Image courtesy of ETS-Lindgren

MR advancements call for new shielding techniques

By Lauren Dubinsky

When Chris Tomlinson, radiology imaging director at the Children's Hospital of Philadelphia, received complaints from other areas of the hospital about the loud noises from their MR scanners, he knew something had to be done about it. "When you put an MR in, if you're not shielding it you can definitely have some complaints from neighbors — they may be on the other side of the wall or even on other floors," he says.

It's also a reimbursement issue now that patient experience factors into how much a hospital gets paid. "Especially in this day in age when we're trying to provide a really positive patient experience and [they] sit in the waiting room and hear all these high-pitched and varied MR noises—it's a real challenge," says Tomlinson.

The newer MRs on the market generate more acoustic noise than the older systems because of their more powerful gradient coils. Meanwhile, the realization and importance of shielding for that noise has become much more prominent over the last five years.

Shielding the noise

"The recognition that this is a problem is now kind of putting more architects on the hook for determining the smartest way to reduce that noise from penetrating the walls into the adjacent space," says Michael Krachon, director of Imedco.

Joel Kellogg, product line manager at ETS-Lindgren, noticed that many children's hospitals in particular are interested in this type of shielding. "You're dealing with young kids that you have to potentially send into an MR and just with the noise alone and the build-up to getting an MR there's concerns about how the kids are affected by that," he says.

A few MR shielding companies including Imedco America Ltd. and ETS-Lindgren now offer solutions for this problem. Children's Hospital of Philadelphia installed Imedco's SilentSHIELD doors and shields in all nine of their MR suites.

At ETS-Lindgren, they acoustically shield an MR room through general construction practices. They make sure that the rooms are constructed so that they're airtight because the acoustic sound can escape through cracks, gaps or poorly constructed joints.

To construct the walls of the room, they use common building materials — two layers of drywall with steel studs— and make sure to carefully arrange it. They ensure that the wall structure connects the ceiling and the floor structures so that there are no cracks or gaps and fill the cavity wall inside of the RF shield with fiberglass insulation.

The air ducts within the room can often be the culprit behind transmitting the noise to adjacent rooms but to avoid that they line the air ducts walls with a thick, absorbent material.

Even though lead shielding costs more than drywall, it can also be effective in reducing acoustic noise since lead is soft and does not readily vibrate. Another method they use is putting the magnet on the ground floor and constructing an isolated room slab or magnet pad to reduce the amount of vibration of the floors and walls.

Opening the door to new features

In the past, when patients were connected to an IV and needed an MR scan, they either had to be disconnected from the IV or the facility had to purchase expensive MR-compatible infusion pumps. But a new technique allows the patient to remain connected to the machine without having to bring it inside of the room.

"What has come of interest is a way to allow that patient to remain attached to the machines and allow the machine to remain outside," says Imedco's Krachon.

Imedco created what they call a Pass-thru IV Door Waveguide, which is a portal built into the door. They weld the waveguide itself into the frame so that it's seamlessly integrated and can be conductively attached to the door when it's closed. The IV lines are then put through the waveguides when the door is open and then when it's closed, the waveguides are enclosed and protected.

Krachon says the waveguide has become more popular over the past two to three years, although the first prototypes were installed in the research setting about a decade

ago. He thinks the interest might be due to the clinical importance of keeping certain patients connected to the IV source, especially neonatal intensive care unit and pediatrics patients, and the high cost of MR-compatible infusion pumps.

Children's Hospital of Philadelphia installed the IV Waveguides in their MR suites and it has greatly helped them improve productivity and patient safety, says Tomlinson. "Here you have this waveguide in the door and you just tuck the tubes and you're done — you're not unhooking anything so it's great for time and patient safety," he says.

Other features that are gaining interest are secured access systems such as keypad entry and card reader systems. "It has become more important to ensure that the only personnel walking into the room are those that are qualified or certified or have authority to do so," says Krachon.

Along those lines, many facilities are also interested in ferromagnetic detection systems that detect ferromagnetic objects before they enter into Zone IV of the MR room. Imedco builds KOPP Development Inc.'s FerrAlert HALO II into their doors, which sets off an audio alarm as well as indicator lights if a ferromagnetic object is detected.

For some states it's becoming a requirement — 16 states have adopted The Facility Guidelines Institute's 2010 guidelines for design and construction of health care facilities, which requires siting of ferromagnetic detection systems.

Additionally, in the Joint Commission's new proposed standards for MR safety, they're requiring that facilities log all ferromagnetic threats that enter into Zone IV of the magnet room. KOPP will be unveiling an accessory at this year's RSNA to help facilities comply with those new standards.

If the indicator lights are green that means that no ferromagnetic objects were detected, if they flash yellow then a ferromagnetic objects is approaching and if they flash red then a large ferromagnetic object such as a ventilator or oxygen cylinder is approaching.

The indicator lights flash in the region of the ferromagnetic object to make it easier to locate it. The lights also flash on both sides of the door so that the people outside and inside of the room are aware of a potential threat.

However, not everyone is convinced that the detection systems are a great idea. Michael Profeta, owner of Magnetic Resonance Technologies, knows some facilities have become complacent because the systems generate too many false positive alarms.

Sometimes, the RF door will set off the alarms when it swings into the room since it has some amount of ferrous hardware incorporated into it. Also, when a technologist is walking out of the room, if she is wearing an undergarment with metal underwire it may also cause false positive alarms

KOPP will be unveiling two accessories at this year's RSNA that will prevent both of those issues.

Is copper the way to go?

Many shielding companies agree that copper is the best material to use to construct shields. Copper is known to be one of the most conductive materials available that is reasonably priced, according to ETS-Lindgren's Kellogg.

"The higher the conductivity of the material, theoretically the higher the performance should be or the easier it is to achieve that higher performance," he says.

ETS-Lindgren constructs almost all of their shields with copper except for the door jamb and the windows, which are made with aluminum.

Imedco's Krachon also chooses to use copper for their shielding because it's the only design concept that they can warrantee for its lifetime since it does not degrade overtime due to oxidation or rust. He says copper is also a good choice for an area that is prone to flooding. The zinc in galvanized steel, another popular choice, deteriorates if it's exposed to a lot of moisture.

Copper seams are also covered by soldering, which seals them tightly but galvanized steel seams are bolted together and much more likely to lead to leakage.

However, not everyone agrees. Howard Newman, vice president of Universal Shielding Corp., says that his company constructs their shields with galvanized steel. They chose that material because it provides some degree of magnetic shielding and he believes that copper is not an essential.

"You don't really have to have copper to do an MRI room—it's really not necessary," said Newman. "I think a lot of customers think that they have to have copper."

Although copper RF shields are more expensive than galvanized or aluminum shields, Imedco believes that the reliability and ease of modification justify the price. Magnetic Resonance Technologies and National MRI Shielding also use copper for their RF shields.

Repair it, don't replace it

About five years ago, Magnetic Resonance Technologies started their MRI Shielding Planned Maintenance Program in which they go into facilities quarterly, biannually or yearly to test RF shields.

"Finding the leaks in a shield is more of an art than a science," says Profeta. "You have to pair a lot of things together — test equipment, measuring, intuition, experience and you have to have technical understanding of what you're doing."

Over the years, he found that 90 percent of the rooms he tested didn't meet specification. The most common issue is the doors, which is just a matter of wear and tear.

"Door maintenance is part of it, but there are things that can happen overtime that other areas become compromised," he says.

In prefabricated MR rooms that are bolted together, Profeta finds that the wood shrinks and the bolts loosen up over a period of four to five years. Water from sinks in an upper level that overflow, a broken sprinkler pipe or flooding from weather events are also common problems he comes across.

About 150 facilities use the service but Profeta says that it's not something that every facility is willing to shell out the money for. "It's a hard sell because people don't want to spend money on something they're not making money on," he says.

However, there are a few ways that shield testing and maintenance can indirectly save facilities money. If a facility is noticing artifacts in their images and they call a service person from their MR vendor, the service person will say that they want to ensure that the RF shield is working to specification before they continue to work.

"Now they are dealing with compromised imaging until someone gets there to do the task and see what's going on and then they have the repairs to deal with," says Profeta.

When a facility purchases a new MR, they must have the room tested, but before they get to that point, they already would have hired a contractor, rented a mobile or suspended MR procedures until the project is finished.

However, if they find out after the test that the room has a lot of problems, that will add more days to the project, which will cost them more money. "You won't get away from the cost of the repairs but you can get away from the surprise of adding time to your project that you didn't budget for," says Profeta.

Profeta is a big advocate of repairing shields rather than purchasing a new one because he believes it's always less expensive. "You can always fix it and it's always cheaper and it's not compromising any quality," he says.

ETS-Lindgren also believes that facilities should avoid purchasing a new MR shield. When a client is purchasing a 1.5T MR, they will ask them if they are considering upgrading to a 3T MR in the future. If the

answer is yes, then they will recommend designing the room for a 3T MR so that they won't have to upgrade the RF shield or get a new one.

"You're largely reusing that shield and you're minimizing your construction costs and your downtime," says Kellogg.

However, there are times when a new shield is needed, but that's usually when it's over 20 years old. "If the shielding is in really bad shape — it's not testing well, they're finding all sorts of problems with the shield — then there may be a recommendation to pull that out and replace it," said Kellogg.

The complexity of an iMR shield

A lot has to be taken into consideration when constructing a RF shield for an MR suite, but shielding for intraoperative MR (iMR) can be even more cumbersome. The MR can be sited three different ways — permanently or temporarily in the surgical suite or in a room adjacent to it.

When the MR is in an adjacent room, the only primary shielding requirement is a connecting RF door, which can either be a swinging double or a sliding door.

It gets more complicated and costly when the MR is permanently within the surgical suite. The entire suite has to be RF shielded and every service coming into or out of the suite has to have a RF filter or waveguide.

Additionally, instead of just having one door like a typical MR room, it must have multiple doors and all of them must be RF shielded. "You'll have multiple doors going into the OR and the MR rooms and adjoining rooms as well, and that creates a situation where you really need to pay attention to how you're coordinating or interlocking these doors," says ETS-Lindgren's Kellogg.

It's even more challenging to accommodate an MR that is temporarily in the surgical suite. Firstly, the doors have to be big enough for the magnet to move into and out of the suite and they also have to be automatic and have non-friction seals and a flat threshold.

The magnets are moved into the suite by an overhead rail and its supports are tied into a structural system, which must also be RF shielded.

Since the MR has to remain connected to an exhaust ventilation system that trails into the suite, that means the doors cannot be closed when the magnet is scanning. As a result, the room where the magnet is stored also has to be RF shielded, which means more RF doors, filters and windows are needed.

All of the scenarios also require an RF floor that can be easily maintained in a sterile surgical suite such as a moisture resistant RF floor system. If that type of floor system is not installed then the floor will degrade because the amount of cleaning the surgical suite requires.

Brigham and Women's Hospital has an intraoperative suite that is compromised of a central operating room flanked by two rooms housing an MR scanner in one and a PET/CT scanner in the other.

"We have two paradigms of workflow—the MRI scanner moves on ceiling tracks into the operating room to the patient, whereas the patient must be transferred to the PET/CT room and into the stationary scanner," says Daniel Kacher, clinical engineer in the biomedical engineering department at the hospital.

They installed a set of ETS-Lindgren's Intra-Operative Sliding Doors between each of the rooms. Initially, the doors were too heavy to move because of the copper and lead shielding but they solved that by making them pneumatic and developing a programmable logic controller with a touch-screen interface.

The doors have a couple safety features including a light curtain on the inside edge of the door that can detect anything preventing the door from closing including a person or piece of equipment. The hospital also partnered with ETS-Lindgren to develop interlocks so that the door between the MR room and the control room lock when the sliding door is open.

"This is critical because when the MRI scanner enters the operating room, the attention of the MRI technologist is required at bedside," says Kacher. "Since the door is locked, we can remain confident that no one will inadvertently enter the MRI room, which reduces risk of adverse events with the magnet."

Imedco's Krachon says that iMR suites have become more popular in recent years. "It's certainly becoming much more common to see an intraoperative suite — it's been available for quite a few years, but the prominence of that something that I believe is increasing," he says.

Since it's such an expensive project, he thinks that facilities will continue to investigate its payback in the future.

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