

## Prescription for EMI Problems in Healthcare

by Yadin David, PhD, Director of Biomedical Engineering, Texas Children's Hospital, Houston, Texas

Sophisticated electronic medical devices are pivotal to the future of the healthcare industry because of their promise for greater productivity, more efficient organization, accelerated diagnosis of illness, and more rapid treatment of diseases. Already, these devices are flourishing in hospitals and other healthcare facilities.

In 1982, when we began collecting statistics about electronic medical devices at Texas Medical Center—which includes Texas Children's Hospital, St. Luke's Episcopal Hospital, and the Texas Heart Institute—we had about 1100 beds and 4040 devices in our inventory, averaging about four devices per bed.



Photo courtesy of Texas Children's Hospital

Healthcare industry experts anticipate EMI problems may escalate as a result of the increased density of electronic equipment in the clinical environment as well as the proliferation of wireless and cellular communications technologies.

Today, the number of beds has increased slightly to 1300, while the number of devices has ballooned to approximately 20,000—or about 16 devices per bed.

Along with the benefits these electronic devices provide is the greater likelihood of electromagnetic interference (EMI)—invisible waves and pulses, natural and man-made, that move through space and matter. These EMI waves can occur within a facility's physical plant or between broadcasting and telecommunications systems and nearby medical devices. Although the waves are usually harmless, certain devices can and do react to EMI.

As a result, there is a growing need in healthcare facilities to be able to identify and contend with EMI from the standpoint of risk assessment and management. The challenge is that EMI problems tend to be very difficult to identify, are typically transient in nature, and may be impossible to reproduce. In addition, power disturbances from the external utility system, as well as those generated inside the healthcare facility, are key factors.

The most common sources of EMI in healthcare facilities, and therefore of greatest concern, are

- radio transmitters, including radio-paging transmitters and the familiar walkie-talkie units used by maintenance and security personnel;
- television receivers and video monitors;
- cellular and wireless telephones, both analog and digital;

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## Point of View

Deregulation of the electric utility industry is likely to tempt some utilities to deflate their levels of customer service and power system investment. As I see it, power quality will need to be regulated in a more competitive environment.

Already, indices are being developed to facilitate the characterization of power quality levels on the electric power system. The Institute of Electrical and Electronics Engineers Standard 1159-1992 provides a starting point by standardizing power quality definitions. Results from a two-year monitoring project, recently completed by EPRI, provide a benchmark for power quality levels on distribution systems across the United States. The Euronorms (EN50160) in Europe define the levels of power quality to be expected in such categories as harmonics, flicker, regulation, unbalance, and disturbances.

Once deregulation becomes the norm in this country, what will happen to the theme of cooperation between electric utilities and customers? Will utilities still have incentives to help customers improve their productivity and system compatibility? No doubt customers will continue to have power quality problems. So, just where will they go for help in a deregulated environment, in which the power they buy from one utility is wheeled across the transmission system of another, delivered by a third, and metered by someone else? Some type of regulation requiring a basic level of quality and reliability would be a valuable resource.

*Marek Samotyj*

Marek Samotyj, Manager  
Power Quality Joint Target

## SDG&E Power Quality Program Benefits Healthcare Customers

by Robert Gilleskie and Anthony St. John, San Diego Gas and Electric Company, an Enova Company

The San Diego Gas and Electric (SDG&E) service area in Southern California is home to large populations of two significant healthcare audiences—retired senior citizens and young families with children. As a result, we provide electrical service to a high concentration of hospitals, medical centers, and other types of healthcare facilities.

San Diego is also a hub of biotechnology activity. Both the biotechnical and healthcare facilities in the area employ highly sensitive microprocessor-based equipment that can cost in the millions of dollars and require a high-quality source of power. Problems with power quality can disrupt, even damage, these sensitive and expensive devices. In healthcare, especially, we have found that simple power quality problems are often compounded by the industry's critical mission—caring for the quality of life. Uncovering these problems through trial and error places both healthcare facility and utility in a difficult position.

With this in mind, in 1985 we established the SDG&E Power Quality Program to handle the growing number of sensitive electronic loads being served by our power system. The program is designed to respond to any customer call—within four hours—about the way electronic devices use electricity, and about wiring and grounding and their effect on equipment performance.

At the inception of the Power Quality Program, there was not a need to charge for its services. However, with today's incentive to compete in a deregulated environment, we have restructured the program not only to recover costs

but to produce revenue as well. New fee-for-service options are power quality field investigations, power quality audits, extended power line monitoring, problem analysis of data, power quality literature references, equipment specifications, and assistance with the purchase and installation of power-conditioning technologies. Still available at no charge are phone consultations, an on-site visit, and power line monitoring for less than a week.

Following are three case studies to illustrate how our healthcare customers, in particular, have benefited from the program:

- A San Diego health maintenance organization called about failures in its time clock-setting system, which were creating confusion around appointments and other activities. During our power quality field investigation, we learned that power line-carrier devices within the facility's internal power wiring system were being used to send time-keeping communication signals to the clocks. Investigation also revealed that high-frequency "noise," or interference, from electronic equipment within the facility was affecting the communication signals. On our recommendation, the manufacturer installed "noise" attenuation filters on the clocks, which resolved the problem.
- A large community hospital in San Diego was having problems with its emergency generator system, adjustable speed drives (ASDs), and chiller tripping off-line. The hospital attributed these defaults to poor power quality. Upon investigation, however, we found that some of the generator controls and protective devices had been set incorrectly and that most of the ASD and chiller trips were in response to internal disturbances. We verified equipment specifications and provided information to assist the hospital engineer with protection coordination and resetting generator controls.

- Another San Diego hospital was experiencing regular failures of its computerized tomography (CT) scanner, causing the hospital to take this vital piece of medical imaging equipment out of service. During phone consultation, it was noted that equipment failures tended to occur in the morning, coinciding with the time each day when we switched on capacitors to compensate for increasing customer loads on the system. Investigation showed that capacitor switching was causing an oscillatory transient, which was impacting the CT scanner. We worked with the manufacturer to analyze the situation but could not find an acceptable design or power-conditioning solution. To ensure uninterrupted customer service, we changed our capacitor-switching schedule as much as system requirements would allow.



Photo courtesy of Siemens

Electronic medical equipment, like the computerized tomography scanner above, can malfunction or fail as a result of power quality disturbances. Utilities can best serve their healthcare customers by integrating corrective programs into their power systems to handle the growing number of sensitive and high-value electronic loads.

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## Utilities: A Logical Healthcare Ally

by Carolyn Hill, RN, DA, Healthcare Consultant,  
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The healthcare technician completes the electrocardiogram. She removes the leads from the patient as the electrocardiograph prints out the final inch of data. While inspecting the printout, the technician notices an artifact on the machine display that looks like a patient readout. She taps the side of the electrocardiograph. How could this be? Is a stored image inadvertently being displayed? The machine is probably picking up electromagnetic interference (EMI), but she just chalks it up as another equipment aberration.

The larger issue here: Can the technician trust the data? A clinical diagnosis based upon information from electronic medical equipment must be predictable and reliable. Failure to perform a procedure accurately the first time not only compromises patient care, it taxes a hospital's limited resources and saps employee morale.

In my years as a practicing registered nurse and hospital chief executive officer, I encountered many equipment malfunctions without obvious causes. I did not view these malfunctions as mysteries—they were just a way of life. The only solutions I and my colleagues knew were the simple ones: turn off the machine and reboot, change to a different plug, or move to another location. Today, the machines are even more sophisticated, but the way healthcare professionals deal with power quality disturbances and EMI remains unchanged. Rarely are hospital personnel trained to identify and solve such problems.

### *Needed: Utility Expertise*

Utilities can provide a real service to their healthcare customers by helping them learn to identify and solve power quality and EMI problems. While this is a tough job, it's not impossible. And, active support from utilities can pay off in satisfied healthcare customers.

With such support, healthcare personnel can develop a long-term system compatibility plan as an important first step toward addressing power quality and EMI problems. This plan should include policies and procedures that reduce the effects of power disturbances and EMI to acceptable levels. Policies should focus on identifying problems and their associated risks to patient safety, taking proper precautions when problems are identified, and posting appropriate signage—such as *No Cellular Phones*—in critical-care and other areas containing sensitive life-support and monitoring equipment. Procedures should include a mechanism for reporting unusual behavior of medical equipment and a follow-up process for investigating each observation.

A system compatibility program fledged from these policies and procedures and put in place by healthcare facility administrators should include three basic routines:

1. Inventory and record the locations of all equipment known to be sensitive to power disturbances and EMI.
2. Log symptoms attributable to power disturbances or EMI for each piece of equipment in the



*By partnering with healthcare in training programs and problem-solving forums, utilities can play a key role in the development of system compatibility programs addressing power quality and EMI problems in healthcare settings.*

inventory. Interview people who use or have used the equipment, and establish patterns for when symptoms occur and where the equipment is located.

3. Match symptoms to solutions. Find out whether other healthcare facilities have experienced similar symptoms and how they solved the problems. Consider the following six areas when evaluating information from staff and other facilities: applicability, capability, quality, future needs, supplier support, and cost.

Utilities can also provide valuable information and training as their healthcare customers endeavor to inform patients, staff, and the public about system compatibility in the healthcare environment. Equipped with knowledge about power quality, healthcare technicians and managers, in particular, can convene as a power team to lead the effort. Guidance by a skilled facilitator would lend credibility to the team. After all, utilities are the best and most logical place for healthcare facilities to turn in their search for solutions to power quality and EMI problems. ■

## Standards Update

by Tom Key, EPRI PEAC

This column serves as an open forum on power quality standards activities and developments. Please send your comments to [tkey@ieee.org](mailto:tkey@ieee.org) by e-mail.

Standards play a very important role in healthcare. After all, in what other industry are we more concerned with consistent, safe, and reliable services? And, since standards are expected in the healthcare industry, they receive a lot of attention and a high degree of development and practical use. In the area of electrical power, the unique requirements of healthcare have led to a number of special codes, standards, and recommended practices relating to electric service continuity, quality, and interactions.

In healthcare, power quality standards can be characterized in two ways. They either concern (1) a facility's electrical system and wiring, or (2) the way patient monitoring and treatment devices interact with each other and the electromagnetic environment.

**Electrical Systems.** This area includes a facility's power source and wiring to the point of equipment connection, as illustrated in the figure. National Electrical Code (NEC), Article 517, defines the essential electrical system (EES) and specifies its critical and life-safety branches as well as a dual-fed bus for essential support equipment.

Critical branch circuits feed life-support equipment such as cardiac monitors, respirators, and operating-room task lights. Life-safety branch circuits support loads such as egress lights and fire alarms. Both branches must have an alternate source of power within 10 seconds of interruption, with standby power for critical branch circuits being a legal requirement in most jurisdictions. This requirement stems from the concern that power loss may threaten patients using life-support systems.

The bus for essential support equipment powers equipment such as heating and air supply units in patient care areas and fans affecting isolation room pressurization. This bus is also expected to have a backup power source. Voltage drop can be common when large equipment is started on the standby generator, and for this reason, EES wiring must not share panel boards, raceways, or receptacles with other wiring or equipment in the facility.

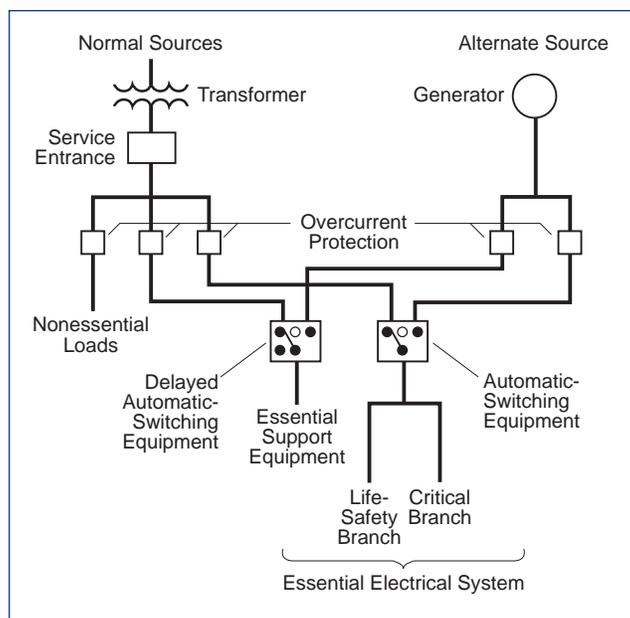
A number of other wiring and grounding practices are permitted or required by the codes and standards of the National Fire Protection Association (NFPA), which are listed in the table along with the other power quality-related standards for healthcare facilities and equipment. These practices include use of metal conduit, separate green-wire ground conductors for branch circuits, physical separation of power and control circuits, local equipment grounding systems, and hospital-grade receptacles in patient care areas. While NFPA 99, *Standard for Healthcare Facilities*, makes local equipment grounding systems optional, it does require performance testing of grounding in patient care areas of new and renovated facilities. Applied as intended, these practices are expected to enhance power quality for medical equipment.

Hospital-grade, or "green-dot," receptacles are not the same as special-grounding "orange-face" (now "orange-triangle") receptacles used for isolated grounds (IGs). In simple terms, hospital grade indicates a receptacle that is capable of high mechanical and overload abuse, has improved equipment

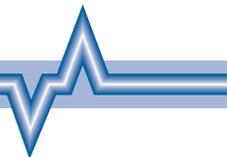
grounding, and is listed by Underwriters Laboratories (UL). These "green-dot" receptacles—long a standard for operating rooms and intensive care units—have been required in general patient care areas since 1990. The IG receptacle, which is optional, is used to protect sensitive electronic equipment from electrical "noise," or stray ground currents. It has been permitted in NEC Articles 250-74 and -75 since 1981.

Another healthcare practice that often affects power quality is the isolated power system. This had been required by NEC Article 517 since the 1940s but was removed as a general requirement of NFPA 99 in 1984. It is used extensively to reduce the possibility of electrical shock during patient monitoring and treatments.

NEC Article 517 also requires the use of a line-isolation monitor with isolated power systems in areas such as operating rooms. In other treatment areas, it dictates special powering, wiring, and grounding requirements—including physical isolation between the power and signal systems—and addresses the



A typical healthcare facility electrical system, as defined in the National Electrical Code Handbook, includes the essential electrical system and its critical and life-safety branches, an essential support equipment system, wiring, and two power sources.



high-power and high-voltage hazards of X-ray machines and other devices.

Healthcare standards allow for considerable isolating—or insulating—of the power supply, related wiring, and equipment grounding. Unfortunately, this can be a significant source of confusion for facility electricians and engineers. With this in mind, two cautions are offered regarding use of the power quality-related IG receptacles:

- Unless specified as hospital-grade, IG receptacles should not be used in healthcare.
- Most IG receptacle applications are ineffective for electrical “noise” control and, in some cases, contribute to equipment malfunction and data-communication problems.

*Patient Monitoring and Treatment Equipment.* These devices are subjected to a multitude of strict electrical requirements, starting with safety standards from UL and the International Electrotechnical Commission (IEC). Additional requirements include emission rules from the Federal Communications Commission (FCC), compatibility limits from IEC and the International Special Committee on Radio Frequency (CISPR), and recommended practices from IEEE and the American National Standards Institute (ANSI).

NFPA 99 also requires medical-equipment manufacturers to test grounding continuity and leakage current of cord-connected appliances in patient care areas according to limits specified in IEC 601. Of these, the main standards for medical devices are electromagnetic compatibility (EMC)-related. They cover installation practices to optimize the environment, and emission and immunity requirements to minimize electromagnetic interference.

Power Quality Standards in Healthcare	For Facilities			For Equipment			
	Emergency Power	Isolated Ground	Wiring	Immunity Limits	Immunity Tests	Emission Limits	Emission Tests
National Electrical Code (NFPA 70)	C	C	C				
Healthcare Facilities (NFPA 99)	S	S,RP	S,RP				
Electric Systems in Healthcare Facilities (IEEE 602, <i>White Book</i> )	RP	RP	RP				
Emergency and Standby Power Systems (NFPA 110)	S	S					
Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE 446, <i>Orange Book</i> )	RP	RP					
Powering and Grounding Sensitive Electronic Equipment (IEEE 1100, <i>Emerald Book</i> )		RP	RP	RP		RP	
Electromagnetic Compatibility (IEC 1000-3, -4)				S	S	S	S
Medical Electrical Equipment (IEC 601)				S	S	S	S
Electromagnetic Compatibility (ANSI C63.18, 19, 21 to be published)			RP,G		RP,G		RP,G
Industrial, Scientific, and Medical Equipment (ISM) (FCC Part 18)						R	R
Radio-Frequency, ISM Equipment (CISPR 11)						S,R	S,R

R=regulation or rule, C=code, S=standard, RP=recommended practice, and G=guide.

Standards supporting the electrical design of healthcare facilities and equipment cover the areas of facility powering, grounding, equipment limits, and testing. They are given legal status when adopted by state or local authorities.

Emissions from and interference between electronic devices have received the most attention from standards. In the United States, the ANSI C63 series addresses the EMC of these devices. Recommended practices to be published include 63.18, focusing on medical-device testing and immunity to specific radio-frequency transmitters; 63.19, targeting interference between cell phones and hearing aids; and 63.21, defining radio-frequency compatibility of patient-connected medical devices. In addition, *IEEE Emerald Book*, Standard 1100, addresses sensitive electronic equipment, and FCC Part 18 regulates emissions of industrial, scientific, and medical equipment.

European standards on medical-equipment EMC are often mandated by local jurisdictions or directed by the entire European Union, whose 1993-issued Medical Device Directive will be effective in June 1998. Some European standards are gaining acceptance in North America as well.

For example, medical-electrical equipment specifications often cite IEC 601-2-1, which covers compatibility limits, tests, and standards from the IEC 1000 series on EMC. They also cite CISPR standards on conducted and radiated emissions and radio-frequency interference.

Given the increasing sophistication of electronic medical technologies and the complexity of power disturbances and EMC problems, power quality standards for healthcare are likely to remain in the spotlight. Utilities that are able to help their healthcare customers solve or avoid compatibility problems will be seen as providing a valuable service. ■

Thank you to two knowledgeable and active participants in healthcare standards development and electrical system design. Hugh Nash of Smith Seckman Reid, Inc. in Nashville, Tennessee, and Rick Smith of Oklahoma Gas and Electric Company in Oklahoma City provided valuable input to this *Update*.

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- computing devices, including microprocessor-based patient monitoring and therapeutic equipment such as electrocardiographs, blood pressure monitors, hyperthermia machines, and security detectors; and
- radiating medical instruments such as fixed and mobile X-ray and electrosurgery units.

In a children's hospital, we also need to consider such potential sources as remote-controlled toy cars and video games.

Some of the complications due to EMI are merely inconvenient, but others can be truly life-threatening. For instance, the Food and Drug Administration (FDA) examined a problem at one hospital involving an anesthetic gas monitor, which detects and reports the amount of anesthetic given to a patient. The device would sometimes display erroneous gas concentration readings during surgery. Investigation revealed that the problem was caused by EMI from the electronic knives used during surgery. (The manufacturer corrected the problem by modifying the gas monitor's software.)

In a 1994 article in *Compliance Engineering*, the FDA listed more than 100 cases of confirmed or suspected EMI problems involving medical

devices taken from reports submitted to the Center for Devices and Radiological Health between 1979 and 1993. These included patient breathing monitors that, because of radio-wave interference, failed to sound alarms when needed; cellular phones that, when used too close to an electronic medical device, interfered with the device's operation; and power-driven wheelchairs that moved unexpectedly as the result of radio-wave interference.

#### *What to Do*

At Texas Children's Hospital, we have implemented a plan with specific procedures for mitigating these types of situations. Our preference, though, is to take the proactive approach. For example, we have identified the frequencies and power of radio-frequency transmitters around the hospital. Then, when a new medical device is being considered for purchase, we test for its susceptibility to the kind of frequencies already known to exist. These steps help us keep an eye on frequencies as they aggregate in the area.

We have also developed a life-cycle replacement plan that allows us to track power system problems on both sides of the meter. Utilities could provide additional support in this regard by furnishing reports of power line disturbances or related events such as lightning flash data.

When considering the installation of new wireless technologies, we conduct a careful field survey to see how the new equipment will affect equipment and systems already in place. When purchasing these technologies, we request electromagnetic compatibility (EMC) data from vendors as a requirement of prepurchase agreements. Manufacturers unable to provide this information are viewed with caution.

We also educate our medical and nursing staffs about the reasons and potential for EMI occurrences. And,

we conduct training programs to make sure that the engineering staff can communicate effectively with physicians, subcontractors, and visitors regarding possible EMI interactions and how to recognize them and mitigate their consequences.

#### *Sufficient Standards*

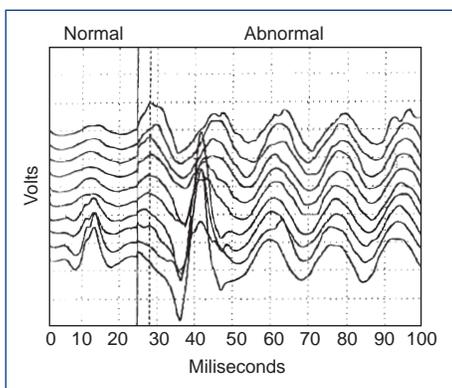
Healthcare is a heavily regulated industry with a solid foundation for ensuring the safety and consistency of patient care. Between the standards and requirements of the FDA, the National Fire Protection Association, and accreditation agencies like the Joint Commission on the Accreditation of Healthcare Organizations, the needed consumer safeguards are in place.

Rather than creating more standards, I would like to see the start of an ongoing dialog between standards-making bodies, regulators, utilities, manufacturers, and healthcare personnel. This would allow us to provide our perspective on the role standards play in promoting safe healthcare operations and serve to bring us into standards development earlier in the process. Such a dialog would also give us more insight into the intent of standards, helping us work with the standards instead of being constricted by them.

Along these lines, I would also like to see the creation of a standards clearinghouse to provide information, interpretation, and guidance to users concerned with the application of standards. Presently, keeping up with the latest standards and requirements for installation and maintenance of electronic medical devices can be a fragmented, costly, and time-consuming process.

#### *More Education*

I consider education to be the answer to many of the power quality and EMC issues facing the healthcare industry today. Utility-sponsored conferences, seminars, workshops,



This electromyogram—of electrical activity in a patient's muscle—shows the impact of 60-Hz electromagnetic interference.

and exhibits would be invaluable, keeping us up-to-date on the evolution of the utility industry while providing training on the best mechanisms for maintaining normal operations during surges, brown outs, and other critical events.

There is also a great need for education on the typical electrical environment in healthcare facilities. Utilities could do more to educate healthcare personnel about the state of the art in utility systems. Case studies could be used to illustrate what works and does not work and then be analyzed for cost-effectiveness. We all know about the cost pressures being put on the healthcare industry these days.

In addition, utilities could offer a multidisciplinary training program in the new language of power quality. This would allow engineering, medical, and nursing staffs to communicate more easily and effectively about power quality-related situations.

Finally, manufacturers and utilities could collaborate to provide an on-site class or simulation study that would give engineers expertise in testing and preventing medical-device interactions. Such instruction would give healthcare facilities a well-trained, on-site professional to provide power quality and EMC guidance—much like pharmacists who offer information on the potential interactions and side effects of medications.

### *Greater Teamwork*

I see a disconnect between research and development in the private sector and the clinical application of electronic devices. For instance, there is very little communication between cellular-telephone manufacturers and the healthcare industry. Education, again, could be a major part of the solution. Common conferences, publications, and exhibits would bring utilities, manufacturers, and healthcare personnel together to discuss electronic-device development, applications, and problems.

## Hotline Highlights

**Problem:** A mobile lithotripter system—used to treat patients suffering from kidney stones—operated erratically at one of several hospital stops in the Southeast. Circuits for positioning patients in the system’s warm-water bath and for targeting a 30-kV arc-generated shock wave to the kidney stone would occasionally malfunction. As a result, the lithotripter was taken out of service at that site, forcing patients to reschedule their treatments for the mobile system’s next visit one month later.

PEAC investigators began by measuring radiated emissions in the area of the lithotripter trailer site. Spectral measurements taken without the lithotripter on-site indicated high levels of 100-MHz radiated emissions, suggesting that an MRI system located just 120 feet away might be producing conducted emissions, or electrical “noise.” Inspection of the hospital’s one-line diagrams showed that the lithotripter and MRI system were powered by the same circuit. Site investigation of this wiring revealed that the power panel containing the lithotripter-circuit main disconnect had no neutral-to-ground bond and that the ground at the trailer pedestal was missing.

In addition, a power line monitor installed in the hospital showed oscillatory transients, which were the result of capacitor switching by the utility. A power line monitor installed in the trailer showed that severe

neutral-to-ground voltage spikes only occurred at the problem site, while oscillatory transients were detected at all hospital sites. Therefore, oscillatory transients were ruled out as a unique problem at the one site. With the mobile trailer on-site, ground-current measurements from the lithotripter power disconnect indicated reversed neutral and ground conductors inside the trailer.

**Solution:** For the grounding problems, PEAC recommended bonding neutral to ground at the lithotripter-circuit main disconnect, installing a ground rod at the trailer outdoor power-supply pedestal, and correcting the neutral-to-ground reversal inside the trailer. For apparent interference problems, PEAC recommended the installation of an isolation transformer as close to the trailer as possible to isolate the lithotripter circuit from conducted emissions from the MRI equipment. The hospital was also advised to add surge protection at the trailer in case of nearby lightning. These changes were made, eliminating all problems at this site. Ideally, in a new siting the trailer should be relocated farther away from the “noisy” MRI system and put on a dedicated circuit with a stiff source (short run) from the hospital’s electrical distribution room.

Highlights come from the PEAC Hotline. If you have problems you would like addressed, call 1 (800) 832-PEAC.

Community disaster planning provides an excellent model of collaboration between utilities and healthcare providers. In disaster planning, a task force with representatives from both industries establishes an emergency command post and maintains a diligent dialog because of the critical need being served. There is a clear understanding of the need to work together, with well-defined expectations. I would like to see this relationship extended to day-to-day operations to include utility personnel,

architects, contractors, biomedical engineers, doctors, nurses, administrators, security officers, and other physical plant personnel.

The use of electronic technologies in healthcare facilities is only going to keep growing. With this in mind, now is the time to expand the dialog between healthcare facilities, utilities, regulators, and manufacturers. It needs to happen sooner rather than later. ■

We have found that power quality is one of the best ways to add value to the electricity we provide. This has been confirmed in survey after survey, with customers stating that power quality advice is one of the services they appreciate most. This fact has driven not only our consulting and monitoring services, but also the preparation of brochures and information guidelines and the planning of services and seminars. In 1997, for example, we will offer our customers six power quality seminars covering such topics as economics, wiring and grounding, power quality disturbances, and monitoring.

In another effort to help customers solve power quality problems, we have agreements with manufacturers, who are available to provide mitigation equipment such as uninterruptible power supplies, isolation transformers, and surge protectors.

We have also put in place a number of internal tools. These include a special request form on the company e-mail system that enables anyone at SDG&E to request help from power quality engineers. This program facilitates the timely assignment of power quality tasks to engineers and prompt solutions to customer problems. We also intend to use the EPRI Power Quality Database to compile site investigation reports. These reports will be helpful in recommending solutions to specific power quality problems and will provide valuable data for solving similar problems in the future. Finally, we conduct regular customer surveys to keep tabs on the perceived value of

## EPRI R&D Corner

Member utilities can enhance their power quality support to healthcare customers through two EPRI programs:

The EPRI Healthcare Initiative (HCI) involves more than 90 electric utilities working together to help hospitals and other healthcare facilities reduce risk and liability, meet regulatory compliance demands, and provide the highest-quality patient care. Power quality services include facility assessments to identify methods for improving building efficiency and power quality, on-site troubleshooting, and use of advanced monitoring equipment to solve customer power quality problems. In addition, HCI offers power quality overview training seminars for member utilities and their customers, covering the impacts of wiring and grounding, voltage variations, harmonic distortion, and transient disturbances on electronic medical equipment.

Task 22 of the EPRI PEAC System Compatibility Research Project is studying the electromagnetic compatibility (EMC) of electronic medical equipment. Research focuses on identifying and finding solutions to the root causes of compatibility problems with

medical devices. To this end, PEAC coordinates participation of the utility and healthcare industries as well as manufacturers of medical devices. Deliverables include a detailed report of case studies, a database linking case studies and information about medical equipment and healthcare standards, a complete report of testing and field investigations, and one or more power quality training workshops for utilities and their customers.

Participation in both HCI and Task 22 allows utilities and customers to characterize the overall power quality performance of a healthcare facility while obtaining information about the EMC of selected electronic medical equipment. EPRI shares this information with equipment manufacturers and standards organizations to provide a better understanding of how power disturbances and electromagnetic interference affect the performance of medical equipment.

For more information on HCI, contact Karen Forsten at (423) 570-8014 or [kforsten@aol.com](mailto:kforsten@aol.com) by e-mail. For Task 22, contact Gene Sitzlar at (423) 974-8314 or [gsitzlar@epri.com](mailto:gsitzlar@epri.com) by e-mail.

our program. In cases where customers indicate they are less than "very satisfied," we do follow-up surveys to determine why and what more can be done.

We've found that our power quality efforts do not go unnoticed by SDG&E customers and have seen continued growth in the levels of customer satisfaction with power quality. Last year, 95% of our large customers—which includes healthcare—called themselves "very satisfied." ■

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