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You Can't Make This Stuff Up!



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24 Growing the Engineer's Toolkit

Project Management Tips and Techniques

In today's fast-paced product development cycles, the pressure to compress testing and certification schedules is constantly increasing, with global competitors all rushing to get their new technology to market first. Utilizing project management techniques can provide great benefits by improving the efficiency and quality of compliance projects.

Mark Maynard

DEPARTMENTS

8 News in Compliance

12 Technically Speaking
Understanding Creepage Distances

14 Mr. Static
Static Hocus Pocus

20 On Your Mark
Your Guide to Effective Product Safety Labels

49 Product Showcase

50 Authors

50 Advertisers

FEATURES

32 Furthering Your Professional Development in 2014

The start of a new year is a time when, traditionally, we reflect on the progress we made during the year passed and set our goals for the new year. We've queried training resources in our niche industry to provide you with an overview of affordable solutions to meet your training goals in 2014. You'll find here sources of compliance related seminars and workshops offered online and on location, public and private.

In Compliance Editors

42 Fundamentals of Electrostatic Discharge

Part One: An Introduction to ESD

To many people, Electrostatic Discharge (ESD) is only experienced as a shock when touching a metal doorknob after walking across a carpeted floor or after sliding across a car seat. However, static electricity and ESD has been a serious industrial problem for centuries. In this article, we will discuss electrostatic charge and discharge, the mechanisms of creating charge, materials, types of ESD damage, ESD events, and ESD sensitivity.

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COURSE CONTENT

CABLING

Electric and magnetic field coupling, crosstalk. Cable types: coax, twisted pair and ribbon cables. Cable shielding and terminations.

GROUNDING PRINCIPLES

Why do we ground? Ground systems: single point, multipoint, hybrid. Ground loops. Return current paths, split reference planes. EMC grounding philosophy. AC power grounds.

DIGITAL LAYOUT & GROUNDING

Noise sources, PCB layout, power distribution, ground grids, characteristics of ground planes. Decoupling capacitors: value, placement, resonance and limitations.

HIGH SPEED DIGITAL DECOUPLING

Alternative decoupling methods, use of distributed decoupling capacitance, power supply isolation, effect of paralleling capacitors. Embedded PCB capacitance.

DIFFERENTIAL-MODE EMISSION

Radiated emission mechanisms. Fourier spectrum. Methods of controlling differential-mode emission. Clock dithering. Cancellation techniques.

COMMON-MODE FILTERING

Basic C-M filter theory. Filter source and load impedances. Single and multi-stage filters. Ferrite chokes versus shunt capacitors. Effectiveness of various filter configurations. Filter mounting and layout.

TRANSMISSION LINES

What is a transmission line? Transmission-line effects, transmission-line radiation, and matching. How currents flow on transmission lines. Series, shunt and AC terminations. Simulation.

MIXED SIGNAL PCBs

Defining the problem, A/D converter requirements, return current paths, split ground planes, PCB partitioning, bridges & moats, routing discipline.

RF & TRANSIENT IMMUNITY

RF immunity: circuits affected, PCB layout, audio rectification, RFI filters. Transient immunity: circuits affected, the three-prong approach, keeping transient energy out, protecting the sensitive devices, designing software/firmware for transient immunity.

CONDUCTED EMISSION

AC power line conducted emission models, switching power supplies, parasitic capacitance, layout. Common-mode and differential-mode conducted emission, common-mode chokes, saturation. Power line filters.

SHIELDING

Absorption and reflection loss. Seams, joints, gaskets, slot antennas, and multiple apertures. Waveguides below cutoff, conductive coatings. Cabinet and enclosure design.



HENRY OTT

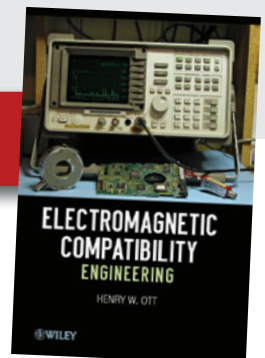


Henry W. Ott is President and Principal Consultant of Henry Ott Consultants, an EMC training and consulting organization. He has literally "written the book" on the subject of EMC and is considered by many to be the nation's leading EMC educator. He is the author of the popular EMC book Noise Reduction Techniques in Electronic Systems (1976, 1988).

The book has sold over 65,000 copies and has been translated into six other languages. In addition to knowing his subject, Mr. Ott has the rare ability to communicate that knowledge to others. Mr. Ott's newly published (Aug. 2009) 872-page book, Electromagnetic Compatibility Engineering, is the most comprehensive book available on EMC. While still retaining the core information that made Noise Reduction Techniques an international success, this new book contains over 600 pages of new and revised material.

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***Electromagnetic
Compatibility Engineering**,
by Henry W. Ott

Who Should Attend

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COURSE DATES/TIME: April 22-24, 2014
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Wednesday 8:30 a.m. to 5:00 p.m.

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COURSE FEE: \$1,495 (\$1,295 until 3/7/2014). Fee includes notes, textbook*, breakfast, luncheon and beverage breaks. Payment required prior to course. Hotel accommodations are NOT included.

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FCC News

FCC Proposes to Revitalize AM Radio Service

The U.S. Federal Communications Commission (FCC) has proposed a number of possible technical improvements to AM (amplitude modulation) radio services, as well as changes to its rules applicable to AM radio broadcasting.

In a Notice of Proposed Rulemaking issued in October 2013, the Commission has requested comment on possible changes in the following areas:

- Providing AM licensees and permittees with an exclusive opportunity to file for an FM translator radio license
- Modifying daytime and nighttime community coverage standards for existing AM stations
- Eliminating the FCC's so-called "ratchet rule," which restricts the amount of skywave interference that certain AM broadcasters may create
- Permitting wider implementation of modulation-dependent carrier-level control technologies
- Modifying current AM antenna efficiency standards

The Commission notes that the proposed changes to its current

regulation of the AM radio service will enable AM broadcasters to better serve the public, thereby advancing the Commission's goals of competition and diversity in broadcasting.

Comments on the proposed changes are due to the FCC by the end of December 2013.

The complete text of the Commission's Notice of Proposed Rulemaking is available at incompliancemag.com/news/1401_01.

FCC Proposes An Additional \$33 Million in Penalties for Lifeline Program Violations

The U.S. Federal Communications Commission (FCC) has proposed \$32.6 million in monetary forfeitures against three wireless Lifeline service providers who allegedly established multiple Lifeline wireless phone service subscriptions for individual consumers, in violation of the program's rules.

The Commission issued Notices of Apparent Liability (NALs) in October 2013 against wireless carriers Conexions Wireless, i-Wireless and True Wireless. In each instance, the Commission says

that the carriers knew or should have known that targeted consumers were already participants in the Lifeline program, and therefore ineligible for multiple subscriptions under Lifeline program rules.

The proposed monetary forfeitures were based on the number of unlawful payment requests made by each respective carrier, which was then adjusted upward by three times the total duplicate payments requested. The proposed forfeitures issued by the Commission in October 2013 follow more than \$14 million in proposed forfeitures issued in September 2013 against five other wireless Lifeline service providers, as well as stepped-up enforcement efforts by the FCC.

Established in 1985, the Lifeline program provides discounted wireless service subscriptions to low-income consumers. However, evidence of widespread abuse led the Commission to overhaul the program in 2012, and to aggressively pursue investigations of duplicate service and fraud. The Commission says that its actions to date have eliminated more than 1.1 million duplicate Lifeline subscriptions, and that continued enforcement efforts will result in savings of over \$2 billion over a three-year period.



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European Union News

EU Commission Updates Standards List for ATEX Directive

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate conformity with the essential requirements of its directive concerning equipment and protective systems intended for use in potentially explosive atmospheres.

The directive, 94/9/EC, which is also known as the ATEX Directive, applies to “machines, apparatus, fixed or mobile devices, control components and instrumentation...and detection or prevention systems which...are intended for the generation, transfer, storage, measurement, control and conversion

New List of Standards Issued for EU’s Machinery Directive

The Commission of the European Union (EU) has issued an updated list of standards that can be used to demonstrate compliance with the essential requirements of its Directive 2006/42/EC, also known as the Machinery Directive.

The EU’s Machinery Directive defines the essential health and safety requirements for a wide range of products, including: machinery and partly completed machinery; lifting accessories; chains, ropes and webbing; interchangeable equipment; removable mechanical transmission devices; and safety components.

The revised list of standards can be viewed at incompliancemag.com/news/1401_03.

Updated Standards List Published for the EU’s Electrical Safety Directive

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate conformity with the essential requirements of its directive relating to electrical equipment designed for use within certain voltage limits (2006/95/EC).

The Directive defines ‘electrical equipment’ as any device designed for use with a voltage rating of between

The Commission of the European Union has updated the standards lists for the ATEX Directive (94/9/EC), the Machinery Directive (2006/42/EC) and the Electrical Safety Directive (2006/95/EC).

of energy and/or the processing of material,” and “which are capable of causing an explosion through their own potential sources of ignition.”

The updated list of standards was published in November 2013 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the ATEX Directive.

The complete list of standards can be viewed at incompliancemag.com/news/1401_02.

The Directive’s scope specifically excludes electrical and electronic products covered under Directive 2006/95/EC (the EU’s so-called Electrical Safety Directive), including household appliances, audio and video equipment, informational technology equipment and ordinary office machinery.

The extensive list of CEN and Cenelec standards for the Machinery Directive was published in November 2013 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive.

50 and 1000 V for alternating current, and between 75 and 1500 V for direct current.

The updated list of standards that can be used to demonstrate compliance with the Directive was published in November 2013 in the *Official Journal of the European Union*, and replaces all previously published standards lists.

The complete list of standards can be viewed at incompliancemag.com/news/1401_04 (note that the list runs nearly 100 pages).

CPSC News

CPSC Reports Decrease in Toy Safety Recalls

The U.S. Consumer Product Safety Commission (CPSC) says that increased regulation and intensified oversight has resulted in a significant reduction in the number of unsafe toys reaching consumers in the U.S.

According to a press release issued in November 2013, the CPSC and U.S. Customs and Border Protection have stopped nearly 10 million units of about 3000 different toys that failed to meet U.S. regulations and standards from entering the U.S. marketplace over the past five years. This stepped-up enforcement, says the CPSC, has led to a reduction in the number of toy safety recalls as well as a reduction in the number of fatalities related to unsafe toys.

Specifically, the CPSC issued only 31 toy recalls during the federal fiscal year ending October 31. This compares with 38 toy recalls in fiscal year 2012, 34 recalls in 2011, 46 recalls in 2010, 50 recalls in 2009 and 172 recalls in 2008. Importantly, none of the 2013 recalls involved a violation of the CPSC's lead content standard.

Toy-related deaths involving children younger than 15 are also on the decline, from 19 in 2010 to 17 in 2011 to 11 in 2012. Most of the 2012 fatalities involved, or were attributed to, riding toys such as tricycles and scooters.

The CPSC's 2012 annual report on toy-related deaths and injuries was released in November 2013, and is available at incompliancemag.com/news/1401_05.

"I am proud of the work we have done to build a global system of toy safety," noted outgoing CPSC Chair Inez Tenenbaum. "When parents and grandparents walk into a toy store or visit an e-tailer, they

can have confidence that the toys they see have likely been independently tested to ensure compliance."

Viking Recalls Refrigerators Due to Fire Hazard

Viking Range LLC of Greenwood, MS has announced the voluntary recall of about 750 Viking-brand side-by-side refrigerator freezers with in-door water and ice dispensers manufactured in the U.S.

Viking reports that electrical connectors in the refrigerator freezer wiring harness can overheat, exposing consumers to a potential fire hazard. The company says that it has received 27 separate reports of electrical shorts associated with the recalled refrigerator freezers, resulting in four fires. However, there have been no reports of injuries.

The recalled refrigerator freezers were sold through appliance and specialty stores nationwide from November 2012 through May 2013 for between \$5400 and \$6400.

More details about this recall can be found at incompliancemag.com/news/1401_06.

LED Candelabra Light Bulbs Recalled Due to Overheating

The Infinity Green Company of Los Angeles, CA is recalling about 2000 candelabra-shaped LED light bulbs manufactured in China.

The company reports that the light bulbs can overheat and catch fire, posing a fire and burn hazard to consumers. Infinity Green says that it has received two reports of the recalled bulbs overheating

and catching fire, but no reports of injuries or property damage.

The recalled LED light bulbs were sold online through Heartlandamerica.com, OfficeSuperSavers.com, ToolKing.com, Wayfair.com and [Green Express Direct.com](http://GreenExpressDirect.com) from June 2013 through October 2013 for about \$17. The recalled bulbs were also sold through the Heartland America catalog.

Further information about this product recall is available at incompliancemag.com/news/1401_07.

Ryobi Battery Chargers Recalled

One World Technologies of Anderson, SC, has recalled over 500,000 Ryobi-brand battery chargers manufactured by Techtronic Industries Co. Ltd. of China, and sold in the U.S. The company is also recalling an additional 49,000 Ryobi-brand battery chargers sold in Canada.

According to One World, the battery chargers can malfunction, exposing consumers to burn and fire hazards. The company reports that it has received 25 reports of the recalled battery chargers overheating, resulting in damage to the charger as well as surrounding areas, such as workbenches, counter tops and carpeting. However, there have been no reports of injuries.

The recalled battery chargers were sold at The Home Depot, Direct Tools Factory Outlet, and other retail stores nationwide and online from September 2007 through December 2009. The chargers were sold either individually or as part of a kit, and retailed for between \$30 and \$270.

Additional details about this product recall are available at incompliancemag.com/news/1401_08.

You Can't Make This Stuff Up

Virginia Man Faces \$200K in Tolls

A Virginia man has reached a settlement with that state's Department of Transportation over unpaid toll road fees.

According to the NBC News affiliate in Washington, D.C., Jason Bourcier racked up more than \$40,000 in unpaid tolls over three and a half years, as a result of his frequent use of the area's Dulles Toll Road

during his search for work. Bourcier reportedly believed a friend, who told him that he could use the road after 11:30 pm at night without paying a toll.

Bourcier ignored repeated summonses from the Virginia DOT, but was finally hauled into court in November 2013 to settle his bill. The DOT estimated that Bourcier

owed more than \$200,000, including late fees and interest. However, the parties were able to agree on a settlement that will have Bourcier repaying the \$150 a month for the next 54 years!

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TECHNICALLY Speaking

Editor's Note: Over the past couple of years many of you have requested that we include more product safety related information in our issues. Of particular interest has been Rich Nute's series of "Technically Speaking" articles. And so... Mr. Nute has graciously agreed to work with us to bring you that series! Look for his column each month. We hope you enjoy the addition of "Technically Speaking" to the pages of In Compliance.

Understanding Creepage Distances

Product Safety Newsletter, April 1988

BY RICHARD NUTE

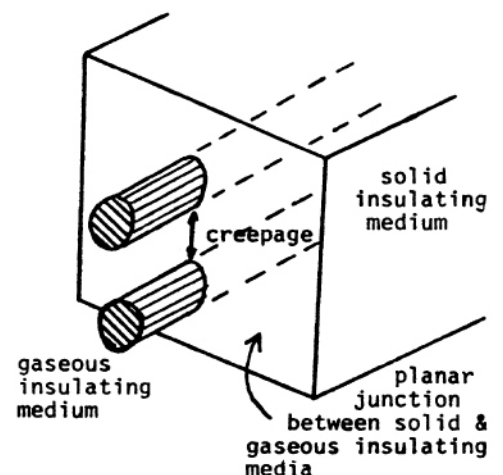
The term creepage refers to the abrupt junction of two, parallel insulating media. It is a particular junction -- such as that between solid and gaseous insulating media.

Note that creepage is *not* an insulator. Creepage is nothing more than a boundary surface. One characteristic of a boundary or junction is that the two insulating media likely have radically different electric strength ratings (volts per unit distance through the medium). Therefore, the distance between two conductors located at the junction *must* be chosen for the insulation with the least value of electric strength. Since air has the least value of electric strength, the distance between the two conductors must be based on the electric strength of air (See IEC 664, Table I).

Assume that the junction in question is a plane. As voltage is increased, eventually the air will break down and conduct. When it does so, an arc occurs, and power is dissipated in the arc. If the arc occurs at the surface of the solid insulation, the heat of the arc could burn the surface of the solid insulation and could result in a carbon path across the solid insulation.

One way to positively prevent this carbon path from happening is to move the arc away from the surface of the solid insulation. This can be done with a parallel clearance with smaller dimensions than the creepage. In this way, any arc will occur at the clearance rather than at the creepage.

Another way to prevent a carbon path is to make the clearance distance very long such that its electric strength approaches that of the parallel solid insulation. This is done by interposing a rib of solid insulation between the two conductors where they emerge




from the solid insulation (in air, the conductors must diverge such that the clearance between any two points has the required electric strength). The clearance path remains the shortest distance through air, but now the path may include some portion of creepage. Thus the air path is very long, and the electric strength of the clearance becomes very high.

My point is that a creepage path is not an insulator. The air and the solid media are the insulators. The electric strength of the AIR PATH determines the breakdown voltage. The air path can be made very long and its electric strength very high by interposing one or more ribs of solid insulation.

Based on the above, consider the following: If a clearance is located

remote from a creepage, and its distance is less than that of the creepage such that the clearance will break down at a lower voltage than the creepage, then what should be

the requirement for the Comparative Tracking Index (CTI) of the solid insulating medium (assume a pollution free environment)? 

(the author)

RICHARD NUTE

is a product safety consultant engaged in safety design, safety manufacturing, safety certification, safety standards, and forensic investigations. Mr. Nute holds a B.S. in Physical Science from California State Polytechnic University in San Luis Obispo, California. He studied in the MBA curriculum at University of Oregon. He is a former Certified Fire and Explosions Investigator.



Mr. Nute is a Life Senior Member of the IEEE, a charter member of the Product Safety Engineering Society (PSES), and a Director of the IEEE PSES Board of Directors. He was technical program chairman of the first 5 PSES annual Symposia and has been a technical presenter at every Symposium. Mr. Nute's goal as an IEEE PSES Director is to change the product safety environment from being standards-driven to being engineering-driven; to enable the engineering community to design and manufacture a safe product without having to use a product safety standard; to establish safety engineering as a required course within the electrical engineering curricula.



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Static Hocus Pocus

BY NIELS JONASSEN, sponsored by the ESD Association

When you read an ad extolling the virtues of some device and promising fantastic results, you often wonder, “Can this be true?” If you’re not familiar with the device, you may let it go, or maybe even believe the hype a little bit—*nid moy*, as they say here in Bangkok. It’s a completely different story, though, when somebody makes outrageous claims in an area that you know well.

INTRODUCTION

Associate Professor Neils Jonassen authored a bi-monthly static column that appeared in *Compliance Engineering Magazine*. The series explored charging, ionization, explosions, and other ESD related topics. The ESD Association, working with *In Compliance Magazine* is re-publishing this series as the articles offer timeless insight into the field of electrostatics.

Professor Jonassen was a member of the ESD Association from 1983-2006. He received the ESD Association *Outstanding Contribution Award* in 1989 and authored technical papers, books and technical reports. He is remembered for his contributions to the understanding of Electrostatic control, and in his memory we reprise “Mr. Static”.

~ The ESD Association

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Mr. Static Column
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Over the years that I have been employed at the Technical University of Denmark, I have experienced this scenario over and over again, generally in one of two forms. In the first, someone who knows very little physics skims a textbook, semidigests it, mixes that scant understanding with a little alternative medicine, and comes up with a gadget that he or she swears will be a boon to mankind. In the second, a company or other producer of devices that already work to a certain degree adds some completely useless component, such as a black box, that is said to boost efficiency by a zillion percent. Needless to say, the new component also boosts the price.

In the static arena, for instance, there’s always the cordless wrist strap. I haven’t seen any of those for a couple of years now, but I expect they’ll come back one of these days. And in the real world, not that long ago, you could have had your house checked for radon at a price that seemed too good to be true—and it was.

And in Europe we have seen, and to some extent still see, widespread concern about something called ground rays, which are said to be a causal agent in a number of serious illnesses, including cancer. No one has actually been able to define what ground rays are, and these ground rays can’t be measured by any physical instrument. But some gifted people claim they can detect—or measure, another misuse—so-called veins of them, using pairs of bent knitting needles. Naturally, these same beneficent people will help you screen your house for this evil phenomenon—at considerable expense to you, of course.

Now, I don’t wish to imply that such activities are necessarily fraudulent; indeed, I suppose some such claims are made in good faith. Nonetheless, these inventions are still just a lot of hocus-pocus, as the following examples attest. In each case, the gadget described met with considerable commercial success or aroused a good deal of public interest. Since some of these devices

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ROHDE & SCHWARZ

One day in 1980 or thereabouts, I received a call at the laboratory from a Mr. PN, who asked if I would be interested in an apparatus that could eliminate static electricity.

are still in production, I have refrained from using their trade names here.

ANTISTATIC ACUPUNCTURE

One day in 1980 or thereabouts, I received a call at the laboratory from a Mr. PN, who asked if I would be interested in an apparatus that could eliminate static electricity.

Of course I would be. I asked what kind of static electricity it eliminated, but PN didn't quite understand my question. As far as he was concerned, there was only one kind: human static electricity. So I invited him to come over and demonstrate his device for me.

It consisted of two shoe-sole-shaped copper cutouts, nicely chrome plated, about size 9. The two plates were connected by an ordinary insulated wire about 150 cm long. The insulated wire was attached to a common wire 2 to 3 m long that ended in a ground connector, which was designed to hook onto a heating radiator or water pipe.

There was also a nice pair of socks that went with the setup.

PN boasted that by wearing these soles inside shoes, the user would be drained of static electricity. (I tried to object that someone who was grounded surely couldn't get charged anyway, but evidently I was missing the point.) And the claims didn't stop there: according to PN, the soles would keep working even after the user took them off!

Not wishing to insult him, I merely said, mildly, "Let's do an experiment."

I demonstrated that just walking across our asphalt floor caused me to become charged to about 3 kV. I then mounted the soles (hoping, as I did so, that nobody else was watching): no charging. I removed the soles and, once again, got charged to 3 kV.

Oh, but I hadn't worn the soles long enough, PN said; they hadn't had time to drain the static from my body. I explained that the charging of a person is a business between the underside of his or her shoes and the floor covering. But no. By PN's reckoning, human static electricity flowed in the body along the acupuncture channels.

He had it all worked out. If you slept with these acupuncture soles on, you slept much better, he said. If you were suffering from one or another of various illnesses, there was a schedule for you to follow that told you what hours of the night you should wear the soles for best effect.

What PN wanted from me was an official statement to use in his patent application. I told him there was nothing there to patent—nothing new—and besides, I said, his soles could be downright dangerous if someone happened to touch a live wire while wearing them.

PN later modified his invention, severing the ground connection and wrapping the two loose ends around a copper core. Thus altered, it gave a reasonable decay resistance, thanks to the semidirty surfaces of the wires' insulation. But what was the point of the copper core? No explanation was forthcoming.

Over the next couple of years, I had the dubious pleasure of dealing with PN on other occasions. He managed to attract a certain amount of public attention to his acupuncture soles, which were written up in several newspapers and even got some sort of endorsement from the secretary of the interior. (I cannot help remarking that this same secretary always carried a couple of chestnuts in his pocket, believing they were good for his rheumatism. They apparently worked—he never had rheumatism in his whole life.

In any event, PN kept sending me copies of his correspondence with all of the various authorities and the institutions at which he talked people into using his device. Of course, he made sure to forward documentation of all the glowing praise heaped on him when his soles won a silver medal as runner-up for best invention of the year at a big exhibition in Brussels! But it was a source of constant irritation to him that he couldn't secure an official approval, and he even went so far as to complain to the president of our university about me, charging that I had hindered people from learning about his brainstorm.

The president answered that I was the expert (thank you).

By sheer chance, I learned that PN had applied for a Danish patent and was on the verge of getting it, due mostly to the fact that none of the patent authorities knew any more about static electricity than did PN himself. I protested, and eventually the patent application was denied. Naturally, PN went to court with a civil case against our laboratory

Of course I would be. I asked what kind of static electricity it eliminated, but as far as Mr. PN was concerned, there was only one kind: human static electricity.

for preventing him from winning the patent he so rightly deserved.

When asked if I wanted to appear in court, I said most emphatically that I did not. The lawyers and judge could read my protest, and besides, they had the wrong plaintiff. PN should have been bringing suit not against our laboratory, but against the laws of physics. Happily, the case was dismissed.

I don't think PN was deliberately trying to con people. He probably honestly

believed his own theories and saw himself as the little man standing up to the men in white coats. I spent many hours trying to teach him a little physics, but to no avail. (Come to think of it, I've often had the same experience with physicians.)

My last encounter with PN ended on a somewhat tragicomic note. PN had succeeded in getting the Institute of Technology of Denmark, an institution for technical applications, to look at his gadget, and the institute staff pleaded with me to come to a demonstration

and put this business to rest once and for all. I agreed to be present.

PN brought his father along to the meeting. At one point during his demonstration (in which there was absolutely nothing new), PN made some outrageous statement, and I could stand it no more. "If that were the case, it would violate Ohm's law!" I cried.

The father then interjected, "The parliament issues new laws all the time. Couldn't it also change this Ohm's law you're talking about?"

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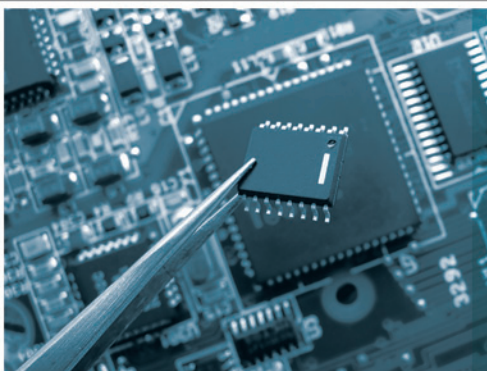
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Over the last couple of decades there has been, at least in Europe, a great deal of concern voiced over the static electric field generated by monitors and television screens.

And now for a more suspicious story.

STATIC FIELD REMOVER

Over the last couple of decades there has been, at least in Europe, a great deal of concern voiced over the static electric field generated by monitors and television screens. It is this field that makes dust and other particles plate out on the screen, due to simple static attraction as well as polarization forces.

If a person is sitting close to the screen, the field will be distorted and will converge toward the person's face, and the particles will then plate out on his or her nose, forehead, and cheeks. Studies have shown that any static field on a person's face will dramatically increase the plate-out rate of particles, and scientists have speculated that this may result in an increase in the occurrence of rashes and more-serious skin diseases such as eczema, given the presence of allergens or other unsavory substances in the air.

As far as I know, this connection has not yet been established definitively, but many years ago we demonstrated

at our laboratory that it was possible to drastically reduce the field put out by a monitor by applying a topical antistat to the screen. (The antistatic layer forms a primitive but fairly effective Faraday screen.) Later, several types of transparent, conductive filters designed to be mounted in front of the screen appeared on the market. Most worked reasonably well, though they were rather expensive.

In the late 1980s, a Danish company that had been selling such filters for some years got the opportunity to market a new American invention—let's call it the Field Remover. Someone very high-up in the corporation had already signed the necessary papers, and the gadget came with a pretty positive report from a Scottish laboratory. But the marketing people wanted an opinion from our university, so I agreed to test the device.

The Field Remover kit consisted of the following:

- A small plastic bottle containing a clear liquid.
- Two (conductive) suction cups with wires ending in small plugs.

- A plastic box (carrying the trade name) measuring about 6 cm³, equipped with a light diode labeled static event detector and a ground wire.

The manufacturer's instructions advised the user to apply the liquid to the monitor screen and, if I remember correctly, to the keyboard; mount the suction cups on the screen and keyboard; connect the suction cups to the box; and, connect the box to ground. The Scottish laboratory had followed these directions and found that the field in front of the monitor was reduced by a factor of about 50 to 100.

Performing only the first step of the prescribed procedure, I applied the liquid to the screen and measured the field. With no suction cups, no magic box, and no ground wire, the field was reduced by a factor of 50 to 100. I then went through the remaining steps—mounting the cups and all the rest—but nothing further happened, and there was no additional reduction in the field.

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I called the staff at the Danish importer and asked them to come and witness my measurements. When they did, we looked at each other and I suggested, "Let's break open that magic box and see what's inside."

The box contained a cube of carbon-black-saturated aerated plastic. When the suction-cup plugs were inserted, they just touched the carbon-black plastic. The diode had only one wire attached, which terminated randomly in the plastic like the ground wire. Obviously, neither the box nor the wiring had any real technical or scientific purpose.

I advised the marketing people, "Buy the liquid; it's a good antistatic. You can probably sell it for \$1.50 a bottle and make a good profit." They had been planning to sell the whole device for somewhere between \$150 and \$200.

As might be expected, my findings caused some problems within the company. Management wasn't happy about the fact that marketing had consulted an independent expert. It wasn't necessary, the higher-ups insisted; they had been told in the United States that this was a fantastic product, and besides, there was always that Scottish report. The marketing people came back to me and asked if I would write up a full report on the test, which I did.

In the end, the company decided not to go ahead with the Field Remover, and I got a grateful letter thanking me for saving the marketers' jobs. I still wondered why the Scottish laboratory had done such a sloppy job.


I also got a phone call from the device's "inventor." He had learned of my report and was furious. I obviously didn't know what I was talking about, he fumed before demanding to know what my background was. I told him I had

about 30 years of university training in the field. Where, I inquired, had he acquired his own expertise in static electricity? At first he was rather vague, but when pressed he finally admitted that his formal training consisted of one three-day tutorial given in Chicago.

That was the last I heard of him, but not of his invention. A couple of years later, I saw the Field Remover advertised in a Swedish magazine.

CONCLUSION

Now, it would be wonderful if the examples cited were the only times the laws of physics have ever been either unwittingly or deliberately misused. But in fact, such abuse is all too common, in electrostatics as in other fields. In sum, there will always be

people who try to sell other people a lot of nonsense, and there will always be people who are willing to buy it. 

(the author)

NIELS JONASSEN, MSC, DSC, worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. After retiring, he divided his time among the laboratory, his home, and Thailand, writing on static electricity topics and pursuing cooking classes. Mr. Jonassen passed away in 2006.



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Your Guide to Effective Product Safety Labels

BY GEOFFREY PECKHAM

Of all the responsibilities product engineers are tasked with, safety labeling cannot be overlooked. Why? Because the bottom line is: if safety matters, your labels matter. This month, we'll explore the key elements to consider in creating the most effective labels possible.

It's a new year – a time for new beginnings, fresh starts, and getting refocused. It's a fitting opportunity to revisit the fundamentals in visual safety communication that can help to create safer products and workplaces. A critical part of the overall safety of your products and equipment is their safety labels. In this article, we'll outline the best practices in developing effective labels that can help to prevent injuries and save lives.

THE GOAL OF YOUR LABELS

Let's first review the goal of today's product safety labels. There are three essential purposes that an effective safety label should meet, and that product safety engineers *must* understand: 1) to communicate hazards to protect those who interact with your product during its anticipated lifecycle (delivery, installation, use, service, decommissioning, and disposal) 2) to enable companies to comply with

their intended markets' codes and regulations (ie., CE marking, UL-compliance, and WEEE/RoHS) and 3) to provide a legal defense in the event of an accident. Here, it's important to note that "inadequate warnings" and "failure to warn" are two of the most common allegations found in liability lawsuits in the U.S. today.

DEFINING TYPES OF LABELS TO MEET YOUR GOALS

Now that we've revisited the vital function your safety labels must perform, let's look at the types of product safety labels that can help to achieve these goals. There are three main¹ kinds of product safety labels.

1. A secondary type of label identifies function and control. Refer to *In Compliance Magazine's* January 2012 *On Your Mark* column regarding "The Grounding Symbols" for more information on this topic.

Hazard alerting labels communicate potential personal injury hazards and how to avoid them. This kind of label includes the signal word "DANGER," "WARNING" or "CAUTION" to indicate the proper risk severity level.

Safety instruction labels communicate explanatory information like safety procedures (such as lockout/tagout instructions).

Notice labels communicate information considered important but not directly hazard-related (such as maintenance information).

DESIGNING AN EFFECTIVE LABEL

So, where does the engineer start in designing an effective label? There are several main building block elements that should be considered.

- **Know the type of content to go on the label.** The ANSI Z535.4 standard makes it very clear what

content should be conveyed on a label.² (See Figure 1 for an example of an ANSI-formatted product safety label.)

- **Know your intended audience.**
The intended audience and intended market must be taken into account. This includes factors like: is the product shipped to a foreign country; what is the education level of your anticipated product users and how much training will be given; and is there a product safety manual available for communicating more detailed safety information?

2. Compliance with the ANSI Z535.4 product safety label standard is voluntary. However, over the past 20 years of U.S. case law, state and federal courts have repeatedly used the ANSI standards as the benchmark to judge adequacy of warnings.

The product risk assessment process is a critical element here. When it's not practical to design out or guard against

a particular hazard, a best practice label can be designed to communicate the risk.



Figure 1: Example of an ANSI 2011 Z535.4 electrical hazard product safety label. (Design ©2014 Clarion Safety Systems. All rights reserved.)

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- Use the latest standards and best practices in considering the elements of your label. This includes:

- **Colors** – using uniform color standards developed by ANSI and ISO will help to speed visual recognition of your safety markings.
- **Formats/text/content** – clear and concise messaging, as well as visual consistency, enables your product safety labels to be more easily seen and understood.



Figure 2: A compilation of all the different elements (from signal words to text messages to symbols) that must be considered, and brought together cohesively, when designing effective product safety labels.

- **Symbols** – symbols communicate efficiently and across language barriers. To be effective, they should come from the most up-to-date standards or be drawn using standards-based illustration techniques.
- **Materials** – a label's performance is only as good as the materials that go into its manufacture. It's important to have an understanding of environmental and surface conditions, as well as the latest high-quality material options available, to achieve your durability objectives.
- **Location** – the final critical factor to the design of an effective safety label is its placement. Consideration must be given to its anticipated viewing distance, legibility, and whether placing the label in multiple locations is necessary for both visibility and repetition of messaging purposes to ensure compliance.

Designing effective safety labels can be a complex task. (See Figure 2 for a snapshot of the many elements that make up labels.) It's also one that is never completely finished; you must periodically reevaluate your labels in light of changes to the standards, new symbols that have become codified, and the latest available product safety and accident information related to your product and its industry. The three future articles in this year's *On Your Mark* column series will explore in more detail the latest best practices regarding several of the key topics mentioned above: symbols, content,

and risk severity levels. These three components are the core elements that must be thoughtfully considered to be able to achieve the goal: effective hazard communication that helps prevent accidents and saves lives from tragedy. [IN](#)

For more information on effective safety labels – including symbols, formatting, and the importance of using the best practice standards – watch a short, educational video produced by Clarion Safety Systems.



(the author)

GEOFFREY PECKHAM

Geoffrey Peckham, the CEO of Clarion Safety Systems, is chair of both the ANSI Z535 Committee for Safety Signs and Colors and the U.S. Technical Advisory Group to ISO Technical Committee 145 – Graphical Symbols, and member of the U.S. Technical Advisory Group to ISO Project Committee 283 – Occupational Health and Safety Management Systems. Over the past two decades, he has played a pivotal role in the harmonization of U.S. and international standards dealing with safety signs, colors, formats and symbols. This article is courtesy of Clarion Safety Systems © 2014. All rights reserved.



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Growing the Engineer's Toolkit: Project Management Tips and Techniques

"If you are not willing to learn, no one can help you.
If you are determined to learn, no one can stop you". – Author Unknown

BY MARK MAYNARD

In today's fast-paced product development cycles, the pressure to compress testing and certification schedules is constantly increasing, with global competitors all rushing to get their new technology to market first. Mistakes made in compliance testing and certification processes can have huge financial impacts if product releases are delayed, or lead to later stop-ships or recalls. Utilizing project management techniques can provide great benefits by improving the efficiency and quality of compliance projects.

WHAT'S IN YOUR TOOLKIT?

As regulatory compliance professionals, we are expected to stay current on the latest international standards and test methods, keep up with the latest regulatory requirements for our company's market countries, and keep pace with the constantly changing

technology in both products and test equipment. But what tools do you have to keep track of your assigned projects, and what do you do when things don't go as you've planned? When you find yourself in a ditch, what do you do to get out?

I will provide a few effective project management techniques that can help increase your efficiency, lower your stress, and help to ensure more success with your compliance projects. This is not a comprehensive overview of all aspects of project management, but rather provides some exposure to the benefits of the subject, and to encourage additional study of this topic.

FASTER, CHEAPER... BETTER?

After a decade working of working in the compliance field at one of the largest ITE companies, I noticed that I kept running into the same types of

problems with my product certification projects, and that my colleagues were having similar issues. As an engineer who was also involved with quality management systems, I knew there had to be a "root cause" for these glitches that kept showing up. As I examined the project data, I saw that these issues weren't related to a lack of knowledge of the regulations or agency processes, nor were they related to a lack of technical knowledge such as operating test hardware or software, or the current prescribed test methods. Instead, they all seemed to be related to the internal processes for product development, the assumptions used to build schedules, and miscommunication.

THE BIG ELEPHANTS IN THE ROOM

This led me to the discovery of the field of project management. I was astounded to learn that not only were my issues fairly common, but there

The Elephants in the Room



Project Management

Project management is a huge field, and has many parts and dependencies required for the full implementation of the methodology, but there are some vital tools that can be applied which will help to make your work more manageable.

Communication & CLEs

In over two decades of product development projects, every project I have observed or participated in that was canceled, late, over budget, or in some other category of failure, had one thing in common: somewhere a critical communication was not delivered.

already existed a huge number of books, magazines, websites, and on-demand videos, all dedicated to these tools and concepts. I quickly realized how beneficial this information would be to increasing my project success and on-time completions. Over the next five years I dove into the study of the best practices of project management, taking formal classes, and culminating with my certification as a Project Management Professional (PMP)

by the Project Management Institute (www.pmi.org).

Please don't get nervous; I'm not recommending that you also spend five years of concentrated study on this subject. I just wanted to share the path that led me to identifying the most common non-technical issues with product compliance and certification projects, which I dive into below; the two "Big Elephants" that we don't

normally talk about in compliance engineering: project management and communications.

Elephant #1: Project Management

As mentioned, project management is a huge field, and has many parts and dependencies required for the full implementation of the methodology, but there are some vital tools that can be applied which will help to make your work more manageable. In this section I'm going to cover three very effective project management tools, those being project planning, risk management, and deliverables.

Defining and Planning Your Projects

Before I started learning about project management, I just accepted whatever schedules came with my assigned projects, and hoped that I could somehow run fast enough to keep up with them. I came to realize that these schedules were developed by well-meaning planners in product groups, who were working from "one-size-fits-all" templates and applying them to very different types of ITE projects, without accounting for the required resources. To have realistic schedules, you must understand your product requirements and the amount of resources needed, in order to develop your own specific compliance schedule, and you must actively work with the project team so your requirements can be grafted into the overall project schedule.

The "Golden Triangle" is an excellent tool for understanding the interplay between scope, schedule, and resources involved in a project, and is a key project management concept (Figure 1). Scope refers to the totality of the features and abilities of the product; for example, if we are making a printer, for our compliance work we would need to define the printing technology (laser? Ink jet?), the data input and output connections (USB? Wi-Fi?), the market country list (US only? EU?

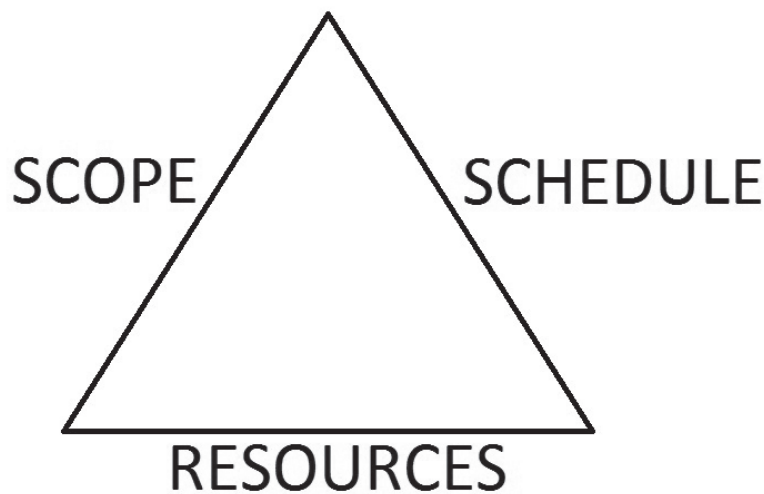


Figure 1: The "Golden Triangle" of Project Management

Worldwide?), and other pertinent regulated features. The schedule part we are interested in is how much time is allotted for the various product compliance activities, such as EMC and product safety testing, report writing, agency submittals and certification timelines, and every other scheduled activity in our process to cover all of the items specified in the scope. And resources refers to the employees, product samples, test equipment, agency and lab fees, and any other expenditure required to complete the project.

In formal project management, scope, schedule, and resources will define the major factors in the project, and how well they are defined can determine the success or failure of a project. You need to have a solid understanding of all of the processes and activities required to complete the compliance work covered by these three terms. If you are a new engineer, you need to seek out more experienced staff members who can provide this information, and help to mentor you through your first projects. In clarifying and documenting all three areas, compromise and trade-offs will be involved. If your company wants to speed up the schedule, it will take more resources, and you may have to drop some features from the scope.

Once you have completed your compliance "Golden Triangle," it is vital that this information is incorporated into the overall product definitions and schedule, as you are the project team's expert on these certification activities. Just think of scope, schedule and resources like the law of conservation of energy; you can't give to one without taking from another, and you can't magically create one out of thin air. The mantra of "Faster, Cheaper, Better" I used to hear in the 1990s was a denial of this reality, and would almost without fail result in products that were late to market, with high cost overruns, and de-featured so they could be shipped, to the point of making them undesirable.

Have a Plan B


In compliance engineering, as in life, it's always good to have a backup plan. Market conditions change, technology advances, and suppliers can go out of business, so identifying the most critical links in your project processes is important in preparing alternatives for when things don't go as expected. In project management terms, this is called risk management.

Think of the most critical paths on your project compliance schedule, such as product testing, agency submittals, and department members. You will realize some things you will have control over, such as where and when you perform EMC tests, and others you don't have control over, like how long it will take for BSMI to review your submitted test reports. So for risk management, we will focus on the items where we have some control, such as choosing which


test lab to use, and we will document the items we don't have control over, like creating an estimated timeline for BSMI approvals, based on historical averages.

The time to address risk management is well before you have an issue. If you've just delivered your new product samples to your favorite test lab you've been using exclusively for ten years, and it is put out of business by a freak flood the next day, that is not the time to realize you have no plan B. Frantically calling labs all over the country to find out if anybody can fit you in right away so you can still meet your schedule is not risk management, it's a crisis.

While most large and medium sized companies have disaster recovery plans, most of these are focused on overall infrastructure issues, such as finding new offices, restoring power,

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and rebuilding IT and communications networks, and are not specific to the needs of the individual departments, such as compliance engineering. You are the experts on what is needed to operate your group, so it is up to you to define and make these alternative plans in advance of issues, so you can quickly implement them with as little impact to your projects as possible.

It is a good idea to have a team made up of several compliance staff members when formulating these plans. Having different levels of experience and backgrounds will help in developing a better overall plan, which will address the most critical areas presenting the highest levels of risk. You can start by brainstorming on the biggest risks, then following that up by rating each item for the potential impacts to a project, and the likelihood it could occur. Then you could create an ordered listing, from highest risk to lowest, and choose the top ten items to address in your risk management plan. Over time you can add in more risks to address, and you should also periodically review your risk management plan to make sure it is still addressing the likely major risks.

Here's some examples of common compliance items needing contingency plans:

1. Having internal test labs
2. Losing key staff members
3. Project load increases with a hiring freeze
4. Regulatory documentation and certificates data storage
5. Test equipment failures
6. In-country representatives
7. Product recalls
8. Critical component suppliers

Once you have made your plans, they need to be documented, and the compliance team will need to receive training. There will also need to be someone designated as being in charge of these plans, making sure they are complete, periodically reviewed, and

kept current. My experience has been if the attitude is "everybody is in charge" of the risk planning, then nobody is in charge.

The purpose of risk management is to lower the possibility of catastrophic impacts to the project by being ready to quickly implement prepared contingencies on the areas where you have choices and influence. Once you get into this mindset, you will start seeing the possible risks in other areas of your compliance work, and you'll be able to make those processes more robust. Start by evaluating your own situation, and develop your own plan B.

Deliverables

Deliverables is simply project management-speak for your work product. In our world, that means compliance test reports, agency submittal forms and applications, and other required documentation supporting product certification and approval activities. This can be a key area for finding efficiencies, lowering costs, and increasing accuracy in submittal documentation, depending on the current processes in place at your company. Here's the story of one of my experiences.

One of the first jobs I was assigned when I started my quest to learn about project management was the task of looking at our internal EMC compliance report writing process. I was at a global ITE development and manufacturing company, and we sold our products into over 200 countries, so we were dealing with a lot of regulatory agencies. We were receiving critical feedback, rejected reports, and complaints from almost every agency, mostly due to inconsistent report formats, and the large number of errors in the reports. Also, our EMC engineers were complaining, because the multitude of compliance reports they had to write for each product they were assigned was taking up an ever-larger portion of their workday, keeping them from their engineering duties. All

of this was giving management a king-size headache; I couldn't find anybody who was happy with the status quo.

I started off by interviewing agency contacts and our own EMC engineers, to document all of the issues, and to also define what actually needed to be accomplished to support the intended outcome of successful EMC agency approvals. The EMC agencies main complaint was that every report they received had a different format; they might receive one with radiated measurements in the front part of the report, followed by the conducted data, then concluding with the written portion of the analysis and summary, and the next day they would receive another with a totally different design and organization with sections covering combined radiated and conducted measurements for different voltages. They wanted a consistent standard report format to reduce the amount of time necessary for their reviews and so they could more easily identify errors in the reports.

In my interviews with the thirty EMC engineers we had in our regulatory compliance group, I discovered that each engineer was using their own individual report design, and thus I found the agencies had a valid complaint. We were, in fact, submitting thirty different versions of EMC reports. As to the errors contained in the reports, this seemed to be related to an overload of work and the reports were not being reviewed internally to catch mistakes prior to being sent out. For each assigned product, the engineer had to write eight different types of EMC reports. This could take more than a week to complete because the engineers had to gather the data, samples, photos, and everything else required for the submittals and also complete all of the agency application paperwork. Between this and their normal engineering duties, reviewing reports was not a priority, so it wasn't happening.

After analyzing the agency requirements for the reports, I could see that we were wasting a huge amount of engineering time and resources with this system, as well as hurting our reputation and relationships with the agencies. I determined that a large part of the report preparation did not need an engineer to construct it, but how could this be addressed?

Our solution was to use this as a cross-training opportunity for our EMC technicians. This would free up our engineers to focus on engineering tasks, as well as implementing three levels of critical reviews of the reports. The EMC report templates were reduced to eight standard types, covering all of our worldwide market countries, and the product information, test data, and photographs added in by the technicians. The technicians would then review their work, checking against the original data. Next the EMC

engineer assigned to this project would add in his or her engineering analysis, conclusions, and summary, then review the entire report for completeness and accuracy. The final report review would be conducted by another EMC engineer outside of this department. Each of the three reviewers would sign the report, and, to ensure accountability for the task of report reviews, their annual performance review included a metric for report accuracy.

Your situation is probably different, but ask yourself some questions about how you generate your deliverables:

1. Can you automate any part of the process?
2. Do you use standard templates?
3. Who's doing the data entry?
4. Who reviews reports?
5. Have you sought feedback from regulatory agencies?

Elephant #2: Communication & CLEs

In over two decades of product development projects, every project I have observed or participated in that was canceled, late, over budget, or in some other category of failure, had one thing in common: somewhere a critical communication was not delivered. Sometimes it wasn't sent, other times it was not received, but the root cause I attribute to these transmission failures are assumptions. Assumptions may be human nature, but they kill effective communication.

In formal project management, the term stakeholder is used to mean anyone that is involved in a project, or affected by the outcome of a project. In the product compliance field, our stakeholders are our product development teams, management, regulatory agencies, and our

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customers, among others. Having constant and timely communications with our stakeholders is vital to having successful projects (Figure 2). Remember that communication is a two-way process; both sending and receiving, and to increase your chances at success you need to listen to your stakeholders a lot more than you talk at them. Regular communication with stakeholders also makes it more likely they will return the favor and keep you in the loop on any relevant information they receive.

At the beginning of your project, you should find out who is on the project team. This will be the group of stakeholders that you are in contact with the most. Find out their requirements and intended uses for project information; such as how often, and how much detail is needed. Next, do the same for stakeholders outside of this team who will need to know about any changes as quickly as possible, such as management (who can help when you run into obstacles), and your customers who will actually use the product (or marketing, as the customer's representative). Provide project updates frequently, which might

be weekly updates, but for critical issues daily updates may be required. The important point is to be out in front of the news cycle, meaning you are the one providing the latest updates, not the company rumor mill.

This up-front communication is important in keeping everyone informed so the current information can be used when making team decisions, but it is invaluable for those times when bad things happen to your project. If the project team hasn't heard a peep out of you in the first three months of the project, and then you speak up for the first time proclaiming that the compliance submittals have all crashed and burned and there is no way the approvals will be received by the ship date, you will just have killed your credibility for future projects. If you had been providing those weekly updates, there would have been earlier indications of issues and someone else on the team could have stepped in to assist you to keep it on track. Don't get the reputation for only being a bearer of bad news; we in the compliance field have a hard enough time as it is. Make sure you are reporting the good news when everything is going well.

One of the stronger impulses in humans is to try to hide bad news when it is received, hoping it can be fixed before anyone finds out, but this is another project killer. Usually by the time the truth comes out (and believe me, it will come out) the small, solvable problem has become a huge crisis and can be the death of a project. Stay open and honest, keep the constant communications open, and keep your integrity. This will open up the possibility for novel solutions from other team members and leaves open a path for you to recover your good name.

So speaking of bad news, let's talk about something called a "Career-Limiting Event," or CLE. I first learned about CLEs from my first compliance manager, and later mentor, Dave Staggs, who also taught me how to recover from them, which I'll outline next. As a human, you will make mistakes from time to time, and every once in a while, they will be an error of monumental proportions. When we are talking about a product development project, this can have huge financial impacts which can result in a questionable employment future, hence the term Career-Limiting Event. If you've been keeping up the constant communication with your stakeholders prior to this event, I have advice to share with you on redeeming yourself. But if you haven't, your time might be better spent on Monster.com.

First, you want to be the first to admit your mistakes. But before you do, you need to do some work, and do it quickly. Research what happened, and why it happened. Next, develop recovery plan options (more than one). This is vital, and the best single piece of advice I ever got from anyone about business: you have to come with solutions, not just talk about the problems. If you only talk about the problems, you're being a victim. Don't be a victim; they don't have long careers.



Figure 2: Constant communication is the key to successful projects

Once you have all of this information, prepare and practice your presentation. Yes, just like any other presentation, you need to practice to make sure you can clearly and concisely deliver your message. This is not the time to “wing it” and hope for the best; your job security and future prospects may well be riding on this. Stick to the facts and focus on the issues; this is also not the time to start pointing fingers and spreading around the blame. You’re an adult, you made a mistake and you can take the consequences.

As soon as possible, deliver the news. Don’t delay this presentation. Be transparent, direct, positive, and truthful. Don’t dig a deeper hole by guessing or making assumptions.

At the end of your presentation, ask for feedback, and take notes on what is said and asked. Answer the questions you can at this time. If you don’t know the answer, state that you don’t know, and promise to find the answer and get back to them. Follow up on your commitments, implement the selected recovery plan, and then follow up to verify the results. Ensure frequent constant communications with your stakeholders during this recovery phase. Thank your stakeholders for allowing you the opportunity to recover; now is not the time to let pride or ego get in your way.


Admittedly, this is not a pleasant process, and it is not easy, but I haven’t found anything else that works better while also allowing me to feel good about myself. There is a way to avoid this, however.

To avoid your own future CLE, follow this process:

1. Learn from the mistakes of others; note what they did right, and what they did wrong
2. Learn from your own previous mistakes; and don’t repeat them
3. Keep your skills current, be a permanent student

4. Stay transparent and open; don’t have hidden agendas
5. Assumptions: Don’t make any; communicate instead
6. Projects: Verify, review, evaluate, check, re-check

Additional material on project management and communications are available from a wide variety of sources. In addition to the Project Management Institute (PMI) mentioned earlier, which has monthly meetings at local chapters throughout the world, there are many groups on LinkedIn, as well as a host of project management education providers available on the Internet. The IEEE Communications Society is also another great resource, also with monthly chapter meetings that are great for learning, networking, and finding experienced mentors. The

only limitations are the ones you set on yourself, so don’t hold yourself back, and keep learning! 

(the author)

MARK MAYNARD is a Director at SIEMIC, a global compliance testing and certification services firm with strategic locations worldwide. He is also an IEEE Senior Member, INARTE Certified Product Safety Engineer, and a certified Project Management Professional (PMP). Mark holds two degrees from Texas State University, a BS in Mathematics, and a BAAS in Marketing and Business. Prior to SIEMIC, he worked for over 20 years at Dell, in international regulatory compliance and product certifications, with various compliance engineering positions including wireless, telecom, EMC, product safety, and environmental design. He can be reached at mark.maynard@siemic.com.



The Applied Computational Electromagnetics Society



The 30th International Review of Progress in Applied Computational Electromagnetics

March 23 - 27, 2014 Jacksonville, FL

The international ACES symposium serves as a forum for developers, analysts, and users of computational techniques applied to electromagnetic field problems at all frequency ranges. The symposium includes technical presentations, software demonstrations, vendor booths, short courses, and hands-on workshops.

Plenary Speaker

Prof. Todd Hubing
How EMC Engineers use Computer Modeling Tools Productively

Plenary Speaker

Prof. Andrew F. Peterson
High Accuracy Computations in Electromagnetics

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C. J. Reddy
EM Software & Systems Inc.

Registration Chair

O. A. Mohammed
Florida International University

For more information, please visit ACES on-line
www.aces-society.org/conference/2014



Furthering Your Professional Development in 2014

The start of a new year is a time when, traditionally, we reflect on the progress we made during the year passed and set our goals for the new year. More often than not your professional development goals include training or some form of higher education to expand or refresh your technical knowledge. We've queried training resources in our niche industry to provide you with an overview of affordable solutions to meet your training goals in 2014. You'll find here sources of compliance related seminars and workshops offered online and on location, public and private.

We invite you to submit your own suggestions for additional listings as we continue to update our events section online at www.incompliancemag.com. Send your comments to us at editor@incompliancemag.com.

EMC CLASSES AND WORKSHOPS

D.L.S Electronics Systems, Inc. offers a two day applications seminar and one day workshop. For more information, visit www.dlsemc.com/emc-class/emc-seminar.htm.

EMC By Your Design: A Practical Applications Seminar and Workshop
Using updates of the latest developments in research, standards, regulations, instrumentation and services, participants

will study EMC design techniques and the calculations required to design a product to meet compliance regulations. They will use materials developed by the instructors, Donald L. Sweeney and Roger Swanberg, in conjunction with the textbook *Design Techniques for Controlling Radiated Emissions*, 3rd edition by Michel Mardiguian, edited in part by Donald L. Sweeney and D.L.S. staff. After two days of intense study of EMC and design principles, students in the workshop will design, from start to finish, an EMC compliant product. The goal of this workshop is to help design engineers and technicians learn to apply the EMC design principles they learn in the seminar to real life products.

The release of the 3rd edition of *Design Techniques for Controlling Radiated Emissions* includes updates and revisions to all 13 chapters addressing newer

technologies that have come along, especially the update of clock speeds and the examples worked out in the book. Those who have previously attended a D.L.S. Seminar using the 1st or 2nd edition of the book, and who would like to take a refresher course using the new book, will be given a 50% discount from the April 2014 seminar price.

- April 8-10, 2014 – Northbrook, IL

ETS-Lindgren offers hands-on training courses throughout the year. Below is a list of those courses currently scheduled through ETS-U. For more details, visit www.ets-lindgren.com/Learning.

Fundamentals of EMC Testing

A three-day hands-on course designed for engineers or lab technicians who want to expand their knowledge of EMC compliance testing, or are new to the

subject and want to “learn-how” quickly. Instruction is divided between class lectures and hands-on lab experience. Students are taught how to perform actual tests in a fully instrumented lab that includes a 3 meter anechoic chamber, GTEM, and a demonstration reverberation chamber.

Tests are made according to published standards for radiated and conducted emissions and immunity/susceptibility measurements. Students receive an illustrated textbook written specifically for the Fundamentals of EMC Testing course, with many of the test setups illustrated.

- March 4-6, 2014
- July 15-17, 2014

MIL-STD 461F Testing

A three-day hands-on course designed for engineers or lab technicians who want to expand their knowledge of Military-Standard 461F testing, or are new to the subject and want to “learn-how” quickly. Instruction is divided between class lectures and hands-on lab experience. Students are taught how to perform actual tests in a fully instrumented lab that includes a semi-anechoic chamber and a conducted susceptibility test station. Tests are made according to current (MIL-STD) standard for radiated and conducted emissions and susceptibility measurements. Students receive an illustrated textbook written specifically for the Fundamentals of EMC Testing course, with many of the test setups illustrated.

- March 18-20, 2014
- November 11-13, 2014

Overview of Radiated Immunity/ Emissions Test Facilities

A three-day hands-on course designed for engineers or lab technicians who want to expand their knowledge of Radiated Immunity and Emissions test facilities, or are new to the subject and want to “learn-how” quickly. This course will provide a basis for making informed radiated emission/immunity testing decisions by answering questions like what kind of test facilities are available? What type of Electromagnetic Environment is available with each test facility? What to expect from test? What type of facility should you buy? In addition this course will also cover some standards overview, test planning issues, detailed coverage of major test techniques, sources of uncertainty in test results and uncertainty propagation and impact on test results.

- June 10-12, 2014

Henry Ott Consultants offers a three-day course covering the practical aspects of noise and interference control in electronic systems:

Electromagnetic Compatibility Engineering

This course will provide the participants with a working knowledge of electromagnetic compatibility principles. Emphasis is on cost effective EMC design for digital systems. The commercial and industrial aspects of EMC Engineering are emphasized. The amount and complexity of mathematics will be kept to a minimum, and ideas will be illustrated with examples of actual case histories. More information

is available on the Henry Ott Consultants website (www.hottconsultants.com), both on the public and in-plant EMC courses.

- April 22-24 2014 – Seattle, WA
- Fall 2014 – Baltimore/ Washington DC area

Kimmel Gerke Associates offers several public seminars throughout the year. Following are course descriptions and dates and locations of those courses currently scheduled.

Design for EMC & Signal Integrity (2 days)

EMI Troubleshooting (1 day - optional add-on)

This very popular class has been co-hosted by Kimmel Gerke Associates and Tektronix since 1992. The focus is “inside the box” at the electronics level - components, printed circuit boards, power electronics, grounding, and shielding, with over 30 specific fixes. The class is introductory and is regularly updated to reflect the latest EMC design issues.

For more information, visit Kimmel Gerke Associates at www.emiguru.com.

- Date TBD - Orlando, FL
- Date TBD - San Diego, CA

Wyatt Technical Services offers several public seminars throughout the year. Below are Ken’s currently scheduled offerings. Visit Ken’s website www.emc-seminars.com for updates and information.

EMC Design

Presentation at DesignCon

- January 28-31, 2014 – Santa Clara, CA

EMC Essentials –

Theory & Troubleshooting

EMC Integrity will be hosting a two-day design seminar and workshop.

- April 1-2, 2014 - Longmont, CO

EMC Troubleshooting Toolkit

Workshop will be held during the IEEE ISPCE Symposium, May 5-7, 2014. Additional details will be available soon.

- May 5-7, 2014 – Santa Clara, CA



EMC Essentials – Theory & Troubleshooting

SIEMIC will be hosting a two-day design seminar and workshop.

- May 8-9, 2014 – Milpitas, CA

EMC Consultants Toolkit

Workshop will be held during the IEEE International Symposium on Electromagnetic Compatibility.

- August 2014 – Raleigh, NC

Silent Solutions offers a series of courses designed to expand your skills and improve job performance. Below are their course descriptions. For more information, please visit www.silent-solutions.com/education.htm.

Electronic Product Design and Retrofit for EMC

This two-day class gives engineering professionals the ability to successfully recognize, solve and avoid common EMI problems. Demonstrations using working hardware illustrate concepts such as radiated emissions, high frequency antennas, radiated and conducted immunity, and crosstalk in connectors, cables and IC packages. This class is appropriate for experienced circuit and system design engineers, EMC engineers, as well as those who are new to EMI problem solving. Engineers with time-to-market projects will find this workshop extremely useful.

EMC – Printed Circuit Board Design

This two-day class provides technical training intended for electrical and EMC engineers interested only in PC board design. It is an excellent follow-up class for students who have recently completed our two or three-day EMC class. Course topics include component placement, signal routing and stackup, power bus decoupling, signal theory and signal integrity, “ground” splits, and a critique of bad applications notes from IC vendors. Students will examine good and bad design techniques using hardware demonstrations, schematic reviews, and sample PCB layouts.

Circuit-to-Circuit Interference

This unique one-day class is for electrical design engineers at all levels challenged by electrical noise problems in products containing RF (wireless), analog, switching

power supply and digital electronics. Through a unique combination of lecture and hands-on experiments, class participants will master the ability to anticipate, solve and avoid electrical noise problems that can inhibit functionality in new product designs. By participating in this class, design engineers will be able to accelerate time-to-market design.

Mechanical Design for EMC

Unique to the industry, this two-day class provides clear applications, theory and demonstrations for the successful design of mechanical enclosures for good system emissions and immunity performance. Key topics include grounding at the PCB and enclosure, system ground maps, PCB component placement and control drawings, enclosure and cable shielding, PCB device “cans”, resonant slots and enclosures, heat sinks, unintentional antennas, as well as connector, screw, and conductive gasket spacing.

Grounding for EMC, Signal Integrity and Instrumentation

Theory, applications and hardware demonstrations in this one-day class describe effective design and troubleshooting techniques. The real-time demonstrations use a spectrum analyzer, oscilloscope and signal generators to illustrate inductance, common-impedance coupling, and ground loops. Specific examples of single-point, multi-point, “good” and “bad” grounds will be discussed.

Mastering the Spectrum Analyzer for Electrical Noise Measurement

SILENT’s newest one-day class is packed with practical tips, applications, and demonstrations to help make it easy for

you to pick up a spectrum analyzer and start measuring and troubleshooting electrical noise and EMC problems. We will have a minimum of 3 different spectrum analyzers in class to help explain and demonstrate operating techniques that we have honed over the last twenty years. Our unique combinations of digital, RF and EMC design troubleshooting, and training experience combined with our graduate education from the Missouri University of Science and Technology (MS&T) ensures that our classes have the right balance of technical rigor, instruction.

Doug Smith is offering the following classes in 2014. For additional information visit his website www.dsmith.org or email Doug for details at doug@emcesd.com.

Design Troubleshooting, EMC, and ESD

This three day seminar takes the best points from Doug Smith’s seminars and compresses them into three action packed days with lecture, video, and many demonstrations on live circuits. Time is allowed for attendees to operate the experiments if they want. In two days, you will learn how to make accurate measurements in the lab and then apply those techniques to design verification and troubleshooting as well as EMC problems. The techniques and experiments are geared to the development lab and common equipment found there. During an optional third day, ESD/EMI at the system level will be covered as well as applying system level ESD stress to components, such as LEDs, in a test environment.

- February 24-26, 2014 – Boulder City, NV

Training

Knowledge, competencies,
professional development,
teaching of vocational or practical skills provides the b
practical skills provides the b
• On-the-job training tak
• Off-the-job training aw

Dr. Tom Van Doren teaches participants how to diagnose and solve electromagnetic interference and signal integrity problems:

Grounding & Shielding of Electronic Systems

This course treats signals and currents; explains fundamental grounding, shielding, and signal routing principles; clarifies troublesome terminology; and demonstrates many techniques for identifying and fixing electrical interference problems. The principles will be described as concepts rather than theoretical equations. The emphasis on concepts will make the course useful for people with technical experience ranging from beginner to advanced designer. Since many noise emission and susceptibility problems are related to the mechanical design of systems, mechanical engineers and technicians can benefit from attendance. Several interface mechanisms and shielding techniques will be demonstrated. Additional details about the course can be found: dce.mst.edu/noncredit/facetoface/groundingandshieldingstlouis/index.html

- March 25-26, 2014, University of Missouri-St. Louis (UMSL), St. Louis, MO

Washington Laboratories Academy

will be offering a range of training opportunities in 2014, including the very popular and often sold-out MIL-STD-461 training. As always, the engineering community can take advantage of its core training offerings in EMC Design and Mitigation. Other offerings will focus on Wireless Regulatory topics, including International Approvals for RF devices, Simulation, Nuclear EMC, Shielding Design, Environmental Testing and Design and breaking topics in Engineering Reliability and Maintainability. Served up in-house, on the road and on the web and teaming with its slate of expert instructors, WLA delivers the best selection and options for engineering development. In the coming twelve months, the Academy will expand its partner opportunities to support the engineering community with the finest in professional development. Contact Mike Violette (mikev@wll.com) for more information, or visit the Washington Laboratories Academy at www.wll.com/academy.

PRODUCT SAFETY AND ENVIRONMENTAL TESTING SEMINARS

AEMC Instruments offers the following public training opportunities:

Understanding Ground Resistance Testing Training Seminar

This one-day training seminar consists of two sessions. The first session consists of classroom presentations and discussions on all aspects of soil resistivity and ground resistance testing. The second session consists of on-site field tests demonstrating the different methods of ground resistance testing discussed during the first half of the day. Participants will have the opportunity for hands-on experience and demonstrations of proper testing procedures including measurement of soil resistivity, correct placement of test rods, using the 3-Point method and proper use of the clamp-on test method. For additional details, please visit www.aemc.com/techinfo/seminars/ground_resistance_testers/ground-seminar-listings.html.

- February 11, 2014 – San Diego, CA
- March 11, 2014 – Jacksonville, FL
- April 8, 2014 – Salt Lake City, UT
- May 13, 2014 – Chicago, IL
- June 10, 2014 – Denver, CO
- July 8, 2014 – Syracuse, NY
- August 13, 2014 – Cleveland, OH
- September 9, 2014 – Dallas, TX
- October 7, 2014 – Richmond, VA
- November 4, 2014 – Tucson, AZ



CST of America offers the following public courses throughout the year. Additional details can be found about each training course online at www.cst.com/events/training.

CST STUDIO SUITE®

EMC/EMI Training

The CST STUDIO SUITE® EMC/EMI training course consists of 2 full days. This training class is intended for Engineers involved in Electromagnetic Compatibility (EMC), Electromagnetic Interference (EMI), Electrostatic Discharge (ESD), Electromagnetic Environmental Effects (E3) and antenna integration.

- April 8-9, 2014 – Darmstadt, Germany
- May 14-15, 2014 – Framingham, MA
- May 21-22, 2014 – San Mateo, CA

CST STUDIO SUITE® Training for EDA/Signal Integrity

This 2-day hands-on training course is focused on modeling and solver overview and focuses on EDA/SI/PI applications.

- February 4-5, 2014 – Darmstadt, Germany
- April 15-16, 2014 – Rome, Italy
- May 20-21, 2014 – Treviglio, Italy
- June 3-4, 2014 – Darmstadt, Germany

CST STUDIO SUITE®

Low Frequency Training

How to work efficiently with CST EM STUDIO® (CST EMS). Improve your performance with our hands-on training course.

- February 4, 2014 – Darmstadt, Germany
- April 8, 2014 – Darmstadt, Germany

CST STUDIO SUITE® Microwave & Antenna Training

This 2-day hands-on training course focuses on modeling and solver overview and concentrates on antenna simulation.

- January 22-23, 2014 – San Mateo, CA
- January 29-30, 2014 – Framingham, MA
- February 4-5, 2014 – Darmstadt, Germany
- February 25-26, 2014 – Munich, Germany
- February 25-26, 2014 – Nottingham, UK
- April 2-3, 2014 – Helsinki, Finland

- April 8-9, 2014 – Darmstadt, Germany
- April 16-17, 2014 – Los Angeles, CA
- May 13-14, 2014 – Turkey
- May 20-21, 2014 – Nottingham, UK
- May 28-29, 2014 – Rome, Italy
- June 3-4, 2014 – Darmstadt, Germany
- June 10-11, 2014 – Israel
- June 24-25, 2014 – Munich, Germany

CST STUDIO SUITE® Signal Integrity and Power Integrity Training

The CST MWS Signal Integrity training course consists of 2 full days. It is helpful to be familiar with the Getting Started manual. This training course is focused on modeling and solver overview, and concentrates on SI/PI applications.

- March 26-27, 2014 – San Mateo, CA
- April 2-3, 2014 – Framingham, MA

CST PARTICLE STUDIO® Training

This full CST PS training course consists of 2 full days focused on modeling and particle solver overview.

- February 4-5, 2014 – Darmstadt, Germany
- March 5-6, 2014 – Israel
- June 3-4, 2014 – Darmstadt, Germany

Particle Signal Integrity Applications

With the advancement of today's technology, high-speed devices have rise/fall times as low as 1 ns. Signal traces in the printed circuit board (PCB) can no longer be treated as simple short-circuit interconnects; instead they behave as transmission lines. The fast slew rate can contribute to Signal Integrity (SI) and Electromagnetic Interference (EMI) problems, such as impedance mismatch, signal reflection, crosstalk, ground bounce and radiation. Thus, it is highly possible that a high-speed PCB fails to work due to SI & EMI issues. Proper PCB design techniques and good understanding of high-speed concepts are required to ensure the smooth transition from circuit design to first prototype and final product.

3D EM simulation can provide a valuable insight into all phenomena related to today's SI issues.

The instructors at this training are senior engineers with many years of experience in the field. As a hands-on-tool CST STUDIO SUITE® will be used in order to demonstrate the theoretical aspects in praxis.

- February 24-26, 2014 - Kuala Lumpur, Malaysia

Equipment Reliability Institute offers the following public courses throughout the year. Visit www.equipment-reliability.com for more details about each course.

Fundamentals of Random Vibration and Shock Testing, HALT, ESS, HASS Measurements, Analysis and Calibration

- February 18-20, 2014 – Santa Barbara, CA
- April 8-10, 2014 – Detroit, MI

Military Standard 810G (MIL-STD-810G) Testing

Understanding, Planning and Performing Climatic and Dynamic Tests

- January 13-16, 2014 – Cape Canaveral, FL
- February 4-7, 2014 – Santa Clarita, CA
- March 18-21, 2014 - Rovaniemi, Finland

MET Laboratories Compliance College

offers seminars at various locations throughout the year. Visit www.metlabs.com for additional details.

Product Compliance Seminar

Hosted by MET Laboratories and Wurth Electronics Midcom, this one day seminar



is designed by engineers and technicians, for engineers and technicians, with practical content to give you support for the development of undisturbed electronics and equipment.

- January 15, 2014 – Austin, TX

O'Brien Compliance Management

offers a training course in IEC 60601, the medical electrical equipment standards for basic safety and essential performance. A brief description and dates and locations are below. For further details, please visit www.obcompman.com.

IEC 60601 Training Seminars 2014

These three-day seminars teach the basics behind the IEC 60601-1, 2nd & 3rd editions. The seminars are targeted for design and compliance engineers who need to incorporate 60601-1 safety knowledge into their everyday jobs.

- March 25-27, 2014 – San Jose, CA
- April 15-17, 2014 – Boston, MA
- May 13-15, 2014 – Galway, Ireland
- September 23-25, 2014 – Amsterdam, Netherlands
- October 21-23, 2014 – Boston, MA

TÜV Rheinland

Step-Ahead Educational Series

Drawing on the expertise and skills of TÜV Rheinland's experts, who include engineers and scientists from all over the world, Step-Ahead Educational Series continues in 2014 with a comprehensive selection of seminars, webinars, round-tables and other educational events. For more information, email TÜV Rheinland at education@tuv.com or visit education.tuv.com/step-up-educational-series.

Risk Management for 60601-1 3rd Edition

ISO14971:2007 is commonly used as the risk management standard for electrical medical equipment. The educational series will examine the best ways to document your conformity to both ISO14971 and IEC 60601-1 3rd Edition. The changes imposed by EN ISO 14971:2012 will also be discussed.

Corporate Social Responsibility

Learn how your company can benefit from a corporate social responsibility program

(CSR). CSR webinars will give you tools for managing risks and implementing sustainability programs of any size.

International Approvals

Today, companies need more than ever seamless solutions for access to world markets with timely and accurate product certification management. Learn about the current rules and regulations for gaining market access to Brazil, Mexico, Customs Unions, China, Australia, and more. The focus will be on telecom/radio, wireless, product safety, EMC and Mutual Recognition Agreements, ensuring that the event addresses the needs of most products, including information technology, audio/video, household, medical and commercial/industrial.

Environmental Compliance

Manufacturers of electrical and electronic equipment who export to the EU must comply with the REACH, WEEE Recast and RoHS Recast Directives, or risk losing access to market. Previously exempted medical and consumer monitoring and control equipment will now need to comply with the RoHS by July 21, 2014, and industrial monitoring and control equipment will need to comply by July 21, 2017. Learn how to ensure the product's compliance from TÜV Rheinland experts, some of whom actually helped develop new RoHS standards.

Smart Grid & IoT

As the number of smart grid products and services increases in the market, factors such as interoperability of devices and cyber-security have become increasingly important. TÜV Rheinland is in the forefront of smart grid testing, so join the experts to discuss the success of SG technology, how Internet of Things (IoT) is changing the consumption of energy, and the value of alliance certifications – from ZigBee to Wi-SUN.

Systems Certification

Take a first glance at the upcoming 2015 revision of ISO 9001 that will have a big impact on organizations. TÜV Rheinland will provide analysis of the changes and what they will mean to your organization.

ITE Safety Compliance

To export to the EU, Information Technology and office equipment manufacturers will need to comply with IEC/EN60950-1, Amendment 2 for their existing and new products. The old version of the standard expires in 2016. You will also learn about the second edition of IEC/EN 62368 and the changes it will bring about, superseding the standards for A/V and ITE equipment 60950-1 and 60065, respectively.

Energy Efficiency

It is estimated that over 80% of all product-related environmental impacts

are determined during the design phase of a product. Join us to learn about the updates in energy efficiency regulations for electronic products for US, Canada and EU and ensure your product's compliance.

EMC

With the 4th Edition of IEC 60601-1-2 on the horizon, changes are looming for EMC compliance for electrical medical equipment. The educational series will inform you of the new regulations and help you understand the FDA guidance document on RF wireless technology in medical devices. You will also learn about EMC in fixed installations, EMC testing for Proton Beam Therapy Centers and Equipment and how to proceed when “CE + CE Does Not Work for EMC.”

TÜV SÜD Academy public training courses are enhanced by the real life experiences of our auditing and testing teams, offering years of experience in the worldwide international standards arena. This relationship allows us to provide clients with seasoned auditors and engineers as trainers and subject matter experts, transferring their knowledge and expertise directly to you. Visit their website for details, tuvamerica.com/tuvnews/publictraining.cfm.

UL Knowledge Services (ULKS) is UL's training and advisory services business unit, providing safety and compliance-related knowledge solutions that facilitate product development and create safer working environments for people. ULKS's comprehensive service offerings are designed to help customers access first-hand, real-time, industry-critical information. In addition to comprehensive coverage of UL standards, ULKS addresses specific topics intended to help customers and constituents design and/or install safer products, increase efficiency and realize improved speed to market. Following are ULKS featured offerings. For a full listing of 2014 dates and locations please visit: lms.ulknowledgeservices.com/catalog/display.resource.aspx?resourceid=100612.

Designing Safety-Related Machinery Control Systems in Accordance with ISO 13849 and IEC 62061

This workshop provides detailed



information on how to specify, implement and validate safety-related control systems for machinery to establish conformance with regulations and standards.

- April 8, 2014 – Chicago, IL

Globalability: The Key to International Compliance

Spend two days with UL to learn how to identify and comply with product regulations in your key international markets, and then leverage the similarities and differences among those markets to develop a compliance strategy.

- March 19, 2014 – San Jose, CA
- May 13, 2014 – Raleigh, NC
- September 17, 2014 – Chicago, IL

Industrial Control Panels UL 508A and Short-Circuit Current Ratings

This comprehensive one and a half-day workshop provides technical information to industrial control panel professionals. The workshop is ideal for those who need to understand the safety compliance requirements of the UL 508A Standard for industrial control panels, as well as the new requirements found in the National Electrical Code (NEC) Article 409 and UL 508A Supplement B.

- January 29-30, 2014 – Orlando, FL
- March 11-12, 2014 – Brea, CA
- March 12-13, 2014 – Raleigh, CA
- March 25-26, 2014 – Cincinnati, OH
- April 1-2, 2014 – Minneapolis, MN
- April 15-16, 2014 – Nashville, TN
- April 22-23, 2014 – Houston, TX
- June 17-18, 2014 – Denver, CO
- July 9-10, 2014 – Fort Smith, AR
- July 29-30, 2014 – Chicago, IL

Measurement, Control and Laboratory Use Equipment: Designing for Compliance to IEC 61010-1 3rd Edition

This three-day course provides a thorough understanding of how to effectively design for compliance to IEC 61010-1 3rd Edition. The content and activities covered in this course will help you gain practical skills and enhance your technical understanding of the standard.

- March 4, 2014 – Boston, MA
- April 22, 2014 – Minneapolis, MN

- July 15, 2014 – Raleigh, NC
- August 12, 2014 – San Jose, CA
- November 4, 2014 – Chicago, IL

The CE Marking: Strategies for European Compliance

This two-day workshop is designed to give you essential information about the European regulatory system and step-by-step instructions on how to develop a compliance strategy fit for your needs.

- February 18, 2014 – Brea, CA
- June 4, 2014 – Chicago, IL

Safety of Household and Similar Electrical Appliances; General Requirements, IEC 60335-1, 5th Edition

Knowing how to use IEC 60335-1, 5th Edition effectively in a product's design phase is critical to its certification and acceptance within the global marketplace. This two-day technical workshop will give you in-depth exposure to essential topics such as spacing and insulation requirements, supply connections, component requirements and performance test criteria.

- February 25, 2014 – Brea, CA
- June 17, 2014 – Chicago, IL
- September 10, 2014 – Raleigh, NC

Washington Laboratories Academy offers Product Safety Seminars throughout the year. Visit them online at www.wll.com/academy.html for locations and dates.

ESD SEMINARS

The ESD Association holds educational opportunities throughout the year both online and at events. For full details, visit the ESD Association's website at www.esda.org.

ESD Basics for the Program Manager: How To's of an In-Plant ESD Survey and Evaluation Measurements

This tutorial provides the foundation material for understanding electrostatics and ESD and their role in the manufacturing and handling of ESD sensitive devices. The fundamental properties of charge, electric fields, voltage, capacitance, and current are discussed

with a view towards understanding key electrostatic phenomena and electrical processes. These include charge generation and decay, material properties, and induction. An overview of device failure mechanisms is presented, including how these models impact ESD control programs. Finally, the course provides an overview of ESD control procedures during handling and manufacturing and an overview of ANSI/ESD S20.20 program requirements. This full day course is required for those in-plant auditors and program managers who are working toward professional ESD certification. The presentation includes many in-class demonstrations, videos, and animated slides.

- February 26-27, 2014 – Rome, NY

ESD Association Meeting Series

- April 1-8, 2014 – Tucson, AZ

8th Annual International Electrostatic Discharge Workshop (IEW)

- May 19-22, 2014 – Villard de Lans, France

ESD Association Meeting Series

- September 4-12, 2014 – Tucson, AZ

OTHER PROFESSIONAL DEVELOPMENT SEMINARS

iNARTE Certified Laboratory Auditor, (iNCLA) Training and Credentialing Program

iNARTE (www.narte.org)

For more information and to register visit www.narte.org/h/iNCLAConference.asp.

iNARTE also offers the following workshops throughout the year. Please visit their website for additional details www.narte.org: HPEM/HEMP/IEMI Workshop, Personal Development through Engineering Excellence, Workshop on ANSI C63.10 – 2009: Testing Unlicensed Wireless Devices.

**Send your events to
editor@incompliancemag.com**

PRIVATE/CUSTOM SEMINARS

Many experts offer private seminars designed to train select personnel at your location. These seminars offer companies an opportunity to train multiple compliance personnel with a customized approach designed for their needs. Following is a list of experts who offer private seminars.

Best ESD Technical Services

(www.bestesd.com)

Classes and seminars can be arranged on different topics - from basic introduction to highly-specialized classes on a particular subject of ESD or EMC/EMI relevant to your applications.

Cherry Clough Consultants

(www.cherryclough.com)

Seminars allow for a customized approach to training in basic and advanced EMC design, the EMC Directive and EMC engineering practices for EMC testing techniques and EMC functional safety.

DLS Electronics Systems

(www.dlsemc.com/1101)

DLS experts offer practice oriented seminars and workshops on EMC design and regulatory compliance issues.

Kimmel Gerke Associates, Ltd.

(www.emiguru.com) offers seminars on EMC design fundamentals and techniques for ensuring EMC Compliance.

Montrose Compliance Services

(www.montrosecompliance.com) offers worldwide customized training programs on achieving EMC compliance, EMC design fundamentals and techniques.

Henry Ott Consultants

offers one to three day EMC seminars (in plant and public) on over 25 different topics, including "Partitioning and Layout of Mixed-Signal PCBs" and EMC Considerations in Switching Power Supply Designs". Please visit Mr. Ott's website for additional information, www.hottconsultants.com/seminary.html.

Wyatt Technical Services, LLC

An independent consulting firm that specializes in EMC design, troubleshooting

and training services to commercial and industrial manufacturers with global distribution in the consumer, computer, network & telecommunications, industrial and scientific industries. Visit www.emc-seminars.com for further information.

ON-LINE TRAINING

If webinars are your preferred style of learning, many companies sponsor on demand style webinars for viewing at your convenience. Please visit the following sites to view topics and make your selection.

Associated Research

(www.asresearch.com) offers webinar programs providing detailed information on many aspects of electrical safety testing. They are a valuable resource that can be used to learn more about common electrical safety tests.

CST of America

(www.cst.com/events/webinars) offers webinar programs throughout the year that focus on design challenges across the field of electrical engineering, in microwaves and RF, EMC, EDA and charged particle dynamics.

Intertek Academy

(www.intertek.com/training) offers educational opportunities in quality, safety and Energy Efficiency. Intertek's 2014 line-up of technical seminars, webinars, workshops, training events, conferences and White Papers provide in-depth guidance for understanding new standards and specs, innovative techniques and compliance. Visit their website for dates and details.

Kimmel Gerke (EMI Guru) offers webinars throughout the year. Please visit www.emiguru.com for details.

MET Laboratories offers webinars throughout the year. Please visit www.metlabs.com for details.

MET Laboratories also offers on-demand viewing of past webinars at www.metlabs.com/News-and-Events/Seminars-and-Webinars.aspx



The ESD Association IEW Seminars

The ESD Association is offering four ESD Seminars presented at the International ESD Workshop and now updated for online presentation. These four, 80 minute, in-depth IEW Seminars review and explore new work in process ESD, ESD design and ESD test of ICs and systems, presented by ESD experts in these fields. Visit www.eda.org for more information.

A Review on the ESD Robustness of Drain Extended MOS Devices

- February 27, 2014 - 11:00AM EST

Overview on Efficient and Reliable System-Level ESD

- March 13, 2014 - 11:00AM EST

HBM Tester Artifact Review

- March 27, 2014 - 11:00AM EST

TCAD Methodologies for Industrial ESD Design

- April 8, 2014 - 11:00AM EST

SIEMIC Regulatory Compliance Webinars for 2014

Presented in a series of monthly one-hour webinars, by industry leaders in worldwide compliance testing and international product certifications, these seminars will present the latest regulation changes, importation requirements, and hot compliance issues for the most important and dynamic market countries, and show manufacturers how to access these markets with clear pathways to successful entry of their electronic products.

See more information and registration instructions at www.siemc.com/US/news_media/webinars_2014.php.

- January 23, 2014
- February 27, 2014
- March 27, 2014
- April 24, 2014
- May 22, 2014
- June 26, 2014
- July 24, 2014
- August 28, 2014
- September 25, 2014
- October 23, 2014
- November 13, 2014
- December 11, 2014

Webinar times for US time zones:

Eastern Time Zone: 1:00 PM to 2:00 PM

Central Time Zone: Noon to 1:00 PM

Mountain Time Zone: 11:00 AM to Noon

Pacific Time Zone: 10:00 AM to 11:00 AM

TUV SUD America (www.tuvamerica.com/tuvnews/webinars.cfm) offers webinars and online seminars in the areas of Safety, EMC, Management Systems and Competency Assessments.

INDUSTRY SYMPOSIA AND TABLE TOP PROGRAMS

These annual symposia are an excellent resource for extensive technical training, and exchange of new ideas and technical concepts. The benefit of attending these events is that attendees can sample a vast array of workshops quickly and efficiently while networking with colleagues and professionals with the same interests.

2014 Global Symposium on EMC, SAFETY and Product Compliance Engineering (GLOBESPACE)

www.globespace.org

March 3-6, 2014 – Tel-Aviv, Israel

EMV 2014

www.mesago.de/en/EMV/home.htm

March 11-13, 2014 – Dusseldorf, Germany

Microwaves & RF 2014

www.microwave-rf.com

March 19-20, 2014 – Paris, France

30th International Review of Progress in Applied Computational Electromagnetics

www.aces-society.org/conference/2014

March 23-27, 2014 – Jacksonville, FL

EuCAP 2014 – The 8th European Conference on Antennas and Propagation

www.eucap2014.org

April 6-11, 2014 – The Hague, Netherlands

IEEE Symposium on Product Compliance Engineering

www.psessymposium.org

May 5-7, 2014 – San Jose, CA

IEEE International Instrumentation and Measurement Technology Conference

www.imtc.ieee-ims.org/imtc-2014

May 12-15, 2014 – Montevideo, Uruguay

EMC'14/Tokyo – 2014 International Symposium on Electromagnetic Compatibility

www.ieice.org/~emc14

May 13-16, 2014 – Tokyo, Japan

IMS2014 – 2014 International Microwave Symposium

www.ims2014.org

June 1-6, 2014 – Tampa Bay, FL

2014 China International Exhibition on EMC, Microwave, RF and Safety Tests & Certification (China EMC 2014/China MW 2014)

www.emcchinaexpo.com

June 17-19, 2014 – Beijing, China

IEEE EMC 2014 – International Symposium on Electromagnetic Compatibility

www.emc2014.org

August 3-8, 2014 – Raleigh, NC

EMC Europe 2014 – International Symposia and Workshops on Electromagnetic Compatibility

www.emceurope.eu

September 1-4, 2014 – Gothenburg, Sweden

36th Annual Electrical Overstress/ Electrostatic Discharge Symposium

www.esda.org/symposiaEOS-ESD.html

September 7-12, 2014 – Tucson, AZ

European Microwave Week 2014

www.eumweek.com

October 5-10, 2014 – Rome, Italy

36th Annual Symposium of the Antenna Measurement Techniques Association (AMTA)

www.amta2014.org

October 12-17, 2014 – Tucson, AZ

Electronica 2014

www.electronica.de

November 11-14, 2014 – Munich, Germany

IEEE EMC SOCIETY REGIONAL EVENTS 2014

Milwaukee, WI: February 18-19, 2014
Measurement Uncertainty and CISPR 16-4-2 Ed.2: How both are applied within the EMC Laboratory, Presenter: Werner Schaefer

Crowne Plaza Milwaukee Airport Hotel, Milwaukee, WI

Contact: Jim Blaha, jblaha@ieee.org

Seattle, WA: March 20, 2014

The Reverb Chamber, Anechoic Chamber and OATS User Group Meeting with multiple speakers on related topics
Marriott Seattle Waterfront Hotel, Seattle, WA

Contact: Janet O'Neil, (425) 868-2558, janet.oneil@ets-lindgren.com

Chicago, IL: May 6, 2014

Speakers and topics to be announced, www.emcchicago.org

Itasca Country Club, Itasca, IL

Contact: Frank Krozel, Electronic Instrument Associates, (630) 924-1600, frank@electronicinstrument.com

Detroit, MI: May 8, 2014

Speakers and topics to be announced,

www.EMCSOCIETY.org/emcfest

Canton Summit on the Park, Canton, MI

Contact: Scott Lytle, Yazaki North America, scott@emcsociety.org

Bloomington, MN: September 16, 2014

Speakers and topics to be announced

Ramada Mall of America,

Bloomington, MN

Contact: Dan Hoolihan, (651) 213-0966, danhoolihanemc@aol.com





Fundamentals of Electrostatic Discharge

Part One: An Introduction to ESD

BY THE ESD ASSOCIATION

HISTORY & BACKGROUND

To many people, Electrostatic Discharge (ESD) is only experienced as a shock when touching a metal doorknob after walking across a carpeted floor or after sliding across a car seat. However, static electricity and ESD has been a serious industrial problem for centuries. As early as the 1400s, European and Caribbean military forts were using static control procedures and devices trying to prevent inadvertent electrostatic discharge ignition of gunpowder stores. By the 1860s, paper mills throughout the U.S. employed basic grounding, flame ionization techniques, and steam drums to dissipate static electricity from the paper web as it traveled through the drying process. Every imaginable business and industrial process has issues with electrostatic

charge and discharge at one time or another. Munitions and explosives, petrochemical, pharmaceutical, agriculture, printing and graphic arts, textiles, painting, and plastics are just some of the industries where control of static electricity has significant importance. The age of electronics brought with it new problems associated with static electricity and electrostatic discharge. And, as electronic devices become faster and the circuitry getting smaller, their sensitivity to ESD in general increases. This trend may be accelerating. The ESD Association's "Electrostatic Discharge (ESD) Technology Roadmap", revised April 2010, includes "With devices becoming more sensitive through 2010-2015 and beyond, it is imperative that companies begin to scrutinize the ESD capabilities of their handling processes". Today, ESD

impacts productivity and product reliability in virtually every aspect of the global electronics environment.

Despite a great deal of effort during the past thirty years, ESD still affects production yields, manufacturing cost, product quality, product reliability, and profitability. The cost of damaged devices themselves ranges from only a few cents for a simple diode to thousands of dollars for complex integrated circuits. When associated costs of repair and rework, shipping, labor, and overhead are included, clearly the opportunities exist for significant improvements. Nearly all of the thousands of companies involved in electronics manufacturing today pay attention to the basic, industry accepted elements of static control. ESD Association industry standards are available today to guide manufacturers

Triboelectric Charge

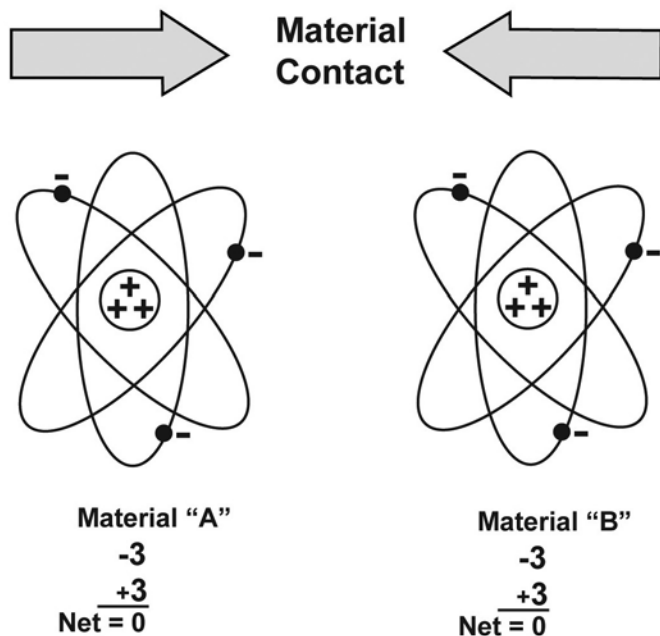


Figure 1: The Triboelectric Charge: Materials Make Intimate Contact

Triboelectric Charge

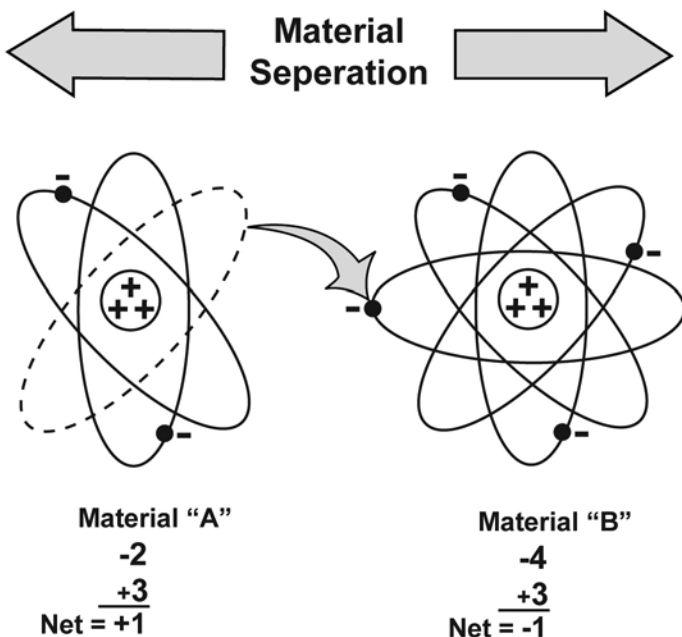


Figure 2: The Triboelectric Charge: Separation

in establishing the fundamental static charge mitigation and control techniques (see Part Six – ESD Standards). It is unlikely that any company which ignores static control will be able to successfully manufacture and deliver undamaged electronic parts.

STATIC ELECTRICITY: CREATING CHARGE

Definitions for Electrostatic Discharge Terminology are in the ESD ADV1.0 Glossary which is available as a complimentary download at www.ESDA.org. *Electrostatic charge* is defined as “electric charge at rest”. Static electricity is an imbalance of electrical charges within or on the surface of a material. This imbalance of electrons produces an electric field that can be measured and that can influence other objects. *Electrostatic discharge (ESD)* is defined as “the rapid, spontaneous transfer of electrostatic charge induced by a high electrostatic field. Note: Usually, the charge flows through a spark between two bodies at different electrostatic potentials as they approach one another”.

Electrostatic discharge can change the electrical characteristics of a semiconductor device, degrading or destroying it. Electrostatic discharge also may upset the normal operation of an electronic system, causing equipment malfunction or failure. Charged surfaces can attract and hold contaminants, making removal of the particles difficult. When attracted to the surface of a silicon wafer or a device’s electrical circuitry, air-borne particulates can cause random wafer defects and reduce product yields.

Controlling *electrostatic discharge* begins with understanding how *electrostatic charge* occurs in the first place. Electrostatic charge is most commonly created by the contact and separation of two materials. The materials may be similar or dissimilar although dissimilar materials tend to liberate higher levels of static charge. For example, a person walking across the floor generates static electricity as shoe soles contact and then separate from the floor surface. An electronic device sliding into or out of a bag, magazine or tube generates an electrostatic charge as the device’s housing and metal leads make multiple contacts and separations with the surface of the container. While the magnitude of electrostatic charge may be different in these examples, static electricity is indeed formed in each case.

Creating electrostatic charge by contact and separation of materials is known as “triboelectric charging.” The word “triboelectric” comes from the Greek words, *tribo* – meaning “to rub” and *elektros* – meaning “amber” (fossilized resin from prehistoric trees). It involves the

transfer of electrons between materials. The atoms of a material with no static charge have an equal number of positive (+) protons in their nucleus and negative (-) electrons orbiting the nucleus. In Figure 1, Material “A” consists of atoms with equal numbers of protons and electrons. Material B also consists of atoms with equal (though perhaps different) numbers of protons and electrons. Both materials are electrically neutral.

When the two materials are placed in contact and then separated, negatively charged electrons are transferred from the surface of one material to the surface of the other material. Which material loses electrons and which gains electrons will depend on the nature of the two materials. The material that loses electrons becomes positively charged, while the material that gains electrons is negatively charged. This is shown in Figure 2.

Static electricity is measured in coulombs. The charge “*q*” on an object is determined by the product of the capacitance of the object “*C*” and the voltage potential on the object (*V*):

$$q = CV$$

Commonly, however, we speak of the electrostatic potential on an object, which is expressed as voltage.

This process of material contact, electron transfer and separation is a much more complex mechanism than

described here. The amount of charge created by triboelectric generation is affected by the area of contact, the speed of separation, relative humidity, and chemistry of the materials, surface work function and other factors. Once the charge is created on a material, it becomes an electrostatic charge (if it remains on the material). This charge may be transferred from the material, creating an electrostatic discharge or ESD event. Additional factors, such as the resistance of the actual discharge circuit and the contact resistance at the interface between contacting surfaces also affect the actual charge that is released. Typical charge generation scenarios and the resulting voltage levels are shown in Table 1. In addition, the contribution of humidity to reducing charge accumulation is also shown. It should be noted however that static charge generation still occurs even at high relative humidity.

An electrostatic charge also may be created on a material in other ways such as by induction, ion bombardment, or contact with another charged object. However, triboelectric charging is the most common.

HOW MATERIAL CHARACTERISTICS AFFECT STATIC CHARGE

Triboelectric Series

When two materials contact and separate, the polarity and magnitude of the charge are indicated by the

materials’ positions in a *triboelectric series*. The triboelectric series tables show how charges are generated on various materials. When two materials contact and separate, the one nearer the top of the series takes on a positive charge, the other a negative charge. Materials further apart on the table typically generate a higher charge than ones closer together. These tables, however, should only be used as a general guide because there are many variables involved that cannot be controlled well enough to ensure repeatability. A typical triboelectric series is shown in Table 2.

Means of Generation	10-25% RH	65-90% RH
Walking across carpet	35,000V	1,500V
Walking across vinyl tile	12,000V	250V
Worker at bench	6,000V	100V
Poly bag picked up from bench	20,000V	1,200V
Chair with urethane foam	18,000V	1,500V

Table 1: Examples of Static Generation - Typical Voltage Levels

+ Positive	Rabbit fur
	Glass
	Mica
	Human Hair
	Nylon
	Wool
	Fur
	Lead
	Silk
	Aluminum
	Paper
	COTTON
	Steel
	Wood
	Amber
	Sealing Wax
	Nickel, Copper, Brass, Silver
	Gold, Platinum
	Sulfur
Negative -	Acetate Rayon
	Polyester
	Celluloid
	Silicon
	Teflon

Table 2: Typical Triboelectric Series

Electrostatic damage is defined as “change to an item caused by an electrostatic discharge that makes it fail to meet one or more specified parameters” and can occur at any point from manufacture to field service.

Virtually all materials, including water and dirt particles in the air, can be triboelectrically charged. How much charge is generated, where that charge goes, and how quickly, are functions of the material's physical, chemical and electrical characteristics.

Insulative Materials

A material that prevents or limits the flow of electrons across its surface or through its volume is called an insulator. Insulators have an extremely high electrical resistance, **insulative materials** are defined as “materials with a surface resistance or a volume resistance equal to or greater than 1×10^{11} ohms.” A considerable amount of charge can be generated on the surface of an insulator. Because an insulative material does not readily allow the flow of electrons, both positive and negative charges can reside on insulative surface at the same time, although at different locations. The excess electrons at the negatively charged spot might be sufficient to satisfy the absence of electrons at the positively charged spot. However, electrons cannot easily flow across the insulative material's surface, and both charges may remain in place for a very long time.

Conductive Materials

A conductive material, because it has low electrical resistance, allows electrons to flow easily across its surface or through its volume. Conductive materials have low electrical resistance, less than 1×10^4 ohms (surface resistance) and 1×10^4 ohm (volume resistance) per Glossary ESD ADV1.0. When a conductive material becomes charged, the charge (i.e., the deficiency

or excess of electrons) will be uniformly distributed across the surface of the material. If the charged conductive material makes contact with another conductive material, the electrons will be shared between the materials quite easily. If the second conductor is attached to AC equipment ground or any other grounding point, the electrons will flow to ground and the excess charge on the conductor will be neutralized.

Electrostatic charge can be created triboelectrically on conductors the same way it is created on insulators. As long as the conductor is isolated from other conductors or ground, the static charge will remain on the conductor. If the conductor is grounded the charge will easily go to ground. Or, if the charged conductor contacts another conductor, the charge will flow between the two conductors.

Static Dissipative Materials

Static dissipative materials have an electrical resistance between insulative and conductive materials ($1 \times 10^4 < 1 \times 10^{11}$ ohms surface or volume resistance). There can be electron flow across or through the dissipative material, but it is controlled by the surface resistance or volume resistance of the material.

As with the other two types of materials, charge can be generated triboelectrically on a static dissipative material. However, like the conductive material, the static dissipative material will allow the transfer of charge to ground or other conductive objects. The transfer of charge from a static dissipative material will generally take longer than from a conductive material

of equivalent size. Charge transfers from static dissipative materials are significantly faster than from insulators, and slower than from conductive material.

Electrostatic Fields

Charged materials also have an electrostatic field and lines of force associated with them. Conductive objects brought into the vicinity of this electric field will be polarized by a process known as *induction* Figure 3. A negative electric field will repel electrons on the surface of the conducting item that is exposed to the field. A positive electric field will attract electrons to near the surface thus leaving other areas positively charged. No change in the actual charge on the item will occur in polarization. If, however, the item is conductive or dissipative and is connected to ground while polarized, the charge will flow from or to ground due to the charge imbalance. If the electrostatic field is removed and the ground contact disconnected, the charge will remain on the item. If a nonconductive object is brought into the electric field, the electrical dipoles will tend to align with the field creating apparent surface charges. A nonconductor (insulative material) cannot be charged by induction.

ESD DAMAGE: HOW DEVICES FAIL

Electrostatic damage is defined as “change to an item caused by an electrostatic discharge that makes it fail to meet one or more specified parameters” and can occur at any point from manufacture to field

service. Typically, damage results from handling the devices in uncontrolled surroundings or when poor ESD control practices are used. Generally damage is classified as either a catastrophic failure or a latent defect.

Catastrophic Failure

When an electronic device is exposed to an ESD event, it may no longer function. The ESD event may have caused a metal melt, junction breakdown, or oxide failure. The device's circuitry is permanently damaged causing the device to stop functioning totally or at least partially. Such failures usually can be detected when the device is tested before shipment. If a damaging level ESD event occurs after test, the part may go into production and the damage will go undetected until the device fails in final test.

Latent Defect

Per ESD ADV1.0 latent failure is “a malfunction that occurs following a period of normal operation. The

failure may be attributable to an earlier electrostatic discharge event. The concept of latent failure is controversial and not totally accepted by all in the technical community.” A latent defect is difficult to identify. A device that is exposed to an ESD event may be partially degraded, yet continue to perform its intended function. However, the operating life of the device may be reduced. A product or system incorporating devices with latent defects may experience premature failure after the user places them in service. Such failures are usually costly to repair and in some applications may create personnel hazards.

It is relatively easy with the proper equipment to confirm that a device has experienced a catastrophic failure. Basic performance tests will substantiate device damage. However, latent defects are extremely difficult to prove or detect using current technology, especially after the device is assembled into a finished product.

BASIC ESD EVENTS: WHAT CAUSES ELECTRONIC DEVICES TO FAIL?

ESD damage is usually caused by one of three events: direct electrostatic discharge *to* the device, electrostatic discharge *from* the device or field-induced discharges. Whether or not damage occurs to an ESD sensitive item (ESDS) by an ESD event is determined by the device's ability to dissipate the energy of the discharge or withstand the voltage levels involved. The level at which a device fails is known as the device's ESD sensitivity or ESD susceptibility.

Discharge to the Device

An ESD event can occur when any charged conductor (including the human body) discharges to an item. A cause of electrostatic damage could be the direct transfer of electrostatic charge from the human body or a charged material to the ESDS. When one walks across a floor, an electrostatic charge accumulates on the body. Simple contact (or close proximity) of a finger to the leads of an ESDS or assembly which is typically on a different electrical potential can allow the body to discharge, possibly causing ESD damage. The model used to simulate this event is the Human Body Model (HBM). A similar discharge can occur from a charged conductive object, such as a metallic tool or fixture. From the nature of the discharge, the model used to describe this event is known as the Machine Model (MM).

Discharge from the Device

The transfer of charge *from* an ESDS to a conductor is also an ESD event. Static charge may accumulate on the ESDS itself through handling or contact and separation with packaging materials, work surfaces, or machine surfaces. This frequently occurs when a device moves across a surface or vibrates in a package. The model used to simulate

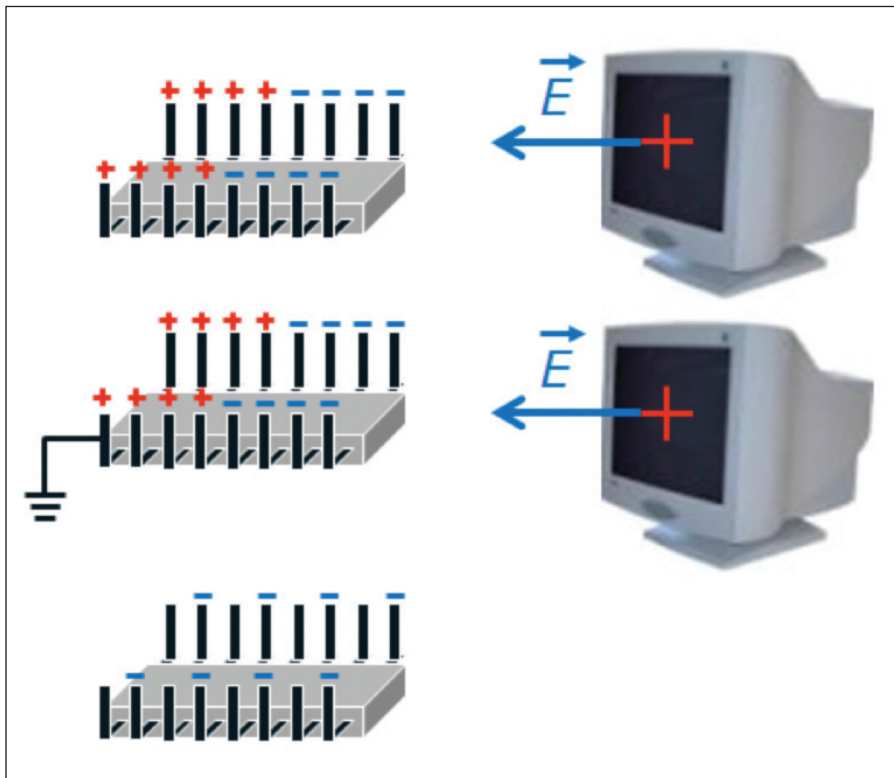


Figure 3: Induction

the transfer of charge from an ESDS is referred to as the Charged Device Model (CDM). The capacitances, energies, and current waveforms involved are totally different from those of a discharge to the ESD sensitive item, resulting very likely in different failure modes.

The trend towards automated assembly would seem to solve the problems of HBM ESD events. However, it has been shown that components may be more sensitive to damage when assembled by automated equipment. A device may become charged, for example, from sliding down the feeder. If it then contacts the insertion head or any other conductive surface, a rapid discharge occurs from the device to the metal object.

Field Induced Discharges

Another electrostatic charging process that can directly or indirectly damage devices is termed Field Induction. As noted earlier, whenever any object becomes electrostatically charged, there is an electrostatic field associated with that charge. If an ESDS is placed in that electrostatic field, a charge may be induced on the item. If the item is then grounded while within the electrostatic field, a transfer of charge from the device occurs as a CDM event. If the item is removed from the region of the electrostatic field and grounded again, a second CDM event will occur as the charge (of opposite polarity from the first event) is transferred from the device.

HOW MUCH ESD CONTROL PROTECTION IS NEEDED?

Damage to an ESDS by the ESD event is determined by the device's ability to dissipate the energy of the discharge or withstand the voltage levels involved—as explained previously these factors determine the parts ESD sensitivity or susceptibility. Test procedures based on the models of ESD events help define the sensitivity of components to ESD.

Although it is known that there is very rarely a direct correlation between the discharges in the test procedures and real-world ESD events, defining the ESD sensitivity of electronic components gives some guidance in determining the degree of ESD control protection required. These procedures and more are covered in Part Five of this series.

The ESD withstand voltage is “the highest voltage level that does not cause device failure; the device passes all tested lower voltages.” Many electronic components are sensitive or susceptible to ESD damage at relatively low voltage levels. Many are susceptible at less than 100 volts, and many disk drive components withstand voltages even below 10 volts. Current trends in product design and development pack

more circuitry onto these miniature devices, further increasing their sensitivity to ESD and making the potential problem even more acute. Table 3 indicates the ESD sensitivity of various types of components.

SUMMARY

In this “An Introduction to ESD”, we have discussed electrostatic charge and discharge, the mechanisms of creating charge, materials, types of ESD damage, ESD events, and ESD sensitivity. We can summarize this discussion as follows:

1. Virtually all materials, including conductors, can be triboelectrically charged.
2. The amount of charge is affected by material type, speed of contact and

Device or Part Type
Microwave devices (Schottky barrier diodes, point contact diodes and other detector diodes >1 GHz)
Discrete MOSFET devices
Surface acoustic wave (SAW) devices
Junction field effect transistors (JFETs)
Charged coupled devices (CCDs)
Precision voltage regulator diodes (line of load voltage regulation, <0.5%)
Operational amplifiers (OP AMPs)
Thin film resistors
Integrated circuits
GMR and new technology Disk Drive Recording Heads
Laser Diodes
Hybrids
Very high speed integrated circuits (VHSIC)
Silicon controlled rectifiers (SCRs) with $I_o < 0.175$ amp at 10°C ambient
*Specific Sensitivity Levels are available from supplier data sheets

Table 3: ESD Sensitivity of Representative Electronic Devices - Devices or Parts with Sensitivity Associated with HBM and CDM*

separation, humidity, and several other factors.

3. Charged objects have electrostatic fields.
4. Electrostatic discharge can damage devices so a parameter fails immediately, or ESD damage may be a latent defect that may escape immediate detection, but may cause the device to fail prematurely.
5. Electrostatic discharge can occur throughout the manufacturing, test, shipping, handling, or operational processes, and during field service operations.

6. ESD damage can occur as the result of a discharge **to** the device, **from** the device, or from charge transfers resulting from electrostatic fields. Devices vary significantly in their sensitivity or susceptibility to ESD.

Protecting products from the effects of ESD damage begins by understanding these key concepts of electrostatic charges and discharges. An effective ESD control program requires an effective training program where all personnel involved understand the key concepts. See Part Two for the basic concepts of ESD control.

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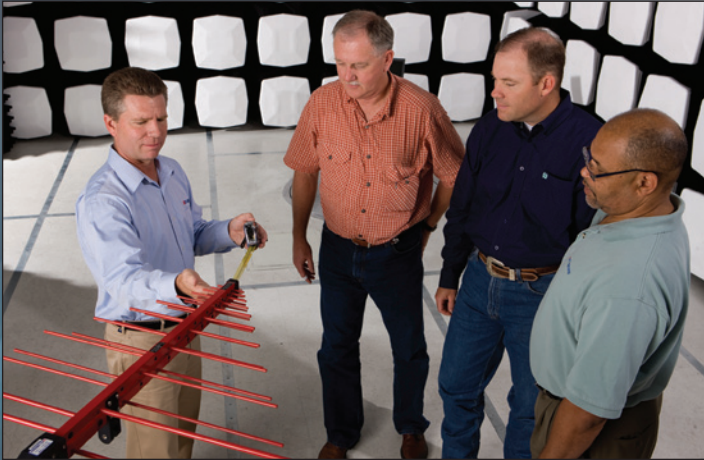
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