (Carts, trolleys, lift trucks)                |
| Workstations   |
| Worksurfaces   |
| Packaging and Materials Handling                               |
| Ionization   |
| Grounding  |
| Continuous Monitors  |
| Seating  |
| Production Equipment   |
| Tools and Equipment (Soldering irons, fixtures, etc.)          |
| Marking  |
| Purchasing Specifications and Requisitions                     |
| ESD Measurement and Test Equipment                             |
| Personnel Training   |

## Checklists

Checklists can be helpful tools for conducting Compliance Verification audits. However, it is important that ESD control program requirements are well documented and accessible to avoid a tendency for checklists becoming *de facto* lists of requirements. Table 3 indicates the type of questions and information that might be included in an auditing checklist. Other checklists are in the ESD Handbook ESD TR20.20 section 4.3.3. Your own checklists, of course, will be based on your specific needs and program requirements. They should conform to your actual ESD control procedures and specifications and they should be consistent with any ISO 9000 requirements you may have. For ANSI/ESD S20.20 based ESD Control Programs, the recognized Certification Bodies (Registrars) use a formal checklist supplied by the ESD Association to aid in conducting the Certification Audit.

In addition to checklists, you will use various forms for recording the measurements you make: resistance, voltage generation, etc. Part of your compliance verification audit will also include the daily logs used on the factory floor such as those used for wrist strap checking.

| <b>Table 3<br/>Partial Audit Checklist<br/>ESD Control Program</b>  |          |          |                 |
|---|----------|----------|-----------------|
| <b>Function/Area Audited:</b> Facilities  |          |          |                 |
| Date:   |          |          |                 |
| By:   |          |          |                 |
| <b>Audit Questions</b>  | <b>Y</b> | <b>N</b> | <b>Comments</b> |
| 1. Where ESD protective flooring is used for personnel grounding, are ESD footwear worn?  |          |          |                 |
| 2. Where ESD floors and footwear are used for personnel grounding, do personnel check and log continuity to ground upon entering the EPA? |          |          |                 |
| 3. Are personnel wearing grounded wrist straps at the ESD protective workstations (if required)?  |          |          |                 |
| 4. Are personnel checking wrist straps for continuity or using a continuous monitor?  |          |          |                 |
| 5. Where continuous monitors are not used, are wrist straps checked and logged routinely and at frequent intervals?                       |          |          |                 |
| 6. Are wrist strap checkers and continuous monitors checked and maintained periodically?  |          |          |                 |
| 7. Are wrist strap cords checked, on the person, at the workstation?  |          |          |                 |
| 8. Are disposable foot grounders limited to one time use?   |          |          |                 |
| 9. Are test records for wrist straps and foot grounders kept and maintained?  |          |          |                 |
| 10. When required, are ESD protective garments correctly worn?  |          |          |                 |
| 11. Are nonessential personal items kept out of the EPA?  |          |          |                 |
| 12. Are personnel working in the EPA currently certified or escorted?   |          |          |                 |
| 13. Are ESD Control requirements imposed on visitors to the EPA?  |          |          |                 |

## **Reporting and Corrective Action**

Upon completion of the compliance verification auditing process, Reports should be prepared and distributed in a timely manner. Details of the audits need to be fully documented for ISO-9000 or ANSI/ESD S20.20 certification. As with all audits, it is essential to implement corrective action if deficiencies are discovered. Trends need to be tracked and analyzed to help establish corrective action, which may include retraining of personnel, revision of requirement documents or processes, or modification of the existing facility.

## Conclusion

Compliance verification and personnel ESD control training are key ANSI/ESD S20.20 and IEC 61340-5-1 requirements to maintain an effective ESD control program. They help assure that ESDS handling procedures are properly implemented and can provide a management tool to gauge program effectiveness and to make continuous improvement.

## For Further Reference

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