NOVEMBER 2011

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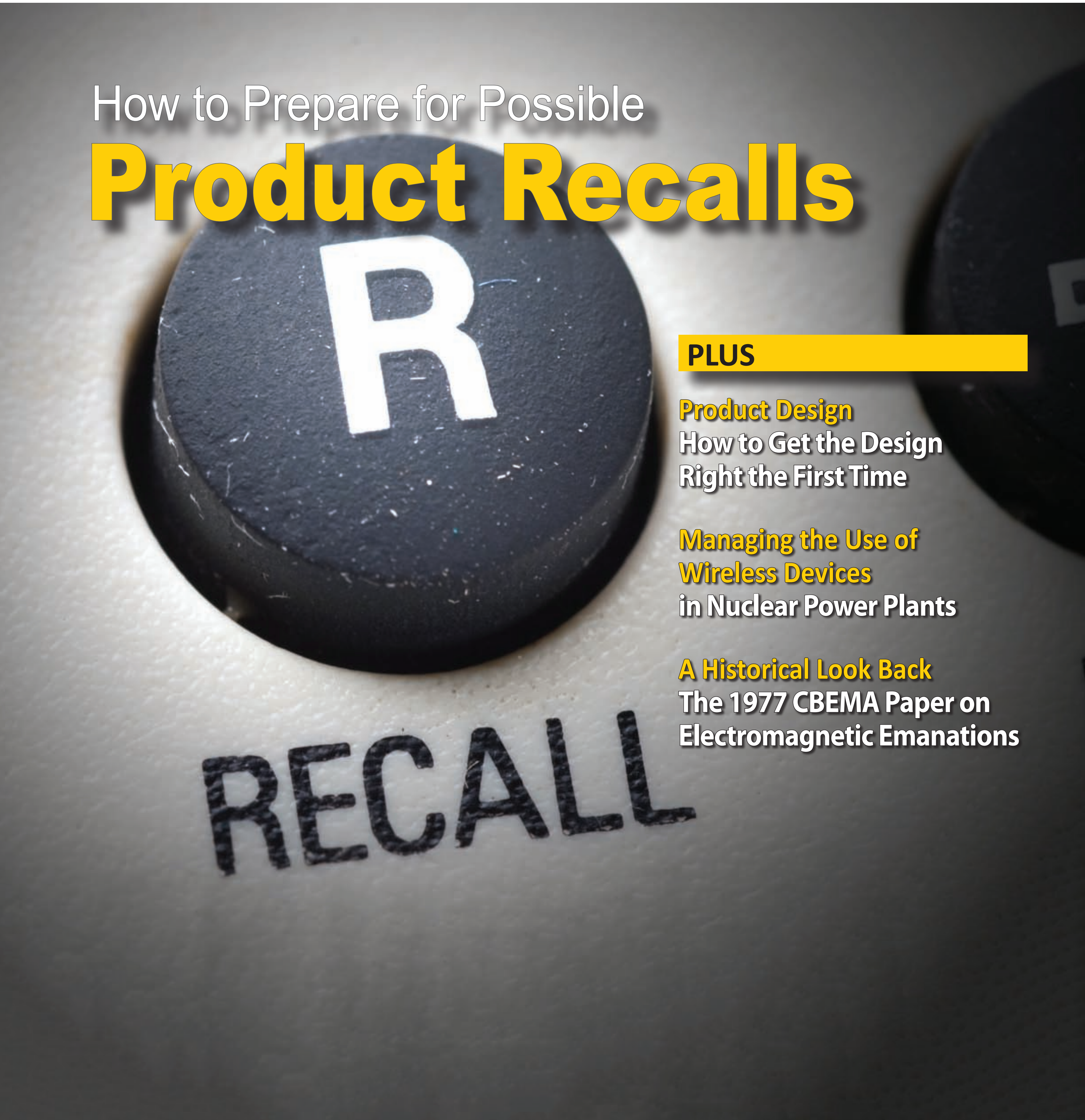

How to Prepare for Possible Product Recalls

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How to Get the Design Right the First Time

Managing the Use of Wireless Devices
in Nuclear Power Plants

A Historical Look Back
The 1977 CBEMA Paper on Electromagnetic Emanations

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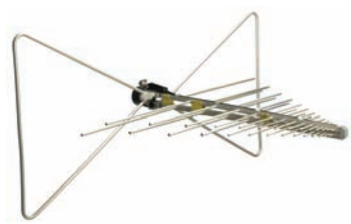
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Letter from the editor

Bridging the Generation Gap

Dear Readers,

We've just returned from Mission Valley, San Diego, CA where the 8th Annual IEEE Symposium on Product Compliance Engineering was held. This year, 125 compliance engineers, 17 exhibiting companies and 30 exhibitor staff members attended the Symposium and shared their knowledge, experiences and ideas. In reflecting on this Symposium, I am struck by the deep commitment of this group to their work in assuring product compliance, their commitment to continuing their education in the field of product compliance.

A recurring topic in many of my conversations at this Symposium (as well as the EMC Symposium held in August) was the missing generations of compliance engineers. It has been recognized by many in our industry that there have been a few generations of compliance engineers who have been displaced due to corporate layoffs and downsizing, leaving an older generation and a new generation with the problem of how to pass the torch of knowledge from one to the next. As compliance engineering is generally learned outside of the classroom through hands-on-troubleshooting and problem-solving, this generational gap continues to widen through the organic loss of the brilliant members of our older generation.

We believe that one of the solutions to this problem is the continued sharing of experiences and learning through the written word. In this issue, we introduce two new columns. *On Your Mark*, a column contributed by Geoffrey Peckham of Clarion Systems, imparts important information on compliance with graphical symbols for safety warnings. A second column, *Myth vs. Reality*, is a series of short pieces contributed by Systems Design Advisor W. Michael King, dispelling the myths of EMI engineering. As part of our featured article line-up this month you'll find the first in a series of three articles taking a historical look back at the 1977 CBEMA Paper on Electromagnetic Emanations. Look for part two of this series in our December issue.

In closing, this month, we encourage your participation and membership with organizations such as the IEEE Product Safety Engineering Society where information sharing is a fundamental mission of the engineers who have worked tirelessly to form and maintain this vital group. Explore their website at: http://ewh.ieee.org/soc/pses.

Until next time,

Lorie Nichols
Editor
editor@incompliancemag.com

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editorial staff

editor/publisher Lorie Nichols
lorie.nichols@incompliancemag.com
(978) 873-7777

production director Erin Feeney
erin.feeney@incompliancemag.com
(978) 873-7756

copy editor Mary Ann Kahl
maryann.kahl@incompliancemag.com

publishing staff

director of sales Sharon Smith
sharon.smith@incompliancemag.com
(978) 873-7722

advertising director Murray Kasmenn
murray.kasmenn@incompliancemag.com
(770) 856-2342

eastern regional sales manager Shellie Johnson
shellie.johnson@incompliancemag.com
(404) 991-8695

subscriptions

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Please contact our circulation department at circulation@incompliancemag.com

advertising

For information about advertising contact:
Sharon Smith at 978-873-7722
sharon.smith@incompliancemag.com

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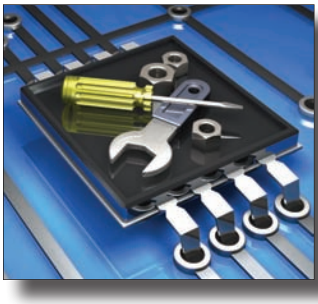

News in Compliance

FCC News

FCC Publishes White Paper on Deployable Aerial Communications

Seeking to explore communications alternatives in the wake of a natural or man-made disaster that damages or destroys terrestrial-based communications networks, the U.S. Federal Communications Commission (FCC) has published a white paper that outlines its vision for a "deployable aerial communications" system.

Titled "The Role of Deployable Aerial Communications Architecture in Emergency Communications and Recommended Next Steps", the white paper offers a detailed analysis of how a deployable aerial communications architecture (DACA) might help to temporarily restore communications services in the immediate aftermath of a catastrophic event. Such a system would rely on state-of-the-art communications systems on aerial platforms, such as manned aircraft, unmanned aerial vehicles and balloons. These are capabilities already available for military operations.

The white paper proposes that such a DACA-based solution could provide vital communications services for first responders and disaster recovery professionals under circumstances in which landline, cellular, broadcast or cable capabilities are unavailable. The white paper also outlines a plan for subsequent action by the Commission to further explore DACA capabilities and the potential to deploy a DACA-based communications system in the event of an emergency.

The complete text of the FCC's white paper on DACA is available at www.incompliancemag.com/news/1111_01.

FCC Explores "Next Generation" 911 Capabilities

The U.S. Federal Communications Commission (FCC) is actively exploring short- and long-term options for expanding the capabilities of the nation's 911 emergency communications system, including the eventual delivery of photos, videos and data over the 911 network.

In a Notice of Proposed Rulemaking issued in September 2011, the Commission called for comments on various plans and approaches that would enable consumers to send text messages via the 911 network. In addition, the Commission's Proposed Rulemaking also requested comments on the long-term development of a multimedia-capable 911 technology that would allow consumers to communicate with 911 operators in the same way that they now communicate with others on a daily basis. Such a system, the Commission noted, would be particularly beneficial for people with disabilities.

The Commission believes that enhanced 911 capabilities would significantly improve emergency response, saving lives and reducing property damage. Further, according to the Commission, such an enhanced system could be developed with technologies already commercially available, thereby speeding deployment and minimizing total costs.

The complete text of the Commission's Notice of Proposed Rulemaking is available at www.incompliancemag.com/news/1111_02.

> The Federal Communications Commission has called for comments on plans and approaches that would enable consumers to send text messages via the 911 network.

FCC Seeks to Amend Part 15 for Auditory Assistance Devices

Continuing its efforts to remove barriers to communications, the U.S. Federal Communications Commission (FCC) has proposed amending its Part 15 rules, broadening its definition of auditory assistance devices to include devices used for simultaneous language interpretation.

In an Order and Notice of Proposed Rulemaking published in September 2011, the Commission responded to a petition for declaratory ruling filed by Williams Sound Corporation, a provider of auditory assistance devices. In its petition, Williams requested that the FCC clarify the allowable uses of simultaneous language interpretation devices. Such devices are expressly permitted under Part 95 of the Commission's rules to operate in the 216-217 MHz band. But Part 15 does not specifically mention such devices, referencing only the broader category of auditory assistance devices which are permitted to operate in the 72-76 MHz bands.

The Williams' petition requested that the Commission issue a declaratory ruling to expressly permit the operation of language interpretation devices under both Part 15 and Part 95. However,

FCC News

the Commission determined that a declaratory ruling would expand the scope of permitted uses so significantly as to constitute a change in the rules themselves, an action beyond the scope or intent of such a ruling. Instead, acknowledging the merits of the Williams' petition, the Commission determined that a formal change in the rules themselves warranted consideration, hence the Notice of Proposed Rulemaking.

The complete text of the Commission's Order and Notice of Proposed Rulemaking is available at www.incompliancemag.com/news/1111_03.

> The FCC has taken action against a manufacturer for apparent willful and repeated violations by failing to include required consumer disclosures in its product manuals.

Company Fined for Omissions in Product Manuals

The U.S. Federal Communications Commission (FCC) has taken action against a manufacturer for failing to include required consumer disclosures in its product manuals.

In a Notice of Apparent Liability for Forfeiture issued in August 2011, the Commission has proposed a forfeiture in the amount of $7200 against Marshall Amplification PLC for apparent willful and repeated violations of the Commission's requirements that user manuals for Class B radio frequency devices include a discloser regarding the potential for the device to create harmful interference to radio communications.

According to the Commission, Marshall marketed its Model MG2FX amplifier in the United States beginning in September 2009 after verifying the device's compliance with FCC requirements, but failed to include the requisite consumer disclosures in the product's user manual. In response to FCC inquiries in July 2010, the company reported that efforts were underway to address the omission. However, user manuals with the requisite disclosures were not reprinted for the MG2FX until mid-2011.

FCC rules require that certain Class B digital devices marketed to the general public be verified for compliance with the Commission's radio frequency limits to avoid harmful interference to authorized radio operations. In addition, user manuals for such devices must include a warning to consumers regarding their potential for interference, and recommended steps that can be taken to eliminate the interference. Willful or repeated violations of these requirements are subject to a forfeiture of up to $16,000 per each violation, or each day of a continuing violation, up to a maximum forfeiture of $112,500 for any single continuing violation.

The complete text of the Commission's Notice of Proposed Forfeiture is available at www.incompliancemag.com/news/1111_04.

News in Compliance

European Union News

EU Commission Revises Standards List for R&TTE Directive

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 Directive 1999/5/EC, covering radio equipment and telecommunications terminal equipment (R&TTE).

According to the Directive, 'radio equipment' is defined as any product capable of communication via emission and/or reception of radio waves. 'Telecommunications terminal equipment' is any device intended to be connected directly or indirectly to the public telecommunications network. The scope of the Directive also includes certain medical devices and active implantable medical devices.

The extensive list of CENELEC and ETSI standards was published in September 2011 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 www.incompliancemag.com/news/1111_05.

EU Commission Publishes Standards List for Directives on Pressure Equipment, Pressure Vessels

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 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 September 2011 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 www.incompliancemag.com/news/1111_06.

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

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

The Directive defines 'electrical equipment' as any device designed for use with a voltage rating of between 50 and 1000 V for alternating current, and between 75 and 1500 V for direct current.

The updated list of standards that can be used to demonstrate compliance with the Directive was published in August 2011 in the *Official Journal of the European Union*, and replaces all previously published standards lists. The complete list of standards can be viewed at www.incompliancemag.com/news/1111_07 (note that the list runs 82 pages!).

> The EU Commission has updated the standards lists for the R&TTE Directive, Pressure Equipment and Pressure Vessels Directives, and the Electrical Safety Directive.

Your participation is welcome. Please send letters to the editor.

In Compliance Magazine
P.O. Box 235
Hopedale, MA
(508) 488-6274
editor@incompliancemag.com

CPSC News

Company Pays Penalty for Failing to Report Defects

A Mississippi company has agreed to pay a civil penalty of $715,000 to settle allegations that it failed to immediately report defects in certain models of its off-road utility vehicles.

According to the U.S. Consumer Product Safety Commission (CPSC), the company, Bad Boy Enterprises, implemented a repair program in 2008 to address reports of sudden acceleration with the off-road vehicles, but failed to notify the Commission of the product defect until August 2009. The CPSC and Bad Boy Enterprises announced an initial recall in October 2009. However, further investigation determined that the company did not provide the Commission with full information about the scope of the problem until May 2010, resulting in a second recall in December 2010. By that time, the company had received more than 50 reports of sudden acceleration incidents, resulting in a variety of injuries to consumers.

Federal law requires that manufacturers, distributors and retailers immediately (i.e., within 24 hours) report to the CPSC information that a product contains a defect which could create a substantial product hazard or pose a risk of injury or death to consumers.

In agreeing to the civil penalty, Bad Boy Enterprises has denied CPSC allegations that it knowingly violated the law.

Fires Prompt Recall of Home Dehumidifiers

LG Electronics Tianjin Appliance Company has reissued its recall of some 98,000 units of home dehumidifiers manufactured in China that are believed to be responsible for more than $1 million in property damage.

According to the company, certain models of its Goldstar and Comfort-Aire-brand home dehumidifiers incorporate a power connector for the dehumidifiers' compressor that can short circuit, posting fire and burn hazards to consumers and their property.

The original recall, issued in December 2009, was initiated when LG Electronics received 11 separate reports of problems with the dehumidifiers, including four significant fires. Since then, the company has received an additional 16 reports of arcing, smoke and fire, including nine significant fires.

Although there have been no reports to date of injuries, only 2% of consumers who purchased the recalled units have requested a free repair, prompting the follow-up recall.

The recalled dehumidifiers were sold at The Home Depot, Wal-Mart, Ace Hardware and others retailers nationwide from January 2007 through June 2008 for between $140-150.

Additional details about this recall are available at www.incompliancemag.com/news/1111_08.

LED Night Lights Recalled Due to Burn Hazard

Convest Acquisitions Inc. (now Camsing Global LLC) of Largo, FL has announced the recall of about 10,000 LED night lights manufactured in China.

Convest reports that the LED night lights can overheat, smolder and melt, which may cause minor burns to consumers. The company says that it has received five reports of the recalled night lights overheating, smoldering or melting, but no reports of injuries.

The recalled LED night lights were distributed by various companies as a free promotional product, imprinted with the company's name, from December 2010 through March 2011.

More information about this recall is available at www.incompliancemag.com/news/1111_09.

> The CPSC has issued recalls for home dehumidifiers manufactured by LG Electronics, and for LED night lights distributed by Convest Acquisitions. Both products were manufactured in China.

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.

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

STANDARDS AND OUTLINES

UL 5: Standard for Surface Metal Raceways and Fittings
New Edition dated September 16, 2011

UL 48: Standard for Electric Signs
New Edition dated September 2, 2011

UL 102: Interim Sustainability Requirements for Door Leafs
New Edition dated September 29, 2011

UL 710B: Standard for Recirculating Systems
New Edition dated September 2, 2011

UL 713B: Sysadmin Test
New Edition dated September 26, 2011

UL 963: Standard for Sealing, Wrapping, and Marking Equipment
New Edition dated September 1, 2011

UL 964: Standard for Electrically Heated Bedding
New Edition dated August 31, 2011

UL 2006: Standard for Halon 1211 Recovery/Recharge Equipment
New Edition dated September 8, 2011

UL 2560: Standard for Emergency Call Systems for Assisted Living and Independent Living Facilities
New Edition dated September 13, 2011

UL 2584: Specification for Bottled Water Program
New Edition dated September 15, 2011

UL 2759: Hard Surface Cleaners
New Edition dated September 26, 2011

UL 2773: Pens, Mechanical Pencils, and Other Writing Instruments
New Edition dated September 29, 2011

UL 2778: Products Made From Recycled Plastic
New Edition dated September 29, 2011

REVISIONS

UL 141: Standard for Garment Finishing Appliances
Revision dated September 27, 2011

UL 471: Standard for Commercial Refrigerators and Freezers
Revision dated September 23, 2011

UL 555: Standard for Fire Dampers
Revision dated September 22, 2011

UL 854: Standard for Service-Entrance Cables
Revision dated September 9, 2011

UL 913: Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations
Revision dated September 23, 2011

UL 962A: Standard for Furniture Power Distribution Units
Revision dated September 19, 2011

UL 1004-5: Standard for Fire Pump Motors
Revision dated September 21, 2011

UL 1028: Standard for Hair Clipping and Shaving Appliances
Revision dated September 15, 2011

UL 1286: Standard for Office Furnishings
Revision dated September 29, 2011

UL 2054: Standard for Household and Commercial Batteries
Revision dated September 14, 2011

UL 2231-2: Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
Revision dated September 16, 2011

UL 2231-1: Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements
Revision dated September 16, 2011

UL 61496-2: Standard for Electro-Sensitive Protective Equipment, Part 2: Particular Requirements for Equipment Using Active Opto-Electronic Protective Devices (AOPDs)
Revision dated September 20, 2011

UL 61496-1: Standard for Electro-Sensitive Protective Equipment, Part 1: General Requirements and Tests
Revision dated September 20, 2011

EVENTS in Compliance

November

14-17
MIL-STD-461F
WL Academy, Gaithersburg, MD
www.incompliancemag.com/events/111114

15
Understanding Ground Resistance Testing A One Day Training Seminar
AEMC Instruments, Houston, TX
www.incompliancemag.com/events/111115_1

15
2011 Today's Engineering Challenges, Tomorrow's Solutions Conference and Exhibition
Argonne National Lab, Argonne, IL
www.incompliancemag.com/events/111115_2

15-16
CST STUDIO SUITE™ EMC/EMI Training
CST, Framingham, MA
www.incompliancemag.com/events/111115_3

16
A/V, Information and Communications Technology Equipment Safety Requirements: Intro to IEC 62368-1
UL University, Research Triangle Park, NC
www.incompliancemag.com/events/111116_1

16
Documenting Required ISO 14971 Risk Management File Elements in the IEC 60601-1 TRF
UL University, San Jose, CA
www.incompliancemag.com/events/111116_2

16
Electric Signs: Designing for Compliance to UL 48
UL University, Phoenix, AZ
www.incompliancemag.com/events/111116_3

16
NPSS Annual Vendors' Night
NPSS, Marlborough, MA
www.incompliancemag.com/events/111116_4

16-17
Data Acceptance Program: Requirements for Participation
UL University, Research Triangle Park, NC
www.incompliancemag.com/events/111116_5

17
Electromagnetic Simulation in Radar System Design
CST, Webinar
www.incompliancemag.com/events/111117

22
EAGLE Advanced, Libraries and Component Design
CadSoft, Webinar
www.incompliancemag.com/events/111122_1

22-23
High Intensity Radiated Field Effects in Aircraft
EMCCons DR. RAŠEK
Unterleinleiter, Germany
www.incompliancemag.com/events/111122_2

24-25
Lightning Electromagnetic Effects on Aircraft
EMCCons DR. RAŠEK
Unterleinleiter, Germany
www.incompliancemag.com/events/111124

29-30
ITE: Designing for Compliance to UL 60950-1 2nd Edition
UL University, Research Triangle Park, NC
www.incompliancemag.com/events/111129_1

29-30
Applied Safety Science and Engineering Techniques (ASSET)™
UL University, Austin, TX
www.incompliancemag.com/events/111129_2

Submit your event information to: events@incompliancemag.com

December

5-9
Electronics Laboratory Technician Training
UL University, Research Triangle Park, NC
www.incompliancemag.com/events/111205_1

5-9
Photovoltaic System Installation Training
UL University, Research Triangle Park, NC
www.incompliancemag.com/events/111205_2

5-9
Six Sigma Green Belt Workshop and Certification
UL University, Northbrook, IL
www.incompliancemag.com/events/111205_3

6
Regulatory Updates in Russia
TUV Rheinland, Webinar
www.incompliancemag.com/events/111206_1

6-7
Electrical Insulation Systems: UL 1446
UL University, Research Triangle Park, NC
www.incompliancemag.com/events/111206_2

6-7
Industrial Control Panels UL 508A and Short-Circuit Current Ratings
UL University, San Jose, CA
www.incompliancemag.com/events/111206_3

13
Regulatory Updates in Korea and China
TUV Rheinland, Webinar
www.incompliancemag.com/events/111213

14-15
Data Acceptance Program
UL University, Brea, CA
www.incompliancemag.com/events/111214_1

14-15
Applied Safety Science and Engineering Techniques (ASSET)™
UL University, Raleigh, NC
www.incompliancemag.com/events/111214_2

iNARTE Informer

Business As Usual

It has been a few weeks since we had a most unwelcome visit from Hurricane Irene in the New Bern area. Most of us are getting back to near normality, but the curbsides are still piled with trees and branches brought down by the storm.

It was not that the winds were as high as some of the hurricanes in the past, but this one was spread over a wide area and seemed to stall along the coast, driving the water further and further upriver. The land is pretty flat around eastern North Carolina, so a few feet of flood water goes a long way.

On Sunday when the waters had subsided, we found ourselves without power, phone or internet service, even the cell phone towers were out in many areas. We headed out to the iNARTE office fearing the worst for our 120 year old building, and dreading the mess that we would find in the basement file cabinets. But there it stood, unscathed, with a dry basement, porch lights lit, telephones working and the internet up and running. We were "business as usual" on Monday and, in fact, our office became almost home for a week where we could charge our phones and keep in contact with the world.

ESDA SYMPOSIUM 2011

Unfortunately, we were still clearing up the mess at our house when it was time to leave for the ESDA symposium in Anaheim. It was a difficult decision, but this year we had to miss the ESDA event. Our thanks go to the ESDA members and symposium organizers who set up our booth, displayed the literature, registered candidates for examination, and proctored our certification exams.

As usual we offered certification examinations at both Engineer and Technician levels, and, for the first time, this year a new short-form examination specifically for people who already hold the ESDA Program Manager Certification. Several ESDA certificate holders took advantage of this new exam, which concentrates on subject matter not generally well covered in the Program Manager training syllabus. Passing the short form-exam will result in the candidate being awarded full iNARTE certification together with a special endorsement as an "ESD Control Program Manager".

MASTER EMC DESIGN ENGINEER CERTIFICATION

Grandfather applications are being received now for certification as a Master EMC Design Engineer. The grandfather period will end on December 31, 2011, after which time all applicants will need to be examined, regardless of seniority and experience. Even today, more than 20 years after the original iNARTE EMC certification was introduced, we meet engineers who tell us they regret having missed out on grandfathering back then and have never had the time to bone up and schedule the examination since. Don't let this happen to you, get your application in now from www.narte.org/d/emcdegrfapp.pdf.

If you are just starting your career as an EMC Design Engineer, then the examination papers that we have ready now are exactly tailored to the knowledge base that industry expects of you, and validating your knowledge with this credential would be a valuable asset for you.

By year end we will have the next level examination ready for the Senior EMC Design Engineer, so all of you out there

Yes, that really is a mail box sticking out of the water.

with 5 or more years working experience in this field can register for examination starting in January 2012.

Remember, this is a closed book examination and certificates are issued for life with no requirement to renew annually in order to remain current. Certificate holders will be under no obligation to upgrade as they gain experience, but this option will be available.

RABQSA – 6 DOWN, 6 TO GO

We are now at the halfway point of our 12 month honeymoon with RABQSA. In six months from now we expect to be fully merged, thereby creating the world's largest personnel credentialing association with almost 15,000 certificate holders.

After the merger, iNARTE will continue with its present certification programs and the iNARTE name will continue as a brand of the new organization. With the greater global visibility and presence of RABQSA, iNARTE will be able to identify new opportunities for personal competency certification in a wider range of disciplines, and our current certificate holders will rapidly become part of a much larger and more visible organization.

IEEE PSES SYMPOSIUM 2011

This week iNARTE is exhibiting and promoting the advantages of certification at the annual PSES symposium. This year the event is at the Mission Valley Hilton in San Diego, and after some recent rainy weather, San Diego is back to its usual 70 degrees and sunny. The IEEE PSES is one of the smaller IEEE societies and their symposium fits neatly into a hotel ballroom and conference complex. This year about 125 attendees were registered, together with another 30 or so personnel staffing 16 exhibition booths.

The PSES currently has a dedicated and enthusiastic membership of a little less than 900. iNARTE has a total of 375 certificate holders in this discipline. However, almost 50% of iNARTE members are in Japan, where relatively few are members of the PSES. Both of us will be working hard to improve these statistics in 2012, when it is hoped that a Japanese Chapter of the PSES can be founded and new PSES members will want to validate their knowledge and experience through iNARTE certification.

REGISTER FOR CERTIFICATION EXAMS

There are no more symposiums or workshop events planned for 2011 where iNARTE will proctor certification examination. However, all examination candidates should visit our web site at www.narte.org/h/testcenters.asp to find an Authorized Test Center that is convenient for travel. Then, on the registration page at www.narte.org/h/examregform.asp, just enter that selected test center and we will make the arrangements from that point.

If none of our centers are conveniently located for you, please e-mail or call our office. We can probably arrange one of the following alternatives:

a. Find a local Community College that is willing to proctor an exam.

b. Set up arrangements with a responsible person from another department in your own company who is willing to proctor the exam.

c. Sometimes a local public library will provide a quiet room and a proctor. IN

QUESTION OF THE MONTH

Last month we asked:

A discrete inductor mounted on a printed-circuit board is modeled at low frequencies as a pure inductance. At higher frequencies, the lumped-element model is?

A. A parallel resistance, inductance, and capacitance circuit
B. Still a pure inductance
C. A series resistance, inductance and capacitance circuit
D. A pure resistance

The correct answer is

A. A parallel resistance, inductance, and capacitance circuit

This month's question is from the Product Safety Engineering field:

What is the minimum acceptable insulation thickness for primary windings of a limited power supply transformer of an IT product operated at 120VAC?

A. 1.0 mm
B. 0.4 mm
C. 0.1 mm
D. 0.8 mm

(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.

MR. Static

Ions

BY NIELS JONASSEN, sponsored by the ESD Association

The word ion (in Greek, ιον) means wanderer. It denotes an entity, a particle, that will move under the action of an electric field. So, in principle, valence electrons in metals or holes in semiconductors could be considered ions. But in practice, the name ion is reserved for two species: electrolytic ions and gaseous ions.

INTRODUCTION

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

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

~ The ESD Association

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Compliance Engineering Magazine,
Mr. Static Column

Electrolytic Ions

If you have an aqueous solution of silver nitrate, the $AgNO_3$ is dissociated as:

$AgNO_3 \rightarrow Ag^+ + NO_3-$

Ag^+ is called a silver ion and NO_3- a nitrate ion.

If an electric field is now applied to the liquid, the positive silver ions will move in the direction of the field toward the negative cathode, where they each will receive an electron, become neutralized, and plate out onto the electrode. This is the basis for electroplating.

A somewhat similar process takes place at the anode—but we are not going to discuss electrochemistry in detail. Rather, I will point out just a few facts about electrolytic ions. The silver and nitrate ions, as well as other electrolytic ions, have well-defined properties. All silver ions are identical, at least chemically speaking, and they never change their properties no matter what you do to them, as long as they remain ions.

If a given ion is exposed to an electric field with the strength E, it will move with a constant velocity v given by:

$v = kE$

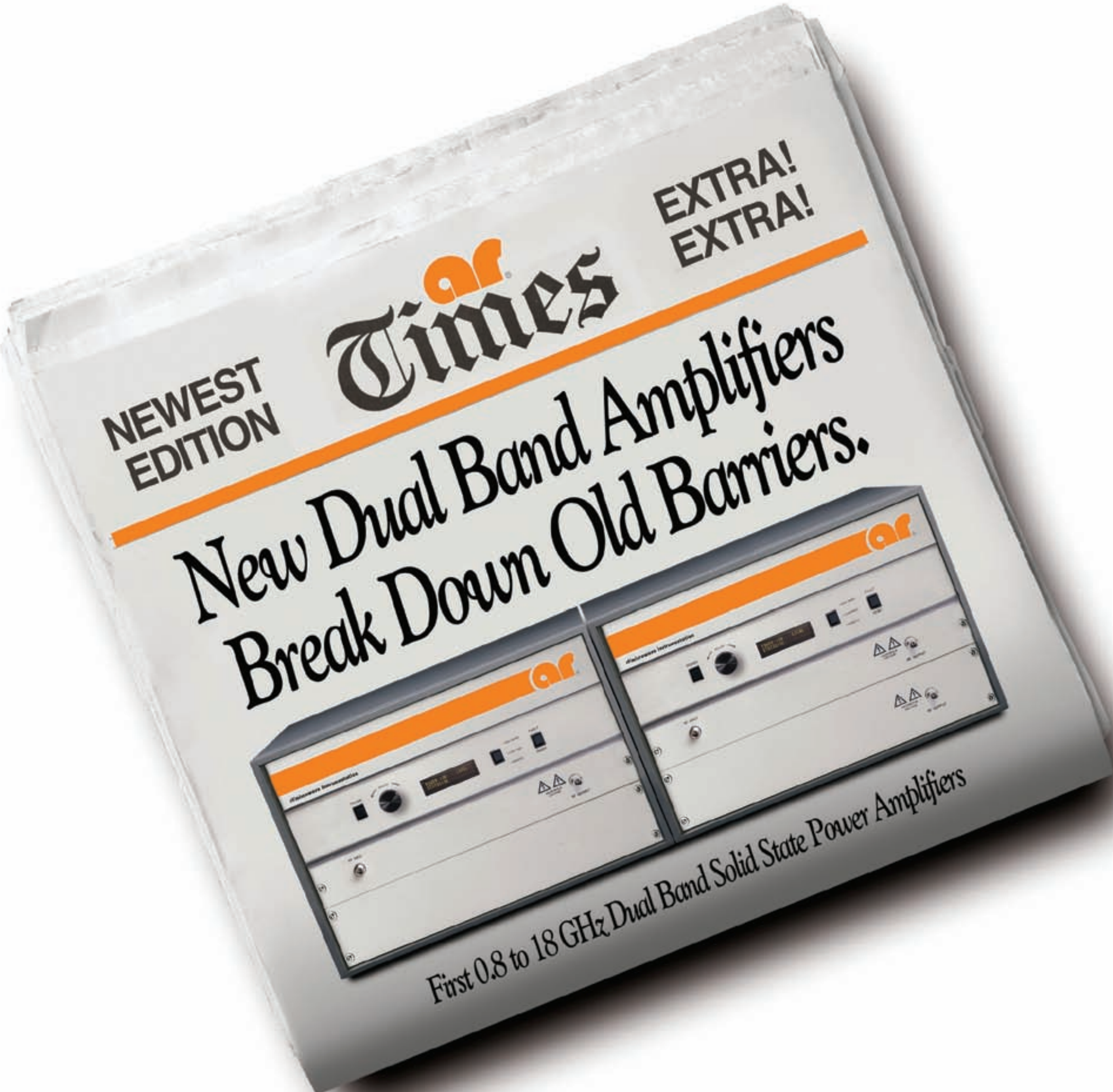
where k is a constant representing the mobility of the ion. Again, a silver ion always has one positive charge and always the same mobility, at least when you consider a given isotope of silver. The same constancy is true for any other electrolytic ion.

Gaseous ions

Although ions may be formed in most gases, we will restrict ourselves here to discussion of those types of ions that may be formed and found in atmospheric air, the so-called air ions or atmospheric ions.

The formation of an air ion starts with an electron being knocked off a neutral air molecule, as shown in Figure 1. The now positive molecule (oxygen or nitrogen) will rapidly attract a number of polar molecules (10–15), mostly water, and this cluster is called a positive air ion. The electron will probably attach to an oxygen molecule (nitrogen has no affinity for electrons), and this negative molecule will attract a number of water molecules (maybe 8–10), forming a cluster called a negative air ion. It is important to note that ions are always formed in pairs, and always the same number of positive and negative ions.

It takes a certain energy, about 34 eV ($\sim 5.4 \times 10^{-18}$ J) to knock off the initial electron. This energy may be delivered by shortwave electromagnetic radiation (x-rays or gamma rays), or more often from a colliding particle.



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MR. Static

Natural ionization

Most of the ionization in the lower atmosphere is caused by airborne radioactive substances, primarily radon and its short-lived daughters. In most places of the world, ions are formed at a rate of 5–10 pairs per cm^3 per second at sea level. With increasing altitude, cosmic radiation causes the ion production rate to increase. In areas with high radon exhalation from the soil (or building materials), the rate may be much higher.

It is primarily alpha-active materials that are responsible for the ionization. Each alpha particle (for instance, from a decaying radon atom) will, over its range of some centimeters, create approximately 150,000–200,000 ion pairs.

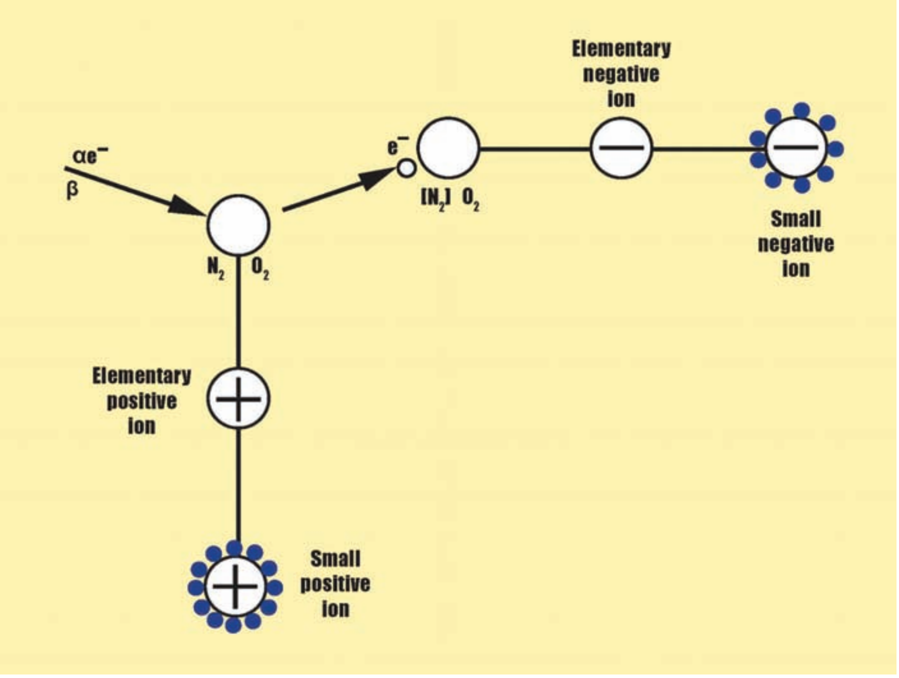


Figure 1: How air ions are formed

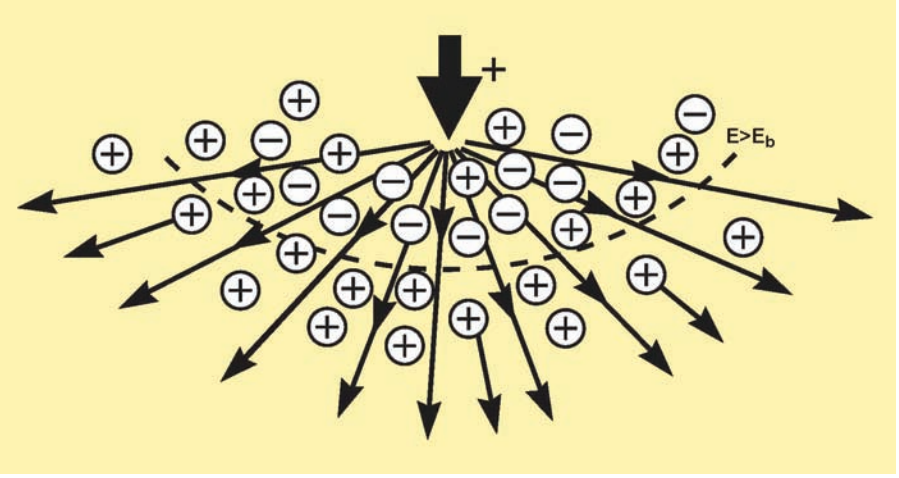


Figure 2: Field inonization, caused by an electric field between an electrode and ground

Field ionization

Although ionization from radioactive sources (often a polonium isotope) is used for technical purposes, and for certain applications it is to be preferred for any other method, the most common artificial method of producing ions is by field ionization.

It's somewhat ironic to realize that this method presupposes an ongoing, however weak, natural ionization. If a sufficiently strong electric field is established—for instance, between an electrode at a potential of some kilovolts and a ground—the electrons being freed by natural ionization may be accelerated to such velocities that they themselves can cause ionization, again creating pairs of (positive and negative) ions. It should be stressed that it does not take a high voltage, but high field strength, to cause ionization.

The breakdown field strength, as it is called, is somewhere around 3 MV/m between plane electrodes (in air at atmospheric pressure). If you have two metal plates at a distance of 1 cm, you need a voltage difference of about 30,000 V for ionization to take place in the space between the plates. If, however, one of the plates is replaced by a sharp metal point or a thin wire, the necessary voltage may be only a few kV. The explanation is that for a given voltage difference, the field strength in front of a point is much higher than between plane electrodes. Thus although the breakdown field strength is higher in front of a point, ionization is still established at lower voltages using sharp electrodes.

Now let's imagine an electrode, say a sharp metal point, kept at a positive potential of some kV with respect to ground, which may be represented by the walls of the room, as shown in Figure 2. In a small volume, perhaps a few cubic millimeters around the tip of the electrode, ion pairs are formed.

Ions don't live forever. They may recombine with oppositely charged ions or, more likely, combine with aerosol particles in the air. The charged particles, sometimes called large ions, will also move in an electric field, although much more slowly than the air ions do.

The negative ions are attracted to the electrode, where they give off their charge and cease to exist as ions. The negative charge from the ions runs through the electrode to the voltage supply, making it look as though the electrode delivers a positive current to the air. The positive ions, formed in front of the electrode, are repelled by the electrode and move away. All in all, it appears that positive ions are emitted from the positive electrode.

But this conclusion is completely wrong. The positive ions have never been in contact with the electrode. The electrode, often called an emitter, doesn't emit anything. Rather, it collects things (specifically, negative ions). Sadly, it's probably too late to change this linguistic malpractice.

What do ions do?

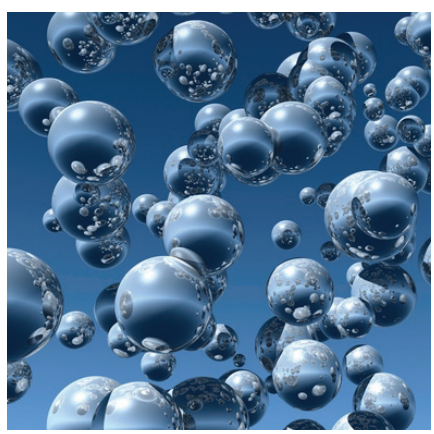
Ions don't live forever. They may recombine with oppositely charged ions or, more likely, combine with aerosol particles in the air. The charged particles, sometimes called large ions, will also move in an electric field, although much more slowly than the air ions do.

This is the principle for the first technical electrostatic invention, the electro filter, without which we would have no means of effectively cleaning the smoke from coal- or oil-fired power plants and many other industrial installations.

Ions may also plate out onto surfaces, either by diffusion or aided by an electric field. And this is the basis for another important technical use of ionization.

Let's assume we have a charged insulator and we want to remove the charge.

Well, let's face it. It can't be done. There's no way by which a charge can be removed from an insulator. But don't panic. The charge in itself doesn't do any harm. It's the field from the charge we have to worry about. And the field may be used to neutralize itself.



If the charged insulator is exposed to an atmosphere containing ions of polarity opposite that of the charge, the field will attract ions, which will move toward the body and neutralize the charge. At least that's what appears to happen.

But a more strict formulation would be that the original (excess) charge is still there, and so is its field. The oppositely charged ions, attracted from the air, will deposit around the original charge, but not annihilate it. The resulting field, the sum of the fields from the opposite charges, will be zero, or at least very close to zero.

The use of air ionization for abating static electric effects is a slow method, compared to methods like the grounding of conductors or surface treatment with topical antistats. But it should be stressed that when we are talking about charged insulators, exposure to ionized air is the only method to remove the effects of the charge.

Ions and people

Soon after the discovery of atmospheric ions about a century ago, it was suggested that the ions might have an effect on people breathing the air containing the ions. Among the effects suggested was that air with an excess of negative ions would feel fresh, while an excess of positive ions would make the air stuffy.

This popular but still undemonstrated belief will be the subject of a subsequent column on static electricity and people. IN

(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

This is the first in what will be an on-going column about compliance with graphical symbols for safety warnings.

BY GEOFFREY PECKHAM

Since 1996 I've chaired the American National Standards Institute's U.S. Technical Advisory Group (TAG) to ISO/TC 145. This is the international committee in charge of standardizing symbols for use in communicating safety, public information, and the function/control of equipment.

These symbols are then promulgated through one of three ISO symbol collection documents:

- ISO 7000 – Graphical symbols for use on equipment (Note: the parallel standard for electrical equipment is IEC 60417)
- ISO 7001 – Public information symbols
- ISO 7010 – Safety signs

The focus of this regular column will be symbols standardized in ISO 7010 since these icons are critical to communicating safety on products and in the workplace.

ISO 7010 is an important standard because graphical symbols are the future when it comes to communicating safety information. Not only do symbols have the ability to communicate across language barriers, but they add an attention-getting element that helps safety signs and labels to be noticed. And, as human factor experts advocate, safety signs must be NOTICED to be effective. Symbols evoke that first engagement step between the sign and the viewer.

All symbols are abstract in that they stand for some particular meaning. Some symbols are designed with representational elements that are easy to understand. Others need to be "learned" to be immediately understood. But through training and repeated exposure even the most abstract symbols can successfully communicate their message to the viewer.

The electrical hazard lightning bolt is one of the most commonly used safety symbols internationally. As with all "warning signs", this symbol is standardized in ISO 7010 inside a black-banded yellow triangle. Its intended message is "Warning; electricity" and it is used to warn people about the risk of coming into contact with electricity (e.g. electric shock, electrocution hazard, hazardous voltage).

Notice in Figure 1 that the symbol's arrow has a clearly defined zigzag shape. There is a reason that ISO 7010 uses this specific double-angled arrow: it comes directly out of IEC 60417 where its form was standardized decades ago to mean "dangerous voltage".

Figure 1: IEC 60417 symbol no. 5036 (right), ISO 7010 symbol no. W012 (left)

According to ISO formatting standards, this symbol (ISO W012) can be used as a safety sign by itself or in combination with text. In the U.S. we most often use this symbol on the symbol panel of an ANSI Z535-style sign with the signal word DANGER, WARNING or CAUTION (a signal word sign format that is also included in several ISO product safety labeling standards). ANSI-style signs often include additional information and symbols to communicate appropriate avoidance procedures such as disconnect power, lockout power, only to be serviced by authorized personnel, and the like.

If international compliance is important for your product, this ISO 7010 symbol should be used on all of your products' electrical hazard safety signs and labels.

For more information about safety signs and symbols, visit www.clarionsafety.com.

Figure 2: A typical ANSI Z535-formatted safety sign using the ISO electrical hazard symbol.

(the author)

GEOFFREY PECKHAM is president of Clarion Safety Systems and chair of both the ANSI Z535.2 Standard for Environmental and Facility Safety Signs 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 safety standards dealing with safety signs, colors, formats and symbols.

MYTH vs. Reality

Power Line Common-mode Conducted EMI Emission

BY W. MICHAEL KING

The myth: Conducted EMI emission profiles are always attributable to conducted currents propagating from the product power connections to the Line Impedance Stabilization (artificial mains) Networks (LISNs)

The reality: Effects from other systems can result in common-mode potentials that when measured at the LISNs appear to be propagated from the product power terminals.

Conducted EMI emission processes in power lines typically involve two characteristics of EMI: differential-mode and common-mode. Differential-mode currents emanating from power supplies in systems-products set up a line-to-line circulation of current. This current spectra then interacts with the series impedances of the LISNs, resulting in a differential-mode voltage spectra between the lines. Since the measurement of the conducted voltages (in dBuV) is typically single-ended to Earth reference, the differential-mode potential in the single-ended test is seen as one-half the value of the amplitude that is actually between the typical power pair.

Common-mode potentials are also measured in the single-ended process. These are superimposed upon any differential-mode spectra. Common-mode potentials typically circulate from both lines of the power pair at approximately equal levels in common-phase, as referenced to Earth. At frequencies below approximately 5 MHz, common-mode potentials may circulate from the power pair back to the earth safety wire. In this case, the current will be out of phase with the safety wire compared to the power pair. At frequencies above approximately 5 MHz, however, any interface connections to the product may become involved in common-mode circulations to the power pair. In effect, common-mode EMI emission from the interface cable(s) can circulate through either direct-conducted or distributed impedance paths of Earth reference back to the power pair. Inversely, common-mode EMI from the power pair can circulate through to the interface. When common-mode potentials sourced from the interface circulate to the power pair, the measurement effect may be seen as higher frequency narrowband voltages at the LISNs in power at "logic frequencies".

To evaluate the propagation modes and separate the effects, use of current probes is effective. Differential-mode effects can be investigated by measuring the currents separately on each line of the power pair, then measuring the two together in the probe aperture. Differential levels will show some degree of cancellation for the combined pair, compared to the amplitudes on either wire. Common-mode circulations between the pair that circulates to the Earth safety wire will show approximately equal currents from the pair (combined in the probe) to the safety wire separately, and will suggest a phase cancellation when the safety wire is combined within the probe with the pair. Conducted circulations that are sourced from the interface can be evaluated by placing the probe around the interface cable(s) at the frequency (or spectra) of interest, then comparing this profile to that displayed on the whole of the power cable. When the interface source effect occurs, the solution to narrowband emissions on the power cable may be found in shielding or otherwise suppressing the common-mode currents in the interface rather than attempting to suppress the power entry (which may be futile, since that was not the source).

ICM wishes to acknowledge the first appearance of W. Michael King's "Myth vs. Reality" series with NTS - Silicon Valley.

(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.


Action Plan:
1
2
3

How to Prepare for Possible Product Recalls

BY KENNETH ROSS

In 2011, Australia and Canada adopted new product safety laws that require manufacturers and others in the supply chain to monitor their products in use, and to report safety issues and take appropriate corrective actions in certain situations. In addition, the U.S. Consumer Product Safety Commission has become more aggressive in levying civil penalties on companies who do not report safety problems in a timely fashion.

Therefore, it is more important than ever that companies be prepared to meet these obligations as they design, manufacture and sell their products. Being proactive and prepared before sale can save all companies in the supply chain significant amounts of money and effort, and make any recall or corrective action implemented after sale much more effective.

PRE-SALE PREPARATION

One of the most difficult things I've ever done is try and convince a manufacturer to prepare for a recall when they are first designing a product. This is not something that most manufacturers want to do. They are focused on trying to get a product into production and sold. Unfortunately, after the product has been sold, it is too late to do many of the practices discussed below.

Various entities in the supply chain should try to establish procedures *before* the product is sold so that each entity can, after sale, easily and efficiently obtain information, analyze it, make decisions about appropriate post-sale remedial programs, and implement any necessary programs.

Some of the most significant elements to build into the product's design, manufacturing and distribution processes are traceability and marking procedures for use before and during manufacture and distribution.

To the extent possible, products and, especially, safety-critical components should be marked or coded so that anyone, including customers, can identify the product or component to be returned.

The Retail Industry Leaders Association and British Retail Consortium recently issued some safety guidelines for their suppliers. One of the requirements is that the supplier "shall have a system to identify and trace product lots including raw materials, components and packaging materials and follow this from the source of the incoming material through all stages of processing to supply of the product to the primary *customer* and vice versa in a timely manner."

Manufacturers should think about what they will need to do to recall their product or withdraw it from the market.

This is not easy to do and many manufacturers, especially those who have never had to recall their products, will wonder if the effort is worth it. Of course, in the event of a recall, this tracing will allow the manufacturer of the finished product or component part to narrow the affected population and clearly identify the population to customers. In that case, everyone benefits, from the manufacturer to the retailer to the consumer.

The next important consideration is for the manufacturer, in cooperation with all entities in the distribution chain, to design and maintain an effective database so that different types of entities, including product users if possible, can be identified. These databases must be updated periodically.

One of the most important and difficult tasks is for the manufacturer to set up a communications network before sale so that appropriate safety information is received. A manufacturer has a number of readily available sources of information anywhere their product is sold. Personnel should be trained to ensure that sufficient information is gathered concerning warranty claims, injury or damage claims, accidents, and near misses so that potential problems can be identified.

Personnel should also be trained to identify and clarify the information received so that it is accurate and substantiated. The manufacturer does not want to gather and maintain inaccurate and overstated complaints and claims that incorrectly make it appear that a problem exists.

Post-sale information, some of it unsubstantiated or even incorrect, can be posted by consumers on the Internet. This information needs to be monitored and followed up where necessary. Ignoring such information is risky, but following up on all alleged safety issues can be time-consuming and fruitless.

Manufacturers should think about what they will need to do to recall their product or withdraw it from the market. While the manufacturer will not know what the problem is before it occurs, it can at least think about the ways in which a recall or withdrawal would be communicated and be prepared to get the information out quickly.

For example, how will press releases, customer alerts, distributor bulletins, Web site postings, and questions and answers be used and how will the manufacturer be able to communicate this information quickly and efficiently to the appropriate people or entities. Another example of monitoring the communication stream is deciding whether the information in returned warranty cards is entered periodically or the company waits until a recall occurs.

As discussed below, the manufacturer must understand all legal reporting requirements for each country in which its product is being sold. The requirements have grown recently and are different from country to country. The result is that there may be a reporting responsibility in one country and not another. This may result in a recall in one country and not another.

Canada has a new reporting law that requires reports, in part, for an

The manufacturer must understand all legal reporting requirements for each country in which its product is being sold.

Post-sale incidents may indicate risks or consequences that were never imagined, or change the estimated probability calculated before sale.

occurrence in Canada or anywhere in the world that resulted or may reasonably have been expected to result in an individual's death or serious injury. Australia's new reporting law is likewise based mostly on an occurrence anywhere in the world for a product that is sold in Australia. One difference though is that "near misses" can trigger a report in Canada but not in Australia. In both Australia and Canada, there is an interesting question as to when a foreign manufacturer has a duty to provide occurrence information to Canadian or Australian entities to trigger a report.

In December 2009, the EU issued a new post-sale risk assessment process (see http://ec.europa.eu/consumers/safety/rapex/guidelines_states_en.htm) that should be used to determine if a report to the EU is appropriate and whether any corrective action is necessary. This process could also be useful in analyzing post-sale risks elsewhere in the world.

There is a new draft ISO standard dealing with recalls that will be published in 2013. It is called ISO 10393 and is being developed by ISO/PC 240. It is a "guidance standard" that contains an "international model code of good practice for consumer product recalls and other corrective actions." This standard contains requirements for recall plans and policies that should be developed before sale.

Lastly, in 2004, the EU published a guide to corrective actions in Europe. This guide included suggestions for actions to take place before sale, many of them already discussed here. This guide is being updated and should be reissued in late 2011 or early 2012.

POST-SALE PREPARATION

As a manufacturer obtains and analyzes post-sale information, it must determine whether any post-sale action is necessary at any point in time. This includes reporting to the relevant governmental agency and possibly undertaking some form of recall.

Analyzing the information and deciding what it means is the most critical phase of this process. Many manufacturers use or should use risk assessment prior to selling their products. This process identifies the risk, probability of the risk occurring, consequences if it occurs, and methods to minimize the risk. Before sale, the manufacturer should make a best guess on the probability of the risk occurring. It is, of course, difficult to estimate the probability of an event occurring when it has never happened before.

After sale, the manufacturer is, in effect, considering new information from field experience. Post-sale incidents may indicate risks or consequences that were never imagined, or change the estimated probability calculated before sale. Redoing the pre-sale risk assessment is a good way to formally recalculate the numbers and assumptions. Unfortunately, doing so doesn't really answer the question of whether and what type of corrective action is necessary.

For products regulated by a government agency, the manufacturer needs to identify the threshold for taking action. For example, the CPSC provides criteria for determining the existence of a defect and substantial product hazard. The criteria to be considered are the pattern of defect, the number of defective products distributed in commerce, and the severity of risk to consumers. Using these criteria will provide guidance to the manufacturer about what information to gather and how to analyze it. However, the CPSC provides little further guidance on this basic question, and expects the manufacturer to report a substantial product hazard or any suspicion that the product contains such a hazard.

After the manufacturer reports to a government agency, the agency will most likely, if not always, strongly encourage some type of corrective action. So, the manufacturer must be prepared, if it can as part of its report, to describe the actions that it believes will minimize the risk. It is possible, however, to propose that no corrective action is necessary.

Every entity needs to have experienced technical and legal personnel who routinely evaluate post-sale data and information and decide whether to report to the government and whether to undertake a corrective action or to undertake a corrective action even if no government agency is involved. If adequate pre-sale planning has occurred, implementing the program will be less difficult and more organized than if no planning occurred. Everyone will know what to do and when to do it.

Again, there is guidance on how to undertake recalls. I mentioned the EU guide to corrective actions. ISO 10377 will also provide general suggestions on how to undertake a recall. The CPSC also has a recall handbook. All of these guidelines discuss "best practices" and it is up to the individual manufacturer or product seller to determine which of these practices to utilize in a particular situation. Therefore, there is no such thing as an "off the shelf" recall plan that would make sense for sales of any product around the world.

Recalls can be extremely difficult and very ineffective, despite the best of efforts. There are no clear guidelines in the common law or even with government agencies about how effective a recall has to be. Recalls or retrofit programs with an effective rate of less than 10 percent have been deemed acceptable by the CPSC; the CPSC has said that the average response rate from consumers for most recalls is between 4 and 18 percent.

Virtually no recalls have 100 percent compliance. As a result, the manufacturer will have many products in the field that it has admitted or intimated are defective or at least pose a risk of injury. After an injury occurs and a lawsuit is filed, how will the manufacturer defend its product?

As the program is implemented, the manufacturer must think about how it will prove that its actions were reasonable and appropriate under the circumstances. Again, experienced personnel in this area can help and should be utilized.

Every entity needs to have experienced technical and legal personnel who routinely evaluate post-sale data and information

CONCLUSION

Preparing for a recall before it occurs can significantly increase its effectiveness and lessen the costs and disruption to the manufacturer, distributor and customer. The effort will be well worth it if something happens. These efforts will also generate post-sale information that can provide insights into how your products and maybe your competitor's products are being used. This will be helpful in making future product improvements. The end result will be safer products, less accidents, and more defensible products and actions if problems occur. IN

(the author)

KENNETH ROSS
is Of Counsel with Bowman and Brooke LLP in Minneapolis. Mr. Ross has provided legal advice and consulted with manufacturers on compliance with their post-sale duties, including recalls, for over 30 years. See his website, www.productliabilityprevention.com, for more of his articles on recalls. He can be reached at kenrossesq@comcast.net.

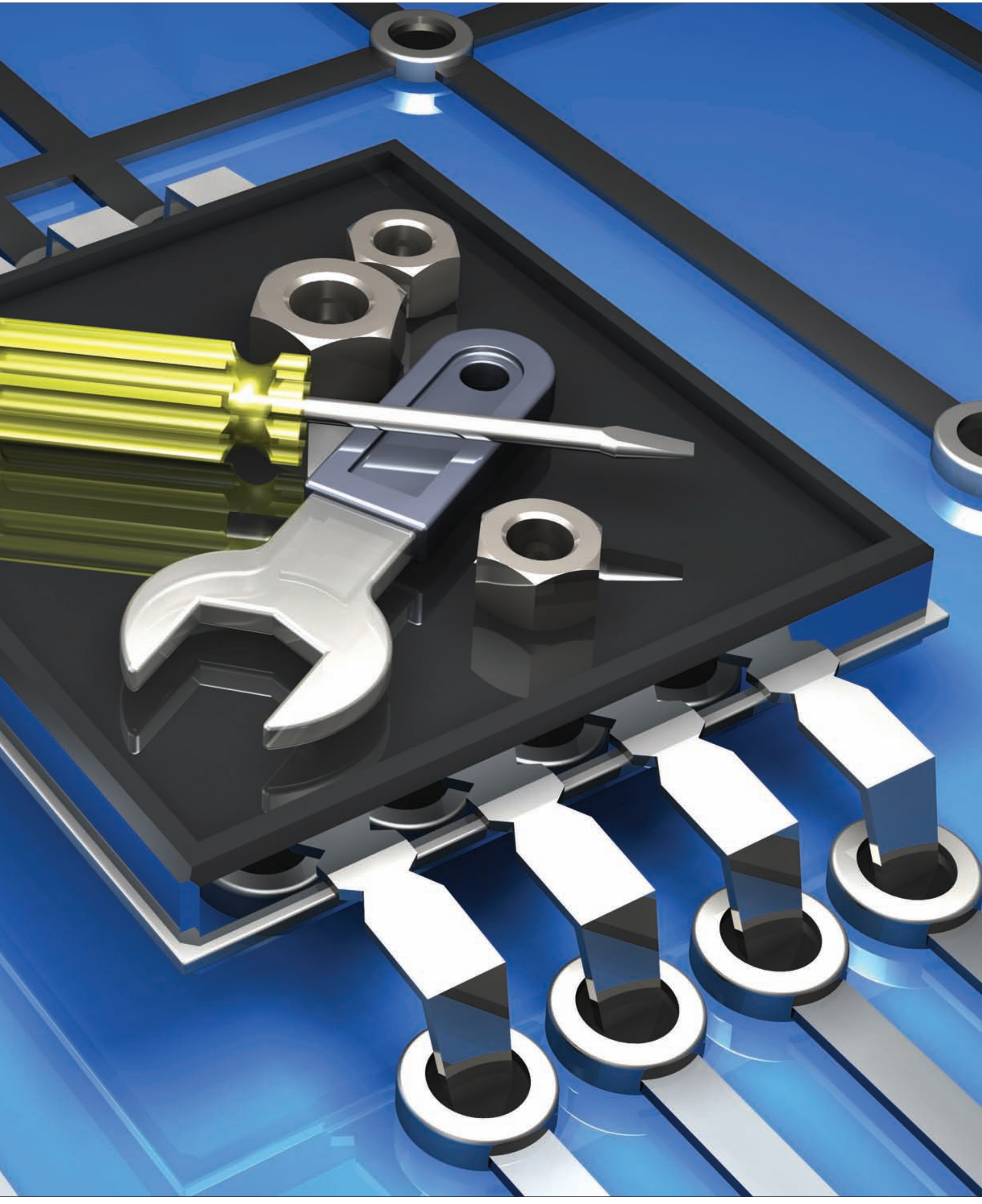
Product Design: How to Get the Design Right the First Time

Many manufacturers design a product first, then attempt to "fix" the design later to meet the applicable safety standard. Prior knowledge of the applicable safety standard and its requirements for the product will help meet deadlines, keep design costs down, and result in a properly designed product.

BY CHERIE FORBES

You spend months, or even years, designing a product. After it's all ready to be shipped to your customer, you find out that you need a safety certification mark. So in a panic, you send the product off to a test lab for evaluation. The shipment is sitting in your loading bay waiting for the final certification to arrive and then the bad news arrives. Your test lab tells you that it fails! This is not only heartbreaking, but time, effort and money are wasted in redesign. Not to mention the delay in shipping your product to the customer! Everyone is looking at you and wondering why it wasn't initially designed correctly. If only you had a manual entitled "Things I need to know to design my product to ensure that it will pass safety testing"! Oh wait…you do! It's called a safety standard. It may have been published by the IEC, UL or CSA, but it contains everything you need to know, right there, in black and white.

If designers have access to safety standards, why is it that most products submitted for certification have a flaw of some sort that causes the product to fail the safety evaluation? Sometimes these flaws are minor in nature (e.g. missing label, wrong wire color used) which don't take much time to fix. But sometimes the flaws require a complete redesign (e.g. replace the power supply, redesign circuit boards, redesign the enclosure). Why don't designers pay more attention to the requirements? A variety of reasons come to mind: lack of time to research the requirements,



Anyone who has read a safety standard will agree that they are not easy to understand, and bring on lengthy discussions when it comes to interpretation of the requirements.

lack of knowledge that the safety standard exists, miscommunication within the design team, etc. Even if the designer doeslook at the standards, it is often difficult to understand the requirements (if you can find them). Anyone who has read a safety standard will agree that they are not easy to understand, and tend to bring on lengthy discussions when it comes to interpretation of the requirements.

What is a designer to do? There are a variety of steps that the designer can take to help insure against costly redesigns.

DETERMINE THE MARKET WHERE THE PRODUCT WILL BE SOLD

The first thing to find out is exactly where your company will want to sell this product. Your marketing department may have already determined this (but may not have shared this with the design team). North American manufacturers will often focus on sales in North America, only later to be surprised when they find out the extent of the redesign required to comply with European requirements. Knowing the target market may affect many aspects of the design: voltage ratings, component selection, wiring methods, etc. For example, selecting an auto-ranging power supply (100-240V) will allow your product to be used in Europe (220-240V), Japan (100V) and North America (120V). If you've designed for the North American market only, you may have neglected the other voltage options, resulting in a costly redesign.

Now that you know what countries you will be targeting, determine what safety related marks are required. The United States and Canada have a variety of options available; many certifiers (e.g. CSA, UL, TUV Rheinland, etc.) are accredited by both the Standards Council of Canada (SCC) and the Occupational Safety and Health Administration (OSHA) as a Nationally Recognized Test Lab (NRTL). Knowing that you can talk to a single certifier to gain simultaneous marks for both countries will make things much easier.

Europe uses a self-evaluation method called the CE Mark. The CE Mark declares compliance to all the directives applicable to the product (e.g. Low Voltage Directive, EMC Directive, and Machinery Directive). Because it is a self-evaluation mark, manufacturers can evaluate the product themselves (with a high level of risk to the manufacturer), or use an agency to evaluate the product on their behalf (low level of risk). Europe has some extra requirements to consider, namely the RoHS and WEEE directives, which have specific restrictions on toxins (mercury, lead commonly used in solder, etc.) and requirements for disposal methods. Many component manufacturers have lead-free alternates to be selected for European markets.

Some countries, such as Japan, have a list of products that need to be certified. Any product not on this list does not need to be evaluated for safety. It's important to look into this beforehand so you can learn the requirements (if any) before designing your product.

DETERMINE THE CORRECT SAFETY STANDARD FOR THE PRODUCT

Now that you know where your product will be sold and the certification marks required for each market, you can determine the safety standard(s) that apply to your product. If you are designing Information Technology Equipment (ITE), you are fortunate because many countries have adopted the same safety standard (IEC 60950-1) [1] and only tweaked it slightly to meet with their National

The first thing to find out is exactly where your company will want to sell the product.

> Most safety standards contain a list of component standards that are acceptable for compliance. Use these when selecting components!

Electrical Codes. Often meeting the requirements for one country will meet the requirement of other countries sharing the same standard.

Some products are not so lucky and have different standards in each country. For example, Industrial Control Equipment has a standard in the United States (UL 508) [2], a very different standard in Canada (CSA C22.2 No. 14) [3], and a completely different standard in Europe (EN 61010-1) [4]. In circumstances such as this, you may need to design with three different standards in mind!

Knowing what the applicable standards are will allow you to purchase them, review their requirements, and use your new knowledge in the design of your product.

SELECT COMPONENTS THAT ARE SUITABLE FOR THE STANDARD

Most safety standards contain a list of component standards that are acceptable for compliance. Use these when selecting components! The safety standards generally allow for two choices: (1) evaluate the component to the applicable component standard (as listed in the standard), or (2) evaluate the component to the product's safety standard. If the component is already certified to the applicable component standard, you can be assured that the component is suitable and will not require additional testing. An uncertified component (including CE marking because it is self-declared) will require additional testing. In general, this testing is at an additional cost and will extend the amount of time allotted for certification.

Always double check that the component is still certified (confirm on the agency website), and ensure that the standard (and the edition of the standard) used for compliance is listed in your product's safety standard.

Keep in mind that each standard may have different requirements for components. For example, the ITE standard for the United States will list many UL standards that need to be met. Since UL standards are used in the United States only, these certifications alone will not be suitable for the European market.

OBTAIN COMPONENT LICENSES

Many component datasheets and catalogues state the safety certification marks and safety standards that the components have been evaluated to. Don't believe them. The marketing teams that produce these datasheets and catalogues make mistakes, incorrect assumptions, or use outdated information. You need to collect proof that each component is certified according to their claims.

Some agencies, such as UL, CSA and TUV Rheinland, have powerful databases on their webpage that allow you to search for licenses. Use these online tools for all your components!

Now that you are sure that the certifications are valid, you need to ensure that you are using the component according to its ratings. Often these ratings are listed on the agency websites and are easy to check. However, for some components, finding the listing on the agency website is not enough. Sometimes the certification record is vague, doesn't list the exact standard, doesn't include things like current and voltage ratings, etc. The only practical way to be sure that the component will be acceptable is to get the licenses from the manufacturer. Component licenses will sometimes include an important section entitled "Conditions of Acceptability", because the component evaluation is not a complete product evaluation. The Conditions of Acceptability include conditions that will need to be met in the end-use product (e.g. enclosure requirements, wiring details) and assumptions that were made during certification (e.g. required airflow, fusing). UL provides this for every component certification in their UL Recognition Program. Other certifiers may provide the conditions, but not always. It is crucial to obtain the Conditions of Acceptability for key components such as power supplies, dc-dc converters and transformers.

Read the Conditions of Acceptability and license and ask yourself "Am I using this component according to its rating?" If you will be using a power supply in a 60°C environment, but the license states a rating of 40°C, then you are using that supply outside its ratings. Never mind that the manufacturer may have provided a derating curve in their datasheet. If it hasn't been evaluated by a certifying agency, consider it to be unproven and therefore unreliable. Using a component outside of its ratings will void the certification of the component and result in retesting of the component in your specific equipment. This is an extra cost and hassle that should be avoided if possible. One simple way of correct this is to source a more suitable component with the correct ratings or adjust your equipment ratings.

Also ask yourself if you are meeting all the conditions stated in the Conditions of Acceptability. If the Conditions of Acceptability state that there must be airflow over the power supply, make sure you are providing that same airflow. If the Conditions of Acceptability state that a terminal block is not for field wiring, you cannot use that terminal for field wiring! You must evaluate these Conditions of Acceptability as they apply to your product with a critical eye!

One more thing to consider is to make sure the licenses you receive from the manufacturer are current! Manufacturers are eager to send you agency licenses that show compliance to old standards or cancelled certificates. Always double check that the component is still certified (confirm on the agency website), and ensure that the standard (and the edition of the standard) used for compliance is listed in your product's safety standard.

Remember, even if the component is certified, if it's not certified to the correct component standard, used outside of its ratings, or certified to an older version of the standard, consider

Design a Suitable Enclosure

There are a variety of things to look at, including material selection, material thickness, openings (including ventilation) and sturdiness necessary to pass the tests of the standard.

Remember, even if the component is certified, if it's not certified to the correct component standard, used outside of its ratings, or certified to an older version of the standard, consider it to be uncertified.

it to be uncertified. If you include that component into your design, you will have increased certification costs to cover the extra evaluation and testing.

DESIGN A SUITABLE ENCLOSURE

There are many things to look for when designing an enclosure for your product. Not only does it have to match the "look" that your marketing department desires, but it has to be functional and pass the tests of the appropriate safety standard. There are a variety of things to look at, including material selection, material thickness, openings (including ventilation) and sturdiness necessary to pass the tests of the standard.

Material Selection

Are you considering a plastic enclosure or metal enclosure? Plastic enclosures have some additional requirements to consider, such as flammability ratings of the plastic. These details are described in the safety standard. Consider the plastic to be a component and look it up on the agency website (UL has an excellent online database for plastics). Make sure the specific plastic you are using is listed there, with the appropriate flammability rating and in the correct color. If your plastic is not listed on this website, not only will you be required to have flammability testing conducted, but annual confirmation tests will also be required (at additional cost to you).

Material Thickness

Plastics that are certified will have been tested at a specific thickness. Often the flammability rating will differ depending on the thickness of the plastic. Making sure that the minimum thickness in your enclosure is greater than that listed on the agency certification is critical.

Openings

Openings in the enclosure, generally for ventilation purposes, create a few challenges: (1) if they are too big the user may be able to touch the circuit inside, creating a shock hazard, (2) if the enclosure is providing a fire enclosure the openings may allow flaming particles to exit or enter the enclosure, thereby defeating the purpose of the fire enclosure, and (3) large openings that house a fan or moving part could introduce pinch hazards without suitable shielding. Ensure that all your openings comply with the requirements of the standard.

Tests

Enclosure tests are commonly conducted in safety evaluations. The enclosure must be sturdy enough that it won't allow a hazard to occur after falling, being leaned on, stood on, impacted, heated, cooled, exposed to UV radiation, or any other foreseeable situation that may affect the safety of the product. You need to consider

Every safety standard is different. You, as the designer, need to thoroughly go through the standard to make sure all requirements are met. Knowledge of these requirements will improve your design.

all the possible tests that will be conducted, as described in the safety standard, and design accordingly.

DETERMINE THE REQUIRED SPACINGS

Knowing what spacings are required between different types of circuits, or between a circuit and an accessible part (i.e. the enclosure) is critical. Planning and designing your wiring boards when you know what is required will save you much time and effort, and will avoid that costly redesign.

Identification of Circuits

The first step is to identify different circuits and accessible parts (i.e. mains circuit, unearthed secondary circuit, earthed enclosure, floating enclosure, etc.).

Create a Block Diagram

Each of these circuits and parts can be considered (and drawn as) a block. Include components that bridge these different blocks (i.e. a transformer, capacitor, relay, etc.). Litter your block diagram with arrows between blocks to indicate where insulation is required. See Figure 1 for a sample block diagram.

Determine the Level of Insulation Required

Referencing the safety standard, determine the type of insulation required between each of the blocks identified with an arrow. Examples of insulation include: basic insulation, reinforced insulation, and supplementary insulation.

Using Tables in the Standard

Determine the creepage distances and clearances required for each of the locations indicated with an arrow. These requirements are found in the safety standard, generally in tables. The required distances will differ depending on the working voltage and the type of circuit.

After determining the required spacings, ensure you are applying these when laying out printed wiring boards. Also consider clearances between boards and enclosures or between adjacent boards.

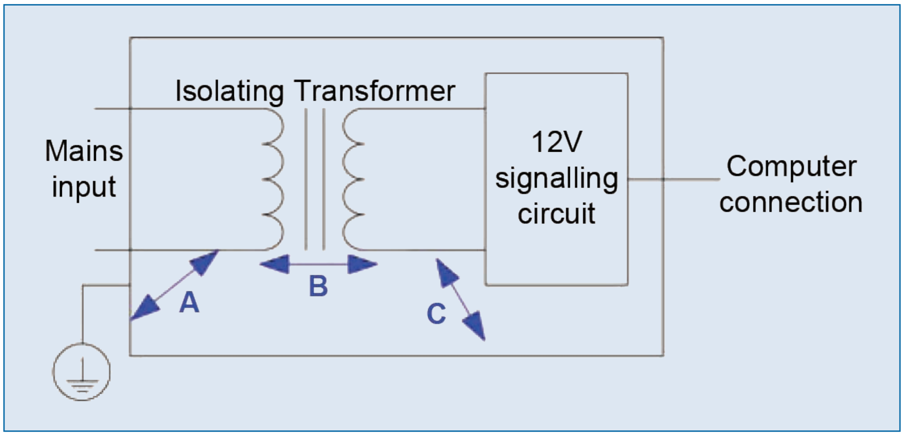


Figure 1: Sample block diagram

SINGLE FAULT EXAMINATION

Knowing what single fault tests will be conducted on your product will help immensely during your design. You need to design your product so it can withstand the fault applied and remain safe. A fire or a shock hazard is unacceptable. Single fault tests include shorting and overloading transformer windings, short circuiting or open circuiting components (i.e. capacitors, legs of optocouplers, transistors, resistors, etc.), blocking air ventilation openings and stalling fans. Anticipating these faults and designing protection devices (such as fuses) into your design will be extremely beneficial.

OTHER STANDARD REQUIREMENTS

Every safety standard is different. You, as the designer, need to thoroughly go through the standard to make sure all requirements are met. There will be clauses about earthing methods and bonding tests, requirements for the sizes of wire used, disconnect devices, fusing requirements, touch current requirements, electric strength testing requirements, etc. Knowledge of these requirements will improve your design.

USING CONSULTANTS WHO UNDERSTAND THE REQUIREMENTS OF YOUR SAFETY STANDARDS

Consultants familiar with your safety standard can be a genuine asset for your design team. They have experience with the safety standard and agencies. They know what requirements you need to consider and can identify

It's critical to know the market your product will be shipped to before the product design is started. Using consultants to assist with understanding the safety standard is another option to be considered.

common pitfalls. They can advise you on the suitability of the components selected and assist with the design of your product (i.e. enclosure design, circuit board layout, etc.). Relying on a consultant will allow you to focus on other aspects of the design, feeling confident that the design will not result in failures during safety certification and evaluation.

SUMMARY

It's critical to know the market your product will be shipped to before the product design is started. Once you know this, you can use the appropriate safety standards when designing your product. Using consultants to assist with understanding the safety standard is another option to be considered.

If you are unfamiliar with the appropriate safety standards that will be used to evaluate your product during safety certification testing, your design will most likely fail. Your components may not be suitable, your enclosure may be inadequate, your circuits may need to be redesigned, etc. When your product fails during safety certification, you will be charged more for extra evaluation. Furthermore, certification failure significantly delays your time to market while you spend time and effort to fix the problems.

Designing to meet the safety standard is the smartest thing you can do! IN

REFERENCES

1. IEC 60950-1: 2005, *Information Technology Equipment – Safety – Part 1: General Requirements.*
2. UL 508, *Seventeenth Edition, UL Standard for Safety for Industrial Control Equipment.*
3. CAN/CSA-C22.2 No. 14-05, *Tenth Edition, Industrial Control Equipment.*
4. EN 61010-1: 2001, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements.*

(the author)

CHERIE FORBES
is an electrical engineer focused on helping manufacturers gain safety certifications such as UL and CSA. She has worked in the product safety industry for fifteen years and is currently an independent consultant at CertAssist Consulting Inc. She was formerly Manager of Engineering for Lamothe Approvals and has published numerous articles and conducted seminars to aid manufacturers with product design. She is currently a member of IEEE Product Safety Engineering Society (PSES), Society of Manufacturing Engineers (SME), Professional Engineers of Ontario (PEO) and Silicon Halton. She can be reached at cherieforbes@certassist.ca or www.linkedin.com/in/forbescherie.

Managing the Use of Wireless Devices in Nuclear Power Plants

BY PHILIP KEEBLER AND STEPHEN BERGER

Wireless technology is experiencing explosive growth. More than just devices of the same kind, there is a proliferation of applications that take advantage of wireless connectivity, using it in new and novel ways. Wireless technology itself is developing and radio access technologies are becoming increasingly complex and sophisticated. The result is that today's electromagnetic environment is changing. This means that old test methods and limits are no longer adequate to insure systems have adequate electromagnetic immunity.

Further, there is a movement to bring wireless into nuclear plants and make it part of plant design. Existing plants have examined the use of wireless, but formal integration is slow. Next generation, advanced plants, some plants presently under construct specify significant use of wireless technologies. There is a wide variety of beneficial applications, including mobile connectivity with personnel, sensing, and wireless data networks. Expanding applications make managing the use of wireless technology in nuclear power plants (NPPs) an emerging requirement.

This article discusses the need to go beyond traditional requirements for EMC interference protection to managing wireless and the use of spectrum so that interference is avoided and wireless services can coexist and operate at the high levels of reliability required by nuclear plants.

The first time a nuclear reactor generated electricity was on December 20, 1951, at the EBR-I experimental station near Arco, Idaho.[1] In 1956, when the first commercial nuclear power station was built, portable wireless devices were not in common use. Portable radio transceivers were first developed in 1940 by the Galvin Manufacturing Company (predecessor to Motorola) who coined the name "Walkie-Talkie". The first Walkie-Talkie was a backpacked unit. Motorola produced the first hand-held amplitude modulation (AM) radio during World War II for military use and called it the "Handie-Talkie". Both devices used vacuum tubes and high-voltage dry-cell batteries. The "Handie-Talkie" became a registered trademark of Motorola in 1951. After the war, Walkie-Talkies were adopted by public safety departments, followed by commercial entities and jobsites. Industrial plants and power plants also adopted them at this time.

The use of wireless devices that transmit and receive radio power in a nuclear power plant (NPP) has been a concern since the first wireless device (i.e., the simple hand-held portable radio transceiver, or Walkie-Talkie) was used in a power plant. Fossil and hydro power plants were the initial users of Walkie-Talkies. When the first NPP went on line in the late 1950s, instrumentation and control (I&C) engineers were surprised to find that Walkie-Talkies were able to cause malfunctions and upsets of analog I&C equipment. EMI problems with I&C equipment caused by portable radios were obviously among the first type of EMI-related I&C problems to be reported.

Similar to the historical path that Walkie-Talkies took, the concept of a radio telephone stemmed from the invention of the radiophone. This was followed by shore-to-ship demonstrations of radio telephony through World War II, when the US military used radio telephony links. Civil service personnel used radio telephony in the 1950s. In June 1946, the first mobile telephone call was made from St. Louis, Missouri using the Bell System's Mobile Telephone Service. The first automatic mobile phone system (Mobile System A), using vacuum tubes and relays designed for an automobile, was launched in Sweden in 1956. A more modern version (Mobile System B), which used transistors to reduce its weight and improve call capacity and operational reliability, was introduced in 1962. This was

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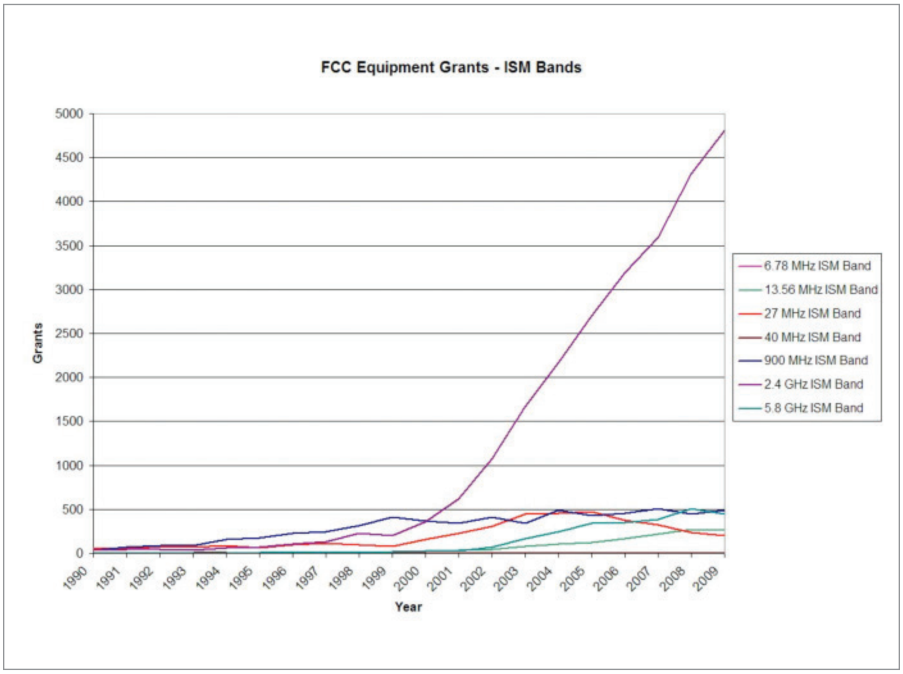

Figure 1: FCC equipment grants for the ISM bands, 1990-2010

followed by the development of Mobile System D, which provided a pathway for different brands of equipment and stimulated the successful use of this technology in commercial markets. In a race against Bell Labs to develop the first practical mobile phone for non-vehicle use, Motorola was credited with its invention in 1973 (the same year that EPRI was founded). As the development of wireless technologies continued to expand, other wireless devices such as cellular telephones (cell phones) began to take shape.

Since that time, efforts to protect against EMI-related events occurring in NPPs have been an ongoing part of risk mitigation. The potential for EMI events from natural and man-made sources has been known for many years. Over time, risk mitigation efforts have seen ongoing development as understanding of the physics of EMI events improves and as changing technology require continual development to keep protection appropriate to the current environment.

THE GROWTH OF WIRELESS TECHNOLOGIES

As the use of wireless technology grows dramatically, not only are the number of devices that use wireless transmission increasing, but the number of bands, modulations and protocols being used are also increasing. The rate of growth in number, as well as the increasing the variety of applications and diversity of potential interference sources, makes a complete listing almost impossible. Furthermore, the result would be of little use, being a long list of devices using virtually every available area of the spectrum for an ever increasing variety of applications. Such a list would provide little to help industries make decisions on how to deal with all the potential sources of interference. Even worse, the list would soon be out-of-date.

A prominent set of examples is the growth of the frequency bands used for industrial, scientific, and medical (ISM) equipment. The ISM bands were established by international agreement to be unlicensed bands, available for a wide range of uses. The ISM bands have been extremely popular, as demonstrated by the dramatic increase of US Federal Communications Commission (FCC) equipment grants for these bands. Figure 1 shows the continued heavy and increasing use of the ISM bands. The 900 MHz, 2.4 and 5.8 GHz bands support the most equipment by far, though recent growth of the 2.4 GHz band is extraordinary. The 900-MHz band seems to have stabilized at a level of approximately 500 new products introduced into it every year. While the 5.8-GHz band is experiencing heavy growth, is it not as notable as the 2.4 GHz band.

Figure 1 through Figure 4 report trends in equipment grants. Each unique model of wireless transmitter must have a FCC equipment grant to be legally marketed in the US. However, the existence of a grant does not indicate whether only a few devices or many millions of them are sold every year. The most popular, high volume product and the very specialized, custom product, each will have one equipment grant. To fully comprehend how widely a set of devices is used requires more information about sales volume, market trends, and whether old models are withdrawn as new ones are introduced. However, equipment grant data is easily quantified and provides an objective basis for demonstrating growth trends. It is important information, but does not provide all the information we want.

Figure 2 through Figure 4 show the most popular equipment categories in each band. As can be seen immediately, a variety of equipment types use each of the ISM bands. Under FCC rules, any device may use the ISM bands so long as it complies with the service rules for that specific band. At one time the FCC tried to designate specific uses for each band, but generally has moved away from that practice for bands such as the ISM. These are now treated as general

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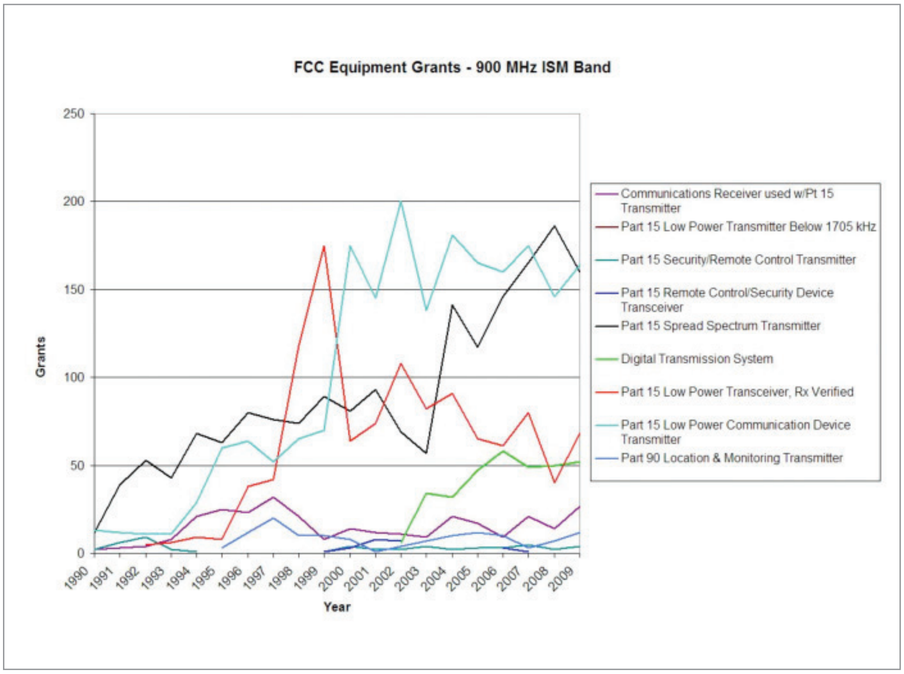

Figure 2: FCC equipment grants, by category, for the 900 MHz ISM band, 1990 to 2010

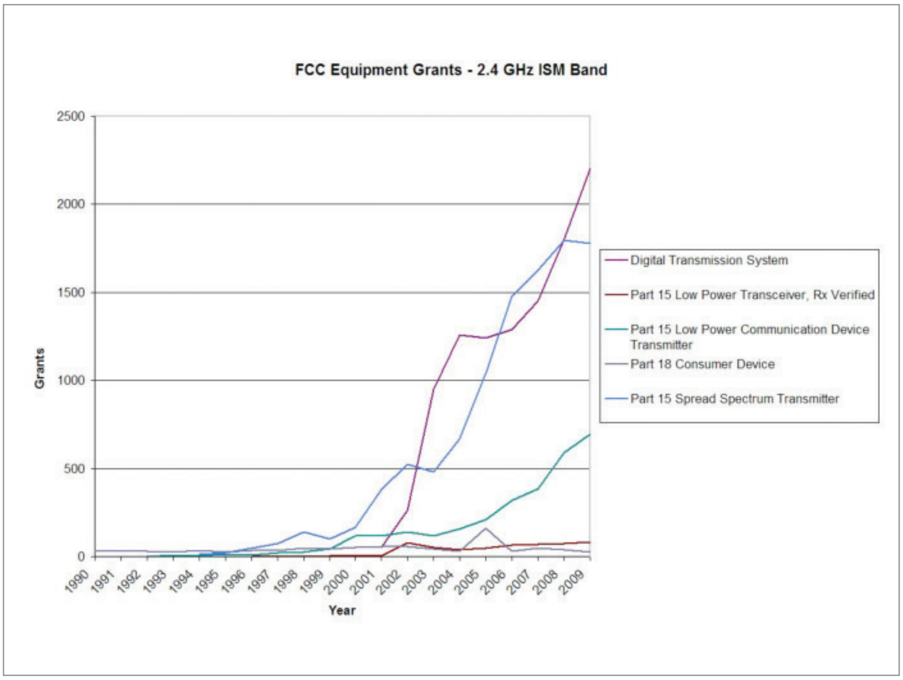

Figure 3: FCC equipment grants, by category, for the 2.4 GHz ISM band, 1990 to 2010

> A method is needed by which those with responsibility for interference avoidance or spectrum management can address classes of products that are of most concern, as well as monitor trends and market changes in many other classes of devices.

use bands, applying a minimum of restrictions and allowing a wide variety of equipment operating access to these spectrums.

Not only is the use of wireless growing dramatically, but the resulting spectrum crowding is requiring a bold, fresh look at how spectrum is regulated. There is an increasing trend toward more flexible spectrum regulations, allowing devices to dynamically share frequency bands. It is now common for devices to be capable of communicating on multiple frequency bands using multiple radio-frequency (RF) protocols. With software-defined radio, a device's capabilities may be changed by a remote software update. The result is that a single device may, from an RF interference viewpoint, be many devices, as it uses different frequency bands and protocols at different times. A single device may be capable of operating on the cellular networks using CDMA, GSM, UMTS or LTE protocols, on local area networks using any of several ISM frequency bands and 802.11 protocols, or by using Bluetooth, DECT, ANT or a number of other protocols and bands. Having access to multiple radio access technologies is a great benefit. However, this benefit presents a real challenge for EMC management.

What is needed for those with a role to play in managing spectrum or protecting against interference is a taxonomy that can bring order to the vast array of potential sources of interference, many of which are known to have caused interference in NPPs. A method is needed by which those with responsibility for interference avoidance or spectrum management can address classes of products that are of most concern, as well as monitor trends and market changes in many other classes of devices. Nuanced solutions are needed if overly conservative requirements, which are either wasteful of spectrum or unnecessarily burdensome on product designs, are to be avoided.

A taxonomy can be conceived that is designed to identify those types of device that have a significant potential for producing RF interference with I&C systems. To produce such a taxonomy, one must understand the characteristics that make a class of equipment sensitive to RF transmission. Using audio interference as an example, audio RF interference requires that the following two conditions exist:

1. The receptor device must be exposed to an RF field with sufficient intensity to overcome its RF immunity.
2. The modulation of the RF field must contain substantial baseband audio components.

Reduction of the RF power or the content of the audio band modulation will reduce the amount of interference created.

Further, for a particular source of audio RF interference to become common, the following two criteria must also be met:

3. The combination of RF field intensity and modulation must be common enough to have an unacceptable probability of causing

an interference problem.

4. There must not be readily available and easily applied remedies available to the user. If interference is easily recognized as being caused by RF and its consequences are neither serious or to rapid for human action to adequately address, then it is entirely possible that some mitigation taken by the operator will be entirely acceptable. An example might be a noise coming from a speaker that is eliminated by moving a walkie-talkie off the console and further away from the speaker.

Relatively few RF devices have these four characteristics. So, serious concerns about RF interference can be focused on those wireless devices that, considered as a class, do have these characteristics and present a serious

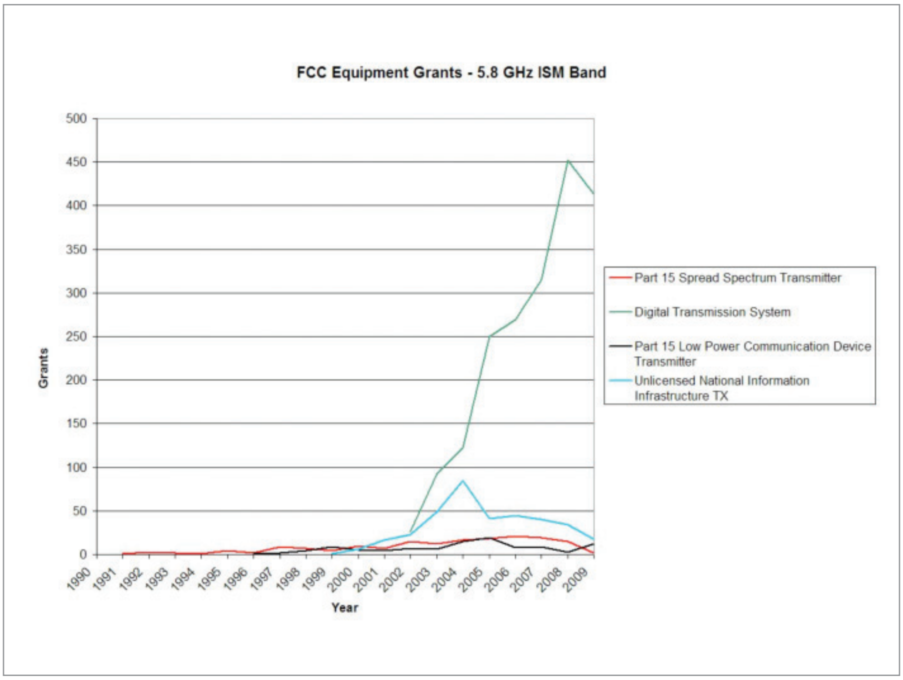

Figure 4: FCC equipment grants, by category, for the 5.8 GHz ISM band, 1990 to 2010

> Some sources of severe interference are not widely distributed in the general population. NPPs may commonly find them introduced. Some kinds of transmitters are intended to be installed in fixed locations, while others are designed to be portable.

threat for producing EMI-related malfunctions and failures. Similar analysis can be developed for I&C systems used in NPPs. The characteristics of a system's susceptibility must be understood in the context of the transmission parameters of potential interferes.

A well developed taxonomy extends from its focal point along multiple dimensions. It will seek to quantify modulation characteristics that impact interference. A constant wattage (CW) signal can introduce a direct current (DC) bias resulting in audio distortion or gain change, but generally these are not observed to be real field problems. At much lower power levels, modulated signals with strong content in the audio band result in disruptive audio interference in devices that produce sound, such as speakers or telephones. Similarly, pulsed modulations may interfere with digital circuits, like those used in digital I&C equipment, in a variety of ways.

Other dimensions may be explored. Some sources of severe interference are not widely distributed in the general population. However, NPPs may commonly find them introduced. Some kinds of transmitters are intended to be installed in fixed locations and remain stationary, while others are designed to be portable. The significance of these sources of interference must be evaluated based on their impact to NPPs.

An additional factor is that the methods used to provide RF immunity to the most common sources of RF interference tend to provide wideband immunity. The result is that I&C systems that are immune to mobile phones will also have good RF immunity to a number of other types of potential interference sources and electronic devices, even though they may operate in different frequency bands. This statement, like most generalities, will have exceptions and must be reexamined as new types of RF interferes are evaluated.

The purpose of this taxonomy is to assure that an adequate level of RF immunity is designed into I&C systems used in NPPs. To achieve this result, the taxonomy must identify the frequency range, power levels and modulation types that systems are likely to respond to. However, the taxonomy must equally identify the severity of the

Few would argue that RF interference is impossible. However, it is more common to hear the defensive response, “My product passed the XYZ immunity standard. How can my product have a problem!!??”

threat so that an inordinate level of RF immunity will not be required, with its attending cost and complexity resulting in overly burdensome specifications for I&C systems.

HUMAN BEHAVIOR

Can humans enable cell phone-related electromagnetic interference problems to occur in nuclear power plants? Perhaps the more significant question to consider is whether humans are in control of the wireless devices they carry. The answer increasingly is NO! Wireless devices are becoming progressively more sophisticated and consistently redesigned to provide new generations of services. At one time, a radio only operated when its user activated it. That is not true today. Many services now provided require that the device be continually in contact with the network and that the network sends information to the device as it becomes available. Consider the simple example of your text messages that appear on your device as soon as they are available. You don’t call in to get your messages, they automatically come to you. That means that your device was in touch with the network, and conducted a communications session to receive the message without your ever being aware of it. If a sensitive piece of equipment like some part of an I&C system had been close at hand, an RF interference event could have occurred.

It is common for humans to assume their normal behavior cannot have negative consequences. Too many of us assume our normal eating and exercise habits do no harm, but our slowly increasing waistline foretells negative health issues in our future. Similarly, many people unconsciously assume their various wireless devices cannot cause problems because they haven’t in the past. Perhaps more accurately, the devices caused problems that were easily solved. Most people have heard interference on their computer or television speaker caused by their cell phones, but solved the problem by moving the cell phone or accepted the interference noise while they were on the phone. They experienced interference but its consequences were either easily dealt with or had little impact. However, in this case the past is not the future (is it ever?). Under the right set of circumstances, RF interference can lead to consequences which have much more impact and, once initiated, are much harder to mitigate or reverse, as in the case of interrupting the operation of a critical piece of I&C equipment in a NPP. Sometimes, once the damage is done, little can be put right and the damage is very bad indeed.

The challenge then is either to train people about the circumstances under which more care must be taken or, alternately, to manage the situation so that those circumstances cannot occur. Either approach works, but historically, if a lot of people (e.g., nuclear plant personnel and subcontractors) are involved, getting consistent, reliable behavior is the more difficult approach. It is often easier and more reliable to manage devices rather than people.

EMI PROBLEMS: CAN THEY REALLY STILL OCCUR?

The fact that wireless devices can cause interference is well documented and easily demonstrated in the laboratory. Even manufacturers of cell phones and other wireless devices know this. The fact that there are RF immunity standards, mandatory for CE Marking and many other requirements, and that many products initially fail these tests demonstrates that susceptibility to RF interference is a real issue. Few would argue that RF interference is impossible. However, it is more common to hear the defensive response, “My product passed the XYZ immunity standard. How can my product have a problem!!??”

Medical Device Interference

Cell phone interference with pacemakers was raised as a problem in the 1990s and received considerable attention at the time.

> Incidents may occur that are not reported because most users of medical devices are unaware that RF fields are present when problems are recognized and because of the intermittent nature of the failures that could cause them to be unobserved.

What is not understood when such statements are made is that all RF immunity standards have a scope and are part of a two-part solution. RF immunity standards are meant to work with RF emission standards to provide a desired level of protection. Standards only work in the context they were written to address, and then only provide the degree of protection they were intended to provide. The commonly used IEC 61000 series of EMC immunity standards were written to provide a basic level of protection to commonly encountered RF environments. The writers of these standards well understand that there are more sever environments and that some kinds of products require a higher degree of protection. Their purpose was to provide general requirements that provide an acceptable level of protection for most equipment. However, as the following examples will make clear, this level of protection is not adequate for all situations or for more sensitive applications.

Medical Device Interference

Cell phone interference with pacemakers was raised as a problem in the 1990s and received considerable attention at the time. However, the issue of RF interference to medical devices is much broader. In a 1998 paper published by the IEEE Engineering in Medicine and Biology Magazine,[2] Howard Bassen of the FDA states:

> *Hundreds of incidents of RFI induced medical device failure have been reported, studied, and summarized. The most likely source of those failures has been RFI from mobile radio transmitters. The consequences have ranged from inconvenience to serious injuries and death. However, many more incidents may occur that are not reported because most users of medical devices are unaware that RF fields are present when problems are recognized and because of the intermittent nature of the failures that could cause them to be unobserved.*
>
> *In the mid-1980s, the US Food and Drug Administration (FDA) had become aware that approximately 60 infants died in the United States while being monitored for breathing cessation by one model of apnea monitor. Subsequent tests have shown that this particular monitor is extremely susceptible to low level RF fields, including those from mobile communication base stations several hundred meters away and FM radio broadcast stations more than one kilometer away. Other apnea monitors have been shown to be similarly susceptible to malfunction. This has resulted in voluntary recall of more than 16,000 apnea monitors.*
>
> *Another device that has demonstrated RFI susceptibility is the electrically powered wheelchair. Unintended motion has been initiated by RFI from transceivers in nearby emergency vehicles, causing persons to be ejected from their wheelchairs or propelled into traffic. New draft performance standards for wheelchairs are being developed by the Rehabilitation and Assistive Technology Society of North America (RESNA) to address these problems; many manufacturers are developing products that conform to these standards.*
>
> *An additional problem area involves implanted cardiac pacemakers and defibrillators. Teams of engineers and cardiologists in several countries have independently studied these devices, either in patients or tissue simulating models, demonstrating that nearby digital cellular phones sometimes induce undesirable effects. The dominant effect observed has been loss of pacemaker adaptive control, causing the device to deliver stimuli either irregularly or at a preprogrammed fixed rate. This is not usually detected by the patient and,*

Electric Wheelchairs

Unintended motion has been initiated by RFI from transceivers in nearby emergency vehicles,

causing persons to be ejected from their wheelchairs or propelled into traffic.

In a Medical Micropower Network (MMN) network, a control unit uses RF communications to receive or send data to implants in a person's body. As can quickly be seen, if an employee has an MMN network prescribed by his or her doctor, it will be extraordinarily hard to keep the MMN network away from the equipment that the employee works with.

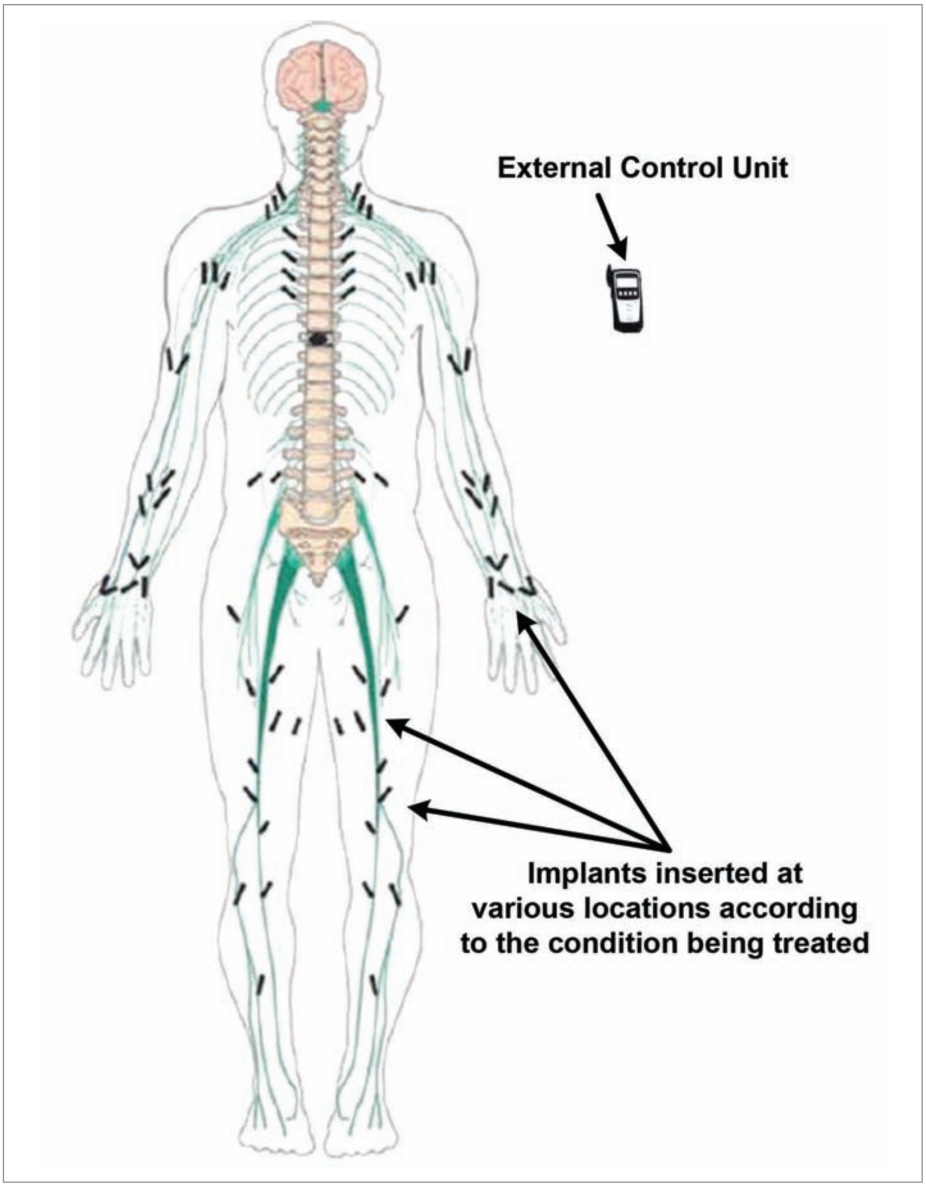

Figure 5: A Medical Micropower Network using RF communication with implants to treat a variety of medical conditions.

when the cellular phones are moved away, the pacemaker resumes its normal operation. Interference with pacemakers has not been observed when the phones are held at the ear. A panel of researchers has concluded that phone/pacemaker interference should not be considered a major public health concern and has offered specific recommendations for pacemaker wearers. Cellular phones have also been shown to cause unintended firings of implantable cardiac defibrillators.

Recently, handheld digital cellular telephones, that use pulse modulated time division multiple access (TDMA), have been found to disrupt the proper operation of in-the-ear hearing aids. TDMA phones include international Global System for Mobile (GSM) communications and North American Digital Cellular (NADC) pulse modulation formats, which utilize schemes that produce 100% amplitude modulated pulses of the RF carrier at frequencies within the audible hearing range. Subjective perception of interference varies from barely perceptible to annoying and loud, starting when the phones are within one meter of the hearing aids and becoming louder when the phones are several centimeters away. This type of interference also occurs in behind-the-ear hearing aids, making it impossible for wearers of this device to be able to use this type of phone.

Recently, warnings have been published concerning the use of wireless communications equipment in the clinical environment. Hospitals worldwide have recommended that cellular phones and two way radios not be used in intensive care units, operating theaters, and patient rooms, where critical care medical equipment is in use. Measurements that have been made inside an ambulance, where electronic patient monitoring equipment is used, have yielded field strengths of up to 22 V/m in the region of 800 MHz. Recommendations have also been made that patients

Today, a powerful transmitter used to connect to the cellular network may not only be a cell phone, but also a laptop computer, electronic book reader, medical device, or even a light pole with a wireless emergency call box.

using medical equipment at home be educated about possible hazards from the simultaneous use of portable telecommunication devices. Extensive measurements have been made to determine the field strengths produced by common RF sources in actual or simulated non-clinical environments, many that are greater than 3 V/m.

This history of medical device interference demonstrates a significant parallel to experiences in NPPs, where the need for constant vigilance of EMI-related interference is well justified. This vigilance is particularly justified by the increasing variety of devices that use wireless connectivity. Today, a powerful transmitter used to connect to the cellular network may not only be a cell phone, but also a laptop computer, electronic book reader, medical device, or even a light pole with a wireless emergency call box. A wireless transmitter may even be in a medical implant located inside an employee's body.

An example to consider is a Medical Micropower Network (MMN) system, which is an exciting new medical technology currently in clinical trials. In an MMN network, a control unit uses RF communications to receive or send data to implants in a person's body.[3] Improved treatment for a wide variety of conditions is potentially possible with such devices. As can quickly be seen, if an employee has an MMN network prescribed by his or her doctor, it will be extraordinarily hard to keep the MMN network away from the equipment that the employee works with. Reassigning the employee may be illegal, as the American's with Disabilities Act (ADA) requires that employers make reasonable accommodations for employees with disabilities. Having digital I&C systems with adequate levels of RF immunity might be considered a reasonable accommodation.

The primary point to be made is that, in the future, wireless devices will be operating inside NPPs. Some even will be part of the I&C systems, such as wireless sensors used to report readings from locations where wired connectivity is not possible. As illustrated by MMNs, wireless transmitters may even be implanted in an employee's body to provide significant health benefits. Labeling wireless devices as "will not cause EMI" and further delaying the development of a wireless device use policy in NPPs is no longer an option. It must be managed intelligently.

Hearing Aid Interference

Early in 1996, the FCC called a Summit between the hearing industry, the wireless industry and consumers to resolve the compatibility issue between hearing aids and cellular phones. Cellular phones using digital technology were then just being introduced in the US. An interference problem with hearing aids had been discovered, and a group of concerned consumer groups petitioned the FCC.

The essence of the problem is that the RF energy transmitted by a cellular phone is received by the circuitry in hearing aids. Significant effort has been invested in understanding and addressing this issue.

In the near-field, the fields from a wireless device are highly variable in intensity and field impedance. Quantification of the environment in which a hearing aid must operate presents a significant challenge.

The new digital telephones caused many hearing aids to "buzz" due to their RF transmission. In their petition, the consumer groups asked the FCC to deal with the problem and assure that people with hearing aids would have the same ability to use these new technologies as everyone else.

As a result of the discussions held at the Hearing Aid Summit, it was decided that a technical standard was needed which would identify a solution to the EMI problem and develop tests to show that a hearing aid and cellular phone were compatible. In the spring of 1996, the American National Standards Institute (ANSI) Accredited Standards Committee (ASC) C63, which is focused on EMC, formed a task group to develop a measurement standard (C63.19) for hearing aid compatibility with wireless communications devices. The goal was to develop a set of parameters and tests that would evaluate and predict the compatibility of hearing aids with cellular phones. The committee recently released the fourth revision of its standard. Each revision has addressed the changing technologies in phones and hearing aids and improved the testing methodology needed to insure RF immunity.

The challenges presented to the task group were formidable. In order to accomplish this task, several significant technical issues had to be faced. The effort required to complete this project ultimately came to include five research projects and over 90 engineers from 50 different companies and organizations including, the FCC and the US Food and Drug Administration (FDA), working together.

The essence of the problem is that the RF energy transmitted by a cellular phone is received by the circuitry in hearing aids. Once the energy is in the hearing aid it may be audio rectified across some non-linear junction, resulting in a "buzz" of different audible noise levels depending on the modulation used by the cellular phone. Significant effort has been invested in understanding and addressing this issue. This mechanism of interference is well known. The challenge in this case is that hearing aid wearers want to be able to use cellular phones. This means that the hearing aid must be located well into the near-field region of the transmitting antenna. Accordingly, an evaluation of the immunity of the hearing aid must be for immunity in the near-field environment, not the usual far-field test used for immunity testing. These near fields can be an order of magnitude or larger than the "standard" immunity test field.

A second challenge is that, in the near-field, the fields from a wireless device are highly variable in intensity and field impedance. Quantification of the environment in which a hearing aid must operate presents a significant challenge. Movements of only a centimeter can produce significant changes in the field magnitude or impedance.

A third challenge is introduced by the hearing aid wearer. The human tissue in the head and hand has a very significant influence on the field

Security personnel who move through all areas internal to the plant and areas external to the plant on the site must be free to use their wireless devices at any time and without limitations.

With the exploding development and use of wireless devices, utilities continue to receive requests for allowing wireless devices in areas of the plant where I&C equipment is installed.

generated by the cellular phone. The question of how to properly account for this field deformation when evaluating a hearing aid's immunity presents special challenges.

A fourth challenge is that many hearing aids are equipped with a magnetic coupling mode, called the TeleCoil (t-coil) mode, in addition to the primary audio coupling mode. Testing for compatibility in this mode has its own set of challenges. For example, there is the possibility of RF interference and electronic noise in the kHz region which adds a second, independent source of interference with the desired reception.

A fifth problem is that the actual annoying effect produced by the use of a cellular phone is highly dependent on the hearing impairment of the user regarding what is really "heard".

The measurement techniques developed for ANSI C63.19 allow the accurate evaluation of system performance for a hearing aid used with the new generation of cellular phones or other wireless communications devices. The resulting tests present new methodology for near-field evaluation of system immunity. This experience illustrates several important points. The first is that new RF immunity standards for specialized standards are necessary. The IEC 61000 series of standards on EMC existed when the ANSI C63.19 effort began, but were not adequate for this specialized issue. ANSI C63.19 also illustrates the need to simultaneously manage both emissions and immunity. In the case of ANSI C63.19, both are managed in the same standard. This is somewhat unusual. The more normal arrangement is that emissions are managed by one standard and often by one regulatory agency, while immunity is dealt with in a different standard and often enforced by a different regulator.

One plant restricted the use of cell phones inside their control room. This decision was based on concerns which stemmed from other plants that cell phones can indeed cause EMI problems with I&C equipment.

CURRENT PRACTICES IN MANAGING THE USE OF WIRELESS DEVICES IN NPPS

With the exploding development and use of wireless devices, utilities continue to receive requests for allowing wireless devices in areas of the plant where I&C equipment is installed. Most of these requests result from internal staff, subcontractors and utility personnel not part of the plant staff who must visit the plant as part of job responsibilities. Moreover, security personnel who move through all areas internal to the plant and areas external to the plant on the site must be free to use their wireless devices at any time and without limitations. With no formal industry-wide policy for controlling the approval or use of wireless devices in NPPs, utilities set out to develop their own internal policies or guidelines, realizing that they would continue to mature as more emphasis was placed on this problem. Some examples are listed below:

1. One NPP has restricted the use of cell phones inside their control room. This decision is based on concerns which stemmed from other plants that cell phones can indeed cause EMI problems with I&C equipment.

2. One utility that operates several plants uses a distributed antenna system in each plant for portable radios operating on the VHF band, cell phones from a specific cell phone manufacturer and approved cordless phones. This utility restricts the use of any other cell phones to office and warehouse areas in NPPs. The utility tried to get another cell phone manufacturer to certify the manufacturer's cell phones to a manufacturing specification, but the manufacturer would not meet their request. As a result, the utility has to test each cell phone model from this manufacturer before allowing the use of that specific cell phone in the plant. Other cell phones have very limited coverage inside these plants.

3. Another utility who operates several NPPs allows intentional transmitters in various areas of the power-block portion of its plants. The utility has some restricted areas that contain sensitive electronic equipment, such as control rooms where only certain intentional transmitters of low power are allowed after they have been evaluated at the plant. The evaluation includes either testing or review of the test report from the FCC submittal of the wireless device, as well as in-situ testing with a setup of electronic equipment that has been shown to be sensitive to radiated emissions from the device. This utility installed a system of slotted coaxial cable in the general areas in most plants for use of portable radios. It also approved some wireless access points and phones to interface with these points. The cables are distributed in limited areas of the plants, including the control rooms. This utility evaluated these wireless systems as follows. It noticed that some modulation and other transmitting schemes had very high peaks of radiated power (many times the stated effective radiated power (ERP)) that do not show up on typical test reports. The peaks do show up on in-situ testing and other evaluations. The utility has requested other specific technical information from cell phone manufacturers, but responses to these requests have been limited. This utility also specifies an "exclusion distance" from electronic equipment that is potentially sensitive to EMI for various approved transmitting devices. The distance is generally three feet for most portable radios and other wireless devices over a few hundred milliwatts. For wireless devices with power levels below 100 milliwatts, this distance is generally one foot.

4. Another utility operating some NPPs states that their control rooms are located inside concrete buildings. The thickness of the concrete prevents wireless power needed to operate pagers and some cellular phones from entering the control rooms. Authorized wireless devices such as wireless telephones used by plant maintenance technicians are allowed to be used in controls rooms.

5. Another utility that owns and operates a number of NPPs does not allow personal cell phones inside its plants. The policy requires that cell phones must be turned off when using electronic dosimeters and at all times in the following areas: power blocks in all buildings, control rooms, cable spreading rooms and relay houses. This utility allows for the use of personal cell phones in the operations and maintenance buildings and in supporting buildings, as well as outdoor areas of the protected and owner-controlled areas. The policies listed above also apply to the line of intelligent interactive cell phones. The use of these policies for these phones stemmed from earlier model cell phones that caused more EMI-related problems in the NPP industry. This utility developed a more mature policy that restricted the use of all cell phones unless an evaluation of the cell phone is done. Usage of a cell phone was allowed because plant workers who came into the plant from the protected area came through the turbine building. This utility has no limitations on the use of older cell phone systems and voice-over-Internet protocol (VoIP) system phones. The utility is aiming to learn how to control wireless devices as they convert their wireless access points to handle data traffic. It also maintains a list of frequencies used by wireless devices inside the plant in an effort to minimize interference problems.

Several plants use a distributed antenna system for portable radios operating on the VHF band, specified manufacturer cell phones and approved cordless phones.

DEVELOPING A WIRELESS MANAGEMENT PLAN FOR NUCLEAR POWER PLANTS

A complete electromagnetic management plan for an NPP should address the following elements:

1. First, the tradition RF immunity requirements of I&C systems should be updated and kept current with changing technology and EM operating environments. As wireless devices are used inside NPPs, these systems must be tested for and immune to wireless transmitters that may operate in very close physical proximity to them. Having a transmitter operate close to a cable or equipment cabinet not only increases the field strength placed on the I&C system, but introduces near-field effects. The electric and magnetic fields will no longer have a fixed relationship, as they do in the far-field. These field components must be considered separately to adequately evaluate the RF immunity of a system.

2. The electromagnetic management plan assumes that wireless devices are part of plant operations, requires that they be tested for co-existence with other systems, and provides adequate levels of reliability even when the spectrum becomes crowded by the growing use of such devices.

3. The electromagnetic management plan should consider low-frequency, high-impact events. Examples are the terroristic and intentional use of electromagnetic interference, direct lightening strikes, and dramatic increases in the use of wireless brought about by the need for emergency personnel responding to a disaster.

4. Finally, the electromagnetic management plan should be alert to the potential for spectrum crowding, looking for bands that may be used by too many devices. Some systems may intentionally be designed to use difference frequency bands so as to separate them from other wireless transmitters. Alternately, RF power management (such as using femtocell base stations) may be part of the plan, allowing transmitters to operate but at much reduced RF power levels.

Together, these components of the electromagnetic management plan, implemented with insight and expertise, will insure that NPPs are prepared to function in their EM environment, benefit from the use of wireless connectivity, but have adequate protection against interference and band crowding issues that otherwise could prove problematic.

> The electromagnetic management plan should be alert to the potential for spectrum crowding, looking for bands that may be used by too many devices.

PRESENT EPRI GUIDANCE ON THE USE OF CELL PHONES IN NUCLEAR POWER PLANTS: WHAT'S WORKING AND WHAT'S NOT

As a result of EPRI's research on EMC and EMI/RFI issues, it published a first cut at developing guidance for the use of cellular phones in NPPs in 1994.

In January 1997, EPRI TR-102323-R1 Guidelines for Electromagnetic Interference Testing of Power Plant Equipment was published. In it, portable transceivers, commercial radios and cell phones were the wireless broadcast devices identified as a continuous, high-frequency radiated source of EMI [see Section 2.1.1 (Sources), Section 2.1.2 (Coupling Mechanisms), Table 4-1 and Table B-1 in TR-102323-R1]. Related susceptibility standards (and guides) MIL-STD-462C: Test RS03, MIL-STD-462D: Test RS-103, IEC 801-3 or IEEE ANSI C63.12 (guide) were also identified as tests that could be applied to I&C equipment to identify susceptibility issues and demonstrate that systems had adequate RF immunity. No further guidance is included in TR-102323-R1 on how to manage the special challenges presented by portable wireless devices. At that time, cell phones were growing in popularity but most were still first generation devices using analog RF protocols. However, by the mid-1990s a second generation of cell phones was being introduced that used digital RF protocols. These devices further accelerated the growth of cell phone use and also introduced a much increased potential for interference. Although the RF power levels of cell phones were the same, the new digital modulation protocols brought a dramatic increase in the potential for EMI problems.

EPRI TR-102323-R2 published in November 2000 and EPRI TR-102323-R3 published in November 2004 provide no further guidance on

Wireless technology has developed to the point where excluding it from nuclear power plants is not a practical solution.

the use of wireless devices, including cell phones. Further research to determine the propensity of these devices to cause EMI problems with I&C equipment used in NPPs was left for the future.

However, in another EPRI report (Product ID# 1011960, Requirements for the Application of Wireless Technology in the Power Industry published in 2005), one of the Equipment Attributes listed in Section 5.3 (Human Asset Requirements for Wireless Sensor Networks) in a table under Section 5.3.1 (Ability to determine what equipment needs to be, and can be, monitored), the following statement is made under 'Sensitivity to EMI/RFI' – "Some equipment itself may be sensitive to electro-magnetic or radio frequency interference. When selecting plant equipment to be monitored, take into account current practices regarding limitations on operation of radios near equipment or control panels." While it is vital to continue warning plant operators and plant I&C engineers on the propensity for wireless devices (in this case, radios) to cause potential EMI problems in power plants, no specific recommendations for determining which wireless devices (or radio) will likely cause EMI problems is made nor is guidance provided on how to mitigate that risk.

FUTURE RESEARCH

EPRI research focused on EMC for NPPs is planned into at least 2013. Through this focus, EPRI engineers are presently utilizing new approaches and methods developed in the EMC industry to solve today's complex EMI/RFI problems and apply them to solving similar problems in the NPP industry. This focused effort is addressing new test methods, developing new standards to integrate new EMI/RFI mitigation technologies into digital I&C equipment while reducing the schedules and costs of digital I&C upgrade projects, understanding what needs to be done to present and future I&C designs to avoid the use of exclusion zones, developing dynamic interactive training materials and modules, further developing electromagnetic management plans and frequency-spectral management plans, and supporting other activities aimed at reducing the risk of EMI/RFI events occurring in NPPs. In addition, EPRI has designed a programmable in-situ test system that can be used to determine if specific transmitting wireless devices will interfere with digital I&C equipment.

CONCLUSION

Wireless technology has developed and proliferated to the point where excluding it from NPPs and where utilizing a blanket-approval approach to allow the use of all wireless devices in NPPs are not practical solutions. Today, wireless connectivity is being planned into many I&C systems, such as reporting critical data from 1,000's of sensors in locations not accessible to plant personnel. What is needed is an RF protection plan complimented by a spectrum management plan which together insure that the risk of interference is adequately mitigated, but further, that the intentional use of wireless transmissions can co-exist and operate at very high levels of reliability.

Taken together, these risk mitigation measures will insure that I&C systems have adequate RF immunity to insure their protection from interference from wireless devices, even interference from low-frequency, high-impact electromagnetic events. Further, wireless connectivity intentionally used in NPPs should be tested for co-existence with other wireless transmission. The ultimate goal is that all systems used in NPPs, wired and wireless, are testing and designed to provide exceedingly high levels of reliability. IN

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(the authors)

PHILIP KEEBLER

is a Senior Research Engineer in the Power Delivery & Utilization Sector at EPRI with one focal area on electromagnetic compatibility (EMC). Philip received his M.S. and B.S. in Electrical Engineering from the University of Tennessee. Philip is active in many professional organizations, including but not limited to IEEE, Illuminating Engineering Society of North America (IESNA), and the Association for the Advancement of Medical Instrumentation (AAMI), and is Chair of the TC-4: EMI Control within the IEEE EMC Society. Mr. Keebler is also currently working on new EMC standards for the nuclear power plant industry.

H. STEPHEN BERGER

Mr. Berger is president of TEM Consulting, an engineering services and consulting firm dealing in regulatory compliance, wireless, voting equipment and EMC.

Stephen was the convener and founding chair of IEEE SCC 41, Dynamic Spectrum Access Networks and immediate past chair of the IEEE EMC Society Standards Development Committee. He is a past president of the International Association of Radio and Telecommunications Engineers (iNARTE), a professional certification agency. Currently he works with ANSI ACLASS as a lab assessor and on issues of conformity assessment.

Before forming TEM Consulting Mr. Berger was a project manager at Siemens Information and Communication Mobile, in Austin, TX, where he is responsible for standards and regulatory management. He has provided leadership in the development of engineering standards for 30 years, including 5 which have been adopted and incorporated into federal regulations by the FCC. More recently he has been active in the areas of dynamic spectrum access and policy defined radio.

A Historical Look Back: The 1977 CBEMA Paper on Electromagnetic Emanations

BY DANIEL D. HOOLIHAN

In the middle of the 1970s, the United States Federal Communications Commission (FCC) began to look seriously at electromagnetic emissions from electronic data processing (EDP) equipment and office equipment (OE). This growing awareness on the part of the United States telecommunications regulation body was a result of the increasing number of computers being used by society and the increased potential for growth by licensed broadcast services due to the proliferation of electronic-computer sources. The Computer and Business Equipment Manufacturers Association (CBEMA) formed a technical subcommittee to assist in preparing an industry response to the concerns of the FCC. This paper reviews the report developed by that technical subcommittee, made public in May of 1977.

TITLE OF PAPER

The title of the published paper was Limits and Methods of Measurement of Electromagnetic Emanations from Electronic Data Processing and Office Equipment.

The paper was published by CBEMA, a trade association dedicated to expanding knowledge in the manufacture, sale, and use of member products. CBEMA was located in Washington, D. C. (CBEMA is now known as the Information Technology Industry Council and is still located in Washington, D.C.).

The report was prepared by Subcommittee 5 on Electromagnetic Interference. SC 5 was organizationally part of the Environment and Safety Committee of CBEMA.

BACKGROUND

The report generated by the Subcommittee on Electromagnetic Interference (SC5) was a result of several years of technical research by the member companies of CBEMA. It was made public "in the belief that it will be of interest and assistance to the CBEMA membership and to other manufacturers of electronic data processing and office equipment, and also to others having an interest in the general subject matter."

In 1977, members of CBEMA had experienced very few interference issues relative to the licensed broadcast

The report suggests general models for establishing the regulatory limits of commercial electronic equipment and presents its results on applying the methodology to products from CBEMA member companies.

Burroughs Corporation	Wally E. Amos, Chairman, ESC5
Control Data Corporation	Daniel D. Hoolihan
Digital Equipment Corporation	Peter Boers
Eastman Kodak Company	Joseph C. Heit
Hewlett-Packard Company	Roy Eberline
Honeywell Information Systems	Herman Held, John Matteson
IBM Corporation	Donald R. Bacon, Ralph Calcavecchio, I.E. Rosenbarker
NCR Corporation	Jack L. Monroe
Sanders Data Systems, Inc.	Richard Bossart
Sperry-Univac	Edward F. Finegan, Al Visek, Vice-Chairman, ESC5
Tektronix, Inc.	Herb Zajac
Xerox Corporation	William T. Rhoades

Table 1: Members of Subcommittee 5 acknowledged in the report.

services in the USA. They attributed this partly to the high standards of engineering and manufacturing in existence for its member companies. At the same time, CBEMA acknowledged the challenge of staying abreast of the fast-moving changes inherent in the transistor-integrated circuit-computer trilogy. CBEMA, therefore, had a strong interest in electromagnetic interference issues and their potential impact on the design and manufacture of EDP and OE.

MEMBERSHIP OF SUBCOMMITTEE 5 – ELECTROMAGNETIC INTERFERENCE

Individual members of the Subcommittee and the companies they represented were acknowledged in the report. They are shown in Table 1.

TABLE OF CONTENTS

The report was 183 pages in length. It included a Title Page, Foreword, Table of Contents, Scope, Definitions, Introduction, seven major sections, Conclusion, and one Appendix.

The seven major sections were:

- Section 4 – Electronic Data Processing and Office Equipment as a Source of Electromagnetic Emanations
- Section 5 – Susceptibility of Communication Receivers to Commercial EDP/OE Emanations
- Section 6 – Interference Potential of EDP/OE
- Section 7 – The Commercial EDP/OE Interference Models
- Section 8 - Emanation Limits for EDP/OE Products
- Section 9 – Comparison of Recommended Limits with Others
- Section 10 – Emanation Measurement

DISCUSSION OF THE SCOPE OF THE REPORT

The report on recommendations from CBEMA on electromagnetic emissions focused on commercial EDP/OE. It addressed both narrowband and broadband emanations from ECP/OE.

The purpose of the report was to disseminate information to manufacturers of EDP/OE, standards organizations (national and international), and regulatory agencies in order to help all parties involved in understanding EDP/OE and its potential for electromagnetic interference. The report suggests general models for establishing the regulatory limits of commercial electronic equipment and presents its results on applying the methodology to products from CBEMA member companies. The limits arrived at through the use of models provides protection of communication services while minimizing emanation control requirements for EDP/OE. Limits and methods of measurement derived from mathematical equations based on the models are also presented.

The limits that were developed are applicable for conducted and radiated

> Since very few interference problems were being reported in the mid-1970s, the CBEMA report identified that the reason for controlling emanation characteristics of commercial EDP/OE is to prevent future interference problems.

emissions from pulsed, periodic, electronic processes occurring in electronic equipment at pulse repetition rates greater than 10 pulses per second and resulting in emanations with a frequency range from 450 kHz to 1000 MHz.

The material in the report was organized in a logical manner based on the basic elements of an EMC interference relationship; that is, the source of the electromagnetic emissions, the propagation means for transferring the energy from the source to the receptor, and the communications receiver that is potentially capable of being interfered with by the sources of emanations.

DEFINITIONS

Definitions covered in the report included: aperiodic waveform, average detector, bandwidth (6 dB), broadband emanation, commercial data processing and office equipment, conducted emanation, electromagnetic interference, emanation, emanation limits, host, identical equipments, interference source, narrowband emanations, peak detector, perception limit, periodic waveform, public power network, pulse repetition rate, quasipeak detector, radiated emanation, radio communication receiver, random waveform, signal-to-noise ratio, spectral occupancy, test unit, and threshold of detectable interference.

REPORT INTRODUCTION

In the "Introduction" of the CBEMA Report, it states that "CBEMA is aware of the responsibilities and concerns of the Federal Communications Commission (FCC) and similar government agencies in other countries to ensure compatibility of RF devices and authorized communication services and has established the ESC5 Subcommittee to study this matter with respect to EDP/OE products."

The Subcommittee studied the technical relationships between electronic products and receivers and their interference relationship. The CBEMA subcommittee admits that the subject is very complex and future studies and reports are anticipated by the subcommittee.

Since very few interference problems were being reported in the mid-1970s, the CBEMA report identified that the reason for controlling emanation characteristics of commercial EDP/OE is to prevent future interference problems.

The Report states that in the USA, the carrier of a continuous wave signal is normally measured with an average detector, while a broadband signal is measured with a peak detector. It points out that in Europe a CISPR quasipeak detector is used to measure all signals. In either case, "measurement of unknown noise source(s) may provide quite different conclusions than observed effects since the measured value depends on instrument characteristics as well as the character of the noise."

The Report highlights the fact that both theoretical and empirical studies

The definition used by CBEMA at that time for the products was:
EDP/OE – electrical/electronic units/systems customarily used in commercial, manufacturing, medical, educational, governmental and similar facilities, and typically not found in home environments.

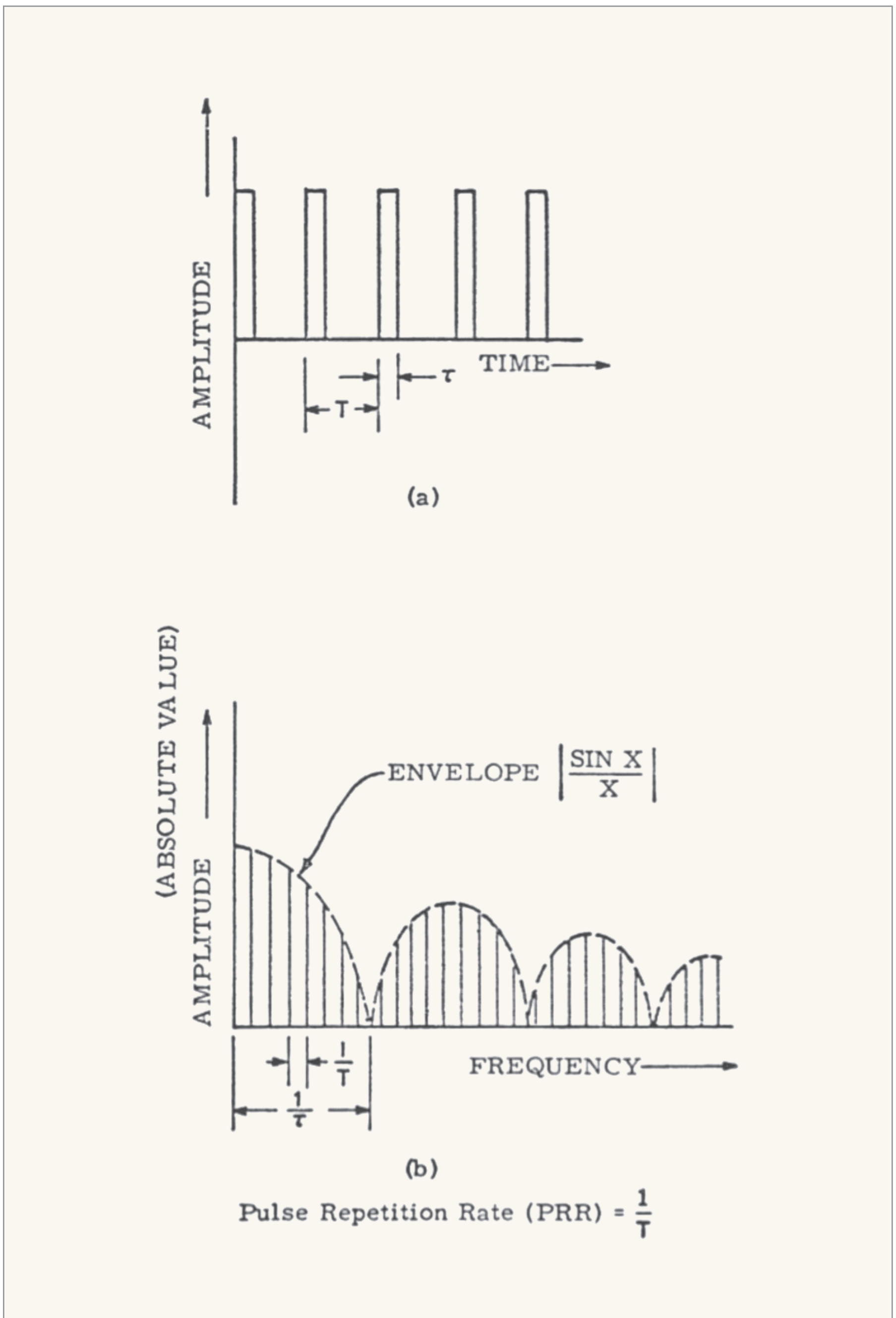


Figure 1: Time/frequency line spectrum for pulsed periodic waveforms

were accomplished over the previous several years to develop a firm technical rationale for the control of EMI. The rationale that was developed implied a quantifiable relationship between emanation sources and communication receivers and is still considered valid for commercial EDP/OE.

The models and resulting limits are considered to be rigorous because:

- They are based on an empirical data base.
- They provide good agreement between the scientific measurement method and the subjective interference effects.
- They are generally conservative.
- They have application to the present USA and International measurement approaches.
- They yield results compatible with environmental experience.

SECTION 4 – Electronic Data Processing and Office Equipment as a Source of Electromagnetic Emanations

CBEMA members designed and manufactured a large variety of computer and business products. The definition used by CBEMA at that time for their products was:

EDP/OE – electrical/electronic units/systems customarily used in commercial, manufacturing, medical, educational, governmental and similar facilities, and typically not found in home environments.

As part of the 1977 Report, EDP/OE were studied to determine their potential sources of emanations. Product installation and product profiles/emanation patterns (polarization and lobing) were study considerations as well.

In the 1970s, EDP/OE were expensive and, therefore, frequently leased by the customer. Whether the equipment was leased or sold, the original manufacturer typically maintained the EDP/OE in the operating environment of the customer (on the customer's premises). Thus, the original manufacturer was responsible for the equipment for its lifetime and the manufacturer could exercise some control over the installation of the product to assist in the control of electromagnetic interference situations.

Sources of emanation in EDP/OE included:

- low-power, periodic, binary pulsed signals necessary for computation of data
- repetitive electronic processes in EDP/OE that produce electromagnetic emanations, which may be transmitted through the air and/or conducted along power lines to the receptors
- authorized communication receivers.

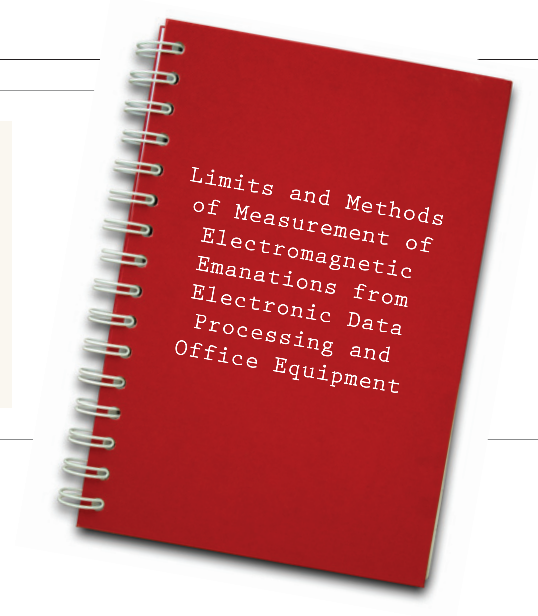
Time-varying signals can be described in terms of their Fourier analysis. The time and frequency spectrums of time varying signals are illustrated in Figure 1.

As part of the 1977 Report, EDP/OE were studied to determine their potential sources of emanations. Product installation and product profiles/emanation patterns (polarization and lobing) were study considerations as well.

The studies resulted in the following conclusions:

- A large number of time-varying processes occur in EDP/OE; some of these signals may have sufficient amplitude to create electromagnetic interference.
- The major sources of electromagnetic emanations are associated with the timing (clock) signals and RF-switching power supplies.
- The periodic sources in EDP/OE occur at pulse repetition rates from 10 to one million pulses per second.
- Higher pulse repetition rates create uniform spectral amplitude distribution over the bandwidth of most communication receivers.
- Spectral line separation increases with pulse repetition rates, and the wide spectral spacing leads to only narrowband receiver responses for most EDP/OE.
- Random sources were found to be few in number and are not considered in the study.
- Aperiodic amplitude-varying sources were also very few in number and also are not considered in the paper.

The following conclusions were reached relative to the propagation of emanations from EDP/OE:



- Emanation profiles of EDP/OE typically decrease rapidly in amplitude above 300 MHz.
- The worst-case emanation profile for radiated emissions is basically the same for different product/system configurations and physical arrangement of the units in the computer system.
- Lobing effects in the 30 to 1000 MHz range are from 8 to 16 dB.

Relative to classification of EDP/OE and their emanations, the report concluded that "the only necessary interference classification should be in terms of the typical environmental relationships between EDP/OE and receivers." Thus, the report concentrated on "commercial environments" for its study since the large majority of computer products at that time were all located in companies.

The emanations from EDP/OE were classified into radiated emissions (propagated through air) and conducted emissions (on alternating current power lines).

(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. Also, he is the Vice-Chair of the ANSI ASC C63® committee on EMC.

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(Authors)

H. STEPHEN BERGER
Mr. Berger is president of TEM Consulting, an engineering services and consulting firm dealing in regulatory compliance, wireless, voting equipment and EMC. For Stephen's full bio, please see page 51.

CHERIE FORBES
is an electrical engineer focused on helping manufacturers gain safety certifications such as UL and CSA. She has worked in the product safety industry for fifteen years. For Cherie's full bio, please see page 35.

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. For Dan's full bio, please see page 57.

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. Mr. Jonassen passed away in 2006. For Mr. Jonassen's full bio, please see page 17.

PHILIP KEEBLER
is a Senior Research Engineer in the Power Delivery & Utilization Sector at EPRI with one focal area on electromagnetic compatibility (EMC). For Philip's full bio, please see page 51.

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. For Michael's full bio, please see page 21.

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. For Brian's full bio, please see page 13.

GEOFFREY PECKHAM
is president of Clarion Safety Systems and chair of both the ANSI Z535.2 Standard for Environmental and Facility Safety Signs and the U.S. Technical Advisory Group to ISO Technical Committee 145- Graphical Symbols. For Geoffrey's full bio, please see page 19.

KENNETH ROSS
is Of Counsel with Bowman and Brooke LLP in Minneapolis. Mr. Ross has provided legal advice and consulted with manufac-turers on compliance with their post-sale duties, including recalls, for over 30 years. For Kenneth's full bio, please see page 26.

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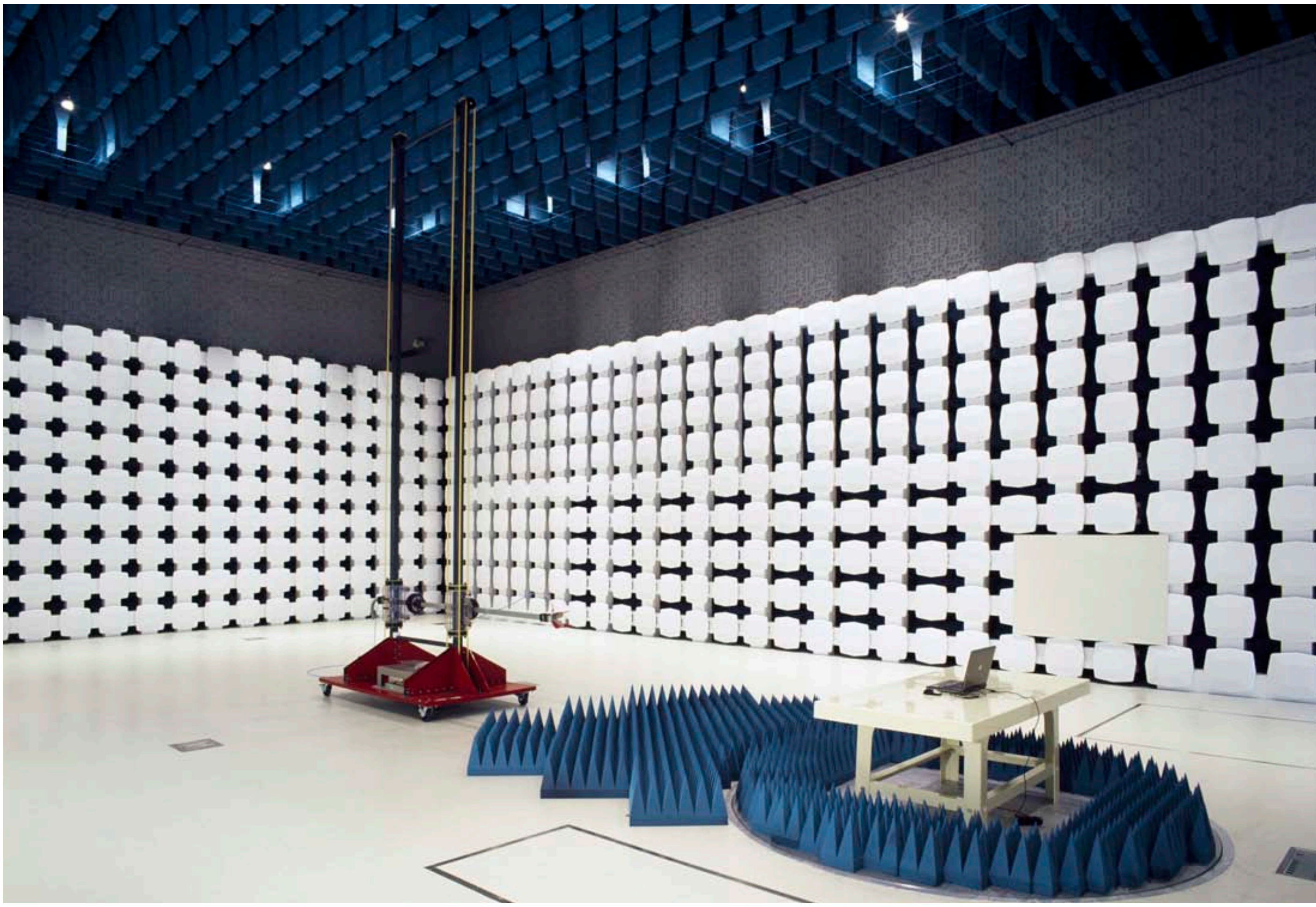

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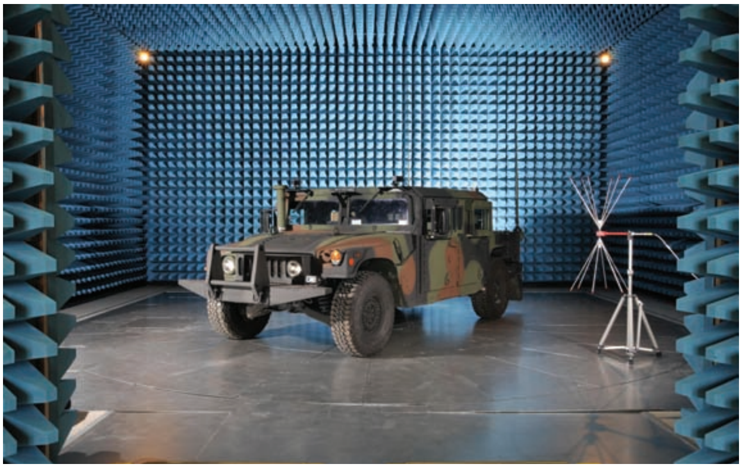

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