OCTOBER 2012

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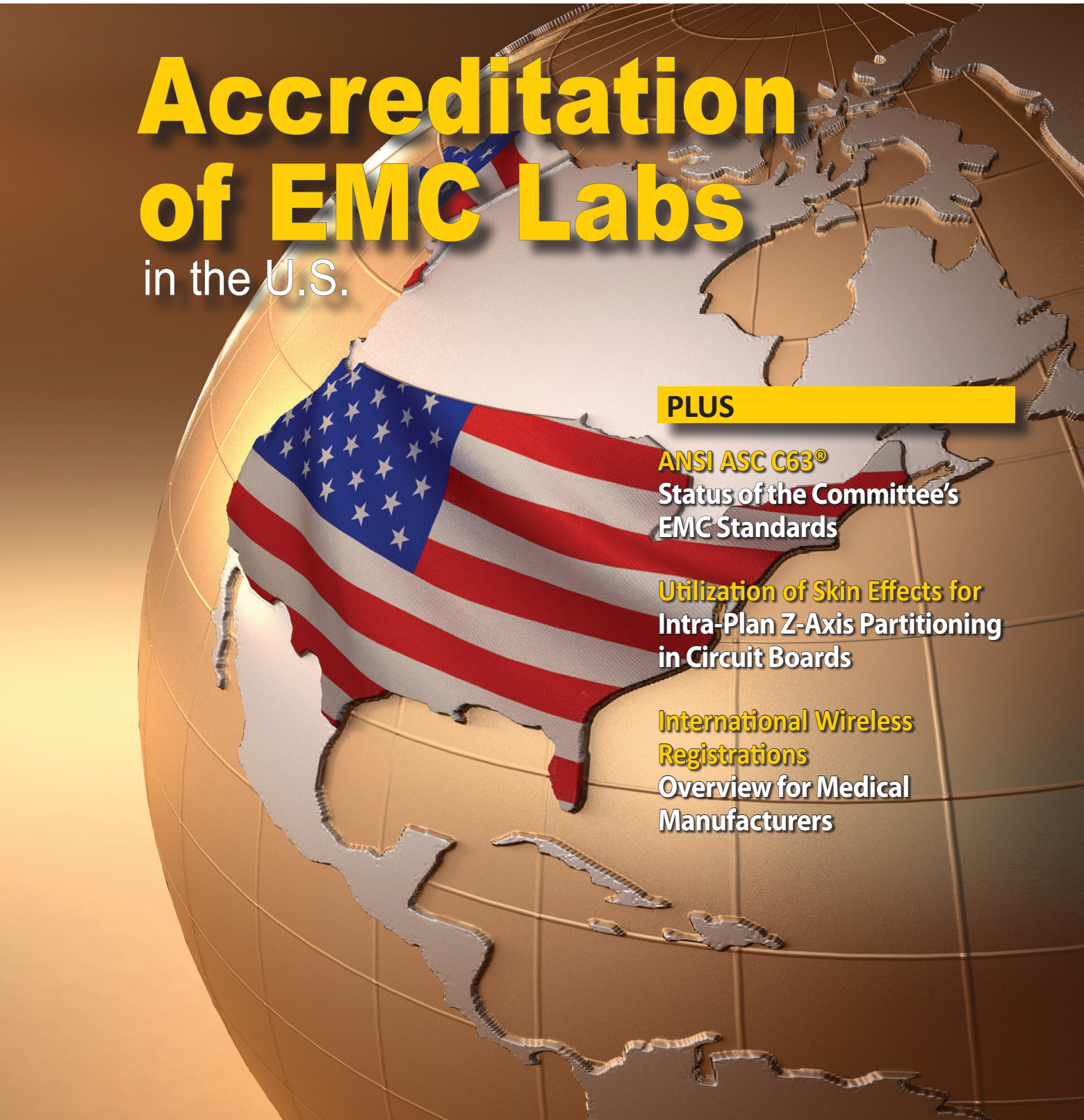

Accreditation of EMC Labs in the U.S.

PLUS

ANSI ASC C63®
Status of the Committee's EMC Standards

Utilization of Skin Effects for
Intra-Plan Z-Axis Partitioning in Circuit Boards

International Wireless Registrations
Overview for Medical Manufacturers

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Editor's Picks

Some of our favorite photographers have shared their photos
from the 2012 IEEE EMC Symposium in Pittsburgh.
See more of these great shots on our site, in our Symposium photo album!
www.incompliancemag.com/photos/2012

An aerial view of the exhibit floor

photo by Kenneth Wyatt

Willie Washington visits the NEC Team

provided by Eriko Yamato

Lou Feudi and Mike Violette

photo by Kenneth Wyatt

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Volume 4 ● Number 10

28 Accreditation of EMC Laboratories in the US

Since 1990, the accreditation of EMC laboratories has become increasingly important in many parts of the world. This development has been mainly driven by the sharp increase in the number of electric and electronic products that have been introduced to the global marketplace.

Werner Schaefer

DEPARTMENTS

FEATURES

News in Compliance

FCC News

FCC Releases Consumer Complaints Report for Q2 2012

The U.S. Federal Communications Commission (FCC) has released its report on inquiries and complaints made by consumers to the agency's Consumer & Government Affairs Bureau during the quarter ending June 30, 2012.

The Bureau regularly tracks inquiries and complaints from consumers on matters within the scope of the Commission's jurisdiction. In the area of wireline telecommunications matters, the Bureau is particularly interested in instances of "cramming" (the placing of unauthorized, misleading or deceptive charges on a telephone bill) and "slamming" (the practice of changing a subscriber's telecommunications service provider or calling plan without the subscriber's permission). The Commission also tracks violations of the Federal Telephone Consumer Protection Act (TCPA), which includes regulations covering both the "Do Not Call" registry and unsolicited fax advertisements.

During the period from April through June 2012, the Bureau received a total of 40.150 complaints regarding wireline telecommunication services, with 37,916 complaints (94.4% of the total) in the area of TCPA issues alone, and more than 3718 complaints in connection with unsolicited fax advertisements. This represents a significant increase from the 29,378 total complaints during the April-June 2011 period, with 26,319 (89.6% of the total) involving TCPA issues.

In the area of inquiries, the Bureau also received 7074 inquiries in connection with wireline telecommunications, including 4699 inquiries dealing with TCPA issues, during the period from April through June 2012. This compares with 5908 total inquiries during the comparable period in 2011, of which 3759 were related to TCPA issues.

The complete text of the Commission's most recent quarterly report is available at incompliancemag.com/news/1210_01.

FCC Implements U.S./Mexico Spectrum Sharing Agreement

The Federal Communications Commission (FCC) has proposed rules to implement the provisions of an agreement with Mexico that will enable the cooperative sharing of spectrum in the 800 MHz band in the areas along the U.S.-Mexico border.

The two countries signed an Amended Protocol in June 2012 that reallocated spectrum band segments between the U.S. and Mexico, and which specified

Mexico and the U.S. signed an Amended Protocol in June 2012 that reallocated spectrum band segments between the U.S. and Mexico, and which specified the technical parameters for operations on these segments within 110 kilometers of the common border.

FCC News

the technical parameters for operations on these segments within 110 kilometers of the common border. The rebanding of spectrum was deemed necessary to alleviate interference to public safety licensees due to commercial cellular operations.

In a Further Notice of Proposed Rule Making issued in August 2012, the Commission proposed rules that will codify the terms of the Amended Protocol, thereby bringing them into effect. Comments on the proposed changes are due to the Commission by the end of September 2012.

The complete text of the Commission's Further Notice of Proposed Rulemaking on the shared spectrum is available at incompliancemag.com/news/1210_02.

FCC Releases Report on Amateur Radio's Role in Emergency Communications

The U.S. Federal Communications Commission (FCC) has released its anticipated report on the uses and capabilities of amateur radio operations in emergency communications.

Amateur radio operators have played a vital role in natural disasters, providing a critical communications link for both first responders and victims. Mandated by the *Middle Class Tax Relief and Job Creation Act of 2012*, the Commission's report provides a thorough review of the role and importance of emergency amateur radio communications. It also identifies recommendations for the enhanced use of amateur radio operators, as well as ways to better integrate amateur radio operators into future Federal emergency response initiatives and programs.

The complete text of the Commission's report on the role of amateur radio in emergency communications is available at incompliancemag.com/news/1210_03.

News in Compliance

European Union News

EU Commission Publishes New WEEE Directive

The Commission of the European Union (EU) has announced significant changes to its key directive on the collection and recycling of electrical and electronic waste that will increase mandatory collection targets in EU Member States.

Published in July 2012 in the *Official Journal of the European Union*, the EU's new directive on waste electrical and electronic equipment (WEEE-2012/19/EU) establishes a recycling collection target of 45% of electronic equipment sold beginning in 2016. Further, beginning in 2019, member states will be required to achieve a collection target of either 65% of equipment sold, or 85% of electronic waste generated. Finally, beginning in 2018, the new directive will extend the scope of its recycling requirements to all categories of electronic waste.

The EU has restricted the use of hazardous substances in electrical and electronic equipment through its Directive 2002/95/EC (also known as the RoHS Directive), and has promoted the collection and recycling of such equipment though Directive 2002/96/EC (also known as the WEEE Directive) since early 2003. However, the Commission's Directorate General Environment has estimated that only about one third of electrical and electronic waste in the EU is being recycled, with the remainder going to landfills and treatment sites outside of the EU.

The changes to the directive, which have been in the works since 2008, are also being driven in part by concerns regarding the rapid growth of technology innovation, which has accelerated equipment replacement cycles and increased the amount of electrical and electronic waste produced.

The complete text of the recast WEEE Directive as published in the *Official Journal* is available at incompliancemag.com/news/1210_04.

Updated Standards List Published for EU's 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 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 August 2012 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/1210_05.

EU Commission Publishes Standards List for Directive on Pressure Equipment

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 97/23/EC concerning pressure equipment, also known as the Pressure Equipment Directive (PED).

The PED addresses safety requirements covering the design, manufacture and testing of a range of equipment subject

"Shocking" Clothing Helps You to Exercise Better (From Our "You Can't Make This Stuff Up" File)

Now there's a garment designed to help the millions of people looking to stay in shape but hoping to escape the clutches of the expensive and all-too-demanding workout trainer.

According to ABCnews.com, the Move tank top was presented at the Wearable Technologies conference in San Francisco, in July 2012. Designed for Pilates devotees, the tank top is equipped with strategically placed sensors that emit a mild electric shock when it senses that the body is not in optimal alignment. Once the wearer corrects their position, the tank top buzzes three times to confirm the correction.

The tank top can also wirelessly transmit workout information to a dedicated app on the user's smart phone, which analyzes individual performance and offers suggestions for future workouts.

The ABC News report on the Move tank top is available at incompliancemag.com/news/1210_12.

A report from IMS Research estimates that more than 14 million wearable electronic devices where shipped in 2011, with most of the devices falling within the fitness or medical category. The firm predicts that shipments of such devices will achieve $6 billion in revenue by 2016.

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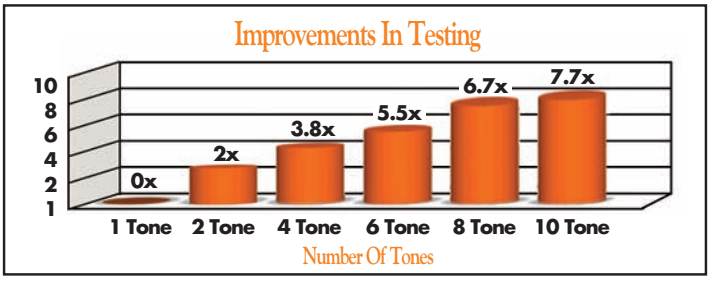

IEC 61000-4-3 1% step sizes, taking into account dwell time

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News in Compliance

European Union News

to a pressure hazard. The types of equipment covered under the scope of the Directive include pressurized storage containers, heat exchangers, steam generators, boilers, industrial piping, and other equipment used in the process and energy production industries, and in the supply of utilities, heating, air conditioning and gas storage.

The list of CEN standards, which was published in August 2012 in the *Official Journal of the European Union*, replaces all previously published standards lists for the PED. The complete list of standards can be viewed at incompliancemag.com/news/1210_06.

Updated List of Standards Released for EU's Directive on General Product Safety

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate compliance with the essential requirements of its Directive 2001/95/EC, related to general product safety.

The EU's General Product Safety Directive covers "any product…which is intended for consumers or likely, under reasonably foreseeable conditions, to be used by consumers even if not intended for them, and is supplied or made available, whether for consideration or not, in the course of a commercial activity, and whether new, used or reconditioned." The Directive is intended to ensure the general safety of products beyond those specific safety issues addressed in other product directives, such as the Machinery Directive, the EMC Directive, or the R&TTE Directive.

The list of CEN standards was published in August 2012 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive.

The revised list of standards is available at incompliancemag.com/news/1210_07.

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 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 August 2012 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive.

The revised list of standards can be viewed at incompliancemag.com/news/1210_08.

CPSC News

Sears, Kmart Recall Dehumidifiers

Retailers Sears and Kmart of Hoffman Estates, IL are recalling nearly 800,000 Kenmore brand dehumidifiers manufactured in China.

The companies have reported to the U.S. Consumer Product Safety Commission (CPSC) that the dehumidifiers can overheat, smoke, melt and catch fire, posing fire and burn hazards to consumers. Sears and Kmart say that they have received 107 reports of incidents related to the recalled dehumidifiers, resulting in more than $7 million in property damage and three cases of smoke inhalation injuries.

The recalled dehumidifiers were sold at Sears and Kmart stores nationwide, as well as through Sears.com and Kmart.com from 2003 through 2009 for between $140 and $220.

Additional details about this recall are available at incompliancemag.com/news/1210_09.

LG Recalls Gas Dryers

LG Electronics, Inc., of South Korea has recalled about 21,000 gas clothes dryers manufactured in South Korea.

According to the company, the dryers, sold under the LG Electronics and

CPSC News

Kenmore Elite brand names, incorporate a gas value that can fail to shut off properly, allowing heat to continue to build up in the dryer, even after the drying cycle is complete. The resulting high temperatures inside the dryer and on the outside surface can burn or otherwise damage the dryer contents, posing a risk of burn, fire and smoke inhalation.

LG Electronics and retailer Sears have received 141 separate consumer complaints about dryers that continued to heat after the completion of the drying cycle. The reports included burnt or scorched clothing in more than 50 cases, and minor burns to hands or arms in three cases.

The recalled dryers were sold by Sears and various appliance stores from November 2009 through August 2010 for between $650 and $1500.

More information about the LG recall is available at incompliancemag.com/news/1210_10.

GE Recalls Dishwashers Due to Fire Hazard

GE Appliances of Louisville, KY has issued a recall for about 1.3 million GE and Hotpoint brand dishwashers manufactured in the U.S.

GE has notified the U.S. Consumer Product Safety Commission (CPSC) that an electrical failure in the dishwasher's heating element can pose a fire hazard. The company has received 15 reports of dishwasher heating element failures, including seven reports of fires, three of which caused extensive property damage. However, there have been no reports of injuries.

The recalled dishwashers were sold at appliance dealers, authorized builder distributors and other stores nationwide from March 2006 through August 2009 for between $350 and $850.

Additional information about this recall is available at incompliancemag.com/news/1210_11.

News in Compliance

UL Standards Updates

Underwriters Laboratories has announced the availability of these standards and revisions. For additional information, please visit their website at www.ul.com.

STANDARDS

UL 1678: Standard for Household, Commercial, and Institutional-Use Carts, Stands and Entertainment Centers for Use with Audio and/or Video Equipment
New Edition dated August 10, 2012

UL 100: Standard for Sustainability for Gypsum Boards and Panels
New Edition dated August 22, 2012

UL 583: Standard for Electric-Battery-Powered Industrial Trucks
New Edition dated August 15, 2012

UL 1686: Standard for Pin and Sleeve Configurations
New Edition dated August 17, 2012

UL 2166: Standard for Halocarbon Clean Agent Extinguishing System Units
New Edition dated August 29, 2012

UL 2799: Environmental Claim Validation Procedure for Zero Waste to Landfill
New Edition dated August 17, 2012

UL 2807: Environmental Claim Validation Procedure for PVC Free Products
New Edition dated August 17, 2012

UL 61800-5-2: Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-2: Safety Requirements - Functional
New Edition dated August 28, 2012

REVISIONS

UL 140: Standard for Relocking Devices for Safes and Vaults
Revision dated August 1, 2012

UL 484: Standard for Room Air Conditioners
Revision dated August 3, 2012

UL 525: Standard for Flame Arresters
Revision dated August 10, 2012

UL 676: Standard for Underwater Luminaires and Submersible Junction Boxes
Revision dated August 14, 2012

UL 746A: Standard for Polymeric Materials - Short Term Property Evaluations
Revision dated August 9, 2012

UL 746E: Standard for Polymeric Materials - Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed-Wiring Boards
Revision dated August 13, 2012

UL 1261: Standard for Electric Water Heaters for Pools and Tubs
Revision dated July 31, 2012

UL 2096: Standard for Commercial/ Industrial Gas and/or Oil-Burning Assemblies With Emission Reduction Equipment
Revision dated August 13, 2012

UL 2255: Standard for Receptacle Closures
Revision dated July 31, 2012

UL 295: Standard for Commercial-Industrial Gas Burners
Revision dated August 27, 2012

UL 296A: Standard for Waste Oil-Burning Air-Heating Appliances
Revision dated August 22, 2012

UL 412: Standard for Refrigeration Unit Coolers
Revision dated August 17, 2012

UL 729: Standard for Oil-Fired Floor Furnaces
Revision dated August 22, 2012

UL 730: Standard for Oil-Fired Wall Furnaces
Revision dated August 23, 2012

UL 731: Standard for Oil-Fired Unit Heaters
Revision dated August 23, 2012

UL 751: Standard for Vending Machines
Revision dated August 17, 2012

UL 896: Standard for Oil-Burning Stoves
Revision dated August 23, 2012

UL 1105: Standard for Marine Use Filters, Strainers, and Separators
Revision dated August 15, 2012

UL 1786: Direct Plug-In Nightlights
Revision dated August 20, 2012

UL 2575: Standard for Lithium Ion Battery Systems for Use in Electric Power Tool and Motor Operated, Heating and Lighting Appliances
Revision dated August 17, 2012

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iNARTE Informer

Successful Transfer

BY BRIAN LAWRENCE

All iNARTE administration has now been successfully transferred to the Milwaukee offices of RABQSA International. Even our legendary telephone number, 1-800-89-NARTE, now rings directly into the RABQSA office. So now there are the following phone numbers that are available to call for information about iNARTE certification or FCC Licensensure:

1-800-89-NARTE
1-888-722-2440
1-414-272-3837

The iNARTE web site remains intact and all information and downloads are available still at www.narte.org. However, we encourage you to also visit www.rabqsa.com, where you will find a quick link to iNARTE on that home page in the "certify me" box.

LOOKING BACK ON PITTSBURGH

Pittsburgh was a pleasant surprise. In my 50 years or so of business travel I had never had the occasion to visit the city of Pittsburgh, but in my mind I had an image of a dark and somber place covered in a film of industrial grime. Not so! Pittsburgh was welcoming, bright and sunny, with pleasant walks to a variety of most enjoyable restaurants, bars and sidewalk cafes. Oh, and so many yellow bridges I gave up counting.

Maybe the only issue was the fact that the convention center seemed to be back to front as far as getting there from the hotel. Had we arrived by boat it would probably have made sense.

The EMC Symposium itself was most enjoyable and we congratulate the organizers on a job very well done. Long Beach in 2011 was a tough act to follow, but Pittsburgh did not disappoint. We were encouraged by the number of visitors to our booth and the greater than expected number of candidates attending our certification examination day on the Friday.

I had not scanned our data base to find the number of iNARTE certificate holders and pending applicant there were in the Pittsburg area before arriving there, so you can imagine how surprising it was to find one of our very

Oh those darn' new questions

first applicants still struggling with those darned 10 new questions that we ask for.

This image has caused us to think about how we might restructure that 10 question requirement to make it easier for applicants and more beneficial for iNARTE.

WHAT ABOUT THOSE DARN' QUESTIONS

The original intent behind asking applicants to write 10 new questions as part of the certification requirement was twofold; first we thought it would give our review committee further insight into the breadth of knowledge of an applicant, and secondly it would give us a wealth of new material to maintain the standard and currency of our question pools. In both regards it has fallen short of our expectations.

Some applicants have taken this requirement very seriously and a number of really good questions are received. However, far too many applicant questions are simply copied from examples given at the end of chapters in more popular reference books and manuals. Many others are extracts from common regulatory standards, or perhaps worse still are taken from highly specialized or obscure standards that most candidates would never think of bringing to the examination room.

From a typical batch of 100 applicant questions, we find about 50 that are essentially duplications of existing questions, another 20 that are not challenging enough to demonstrate competence, 20 that are incorrectly presented or simply incorrect, and maybe 10 that are worthy of keeping. The net result is that over time the quality of our question pools has been difficult to maintain. It is time to take a different approach:

THE FUTURE PLANS FOR APPLICANT QUESTIONS

Now that iNARTE is part of the much larger RABQSA organization, we have a professional psychometrics department available to us. This additional resource will enable us to better understand the science of good question writing and good examination structuring in order to achieve the results that both we and our applicants desire.

By October 1st this year we will have changed the applicant question requirements. Instead of asking for 10 questions we will ask for just THREE (3) questions. However, each applicant will be required to watch a short presentation on good question writing techniques that will be available for viewing on our web site. We will also be asking applicants to write questions for us in categories that we will define. With this change of requirement we will be more demanding and critical of question quality. We will be expecting to see the following important criteria observed:

The web site presentation will help applicants achieve these objectives and will provide us with a much improved number of challenging and suitable questions to maintain our pool quality.

Above all, remember to write questions that are applicable to the certificate for which you are applying. An iNARTE certified Engineer in our classic EMC, ESD or Product Safety program should have 9 years of education and work experience. Consequently that person should be expected to answer almost every good question that requires remembering and understanding the question subject matter. That person should also be able to answer most questions that require the knowledge to

Good Questions	Bad Questions
Help determine which examinees have the subject knowledge	Trick examinees into choosing an incorrect option, even when they know the answer
Have alternate, but incorrect, answers that are within the knowledge domain	Measure knowledge domains outside the intended subject
Include subjects that are meaningful to the scope of the test	Include slang terms or are not sensitive to the diversity of the examinees
Are written clearly and can be understood the first time they are read	Remind examinees that they are taking a test

iNARTE Informer

analyze and apply what they remember and understand. Then perhaps just a few will be able to answer questions that require a higher level of evaluation and creativity to find the right answer.

An examination that is intended to determine engineers that have achieved a competency level to be expected after nine years of experience will be populated with many more of the questions that require the ability to analyze and apply principles, rather than simply remember them.

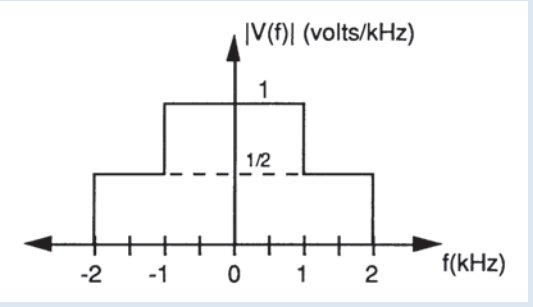
(the author)

BRIAN LAWRENCE began his career in electromagnetics at Plessey Research Labs, designing "Stealth" materials for the British armed services. In 1973 he moved to the USA and established a new manufacturing plant for Plessey to provide these materials to the US Navy. In 1980 he joined the "Rayproof" organization to develop an RF Anechoic Test Chamber product line. As a result of acquisitions, Rayproof merged into Lindgren RF Enclosures, and later into ETS-Lindgren. Following a career spanning more than 40 years in the electromagnetic compatibility field, Brian retired as Managing Director of ETS-Lindgren UK in 2006. Later that year he assumed the position of Executive Director for the National Association of Radio and Telecommunications Engineers, NARTE. Now renamed iNARTE, the Association has expanded its operations and is today an affiliate of RABQSA under the overall banner of the American Society for Quality, ASQ.

QUESTION OF THE MONTH

Last month we asked:

A signal with amplitude spectrum shown below

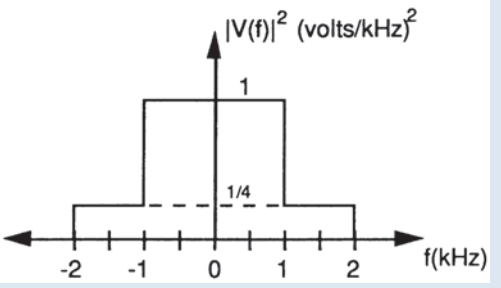


is passed through an ideal lowpass filter with unity gain and 1 kHz bandwidth. The percentage of the input energy appearing at the filter output is _____ .

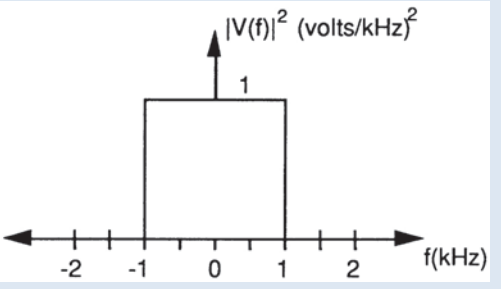
A) 50%
B) 66.7%
C) 80%
D) 90%

The answer is (C) 80%

The input energy is proportional to 1/4 + 1/4 + 2 = 2 1/2 = 5/2 volts^2 • sec^2.



The output energy is proportional to 2 = 4/2 volts^2 • sec2.



The percentage is (4/2)/(5/2) × 100 = 4/5 × 100 = 80%.

This month's question is:

Let H and E be the Phasors corresponding to a plane wave at some point in space, and H* and E* are the complex conjugates of H and E. How would you calculate the average power density in this plane wave?

A) Real (E × H*)
B) Real (E × H*)/2
C) Real (E × E*).
D) Real (H × H*).
E) Real (E × E*)/2Z, (where Z is the impedance of the medium).

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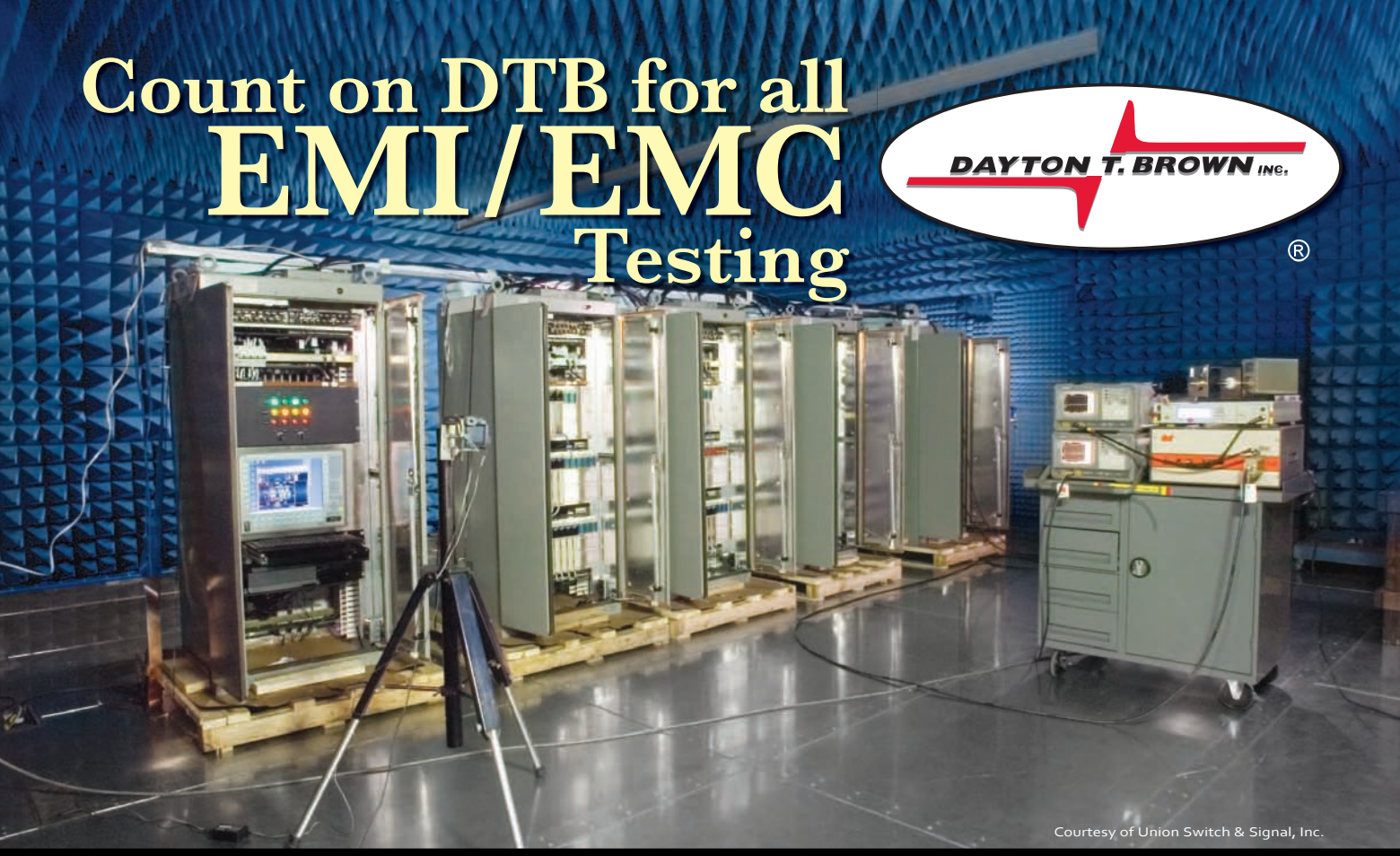

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MR. Static

Explosions and ESD

BY NIELS JONASSEN, sponsored by the ESD Association

Over the years, there have been numerous reports of explosions in grain silos, of oil tankers blowing up during tank washing, of patients being killed during an operation by a pressure wave set off by an ignition of the anesthetic gas, of everything from minor accidents in the laboratory or kitchen to disasters in space vehicles.

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

It's an interesting story in itself how the number of static-caused explosions seems to have dwindled over the last two decades, but we will leave that one to another discussion. Instead, we will look into what a discharge is and what sometimes makes it *incendive*—that is, capable of causing an explosion.

DECAY AND DISCHARGE

A charged body may lose its charge in two ways. First, let's suppose the body is a conductor. If it is connected to ground by a path containing mobile charge carriers, the charge will apparently leak away in a current. This is what happens in any wrist strap or surface layer of a topical antistat. If, by contrast, the charged body is a true insulator, this process can only take place if the body is totally immersed in a conductive fluid—in practice, always ionized air. In this case the body doesn't really lose its charge. Rather, the field is neutralized by oppositely charged ions attracted from the fluid. This is called *charge decay*.

The decay current is driven by the field from the charge to be neutralized, but all the field does is move existing charge carriers. The only effect of a decay current (apart from neutralizing the charge and field) is a dissipation of heat, as given by Joule's law.

The other way by which a body may "lose" its charge, totally or partly, is through an electrostatic discharge. A discharge happens if the field from a charge is high enough to cause ionization in the surrounding medium. The difference between decay and discharge is primarily that, in the discharge process, the charge carriers are created by the field, and the development of the process may be much more dramatic than in decay.

In a casual context, electrical discharges are often called sparks. It is, however, more practical to reserve this name for a special kind of discharge, namely that taking place between well-rounded conductors at different potentials.

TYPES OF DISCHARGE

Bowing to tradition and convenience, we may divide electrical discharges into three sometimes-overlapping groups: corona, spark, and brush discharges.

Corona Discharge. If the field strength in front of a sharp point of a conductor exceeds the breakdown field strength for the medium (air, for instance), a corona discharge will take place. This may happen if a conductor with sharp protrusions is given a high voltage, the critical value of which depends upon the geometric conditions, like distance to grounded surroundings. But it may also happen if a grounded, sharp conductor (at zero voltage) is brought near a charged object, like a piece of plastic that has been rubbed. This event

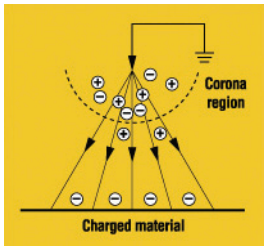

Figure 1: Corona discharge

demonstrates that it does not take a high voltage to cause a discharge, only a high field strength (see Figure 1).

In a corona discharge, the ionization is limited to a small region around the electrode, where the breakdown field strength is exceeded. In the rest of the field, we have just a current of slow-moving ions and even slower-moving charged particles finding their way to some suitable counter electrode, such as the walls of the room.

A corona discharge is also called a silent discharge. It may be maintained as long as the breakdown field strength is exceeded in some region—that is, as long as the voltage of the electrode or the charge density of the charged insulator is high enough.

Spark Discharge. At the other extreme of the discharge range, we have the spark. This kind of discharge may take place between two well-rounded conductors at different potentials, one of them often grounded (see Figure 2). Again, the discharge starts at a point where the breakdown field strength is exceeded. But in contrast to the corona discharge, in a spark the ionization takes place all the way between the two electrodes.

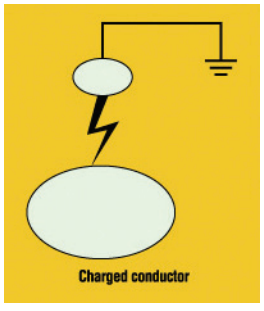

Figure 2: Spark discharge

If the electrodes are connected to a voltage supply, the discharge may turn into a continuous arc, but in the normal case of a spark from an insulated

conductor, the discharge is a very fast process, where energy given by the equation

$$W = \frac{1}{2}CV^2$$

is dissipated in the narrow discharge volume.Here C is the intercapacitance of the two electrodes, V their potential difference.

Brush Discharge. In between the corona discharge and the spark is the brush discharge, which may take place, for example, between a charged material and a normally grounded electrode with a radius of curvature of some millimeters. If a brush discharge is maintained over longer periods, it may appear as irregular luminescent paths (see Figure 3).

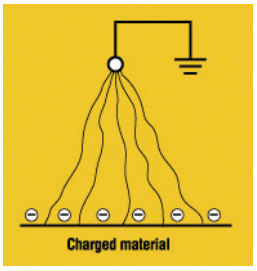

Figure 3: Brush discharge

Almost all discharges from insulators are brush discharges, like the crackle that you hear when you pick up a charged photocopy or that you feel when you pull a sweater over your head. Only if the discharge comes from a heavily charged, thin sheet of an insulator backed by a grounded conductor (stemmed branched brush discharge) can the discharge have something close to the properties of a spark.

INCENDIVITY

For our purposes here, the difference between the various types of discharges, as just described, lies primarily in their different *incendivity* —that is, the ability of a discharge to cause ignition or combustion. If we have a mixture of, say, oxygen (O_2) and diethyl ether ($[C_2H_5]_2O$), the molecules may react with each other if they get into a close-enough encounter, forming water and carbon dioxide. For this to happen, a certain amount of energy has to be delivered in a sufficiently small volume and in a sufficiently short time. The amount of energy depends strongly upon the gas mixture, both in terms of the types of components as well as their relative concentrations.

Figure 4 shows the ignition energies for diethyl ether vapor mixed with either pure oxygen or atmospheric air. For a concentration of approximately 16% ether vapor in pure oxygen, it takes only about 1 μJ to start an explosion. For ether vapor in atmospheric air, the minimum ignition energy is about 0.2 mJ for a concentration of about 6% ether vapor.

Although the curves in Figure 4 are developed specifically for diethyl ether, they are fairly typical for a wide range of vapors of organic compounds, aliphatic as well as cyclic. Consequently, the value of 0.2 mJ may be regarded as a rule-of-thumb lower-energy limit for vapor-air mixtures. Thus, whether an electrostatic charge may cause an ignition in a given environment depends on whether the discharge may deliver an energy of more than 0.2 mJ (or the relevant specific value) in a small-enough volume and in a sufficiently short time.

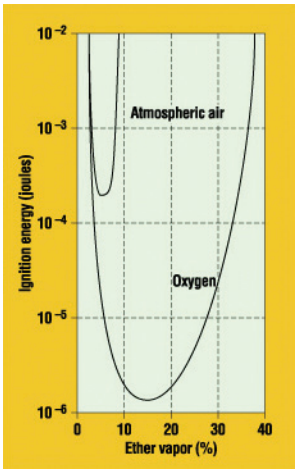

Figure 4: Ignition energy for diethyl ether mixtures

How incendive, then, are the various types of discharge we›ve discussed? The rate and density of the energy dissipated in corona discharges will always be too low to initiate an ignition—in other words, they are not incendive under any circumstances. In brush discharges, the total energy may easily be high enough, but in most cases either the rate or the density of the energy dissipation is too low to cause an ignition. It is nonetheless possible to create such charging and discharging conditions that a brush discharge may cause ignition in a mixture of common organic vapors and atmospheric air. But it should be stressed that such conditions are very rarely, if ever, encountered by accident. Therefore, we may conclude that brush discharges, and thus discharges from insulators, have very low incendivity.

It›s a completely different story with sparks. Again, sparks are discharges between rounded conductors (one of them, often, a grounded object) at different potentials. As already suggested, such a system may be characterized electrostatically by the intercapacitance (or partial capacitance) *C* of the electrodes. If the voltage difference between the electrodes is *V*, an energy *W* given by the equation

$$W = \frac{1}{2}CV^2$$

will be stored in the system. If a spark occurs, almost all of this energy will be rapidly dissipated in the narrow

discharge volume. If the discharge occurs in an explosive atmosphere, ignition may result.

By way of example, let's examine a fairly ordinary situation. A person with a capacitance of, say, 200 pF walks across an insulating carpet or takes off a sweater (or does both). She hereby gets charged to a voltage of 2000 V and is loaded with an electrostatic energy of 0.4 mJ. She then starts to remove her nail polish using a solvent that is mainly acetone, $(C_2H_5)_2CO$. This solvent has a minimum ignition energy like that of diethyl ether, around 0.2 mJ in atmospheric air. If she next touches a grounded item and causes a spark in the vicinity of the open bottle of polish remover, will she cause an explosion?

Most likely not. If we look again at Figure 4, we notice that the curve corresponding to atmospheric air is very narrow. This means that as soon as you move just slightly outside the most easily ignited mixture (6% ether), the necessary energy is much higher. It is therefore possible only in a very small region to cause the acetone vapor to ignite by a 0.2-mJ spark.

On the other hand, somewhere between the surface of the acetone, where the mixture is too rich, to perhaps a couple of feet away, where the mixture is too lean, we'll find the most volatile mixture. If our polish-removing person is very unlucky, that's where she may draw a spark.

EXPLOSION-SAFE VOLTAGE

It is fairly safe to assume that an electric discharge disseminating an energy less than the minimum ignition energy W_{min} ~ 0.2 mJ in atmospheric air is not incendive, no matter what explosive vapors are present. For a capacitive system—that is, an insulated conductor—with the capacitance C, we may thus define an "explosion-safe voltage" V_{ex} as

$$V_{ex} = \sqrt{\frac{2\,W_{min}}{C}}$$

In the case of our friend with the polish remover, we find the theoretical safe voltage to be 1400 V.

The concept of a safe voltage level refers only to explosion risks. When dealing with electronics, the acceptable voltage levels are often considerably lower. And needless to say, the safe voltage concept can also not be applied to charged insulators. Why not? Simply because there is no such thing as the voltage of an insulator.

(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.

ON Your Mark

Alligator Signs and Your Warnings

BY GEOFFREY PECKHAM

In this column, we'll explore the importance of being aware of accidents occurring within your industry, in order to better meet your legal duty to warn.

We all know it: accidents happen. When it comes to effective warnings that better protect people and reduce risk, it's important to not just think "inside the box" of your own company, limiting warnings to the injuries specifically related to your products. You also need to look at the industry that you're part of as a whole. As a safety professional, when you take a wider and more comprehensive view of the hazards affecting your industry, you'll be better equipped to define the safety messages that need to be conveyed on your products.

First let's step back and examine why you need to pay attention to developing the best warnings you possibly can. In recent years, U.S. courts have developed theories of liability that place an emphasis on the duty to warn. In short, you don't want to be found negligent because you failed to warn of "reasonably foreseeable" risks. What this means is that if your product can reasonably be foreseen to be used or misused in a way that would cause harm, you need to take this potential hazard into account when you're creating your product's design, guarding and warnings. "Reasonableness" is a key word here. It is not necessary to design/guard/warn about every possible unsafe misuse of your product. From the standpoint of warning labels, doing this would, no doubt, dilute your more important safety messages, making them lost in a jumble of warning labels applied to your product.

Over the last two decades I have lectured at over sixty seminars centered on product safety and products liability. At nearly all of them there has been a legal or insurance industry expert who states that in the U.S., "inadequate warnings" and "failure to warn" are, by a wide margin, the leading allegations in product liability lawsuits. There are many reasons why this is the case, too many to discuss in this short column. But the fact is, on-product warnings are important and worth the product design engineer's time and continued attention. As this article is meant to emphasize, the creation of your warnings is not a once-and-done task. Today's legal theory of the duty to warn based on reasonably foreseeable risks makes it necessary that you stay aware of accidents occurring in the wider scope of your industry.

To illustrate this concept, I'd like to share a hazard that Clarion recently created a safety sign to warn about. Granted, it's not your average product hazard: alligators. Many public and private premises in the southeast U.S. – including parks, universities, and golf courses – have problems with alligators. In July 2012, news broke of a tragic accident in Florida involving a teen who had lost an arm in an alligator attack. The attack occurred during alligator mating season when, local officials said, such aggressive behavior is not uncommon. In light of what I've discussed above, it can now be argued that property owners of areas that commonly have alligators present now have a reasonably foreseeable risk that they have a duty to warn about. Like many of your old pre-ANSI Z535 product safety labels, the old alligator safety signs, if they did exist, are text-only word message signs not formatted to any standard, much less ANSI Z535. To improve on the current situation, Clarion developed a safety sign using the latest warnings technology – the ANSI and ISO best-practice standards – including a recently-registered ISO safety symbol for alligators. While the Clarion sign was developed for golf courses, it can be used across a number of types of premises to better inform people of the hazard of alligators – with the aim of helping to reduce the risk of accidents and liability exposure, should an accident occur.

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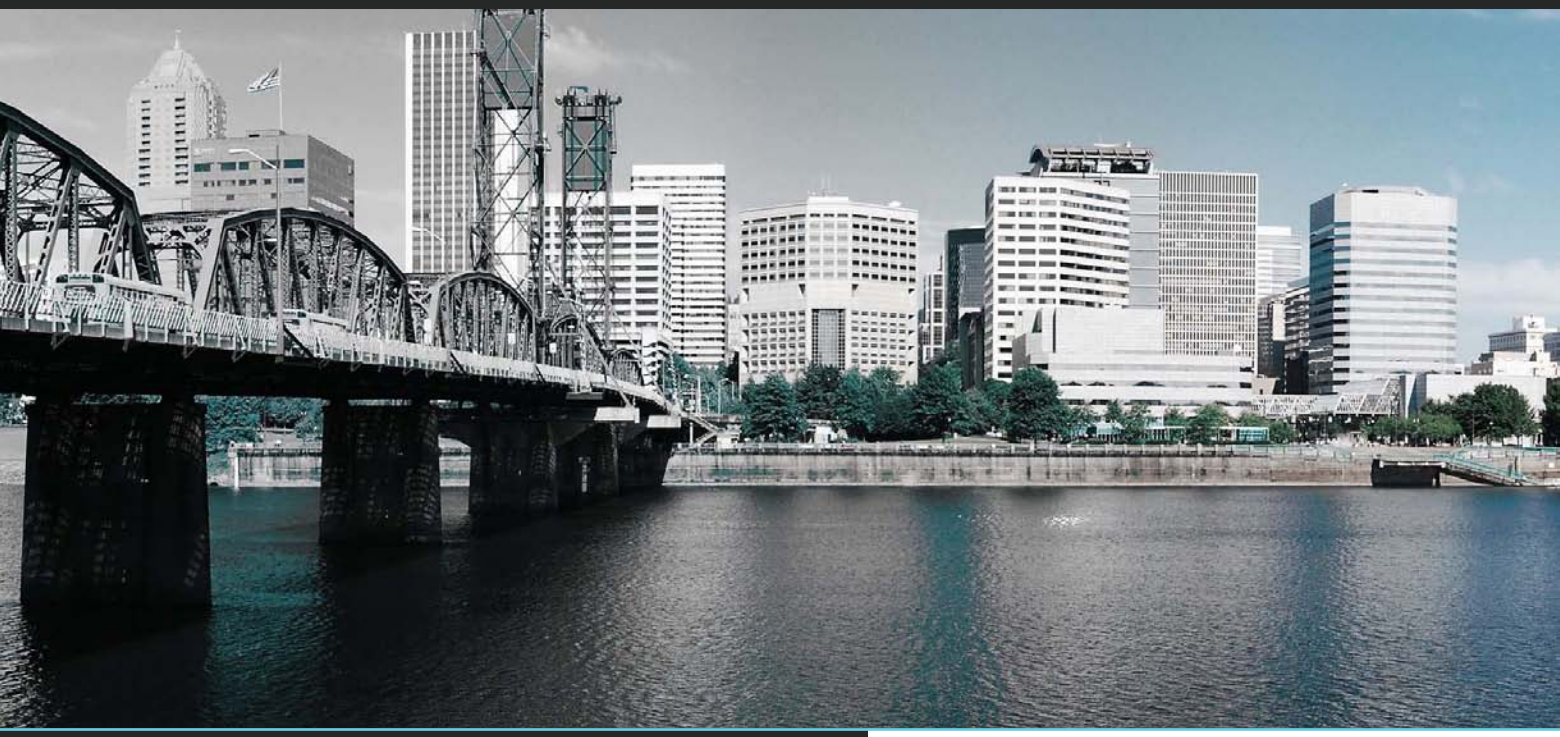

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ON Your Mark

Now, back to how this applies to your work as a product design engineer. When it comes to product liability, as we have seen, there is a duty to protect your product users from reasonably foreseeable risks associated with the use of your products. Courts will hold you responsible for being an expert in your industry and part of being an expert includes being aware of injuries that are occurring in your industry. Staying abreast of the latest industry news,

Many public and private premises in the southeast U.S. – including parks, universities, and golf courses – have problems with alligators. Clarion developed a safety sign using the latest warnings technology – the ANSI and ISO best-practice standards – including a recently-registered ISO safety symbol for alligators.

Alligators present safety sign informs golfers, spectators, and grounds visitors of the presence of alligators on a golf course. Safety messages – whether in the form of warning signs on premises or safety labels on products – should warn against reasonably foreseeable risks. Sign design ©2012 Clarion Safety Systems. Photo credit: www.silverimagephotoagency.com.

speaking with peers, and attending industry conferences are all methods that can help keep you informed. One at-your-fingertips method to keeping informed is to utilize Google alerts. This Google technology allows you to easily set up a system that sends you an automated alert via email for any new content that goes up on the web pertaining to a subject (e.g. news, blogs, video, discussions, articles, books). It's an unprecedented way to monitor hazards related to your industry. For example, you could create an ongoing Google alert to monitor the web for when the keywords "manufacturing," "packaging," or "equipment" are found together with "accident," "injury," or "safety." You will then receive notices via email related to URLs that have these combined words in their content. In effect, this technology does two things: 1) it enables you to be kept informed, and 2) it will most likely set a higher bar for what U.S. courts will consider to be "foreseeable." You could say this technology is both a blessing and a curse. The end result, though, is that it adds more weight to your responsibility as the product design engineer to stay informed so your products' warning labels are kept in line with an industry-wide perspective of what needs to be warned about.

While keeping current on the hazards related to your industry does take time, it's well worth the effort when the lives of people and the livelihood of your company are on the line.

(the author)

GEOFFREY PECKHAM is President of Clarion Safety Systems and chair of both the ANSI Z535 Committee and the U.S. Technical Advisory Group to ISO Technical Committee 145- Graphical Symbols. 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.

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Accreditation of EMC Laboratories in the US

BY WERNER SCHAEFER

Since 1990, the accreditation of EMC laboratories has become increasingly important in many parts of the world. This development has been mainly driven by the sharp increase in the number of electric and electronic products that have been introduced to the global marketplace.

Technological advances in the high tech areas of data communication, wireless communication, computer networking, and many others lead to a proliferation of products not only in the business and professional but also in the residential environment. This proliferation of electronic products and the trend to shorter product life cycles and more rapid consumer product turnovers lead to a drastic increase in the total number of electronic products that are in use today. The compliance of most of these products with national and international electromagnetic compatibility (EMC) requirements is to be determined and documented before they can be marketed. In many countries like the US or economies like the European Union, the manufacturers themselves can declare the conformity of their products with applicable standards. This approach is called Declaration of Conformity (DoC) and is applicable to certain product categories as determined by the regulatory authority of the different countries. This way of determining and documenting product compliance is more efficient than the verification or certification schemes that were in use in the past and required direct involvement of regulatory authorities to various degrees. A rapid product introduction is of the essence today, in light of decreasing product life cycles and the increasing number of product

Accreditation provides a formal recognition to competent EMC testing laboratories based on the verification of implementation of a quality system in the laboratory (in accordance with ISO/IEC 17025) and the determination of a minimum level of technical proficiency to perform the EMC tests for which the laboratory is accredited.

introductions. Many other product categories like those with transmit functions (above a certain level of transmit power) still require specific approval of the regulatory authority in many countries.

The measurements associated with the determination of product compliance with applicable EMC standards and the approvals of products by regulatory authorities can be very time consuming. Qualified test laboratories can help reduce the test and approval periods, especially when regulatory authorities accept test data and reports documented by the test laboratories without further evaluations. For example, in the US, an EMC test laboratory that is accredited by A2LA (American Association for Laboratory Accreditation), NVLAP (National Voluntary Laboratory Accreditation Program) or another recognized accreditation body to perform EMC tests in accordance with applicable FCC rules may prepare test reports which can serve as the basis of a DoC by the manufacturer for information technology equipment (ITE). The regulatory body for EMC in the US, the Federal Communications Commission, (FCC), will not have to be involved in the product approval process for ITE equipment in this case. In the international context, many mutual recognition agreements (MRAs) between the US and foreign economies are in place to allow swifter product introductions into foreign markets and thus stimulate trade. These product introductions involve, among other testing activities, EMC compliance testing by US test laboratories to foreign EMC requirements (like Korean or Taiwanese standards). Accreditation of US EMC test laboratories to these foreign standards serves as a basis for their recognition by the foreign regulatory authority as a conformance assessment body (CAB). There is an additional recognition process established that EMC laboratories in the US have to follow to obtain this recognition.

Due to the author's familiarity of the policies and procedures of the American Association for Laboratory Accreditation, this article will focus on the accreditation process of EMC laboratories in the US today, from the A2LA perspective. It is to be assumed that the application, assessment and overall accreditation procedures and requirements for EMC laboratories used by the two recognized accreditation bodies in the US are similar and deviate only in details of implementation. Additional topics of discussion in this paper are the main principles of the internationally accepted test and calibration laboratory standard ISO/IEC 17025:2005 and the advantages of laboratory accreditation for regulatory authorities, laboratory customers and the general public.

THE BENEFITS OF EMC LABORATORY ACCREDITATION [1]

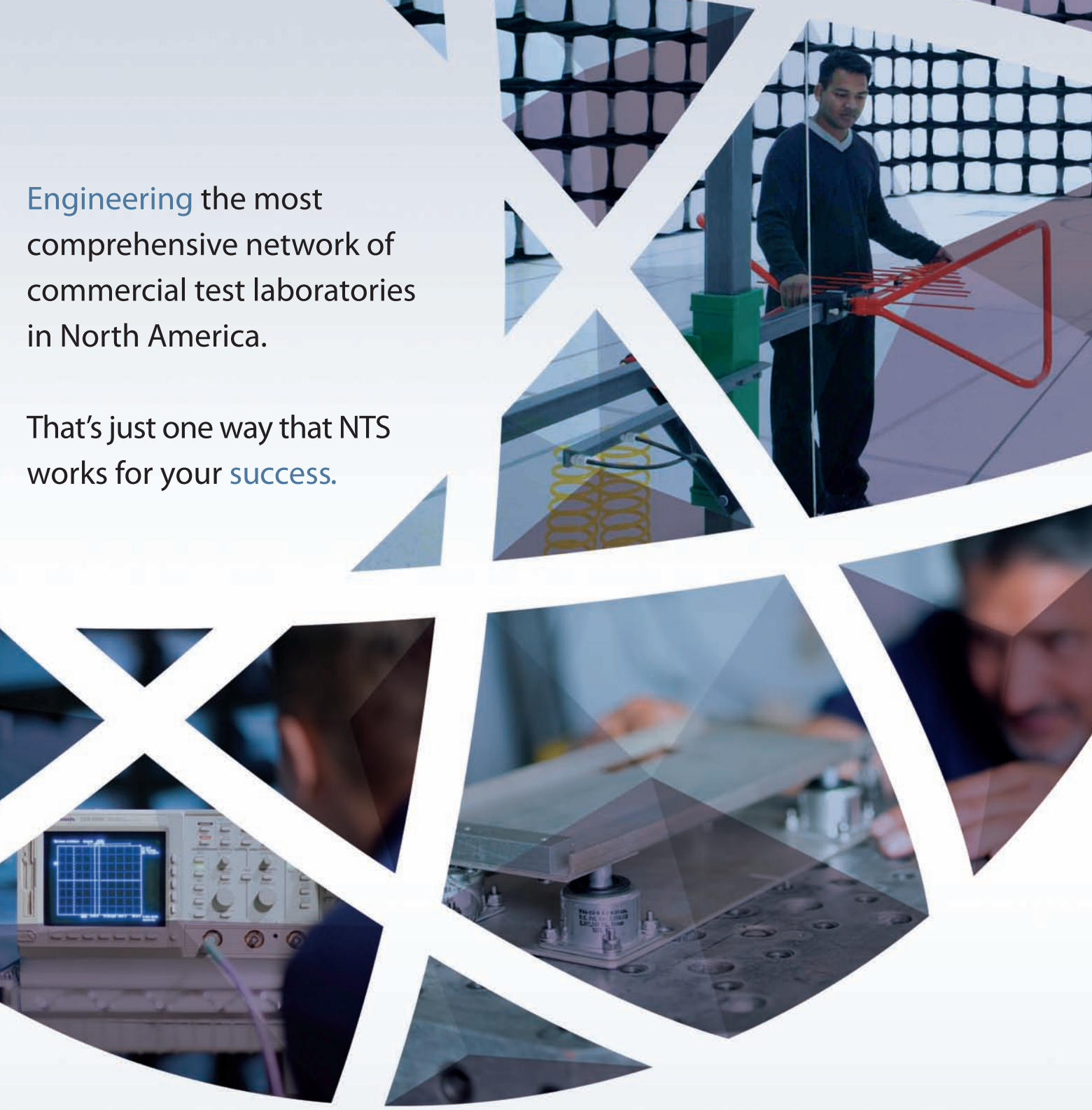
Accreditation provides a formal recognition to competent EMC testing laboratories based on the verification of implementation of a quality system in the laboratory (in accordance with ISO/IEC 17025) and the determination of a minimum level of technical proficiency to perform the EMC tests for which the laboratory is accredited. This formal and public recognition allows customers to identify and select independently verified testing services. For EMC laboratories to maintain this recognition, regular

evaluations by the accreditation body are performed to ensure the on-going compliance with requirements and to verify that the standard of operation is being maintained or improved. The accredited EMC laboratory is also required to participate in relevant proficiency testing programs between reassessments as a further demonstration of technical competence, or the laboratory must design their own testing activities that demonstrate the quality of their test data over time.

There are at least four distinct groups that benefit from accreditation in general: EMC laboratories themselves, users of laboratory testing services, regulatory authorities (private and public entities that require quality test data to operate), and the general public.

EMC test laboratories benefit from a technically sound assessment and accreditation by an internationally recognized accreditation body. Some of these benefits are:

- An independent and public statement of a recognized third party that designates the laboratory as qualified to provide services in the EMC field.



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Many countries around the world have one or more organizations responsible for the accreditation of their nation's laboratories. Most of these accreditation bodies have adopted ISO/IEC 17025 as the basis for accrediting their country's testing and calibration laboratories.

- A regular and objective surveillance that aids the management of an EMC laboratory in the continuous improvement its operation.
- In an increasing number of instances, an entry to a given market that would otherwise be closed to the laboratory.
- Increased laboratory productivity resulting from a decrease in the number of clients who insist on having their own staff members audit the laboratory. More of these clients now base their confidence on third-party accreditation.
- International recognition of the competence of an accredited EMC laboratory is obtained if the accreditation body is a signatory to the mutual recognition arrangement of the International Laboratory Accreditation Cooperation (ILAC).
- On-site assessments help the technical staff members of the accredited EMC laboratory verify that the latest requirements in applicable standards are properly implemented and applied.
- Improved performance by laboratory staff members. Undergoing regular assessments enhances staff discipline and its sense of professionalism. Employees are more likely to be committed to observing the quality management system and standards of performance of the laboratory.

Users of EMC laboratory testing services are a second group of beneficiaries of laboratory accreditation. Customers have greater confidence in the accuracy of the test report they are purchasing because it has been generated by a competent facility. This is particularly true for an educated client who is conscious of the scope of the laboratory's accreditation.

Manufacturers (for example, in the automotive industry) may also gain efficiency because of accreditation since these organizations do not have to perform their own on-site assessments but can defer to the assessments of competent accrediting authorities. Other manufacturers who have in-house EMC testing capabilities can reduce or even eliminate these overhead costs by using external accredited laboratories with the assurance of technical proficiency.

Regulatory authorities often require accreditation to national or international standards. With restricted budgets, many regulatory authorities can no longer perform EMC testing and product approvals themselves and must rely on third-party laboratories to support their regulatory efforts. These authorities need a comparable and meaningful basis for identifying qualified EMC test service providers, which can be achieved through the accreditation process.

Accreditation also has a positive impact on the general public by stimulating higher standards of quality within EMC testing laboratories. This leads to more consistently reliable test data, thereby contributing to more effective EMC regulations, more consistent product quality and the proper functioning of electronic devices within close proximity of each other.

LABORATORY ACCREDITATION FROM AN INTERNATIONAL PERSPECTIVE [2]

Many countries around the world have one or more organizations responsible for the accreditation of their nation's laboratories. Most of these accreditation bodies have adopted ISO/IEC 17025 as the basis for accrediting their country's testing and calibration laboratories. This has helped countries employ a uniform approach to determining laboratory competence. It has

also encouraged laboratories to adopt internationally accepted testing and measurement practices, where possible.

This uniform approach allows countries to establish agreements among themselves, based on mutual evaluation and acceptance of each other's accreditation systems. Such international agreements, specifically mutual recognition arrangements (MRAs), are crucial in enabling test and calibration data to be accepted between these countries. In effect, each partner in such an MRA recognizes the other partner's accredited laboratories as if they themselves had undertaken the accreditation of the other partner's laboratories.

Over 40 laboratory accreditation bodies have signed a multilateral recognition agreement called the ILAC Arrangement, which greatly enhances the acceptance of data across the national borders of the signatory countries. This developing system of international MRAs among accreditation bodies has enabled accredited laboratories to achieve a form of international recognition and allowed data accompanying exported goods to be more readily accepted by overseas markets. This effectively reduces costs for both the manufacturer and the importer, as it reduces or eliminates the need for products to be retested in another country.

MRAs rely on accreditation as a basis for establishing technical competence and building regulator confidence. The accreditation bodies are responsible for accrediting competent conformity assessment bodies (CABs) in accordance with international standards and to the importing party's technical requirements. In the United States, NIST (National Institute of Standards and Technology) currently lists A2LA, ACLASS and NVLAP as acceptable for use by MRAs for EMC and telecommunications test laboratories (ISO/IEC 17025). Both A2LA and ANSI are recognized through the National Voluntary Conformity Assessment Systems Evaluation (NVCASE) Program as accreditors of certification bodies (ISO/IEC Guide 65).

NIST serves as the U.S. Designating Authority. NIST receives and processes applications from U.S. testing laboratories and certification bodies seeking to be recognized under the

Since its origin in the mid-70's, ISO/IEC 17025 (formerly ISO/IEC Guide 25) emphasizes competence of laboratories to perform specified tests, not merely compliance with requirements. Several important principles are imbedded in the requirements of the standard.

MRAs by specific economies/regions as applicable. NIST is responsible for nominating qualified CABs to MRA partner economies/countries. The MRA partners then formally recognize the qualified testing laboratories and/or certification bodies.

From a laboratory perspective, accreditation by an accreditation body that is a signatory to the ILAC Arrangement offers various advantages, especially when a laboratory seeks recognition under a specific MRA through NIST. The benefits of MRAs include:

- Reduced time and costs. Requirements for duplicative testing are eliminated. Products can be tested in one country to another county's regulations, thus allowing products to reach the market faster than before. This is especially important in the telecom sector since the lifecycle of a product is typically short.
- EMC and telecom regulations, laws, policies, and procedures become more transparent.
- Frequent dialogue between regulatory authorities, designating authorities, and accreditation bodies exists in order to maintain consistency of programs.
- Laboratories, product certification bodies, and manufacturers are more knowledgeable and stay up-to-date on changes in technical regulations and policies.
- Industry committees have formed as a means of sharing information and communicating with regulatory authorities, designating authorities, and accreditation bodies.

Again, the basis for recognition as a CAB under a specific MRA is the proper accreditation by an accreditation body that is a signatory to the ILAC Arrangement.

ISO/IEC 17025 – THE STANDARD FOR LABORATORY COMPETENCE [1]

The general requirements for laboratory competence are described in the ISO/IEC 17025:2005 standard. This standard establishes a global baseline for accreditation of all types of laboratories. Since its origin in the mid-70's, ISO/IEC 17025 (formerly ISO/IEC Guide 25) emphasizes competence of laboratories to perform specified tests, not merely compliance with requirements.

Several important principles are imbedded in the requirements of the standard. These principles are summarized as follows:

Capacity

An EMC laboratory must have the resources (staff members with the required skills and knowledge, test environment with the required facilities, equipment and instrumentation, procedures to ensure consistency of test processes, and quality control for the key steps in the testing processes) in order to carry out the tests and produce reliable results.

Responsibility

An EMC laboratory must have staff members in the organization who have the authority to execute specific functions with the overall scope of test work. They also have to be able to demonstrate accountability for the published test results.

Scientific Approach

An EMC laboratory will carry out its work based on accepted scientific principles, preferably following published EMC standards. If deviations

from accepted methods are necessary to perform an evaluation of a specific device, the deviations must be substantiated and documented in a manner considered generally acceptable by experts in the field.

Objectivity

The test results produced should be based upon measurable quantities. If results are subjective (applicable to some immunity tests), they must be produced by testing personnel deemed qualified to make subjective judgments.

Impartiality

The pursuit of reliable results through the use of accepted scientific principles is the primary and overriding influence on the persons carrying out the testing. All other influences are secondary and not permitted to take precedence.

Measurement Tractability

The results produced are based on a recognized system of measurement that is derived from accepted known quantities (i.e., SI system) or other well-characterized references. The chain of measurement comparison between these accepted known quantities and the device providing the objective measurement result is unbroken for the transfer of measurement characteristics, including uncertainty, for the whole of the measurement chain.

Reproducibility

The EMC test methods used to achieve measurement results will produce results that are comparable to future testing results, which will be produced under similar circumstances. These circumstances are defined primarily by the applied EMC standard, the equipment used, and the knowledge and technical proficiency of test personnel.

Transparency

The test and quality processes within an EMC laboratory must be open to both external and internal scrutiny in order to easily identify factors which may adversely affect the laboratory's pursuit of objective results based on published standards.

ACCREDITATION VERSUS CERTIFICATION

Laboratory accreditation uses criteria and procedures specifically developed to determine technical competence. Qualified technical assessors conduct a thorough evaluation of all factors in a laboratory that affect the production of test or calibration data. Very often these criteria are based on ISO/IEC 17025, which is used for evaluating EMC test laboratories throughout the world. Laboratory accreditation bodies use this standard specifically to assess factors relevant to the laboratory's technical competence.

These factors include:

1. technical competency of staff members
2. validity and appropriateness of EMC test methods
3. traceability of measurements to national standards
4. adequacy, calibration and maintenance of test equipment (for example, in accordance with CISPR 16-1-1/2/3/4)
5. adequacy of test environment (for example, in accordance with CISPR 16-1-4)
6. handling and transportation of test samples
7. quality assurance of test data over time
8. reporting of EMC test results

The accreditation of EMC test laboratories around the world becomes more important with the globalization of trade and the proliferation of electronic and electric products in all aspects of life.

By applying this process, laboratory accreditation aims at assuring the accuracy and reliability of test data of an EMC test laboratory. The ISO 9001 quality system standard, is widely used in manufacturing and service organizations to evaluate their system for managing the quality of their product or service. The goal of certifying a quality management system of an organization against ISO 9001 is the confirmation of compliance of the management system to this standard. An EMC test laboratory may be certified to ISO 9001, but such a certification does not make any statement about the technical competence of a laboratory. Despite the fact that accreditation also covers certain elements that are evaluated during a certification process, no minimum level of technical proficiency is established, which is very often required by regulatory bodies (for example, within the framework of the product approval process).

SUMMARY

The accreditation of EMC test laboratories around the world becomes more important with the globalization of trade and the proliferation of electronic and electric products in all aspects of life. Regulatory authorities in many countries have changed product approval processes for various product categories and now allow manufacturers to determine and declare product compliance with applicable standards. Furthermore, qualified EMC test laboratories can now test products in accordance with foreign requirements/standards and prepare test reports that serve as the basis for product approval in foreign markets. In both cases, EMC test laboratories must demonstrate their technical proficiency to perform these tests and also establish a quality framework that allows testing under repeatable and consistent conditions.

The laboratory accreditation process (applied by recognized accreditation bodies), based on the generally accepted standard ISO/IEC 17025, allows test laboratories to obtain this independent determination and documentation of technical proficiency in the technical field of EMC.

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2. ILAC Brochure "The Advantages of being an Accredited Laboratory".

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He was actively involved in the development of the new standard ANSI C63.10 and the latest revision of ANSI C63.4, mainly focusing on test equipment specifications, use of spectrum analyzers and site validation procedures.

Werner Schaefer is also a RAB certified quality systems lead auditor, and an iNARTE certified EMC engineer. He published over 50 papers on EMC, RF/uwave and quality assurance topics, conducted numerous trainings and workshops on these topics and co-authored a book on RF/uwave measurements in Germany.

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ANSI-ASC-C63®
Status of the Committee's EMC Standards for 2012

BY DANIEL D. HOOLIHAN

The American National Standards Institute (ANSI)-Accredited Standards Committee (ASC) C63® (hereinafter C63) has been a United States Standards Development Organization for over 60 years. Its main focus is standards in the electromagnetic compatibility (EMC) engineering discipline. Recently, C63 has become more active in the telecommunications (transmitters and receivers) technical area to reflect the growing importance of wireless devices in today's society. This article describes some of the most recent activity in the domain of C63 standards.

C63.4

ANSI C63.4 (*American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz*) is the most well-known of the C63 standards. It has been adopted by the United States Federal Communications Commission (FCC) as the official test methods guideline document for Part 15 of the FCC Rules.

The 2009 edition of C63.4 is presently being revised. Areas of interest include:

1. addition of what should be on visual displays based on the size of the screen
2. information on test setups for tablet PCs
3. clarification on the proper use of the average detector
4. three tables of acceptable antennas; general measurements, NSA measurements, and compliance testing measurements
5. test site validation intervals for sites above 1 GHz
6. antenna factors for site validation
7. non-manipulation of bundled cables
8. additional clarifications on testing above 1 GHz
9. addition of measurement uncertainty
10. removal of the testing of transmitters and receivers
11. annex B improvement to show methods of verification of LISNs

The "tables of acceptable antennas" are being driven partly by the topic of hybrid antennas. The hybrid antenna consists of a combination of a biconical antenna with a log periodic dipole array antenna. They usually cover the frequency range from 30 MHz to 1000 MHz and they have been used in the EMC industry since around 1993 when they were first introduced in Europe. Many technical studies show

One overall goal of the standard working groups in C63 is to move the language and criteria closer to the international standards. The draft version of C63.4 is presently striving to do that.

that hybrid antennas are equivalent to the individual antennas that make up the "hybrid." Some studies show a difference under certain conditions especially a 3-meter horizontal antenna measurement distance. The draft version of C63.4 is addressing this issue.

One overall goal of the standard working groups in C63 is to move the language and criteria closer to the international standards. The draft version of C63.4 is presently striving to do that.

C63.5

The well-referenced C63.5 (*American National Standard for Calibration of Antennas Used for Radiated Emissions Measurements in Electromagnetic Interference (EMI) Control*) is being revised by the C63 Committee. The standard was last revised in 2006. The standard is being rewritten to reflect changes in technology over the last 6 years.

Topics being addressed include: scope expansion, smooth connection to other C63 standards, redefining "reference site", inclusion of additional reference dipole antennas, and define "antenna calibration site" and "near free-space geometry".

One of the key issues is whether antennas can be calibrated in a semi-anechoic chamber (SAC) for antennas valid in the frequency range 30 MHz to 1000 MHz. The present C63.5 standard specifies that only an open area test site (OATS) can be used for calibrating antennas. The OATS must meet a tighter normalized site attenuation (NSA) criteria than a compliance testing OATS; i.e., plus or minus 2 dB versus 4 dB. The question is whether a SAC that meets the +/- 2dB criteria can be used for antenna calibration.

The advantages of testing antennas in a semi-anechoic chamber (SAC) are obvious:

1. no weather conditions to adversely affect the testing
2. controlled temperature and humidity conditions
3. no ambient signals to interfere with the antenna calibration measurements

C63.10

ANSI C63.10-2009 (*American National Standard for Testing Unlicensed Wireless Devices*) is the standard that encompasses unlicensed receivers and transmitters. The second edition is being worked on to expand on the success of the first edition. The working group has been very active and has had a large number of participants. The wireless technology field is changing rapidly and the working group is reflecting some of those changes in the second edition.

Topics being addressed include: new FCC procedures for DTS devices, updated procedures for UNII devices, additional details on measurements above 1 GHz, and revisions to the annexes of the standard.

SUBCOMMITTEE ACTIVITIES

SC-1
Techniques and Development

SC-1 provides the technical expertise for incorporating new or existing measurement techniques and associated instrumentation related to EMC into C63 documents. This subcommittee is responsible for the three standards mentioned in the first part of this article. In addition, it is responsible for three new standards: C63.23 (Measurement Uncertainty), C63.25 (Test Site Validation – Time Domain), and C63.26 (Licensed Transmitter Test Methods). The working group chairs for those three standards are, respectively, Bob DeLisi, Dennis Camell, and Art Wall. Additional standards under the care of SC-1 include: C63.2 (EM Noise and Field Strength Instrumentation) and C63.22 (Guide for Automated EMI Measurements). Subcommittee 1 is presently chaired by Dennis Camell, NIST-Boulder.

SC-2
E3 Terms and Definitions

This subcommittee is chaired by Marcus Shellman. The responsibility of SC-2 resides in its efforts to develop and document new and emerging definitions and terminology for use by the C63 Committee. The Subcommittee has recently refined its process for accepting definitions into C63.14 (Definitions). Working Group 1 of SC-2 also was assigned an action item to review military standards issued in the last five years for appropriate EMC definitions.

SC-3
International Standardization

This subcommittee actively discusses international standards and organizations for their potential impact on C63 standards.

Its Scope is as follows: *Subcommittee 3 provides a forum for comparing*

A standard under development in Subcommittee-5 is C63.20 (Nuclear Power Plant Immunity). Additional participants interested in this new standard should contact Chair Steve Whitesell.

international standards activities to C63 membership standards activities and makes recommendations to the C63 Main Committee on possible US positions on international EMC matters, to facilitate harmonization of national and international standards, considering US regulatory as well as commercial requirements. Subcommittee 3 may make recommendations to the C63 Main Committee about introducing the work of C63 to the US National Committee Technical Advisory Groups for submission to international standards.

Paul Andersen is the current chair of Subcommittee-3.

SC-5
Immunity Testing

This subcommittee has approximately 20 members and the SC is chaired by Steve Whitesell.

It has responsibility for C63.15 (Immunity Measurement and Instrumentation) and C63.16 (ESD Testing Methodology Guide).

A new standard under development in this Subcommittee is C63.20 (Nuclear Power Plant Immunity). Additional participants interested in this new standard should contact Chair Steve Whitesell (s.whitesell@ieee.org) for additional information.

A fourth standard under development in this subcommittee is C63.24 (Generic In-Situ Immunity Evaluation). The chair of the working group looking at this standard, Steve Berger, has indicated that an additional teleconference must be held with

The C63 Committee is always looking for additional volunteer to help document and develop standards in the EMC arena.

the working group before the first draft document will be ready for subcommittee ballot.

SC-6 Laboratory Accreditation/ Conformity Assessment

This subcommittee is working on C63.11 (Inter-lab Comparison EMC Testing) and C63.8 (Guidance on Specifying Requirements for the Calibration and Verification of EMC Test Equipment). The subcommittee has about 20 members and is chaired by Victor Kuczynski.

Representatives from four laboratory accreditation bodies sit on the subcommittee; U.S. Department of Commerce-NIST/NVLAP, A2LA, A-CLASS, and Laboratory Accreditation Bureau (LAB).

SC-7 Unlicensed Personal Communications Services Devices

The subcommittee is in the process of revising C63.17 (Unlicensed Personal Communications Service [UPCS] Devices). It is being revised in response to recent United States Federal Communications Commission (FCC) changes in the UPCS band service rules.

A new standard is being developed by SC-7; its number is C63.27 and its title is "American National Standard on Evaluation of Wireless Coexistence". It is being developed in response to a recommendation in a general report on the topic. The standard will develop evaluation methods and test procedures for assessing the ability of a wireless device to coexist in its electromagnetic operating environment.

A committee study project is also being started to investigate radio receiver design for improved coexistence. Both the study project and C63.27 are considered to be in the area of "spectrum management". The industry desperately needs test methods that have a high correlation to field experiences with real radio situations. Individuals interested in this project can contact the chair of the subcommittee, Stephen Berger, Stephen.berger@ieee.org.

SC-8 Medical Equipment EMC Testing

This subcommittee is responsible for developing and maintaining C63 standards for medical devices. The subcommittee is chaired by Bob DeLisi of UL and it is responsible for C63.18 (On-Site Medical Immunity Testing) and C63.19 (EMC and Hearing Aids).

The latest revision to C63.18 is undergoing the IEEE editing process and, as a result of that, there were some changes made to the use of trademarked terms. In general, trademarked names must be identified

There is no financial charge to join a working group but the individual is expected to attend meetings and participate in the work effort.

in the footnotes and generic names can be used in the text.

C63.19-2011 was recently adopted in an FCC Report and Order (WT Docket No. 07-250) with a 12-month transition period. Additional interpretations have been requested by users of the standard. These interpretations are being addressed by C63 and will be explained in detail in a workshop planned for the fourth quarter of 2012.

A study project was initiated in this SC to look at developments at the international standards level with hearing aid immunity test methods and techniques. The study project will document their findings in a report to the main committee of C63.

JOINING A C63 WORKING GROUP

The C63 Committee is always looking for additional volunteer to help document and develop standards in the EMC arena. There is no financial charge to join a working group but the individual is expected to attend meetings and participate in the work effort.

(the author)

DANIEL D. HOOLIHAN

is the Founder and Principal of Hoolihan EMC Consulting. He is a Past-President of the EMC Society of the IEEE and is presently serving on the Board of Directors. He is presently an assessor for the NIST NVLAP EMC and Telecom Lab Accreditation program. He is Chair of the EMC Main Committee. For further information on membership, contact Dan at danhoolihanemc@aol.com or 651-213-0966.

If an individual wants to join a subcommittee, there is $550 annual fee and the individual is expected to participate in the meetings and development activities of the subcommittee.

Utilization of Skin Effect for Intra-plane Z-axis Partitioning in Circuit Boards

BY W. MICHAEL KING

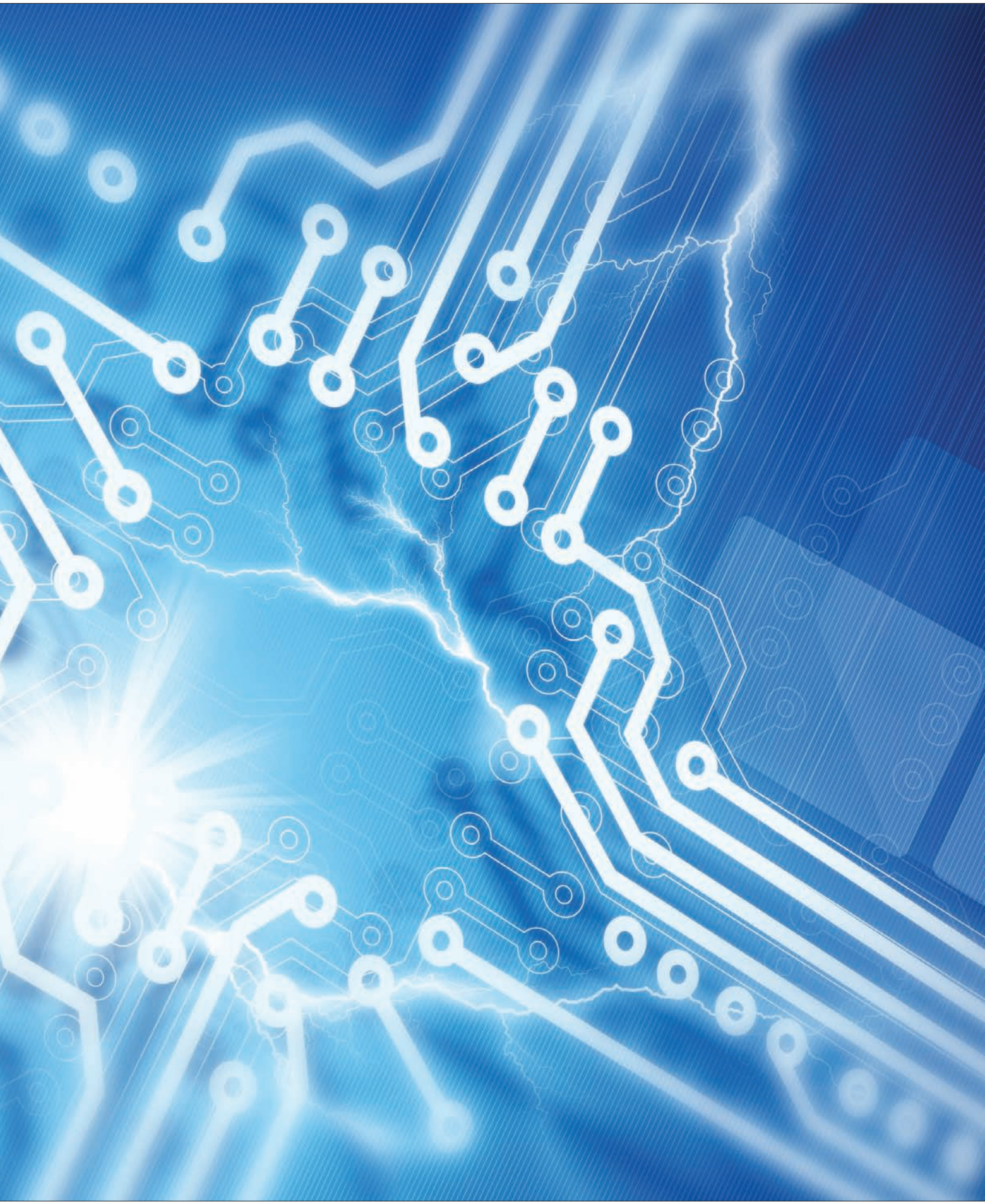
Skin effect is a term that describes the tendency of the current density of high radio frequency currents to become "crowded" toward the surface skins (surface boundaries) of a conducting material. The extent to which the current density is formed toward the surface relates to the depth of the primary radio frequency current below the surface, hence the term skin depth.

For direct current (DC) and lower frequency alternating current (AC) applications (e.g. below one megahertz, where the skin depths are typically larger dimensional values), the cross section of most conductors will be fully involved in the current transfer. This full involvement causes a uniform density of current distribution throughout the conductor cross-section.

Increasingly at higher frequencies, the presence (and location) of magnetic flux impacts the distribution of current density through the cross-section of the conductor (Figure 2, page 46).

For practical descriptions, the combination of the material characteristics, frequency (which in combination determines the skin depth), and distribution of flux pattern will determine the redistribution of current density throughout the cross-section. The flux pattern distribution circumscribing the conductor is the motivating influence to direct the alterations as applied to current density.

Since the motivating factor for current density is the shape and formative presence of flux at high frequency, the direction of the current density distribution in the cross-section of a conductor will be altered by the location of the flux. In Figure 4 (page 47), the flux density is formed intensely in the boundary between



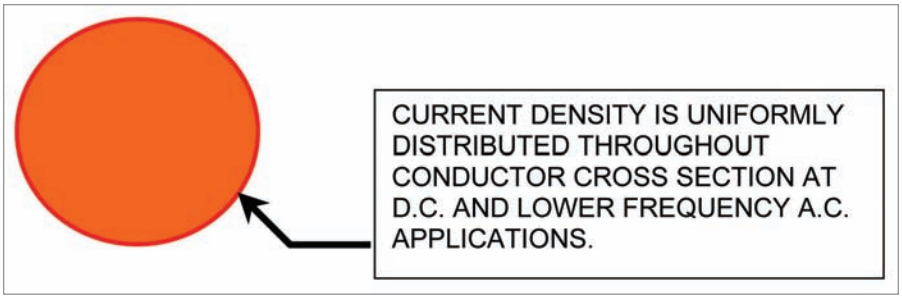


Figure 1

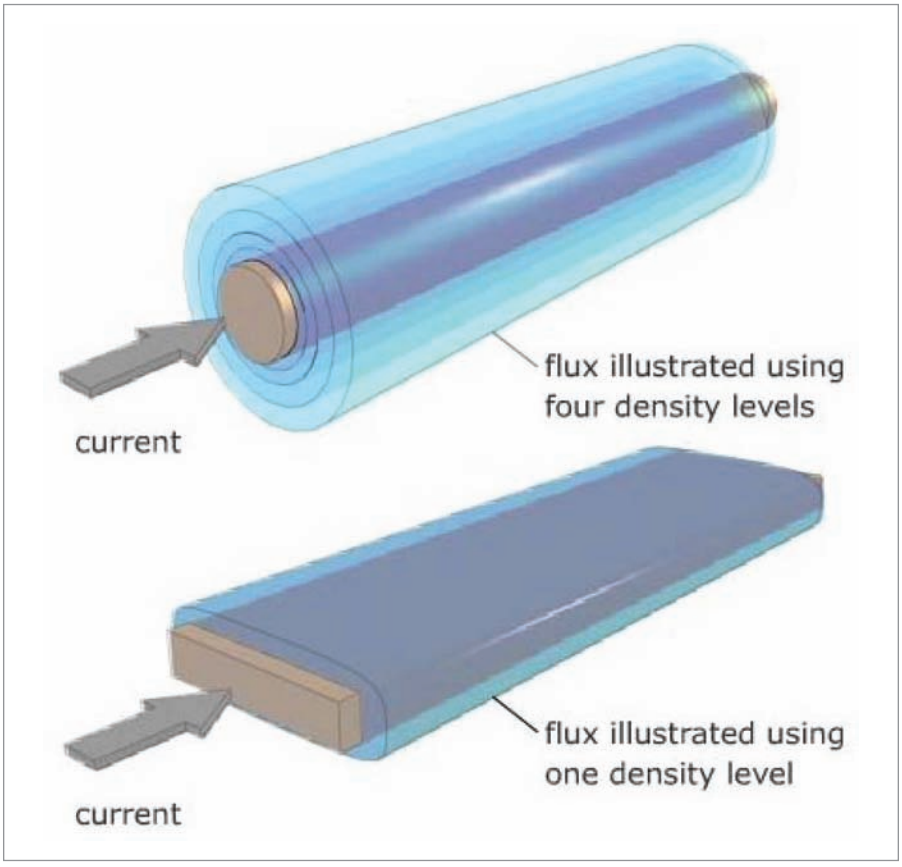


Figure 2

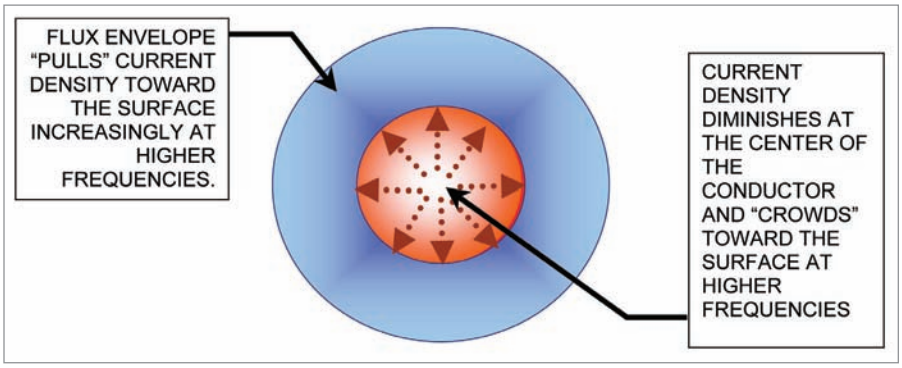


Figure 3

two conductors that carry the current (and form the flux) in an opposing phase relationship. Due to the interrelationship of flux to the distribution of current density at high frequencies, this suggests that the current densities in the two conductors will be "crowded" into the two mutually opposing specific surfaces that correspond to the distribution of the flux density.

Examination of the effect and influence illustrated above suggests that in multilayer circuit boards, the arrangement of the plane layers that propagate high frequency currents in opposing directions may be effective in establishing partitioning of common-mode coupling effects within the Z-Axis. This projection assumes that there exists a sufficient number of skin depths that are actively available within each plane layer in the frequency spectra of interest.

> Increasingly at higher frequencies, the presence (and location) of magnetic flux impacts the distribution of current density through the cross-section of the conductor.

To emphasize the formation of skin effect, the higher the frequency, the smaller the skin depth – and the more conductive and/or the more permeable the material (at higher frequency), the smaller the skin depth. Given this observation, in terms of skin effect, the smallest skin depths occur with most conductive materials at higher permeability (assuming that the permeability is evident as a characteristic of the material at high frequency) and at the highest frequencies.

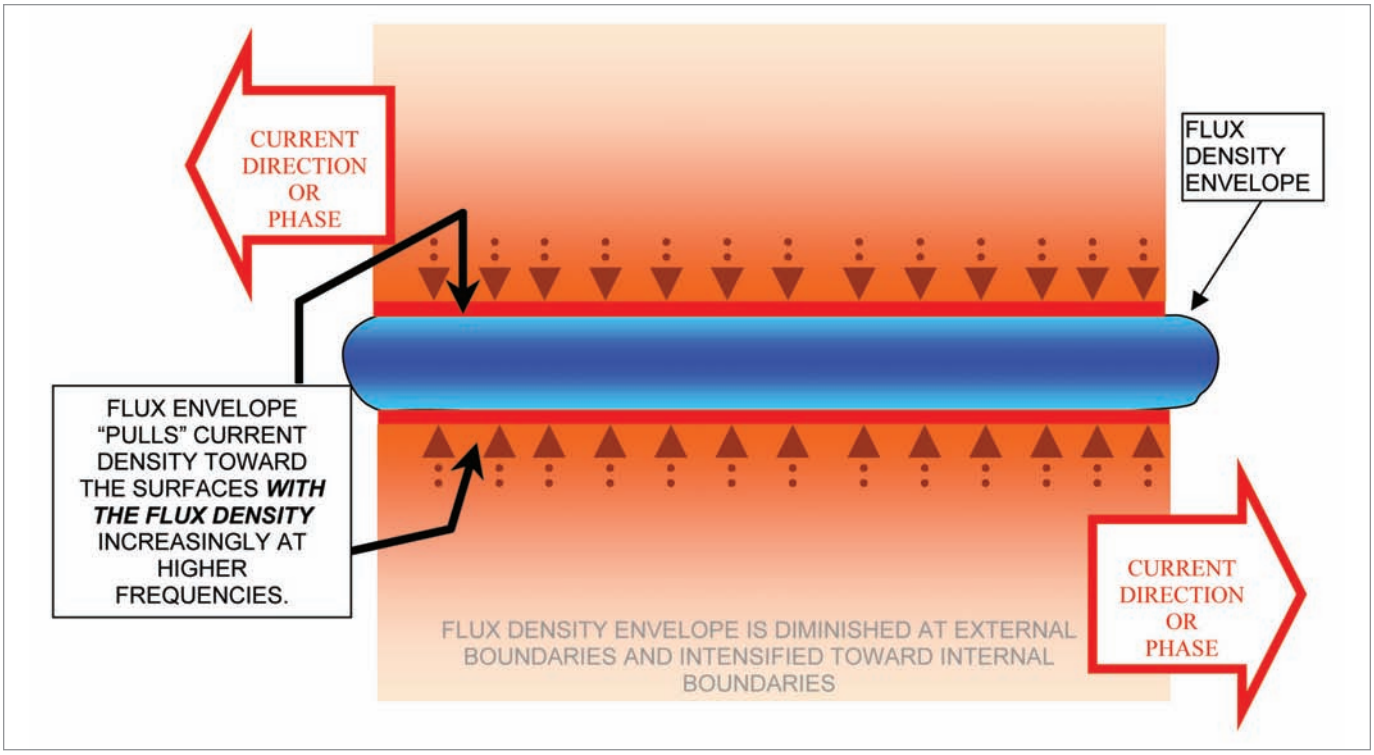


Figure 4

The parameters within a conductor that function to influence skin depth includes the values of relative conductivity and relative magnetic permeability. These are also the parameters that are significant to consider in terms of shielding performance.

To illustrate the extent of skin effect, Figure 6 (page 50) describes the percentage of current capture toward the surface, which is expressed as a percentage of current density as related to skin depths. The conclusion yielded is that 5 skin depths are required to capture approximately 99 percent of the current density.

The significance of skin effect as a characteristic benefit at higher frequencies toward intra-plane partitions (within the Z-axis of a circuit board) may be recognized by reviewing the skin depth of annealed copper in the tabulation shown in Figure 8 (page 50).

With the understanding that a copper weight in the plane of a circuit board of one ounce represents a thickness of approximately 1.4 mils, it is observed that at higher spectral frequency distributions, planes within circuit boards may be utilized for signals, signal categories, and power partitioning within circuit boards.

The parameters within a conductor that function to influence skin depth includes the values of relative conductivity and relative magnetic permeability. These are also the parameters that are significant to consider in terms of shielding performance. In practical terms, most approaches toward shielding relate the conductivity of the material as a value relative to copper. The value of magnetic permeability is relative to the permeability of free space.

For reference, the conductivity of annealed copper is given as the symbol σ, where

$\sigma = 5.82 \times 10^7$ mhos/meters for copper

with the relative values for other metals assigned the symbol σ_r.

σ_r is a numerical value that results by applying the factor indicated by that designated for σ_r to the value of the reference, σ.

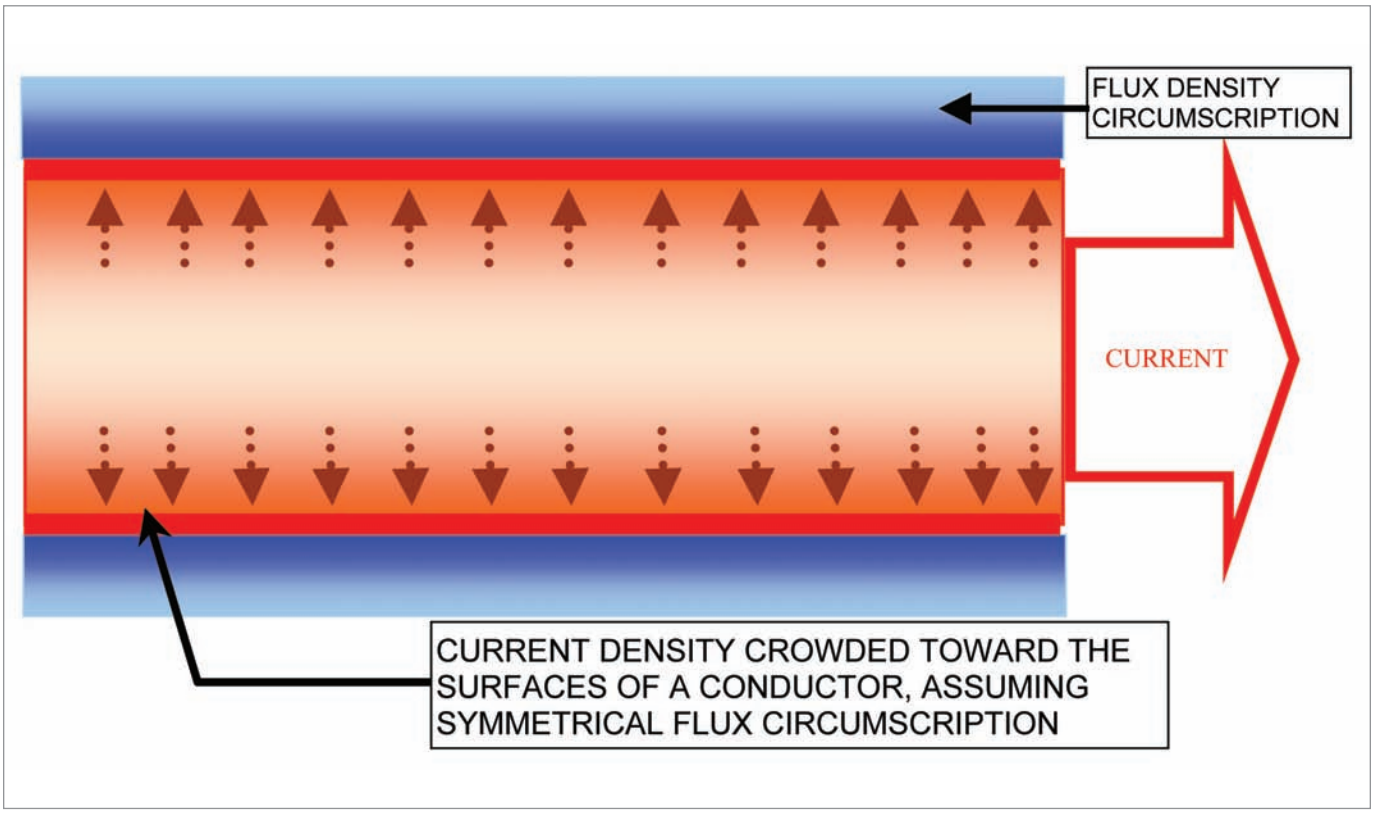


Figure 5

In practical terms, most approaches toward shielding relate the conductivity of the material as a value relative to copper. The value of magnetic permeability is relative to the permeability of free space.

The permeability of free space is given the symbol μ where

$\mu = 4\pi \times 10^{-7}$ Henrys/meter for free space

with the relative values of other materials assigned the symbol μ_r. μ_r is a numerical value that results by applying the factor indicated by that designated for μ_r to the value of the reference, μ.

Copper and many other reasonably conductive materials, such as aluminum, beryllium, brass, bronze, gold, platinum, silver, tin, or zinc, vary in conductivity relative to each other. However, these listed materials are understood to mutually possess a magnetic permeability that is equal to the permeability exhibited in space [$\mu_r = \mu$]. Consequently, for these materials, the skin depth will vary as a function only of conductivity with the materials of higher conductivity, yielding the smaller skin depths. For materials that exhibit permeability values that are greater than free space, the skin depths will also be influenced. Since a characteristic of permeability includes increased efficiency in propagating flux density and since flux density is involved in gathering current density toward the surface of conductors, materials with greater permeability and reasonable conductivity will exhibit smaller dimensions of skin depths compared to those where $\mu_r = \mu$. This observation, however, is not uniformly correct! At higher frequencies, above for example 5 GHz, many ferrous metals exhibit a relative permeability of only 1 even though at lower frequency the value may be 1000! Under this example, the prevalent parameter controlling skin depth would be that of conductivity. If the relative conductivity characteristic of the material displays greater resistance than that of the reference value of annealed copper, then at microwave bandwidth the skin depth of the ferrous metal could be greater. These delineations are specific to each alloy configuration.

For example, typical steels (assuming $\mu_r = \mu \times 1000$) that may be utilized for system-product packaging can exhibit skin depths that are a dimensional factor of 5 to 10 less than those of annealed copper, but only at lower frequencies. Because, however, the conductivity of various compositions of "steels" can vary with carbon content and general molecular densities, the skin depths from one category of steel to another would not be anticipated to be equal among the alloys. Stainless steels, in particular those of Austenitic types, can be alloyed to the level of being essentially non-magnetic, despite the name steel. Austenitic stainless steels typically have high contents of chromium and nickel within the alloy. These components both exhibit

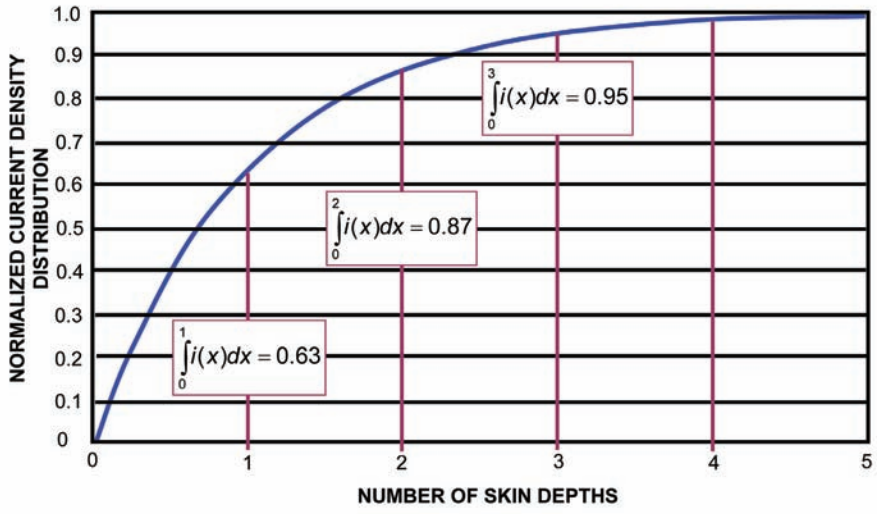
a value of $\mu_r = \mu$ and can comprise approximately 30% of the steel alloy, suggesting that the total value of relative permeability may be half the value of cold-rolled steels. Since the base of stainless steels is often formed with low carbon content steel, the conductivity is also compromised. Generally the reported relative conductivity value for stainless steels is noted to be (σ_r) of only $0.02 \times \sigma$! [1] Consequently, the values suggest that due to the combination of low relative permeability and low relative conductivity, stainless steel alloys yield comparatively inefficient (e.g. deep) skin depths as shields. The low values of conductivity provided by stainless steel alloys also imply that the shielding performance for reflection losses are comparatively limited as well.

Skin Depths	Percent Capture*
1	63
2	87
3	95
4	97
5	99

(*) Approximate, rounded-off values.

APPROXIMATION OF CURRENT DENSITY CAPTURED TOWARD THE SURFACES OF A CONDUCTOR AT VARIOUS SKIN DEPTHS.

Figure 6



EXPONENTIAL EFFECT DISPLAYED IN GRAPH:

$i(x) = I_0 e^{-x/1}$

$I_0 = 1$

Skin Depth = 1

APPROXIMATION OF CURRENT DENSITY CAPTURED TOWARD THE SURFACES OF A CONDUCTOR AT VARIOUS SKIN DEPTHS.

Figure 7

Frequency MHz	Skin Depth Mils (inch)	5 Depths Mils (inch)
1	3	15
10	0.8	4
100	0.26	1.3
1000	0.08	0.4

EXAMPLES OF SKIN DEPTHS FOR ANNEALED COPPER AT SPECIFIC FREQUENCIES.

Figure 8

The value of skin depth is yielded by

$$\delta = \sqrt{\frac{2}{\mu_r \sigma_r \omega}}$$

(in meters since the values of r and r are expressed with relationship to meters)

where, $\omega = 2\pi f$ where f is in Hertz. [2]

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(the author)

W. MICHAEL KING is a systems design advisor who has been active in the development of over 1,000 system-product designs in a 50 year career. He serves an international client base as an independent design advisor. Many terms used for PC Board Layout, such as the "3-W Rule", the "V-plane Undercut Rule", and "ground stitching nulls", were all originated by himself. His full biography may be seen through his web site: www.SystemsEMC.com.

Significantly, he is the author of EMCT: High Speed Design Tutorial (ISBN 0-7381-3340-X) which is the source of some of the graphics used in this presentation. EMCT is available through Elliott Laboratories/ NTS, co-branded with the IEEE Standards Information Network.

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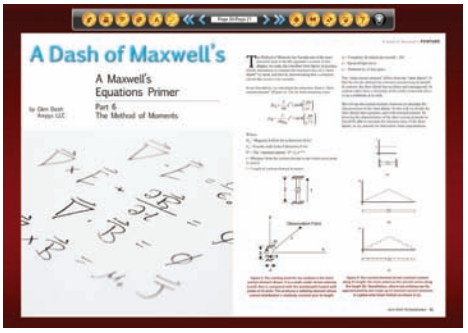

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International Wireless Registrations

Overview for medical manufacturers

BY MICHAEL CASSIDY

As medical devices go wireless, medical manufacturers face a new set of regulatory requirements and restraints. In addition to medical registration, wireless medical devices must receive radio spectrum approval. While the devices vary greatly, the wireless aspects are relatively uniform. That is to say, there are seemingly unlimited healthcare applications but only finite methods of sending data and, of course, limited RF spectrum. Thus, the wireless aspects of even a cutting edge medical device generally fall into familiar categories for international communications and radio spectrum authorities.

In my experience, international wireless compliance is often new territory for medical device manufacturers. Most countries, however, have had regulatory regimes in place for years and have well-established wireless regulations. Certain rules or restrictions may change, but the international process as a whole maintains fundamental characteristics and common pitfalls. Here are a few things to keep in mind before going global with a wireless medical (or any wireless) device.

CHECK OPERATING FREQUENCY AND APPLICATION EARLY AND OFTEN

A manufacturer should never assume commonalties between radio spectrum allocations across countries. Yes, commonalities exist, such as for certain ISM bands. However, one should always verify this and should also note the allowable output power. Many regulatory agencies publish frequency allocations on their website. Further, in some countries, certain RF technologies, such as ultra-wide band, may not be allowed at all.

MINIMIZE WORK AND COSTS

Medical manufacturers often purchase wireless components, from WLAN modules to GPRS modems, from an external vendor. So a radio module may already be approved in a given

Medical manufacturers should speak with their vendors early and present them with a list of documents they will need. Presenting the vendor with this type of list at the last minute may cause delays, and it is best to know if the vendor is unwilling or unable to provide any necessary materials as early as possible.

country. This 'modular' approval might be sufficient for the entire medical device, or it could reduce the cost, in-country testing, or paperwork needed for the regulating communications agency. Many countries require a local representative or license holder for a wireless certification. Manufacturers who have gone through medical registration and distribution with local partners should try to use their existing in-country network to fulfill any local representative requirements.

DON'T FORGET THE EXTRAS

In addition to the RF modules used in the device, medical products or systems may have supplemental components. Items such as power supplies, access points, or notebooks will likely need in-country certification. Medical manufacturers should speak with their vendors early and present them with a list of documents they will need. If, for example, a medical device works with a wireless access point, the AP vendor may need to provide block diagrams, authorizations forms, and even schematics. Presenting the vendor with this type of list at the last minute may cause delays, and it is best to know if the vendor is unwilling or unable to provide any necessary materials as early as possible.

KNOW THE TIMELINE

Those who have dealt with medical registrations may already intuit the often bureaucratic process of product registrations. While it is important to have the good connections on the ground and an understanding of a country's process, the lead-time for applicants is often fixed. Some countries, for example, require local testing at an approved lab before the application goes into review with the communications authority. Given this restraint, the applicant faces a minimum lead-time of several weeks. This is due to the time it takes to review documents, test the product, write the test report, and have the regulator review everything. Failing tests or having samples stuck in customs will, of course, cause unnecessary delays to the project. Knowing the common pitfalls and causes for delays in a given country will reduces the risk of falling behind schedule.

While the applicant should not be overly optimistic on the lead-time for approval, he should also be wary of lead-times that are too long. If the manufacturer is using a third party agent, that agent may want to 'under-promise and over-deliver'. The agent may state the lead-time for RF registration is twelve weeks, knowing that it usually takes only nine weeks. A medical manufacturer, new to international wireless approvals, may then think the agent has come in ahead of schedule. In fact, such sandbagging doesn't help the applicant plan his or her schedule. Therefore, one should err on the side of caution, as lead-times can vary depending on the regulators queue and other factors such as political unrest, natural disasters, etc. But, of course, the principal goal is having a realistic timeline for completion, as the whole team needs to know when they can enter a market. And medical manufacturers have the dual burden of dealing with two time lines for approval.

CONCLUSIONS

International wireless approvals add a new and independent dimension to the compliance picture for medical manufacturers. In the United States, for example, the FDA and FCC have issued a joint press release and the FDA has published recommendations relating to compliance. This suggests some overlap between the organizations on this issue. As *In Compliance Magazine* reported, the FCC has recently authorized the use of medical body area networks (MBANs) in the 23600-2400 MHz range. Medical manufacturers, however, will find that the communications authority ultimately dictates the parameters for use of a country's

RF spectrum. Indeed, the FDA has officially 'suggested' that medical devices using RF adhere to all FCC regulations. In a 2007 publication, the FDA recommended RF medical devices undergo safety, EMC, and wireless testing. This is for the purpose of better anticipating how the device will function in a medical environment and ensuring crucial data transmissions do not fail. While these are valid points, the FDA recommendations are requirements for the FCC. Internationally, one generally sees communications agencies function autonomously. Exemptions to a RF-related regulation on the grounds that a device is medical are rare. Thus the manufacturer enters another jurisdiction.

Employees of medical manufacturers who have dealt with the FDA and its international counterparts may not end up handling the international wireless approval projects for the same devices. This task could go to an EMC, safety, or RF engineer. As mentioned, existing in-country networks, formed from distributors or medical compliance partners, can benefit the wireless process. Yet, since the regulatory agencies function separately, the employee managing international wireless submittals may not need an understanding of the medical registration process as it exists in each country (assuming someone has that covered). As the use of wireless medical technology accelerates, we may see the regulatory landscape evolve throughout the world. For now, medical manufacturers will join the IT, telecommunications, and many other industries in facing the world of international wireless compliance.

This article has not been reviewed by the ICM Editorial Advisory Board.

(the author)

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is the founder of MC Global Access. His company provides product certifications throughout the world and advises clients on regulatory requirements. Michael was a project manager at Intertek's Global Market Access Program before TUV Rheinland recruited him. At TUV Rheinland, Michael worked in the International Approvals group as an international specialist and was promoted to operations manager. He has obtained hundreds of product certifications in countries across the globe for a variety of manufacturers. Michael lives in the San Diego area with his wife Sara. When he is not working on international product certifications, he enjoys surfing and traveling. Michael can be reached at mcassidy@mcglobalaccess.com. The company website is www.mcglobalaccess.com

TECHNICAL Tidbits

Effect of High Voltage Pulses on Resistors - ESD and EFT

BY DOUGLAS C. SMITH

Carbon composition resistors work very well under pulsed conditions, but are getting difficult to obtain. Results of tests run on several modern film resistors using high voltage pulses are presented. For the cases tested, the resistors performed well with no damage.

Figure 1 shows the test setup. High voltage pulses with a duration of about 100 ns were applied from a Mini-Zap ESD simulator in contact discharge mode and a Fischer Custom Communications TG-EFT high voltage pulse generator. The TG-EFT waveform simulates electrical fast transients, EFT, found on power lines. The wave shape is similar to ESD but without the leading peak.

Carbon composition resistors are the resistors of choice for pulsed applications but are becoming difficult to find, especially in electronic stores. I need a supply of resistors that will not be damaged by ESD or EFT waveforms so I decided to test several resistors from a local electronic store.

Several metal and carbon film resistors ranging in value from 51 Ohms (one Watt) to 4700 Ohms (1/2 Watt) were tested. Figure 2 shows a 51 Ohm 1 Watt Carbon Film resistor connected to the Mini-Zap for testing. Also tested were a 51 Ohm 1 Watt metal film resistor, 470 Ohm 1/2 Watt "film" resistor, a 1000 Ohm 1/2 Watt "film" resistor, and 4700 Ohm 1/2 Watt "film" resistor. The TG-EFT generator was used up to 2000 Volts followed by the Mini-Zap at 10,000 Volts.

Figure 3 shows three of the resistors tested including a 51 Ohm 1 Watt Metal Film Resistor, a 4700 Ohm 1/2 Watt "Film" Resistor, and a 51 Ohm 1 Watt Carbon Film Resistor. The 51 Ohm resistors carry more peak current from the Mini-Zap or TG-EFT, but the 4700 Ohm resistor sees more voltage stress. It was not clear before the testing started which ones would be more susceptible to damage. In the past, I have been able to destroy 1 megohm resistors used in ESD control by using an ESD simulator set to voltages on the order of 10 kV.

Figure 1: Test Setup Including Mini-Zap ESD Simulator and TG-EFT High Voltage Pulse Generator

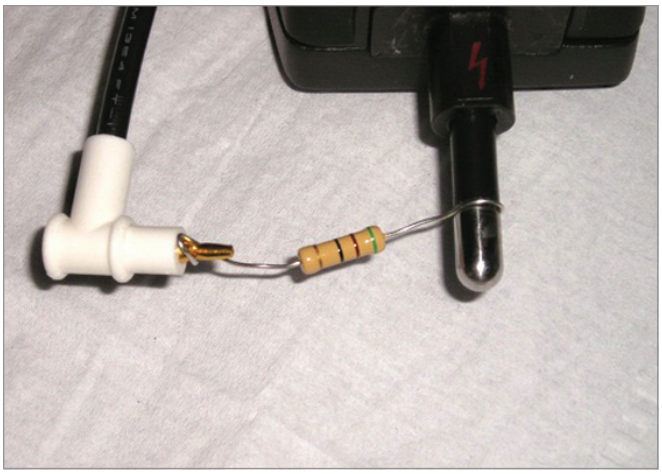

Figure 2: 51 Ohm Film Resistor Stressed by ESD Simulator

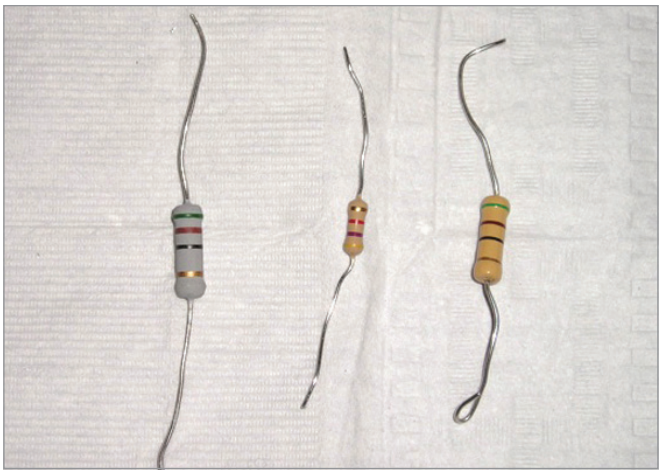

Figure 3: Test Resistors (from left to right: 1W-51 Ohm Metal Film Resistor, 1/2W-4700 Ohm "Film" Resistor, and 1W-51 Ohm Carbon Film Resistor)

Surprisingly enough, all the resistors survived many tens of pulses with no change in resistance as measured on an accurate digital multimeter capable of detecting a change of 1 Ohm out of 1000 Ohms. This is likely due to the fact that these were all 5% resistors and as such were not likely laser trimmed. Laser trimmed 1% resistors often do not survive high peak value pulses because the current concentrates around the end of the laser cut and the resistance exhibits a cumulative change over many pulses often ending in an open circuit or occasionally even a short circuit. The result would also have likely been different if simulated 6 kV lightning pulses were used as these pulses are measured in tens and hundreds of microseconds. Longer length pulses, such as lightning pulses, are much more likely to damage resistors.

SUMMARY

All of the resistors tested survived many tens of pulses at 10,000 Volts from a Mini-Zap ESD Simulator. This suggests that modern film resistors in values up to 4700 Ohms and power levels as low as 1/2 Watt that are not laser trimmed are suitable for use in applications where they are exposed to ESD and EFT stresses. To be safe, you should check any resistors you plan to use this way with an ESD simulator as common resistors are not specified for such use. IN

Equipment related to this Technical Tidbit:

Thermo Scientific Mini-Zap ESD Simulator
Fischer Custom Communications TG-EFT high voltage pulse generator

For more Technical Tidbits, *please visit Doug's site,* http://emesd.com.

(the author)

DOUGLAS C. SMITH

Mr. Smith held an FCC First Class Radiotelephone license by age 16 and a General Class amateur radio license at age 12. He received a B.E.E.E. degree from Vanderbilt University in 1969 and an M.S.E.E. degree from the California Institute of Technology in 1970. In 1970, he joined AT&T Bell Laboratories as a Member of Technical Staff. He retired in 1996 as a Distinguished Member of Technical Staff. From February 1996 to April 2000 he was Manager of EMC Development and Test at Auspex Systems in Santa Clara, CA. Mr. Smith currently is an independent consultant specializing in high frequency measurements, circuit/system design and verification, switching power supply noise and specifications, EMC, and immunity to transient noise. He is a Senior Member of the IEEE and a former member of the IEEE EMC Society Board of Directors.

His technical interests include high frequency effects in electronic circuits, including topics such as Electromagnetic Compatibility (EMC), Electrostatic Discharge (ESD), Electrical Fast Transients (EFT), and other forms of pulsed electromagnetic interference. He also has been involved with FCC Part 68 testing and design, telephone system analog and digital design, IC design, and computer simulation of circuits. He has been granted over 15 patents, several on measurement apparatus.

Mr. Smith has lectured at Oxford University, The University of California Santa Barbara, The University of California Berkeley, Vanderbilt University, AT&T Bell Labs, and internationally at many public and private seminars on high frequency measurements, circuit design, ESD, and EMC. He is author of the book High Frequency Measurements and Noise in Electronic Circuits. His very popular website, http://emcesd.com (www.dsmith.org), draws many thousands of visitors each month to see over 150 technical articles as well as other features.

He also provides consulting services in general design, EMC, and transient immunity (such as ESD and EFT), and switching power supply noise. His specialty is solving difficult problems quickly, usually within a couple of days. His work has included digital and analog circuits in everything from large diesel powered machinery to IC chip level circuits. His large client base includes many well known large electronic and industrial companies as well as medium sized companies and start-up companies.

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. . . . . www.goglobalcompliance.com
HCT Co., Ltd.. . . . . .www.hct.co.kr
Nemko Canada . . . . . www.nemko.com
Nemko USA - SouthEast . . . www.nemko.com
RTF Compliance . . . . . www.rtfcomp.com
SGS Consumer Testing Services
. . . . . .www.us.sgs.com/cts
SIEMIC. . . . . www.siemic.com
TÜV Rheinland of North America
. . . . . www.us.tuv.com
TÜV SÜD America Inc. .www.tuvamerica.com
UL LLC. . . . . www.ul.com

Electrical Safety Testing

ACS - Atlanta, GA. . . . . .www.acstestlab.com
ACS - Boca Raton, FL. . . .www.acstestlab.com
ACS - Melbourne, FL . . . .www.acstestlab.com
American Certification Body, Inc.
. . . . . .www.acbcert.com
CASE Forensics www.case4n6.com
Compliance Management Group
. . . . . www.cmgcorp.net
CSA Group. . . . . www.csagroup.org
Curtis-Straus (Bureau Veritas)
. . . . . .www.bureauveritas.com/ee
D.L.S. Electronic Systems, Inc.
. . . . . .www.dlsemc.com
DNB Engineering, Inc. . .www.dnbenginc.com
Electro Magnetic Test, Inc.. www.emtlabs.com
Elite Electronic Engineering . . www.elitetest.com
EMCC DR. RASEK. . . . . www.emcc.de
eti Conformity Services
. . . . . www.eticonformity.com
F2 Labs www.f2labs.com
G&M Compliance, Inc.
. . . . . www.gmcompliance.com
Global EMC Inc. . . . .www.globalemclabs.com
Green Mtn. Electromagnetics
. . . . . www.gmelectro.com
HCT Co., Ltd.. . . . . .www.hct.co.kr
High Voltage Maintenance www.hvmcorp.com
Intertek . . . . . www.intertek.com
LabTest Certification Inc. . www.labtestcert.com
Lewis Bass International. . www.lewisbass.com
MET Laboratories . . . . . www.metlabs.com
NCEE Labs . . . . . .www.nceelabs.com
Nemko Canada . . . . . www.nemko.com
Nemko USA - SouthEast . . . www.nemko.com
NTS Fremont . . . . . www.nts.com
NTS Fullerton . . . . . www.nts.com
NTS Tinton Falls . . . . . www.nts.com
Product Safety Consulting
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Professional Testing . . . . . .www.ptitest.com
Pulver Laboratories Inc. . www.pulverlabs.com
Retlif Testing Laboratories . . . . www.retlif.com
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SIEMIC. . . . . www.siemic.com
Test Site Services Inc . . www.testsiteservices.com
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TÜV SÜD America Inc. .www.tuvamerica.com
UL LLC. . . . . www.ul.com
Ultratech EMC Lab . . www.ultratech-labs.com

EMC Testing

ACS - Atlanta, GA. . . . . .www.acstestlab.com
ACS - Boca Raton, FL. . . .www.acstestlab.com
ACS - Melbourne, FL . . . .www.acstestlab.com
Alion Science and Technology
. . . . . .rb.alionscience.com
Amber Precision Instruments, Inc.
. . . . . .www.amberpi.com
American Certification Body, Inc.
. . . . . .www.acbcert.com
Americor Electronics Ltd.
. . . . . www.americor-usa.com
Atlas Compliance & Engineering
. . . . . www.atlasce.com
CKC Laboratories, Inc. . . . . www.ckc.com
Compatible Electronics, Inc.
. . . . . .www.celectronics.com
Compliance & More, Inc
. . . . . .www.compliance-more.com
Compliance Management Group
. . . . . www.cmgcorp.net
Compliance Worldwide, Inc. .www.cw-inc.com
Core Compliance Testing Srvs
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CSIA, LLC. . . . . www.csiassoc.com
Curtis-Straus (Bureau Veritas)
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D.L.S. Electronic Systems, Inc.
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Dayton T. Brown, Inc. . . . . www.dtbtest.com
Electro Magnetic Test, Inc.. www.emtlabs.com
Electronics Test Centre. . . .www.etc-mpb.com
Electronics Test Centre - Airdrie
. . . . . .www.etc-mpb.com
Elite Electronic Engineering . . www.elitetest.com
EMC Compliance . www.emccompliance.com
EMC Integrity Inc. . . . www.emcintegrity.com
EMC Testing Laboratories, Inc.
. . . . . .www.emctesting.com
EMCC DR. RASEK. . . . . www.emcc.de
EMCplus LLC . . .www.compliance-more.com
eti Conformity Services
. . . . . www.eticonformity.com
F2 Labs www.f2labs.com
Flextronics . . . . . .www.flexdvc.com
G&M Compliance, Inc.
. . . . . www.gmcompliance.com
Garwood Laboratories Inc.
. . . . . .www.garwoodlabs.com
Garwood Laboratories Inc. SC
. . . . . www.garwoodlabs.com/gsc
General Dynamics C4 Systems
. . . . . www.gdc4s.com
Global EMC Inc. . . . .www.globalemclabs.com
Green Mtn. Electromagnetics
. . . . . www.gmelectro.com
H.B. Compliance Solutions
. . . . . .www.hbcompliance.com
HCT Co., Ltd.. . . . . .www.hct.co.kr
International Certification Services, Inc.
. . . . . www.icsi-us.com

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EMC Testing *continued*

Intertek . . . . . www.intertek.com
Jacobs Technologywww.jacobstechnology.com
Keystone Compliance
. . . . . www.keystonecompliance.com
L-3 Communications Cincinnati
. . . . . .www.cinele.com/environmental.html
LabTest Certification Inc. . www.labtestcert.com
Lewis Bass International. . www.lewisbass.com
LS Research . . . . . www.lsr.com
MET Laboratories . . . . . www.metlabs.com
Montrose Compliance Services
. . . . . .www.montrosecompliance.com
NCEE Labs . . . . . .www.nceelabs.com
Nemko Canada . . . . . www.nemko.com
Nemko USA - SouthEast . . . www.nemko.com
NexTek, Inc. . . . . www.nexteklightning.com
Northwest EMC, Inc. . . . . .www.nwemc.com
NTS - Corporate HQ . . . . . www.nts.com
NTS Europe GmbH
. . . . . www.nts.com/locations/europe
NTS Fremont . . . . . www.nts.com
NTS Fullerton . . . . . www.nts.com
NTS Newark. . . . . www.nts.com
NTS Northeast. . . . . www.nts.com
NTS Plano . . . . . www.nts.com
NTS Rockford . . . . . www.nts.com
NTS Tempe. . . . . www.nts.com
NTS Tinton Falls . . . . . www.nts.com
Professional Testing . . . . . .www.ptitest.com
Pulver Laboratories Inc. . www.pulverlabs.com
Qualtest Inc. . . . . www.qualtest.com
Radiometrics Midwest Corp.
. . . . . www.radiomet.com
Retlif Testing Laboratories . . . . www.retlif.com
RF Exposure Lab . . . . www.rfexposurelab.com
SGS Consumer Testing Services
. . . . . .www.us.sgs.com/cts
SIEMIC . . . . . www.siemic.com
Southwest Research Institute . . . www.swri.org
Test Site Services Inc . . www.testsiteservices.com
Trace Laboratories, Inc. . . www.tracelabs.com
TÜV Rheinland of North America
. . . . . www.us.tuv.com
TÜV SÜD America Inc. .www.tuvamerica.com
UL LLC . . . . . www.ul.com
Ultratech EMC Lab . . www.ultratech-labs.com
Yazaki Testing Center . . . www.yazakiemc.com

Energy Efficiency Testing

ACS - Atlanta, GA . . . . . .www.acstestlab.com
ACS - Boca Raton, FL. . . . .www.acstestlab.com
ACS - Melbourne, FL . . . . .www.acstestlab.com
CSA Group . . . . . www.csagroup.org
CSIA, LLC. . . . . www.csiassoc.com
G&M Compliance, Inc.
. . . . . www.gmcompliance.com
Intertek . . . . . www.intertek.com
MET Laboratories . . . . . www.metlabs.com
Nemko USA - SouthEast . . . www.nemko.com
Pulver Laboratories Inc. . www.pulverlabs.com
SGS Consumer Testing Services
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SIEMIC . . . . . www.siemic.com
TÜV Rheinland of North America
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UL LLC . . . . . www.ul.com
UL Verification Services
. . . . . .www.ul.com/verification

Environmental Simulation Testing

ACS - Atlanta, GA . . . . . .www.acstestlab.com
ACS - Boca Raton, FL. . . . .www.acstestlab.com
ACS - Melbourne, FL . . . . .www.acstestlab.com
Cascade TEK . . . . . www.cascadetek.com/
product-testing-services
Cincinnati Sub-Zero . . . . .www.csztesting.com
Compliance Management Group
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Core Compliance Testing Srvs
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Garwood Laboratories Inc.
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MET Laboratories . . . . . www.metlabs.com
NCEE Labs . . . . . .www.nceelabs.com
Nemko USA - SouthEast . . . www.nemko.com
NTS Europe GmbH
. . . . . www.nts.com/locations/europe
NTS Fullerton . . . . . www.nts.com
NTS LAX www.nts.com/locations/los_angeles
NTS Northeast. . . . . www.nts.com
NTS Plano . . . . . www.nts.com
NTS Santa Clarita . . . . . www.nts.com
NTS Tempe. . . . . www.nts.com
NTS Tinton Falls . . . . . www.nts.com
Professional Testing . . . . . .www.ptitest.com
Qualtest Inc. . . . . www.qualtest.com
Retlif Testing Laboratories . . . . www.retlif.com
Trace Laboratories, Inc. . . www.tracelabs.com
TÜV SÜD America Inc. .www.tuvamerica.com
Yazaki Testing Center . . . www.yazakiemc.com

EuP Directive Compliance

ACS - Atlanta, GA . . . . . .www.acstestlab.com
ACS - Boca Raton, FL. . . . .www.acstestlab.com
ACS - Melbourne, FL . . . . .www.acstestlab.com
Curtis-Straus (Bureau Veritas)
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Intertek . . . . . www.intertek.com
Nemko USA - SouthEast . . . www.nemko.com
TÜV Rheinland of North America
. . . . . www.us.tuv.com
UL Verification Services
. . . . . .www.ul.com/verification

Gost R Certification

CSIA, LLC. . . . . www.csiassoc.com
DNB Engineering, Inc. . .www.dnbenginc.com
Electro Magnetic Test, Inc.. www.emtlabs.com
EMC Integrity Inc. . . . www.emcintegrity.com
G&M Compliance, Inc.
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Global EMC Inc. . . . .www.globalemclabs.com
Go Global Compliance Inc.
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Keystone Compliance
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Nemko Canada . . . . . www.nemko.com
Nemko USA - SouthEast . . . www.nemko.com
Professional Testing . . . . . .www.ptitest.com
SIEMIC . . . . . www.siemic.com

Green Energy Compliance

CSA Group . . . . . www.csagroup.org
Intertek . . . . . www.intertek.com
SIEMIC . . . . . www.siemic.com
TÜV Rheinland of North America
. . . . . www.us.tuv.com
UL LLC . . . . . www.ul.com

GS Mark Certification

Compliance & More, Inc
. . . . . .www.compliance-more.com
Curtis-Straus (Bureau Veritas)
. . . . . .www.bureauveritas.com/ee
Electro Magnetic Test, Inc.. www.emtlabs.com
EMCplus LLC . . .www.compliance-more.com
Global EMC Inc. . . . .www.globalemclabs.com
Intertek . . . . . www.intertek.com
Nemko Canada . . . . . www.nemko.com
Nemko USA - SouthEast . . . www.nemko.com
TÜV Rheinland of North America
. . . . . www.us.tuv.com
UL LLC . . . . . www.ul.com

Halogen Testing

Product Safety Consulting . . . . . www.productsafetyinc.com
RTF Compliance . . . . . www.rtfcomp.com
SGS Consumer Testing Services . . . . . www.us.sgs.com/cts

Lithium Ion Battery Testing

Cascade TEK . . . . . www.cascadetek.com/product-testing-services
CASE Forensics www.case4n6.com
Cincinnati Sub-Zero . . . . www.csztesting.com
DNB Engineering, Inc. . . www.dnbenginc.com
Elite Electronic Engineering . . www.elitetest.com
Garwood Laboratories Inc. . . . . www.garwoodlabs.com
Garwood Laboratories Inc. SC . . . . . www.garwoodlabs.com/gsc
Intertek . . . . . www.intertek.com
Nemko USA - SouthEast . . . www.nemko.com
Product Safety Consulting . . . . . www.productsafetyinc.com
SGS Consumer Testing Services . . . . . www.us.sgs.com/cts
TÜV Rheinland of North America . . . . . www.us.tuv.com

Marine Electronics Testing

Cascade TEK . . . . . www.cascadetek.com/product-testing-services
Cincinnati Sub-Zero . . . . www.csztesting.com
Compliance Management Group . . . . . www.cmgcorp.net
Compliance Worldwide, Inc. .www.cw-inc.com
Curtis-Straus (Bureau Veritas) . . . . . www.bureauveritas.com/ee
Dayton T. Brown, Inc.. . . . . www.dtbtest.com
Electro Magnetic Test, Inc.. www.emtlabs.com
EMC Testing Laboratories, Inc. . . . . www.emctesting.com
Garwood Laboratories Inc. . . . . www.garwoodlabs.com
Garwood Laboratories Inc. SC . . . . . www.garwoodlabs.com/gsc
Green Mtn. Electromagnetics . . . . . www.gmelectro.com
Nemko USA - SouthEast . . . www.nemko.com
NTS Northeast. . . . . www.nts.com
Professional Testing . . . . . www.ptitest.com
Qualtest Inc.. . . . . www.qualtest.com
Retlif Testing Laboratories . . . . www.retlif.com
Test Site Services Inc . . www.testsiteservices.com
Trace Laboratories, Inc. . . www.tracelabs.com

Nationally Recognized Testing Laboratory

CSA Group. . . . . www.csagroup.org
Curtis-Straus (Bureau Veritas) . . . . . www.bureauveritas.com/ee
Go Global Compliance Inc. . . . . www.goglobalcompliance.com
Intertek . . . . . www.intertek.com
MET Laboratories . . . . . www.metlabs.com
NTS - Corporate HQ . . . . . www.nts.com
NTS Europe GmbH . . . . . www.nts.com/locations/europe
NTS Fullerton . . . . . www.nts.com
NTS Northeast. . . . . www.nts.com
NTS Tempe. . . . . www.nts.com
NTS Tinton Falls . . . . . www.nts.com
Product Safety Consulting . . . . . www.productsafetyinc.com
Qualtest Inc.. . . . . www.qualtest.com
SGS Consumer Testing Services . . . . . www.us.sgs.com/cts
TÜV Rheinland of North America . . . . . www.us.tuv.com
TÜV SÜD America Inc. .www.tuvamerica.com

Network Equipment Building Systems (NEBS) Testing

Cascade TEK . . . . . www.cascadetek.com/product-testing-services
Compliance Management Group . . . . . www.cmgcorp.net
Curtis-Straus (Bureau Veritas) . . . . . www.bureauveritas.com/ee
Dayton T. Brown, Inc.. . . . . www.dtbtest.com
Electro Magnetic Test, Inc.. www.emtlabs.com
Flextronics . . . . . www.flexdvc.com
Garwood Laboratories Inc. . . . . www.garwoodlabs.com
Garwood Laboratories Inc. SC . . . . . www.garwoodlabs.com/gsc
MET Laboratories . . . . . www.metlabs.com
NTS - Corporate HQ . . . . . www.nts.com
NTS Europe GmbH . . . . . www.nts.com/locations/europe
NTS Fremont . . . . . www.nts.com
NTS Fullerton . . . . . www.nts.com
NTS Newark. . . . . www.nts.com
NTS Northeast. . . . . www.nts.com
NTS Plano . . . . . www.nts.com
NTS Tempe. . . . . www.nts.com
NTS Tinton Falls . . . . . www.nts.com
Southwest Research Institute . . . www.swri.org
UL LLC . . . . . www.ul.com

Product Pre-Compliance Testing

ACS - Atlanta, GA . . . . . www.acstestlab.com
ACS - Boca Raton, FL . . . . www.acstestlab.com
ACS - Melbourne, FL . . . . www.acstestlab.com
Atlas Compliance & Engineering . . . . . www.atlasce.com
CASE Forensics www.case4n6.com
CKC Laboratories, Inc.. . . . . www.ckc.com
Compatible Electronics, Inc. . . . . www.celectronics.com
Compliance & More, Inc . . . . . www.compliance-more.com
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Elite Electronic Engineering . . www.elitetest.com
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Ergonomics, Inc. . . . www.ergonomicsusa.com
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F2 Labs www.f2labs.com
Flextronics . . . . . www.flexdvc.com
Garwood Laboratories Inc. . . . . www.garwoodlabs.com
Garwood Laboratories Inc. SC . . . . . www.garwoodlabs.com/gsc
Global EMC Inc. . . . .www.globalemclabs.com
H.B. Compliance Solutions . . . . . www.hbcompliance.com
International Certification Services, Inc. . . . . www.icsi-us.com
Keystone Compliance . . . . . www.keystonecompliance.com
L-3 Communications Cincinnati . . . . . www.cinele.com/environmental.html
Lewis Bass International. . www.lewisbass.com
LS Research . . . . . www.lsr.com
NCEE Labs. . . . . www.nceelabs.com
Nemko Canada . . . . . www.nemko.com
Northwest EMC, Inc. . . . . www.nwemc.com
NTS Fremont . . . . . www.nts.com
NTS Plano . . . . . www.nts.com
NTS Rockford . . . . . www.nts.com
O'Brien Compliance Management . . . . . www.obcompman.com
Parker Hannifin, Chomerics Div . . . . . www.chomerics.com
Product Safety Consulting . . . . . www.productsafetyinc.com

Testing Laboratory Directory

Product Pre-Compliance Testing *continued*

Professional Testing .....www.ptitest.com
Pulver Laboratories Inc. . www.pulverlabs.com
Qualtest Inc. ..... www.qualtest.com
Radiometrics Midwest Corp.
..... www.radiomet.com
Retlif Testing Laboratories .... www.retlif.com
RF Exposure Lab .... www.rfexposurelab.com
SGS Consumer Testing Services
.....www.us.sgs.com/cts
SIEMIC ..... www.siemic.com
Stephen Halperin & Associates
..... www.halperinassoc.com
Test Site Services Inc . . www.testsiteservices.com
Trace Laboratories, Inc. . . www.tracelabs.com
TÜV Rheinland of North America
..... www.us.tuv.com
UL Verification Services .....www.ul.com/verification
Ultratech EMC Lab . . www.ultratech-labs.com
Wyatt Technical Services LLC
.....www.emc-seminars.com

Product Safety Testing

ACS - Atlanta, GA .....www.acstestlab.com
ACS - Boca Raton, FL....www.acstestlab.com
ACS - Melbourne, FL ....www.acstestlab.com
CASE Forensics www.case4n6.com
Cincinnati Sub-Zero ....www.csztesting.com
CKC Laboratories, Inc. ..... www.ckc.com
Compatible Electronics, Inc.
.....www.celectronics.com
Compliance & More, Inc
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Core Compliance Testing Srvs
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CSA Group ..... www.csagroup.org
Curtis-Straus (Bureau Veritas)
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D.L.S. Electronic Systems, Inc.
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DNB Engineering, Inc. . .www.dnbenginc.com
ED&D Inc. ..... www.productsafet.com
Electro Magnetic Test, Inc.. www.emtlabs.com
Electronics Test Centre. . . . www.etc-mpb.com
Elite Electronic Engineering . . www.elitetest.com
EMC Testing Laboratories, Inc.
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EMCC DR. RASEK ..... www.emcc.de
EMCplus LLC . . .www.compliance-more.com
Ergonomics, Inc. . . . www.ergonomicsusa.com
eti Conformity Services
..... www.eticonformity.com
F2 Labs www.f2labs.com
Flextronics .....www.flexdvc.com
G&M Compliance, Inc.
..... www.gmcompliance.com
Garwood Laboratories Inc.
.....www.garwoodlabs.com
Garwood Laboratories Inc. SC
..... www.garwoodlabs.com/gsc
Global EMC Inc. ....www.globalemclabs.com
Green Mtn. Electromagnetics
..... www.gmelectro.com
H.B. Compliance Solutions
.....www.hbcompliance.com
HCT Co., Ltd. .....www.hct.co.kr
High Voltage Maintenance www.hvmcorp.com
Intertek ..... www.intertek.com
Keystone Compliance
..... www.keystonecompliance.com
LabTest Certification Inc. . www.labtestcert.com
Lewis Bass International. . www.lewisbass.com
MET Laboratories ..... www.metlabs.com
Montrose Compliance Services
.....www.montrosecompliance.com
NCEE Labs .....www.nceelabs.com
Nemko USA - SouthEast . . . www.nemko.com
NTS - Corporate HQ ..... www.nts.com
NTS Fremont ..... www.nts.com
NTS Fullerton ..... www.nts.com
NTS Newark. ..... www.nts.com
NTS Northeast ..... www.nts.com
NTS Pittsfield ..... www.nts.com
NTS Plano ..... www.nts.com
NTS Tempe. ..... www.nts.com
NTS Tinton Falls ..... www.nts.com
O'Brien Compliance Management
.....www.obcompman.com
Product Safety Consulting
..... www.productsafetyinc.com
Professional Testing .....www.ptitest.com
Pulver Laboratories Inc. . www.pulverlabs.com
SGS Consumer Testing Services
.....www.us.sgs.com/cts
SIEMIC ..... www.siemic.com
Test Site Services Inc . . www.testsiteservices.com
Trace Laboratories, Inc. . . www.tracelabs.com
TÜV Rheinland of North America
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TÜV SÜD America Inc. .www.tuvamerica.com
UL LLC ..... www.ul.com

Radio Performance and Functionality Testing

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ACS - Melbourne, FL ....www.acstestlab.com
Compliance Worldwide, Inc. .www.cw-inc.com
Curtis-Straus (Bureau Veritas)
.....www.bureauveritas.com/ee
D.L.S. Electronic Systems, Inc.
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Electro Magnetic Test, Inc.. www.emtlabs.com
Elite Electronic Engineering . . www.elitetest.com
Flextronics .....www.flexdvc.com
Garwood Laboratories Inc.
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Garwood Laboratories Inc. SC
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Green Mtn. Electromagnetics
..... www.gmelectro.com
H.B. Compliance Solutions
.....www.hbcompliance.com
Intertek ..... www.intertek.com
Keystone Compliance
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LS Research ..... www.lsr.com
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