MRSO Exam Prep Course

Module 4

Active Shielding and Passive Shielding

Section 4.1 Active Shielding

Active magnetic shielding is designed to produce a magnetic field that moves in the opposite direction of the primary magnetic and ultimately cancels the field from the primary magnet outside the bore. Any stray magnetic flux outside the bore is unwanted, and the more strength and the further the magnetic flux is present outside the bore, the more problems we can have. This stray magnetic flux outside the bore is classified as the fringe field. Without controlling the fringe field, the magnetic flux can influence materials and equipment from within and outside the scanner room. Ferrous materials and equipment can become attracted to the magnet even if they are not present in the room. A rebar in the concrete slab can become attracted to the scanner and damage the concrete slab. Active and passive shielding has been developed to control this fringe field. Controlling the fringe field allows us to design a room suitable for the facility and adequately house the magnet. If we have control of the fringe field, we will be able to know our limitations around the magnet, ultimately ensuring the safety of patients and medical staff members.

Active magnetic shielding blocks create an external magnetic field in the opposite vector of the main magnet. The basic system for active shielding consists of the following:

1. Magnetic sensor
2. Amplifier
3. Cancelling coil

Because active shielding is dependent on the vector of the primary magnet, active shielding is not effective against radiofrequency (RF) shielding. When we think of active shielding, we think of Helmholtz coils (or bucking coils) near the main magnet. Helmholtz coils, as shown in Image 4.1, consist of two coils strategically placed so that the magnetic field they produce will counteract the static magnetic field along the z-axis. The magnetic sensors monitor how much external disturbance is detected within the static magnetic field. The coils then run additional electricity through them as necessary to increase the counteracting magnetic strength in the Helmholtz coils.

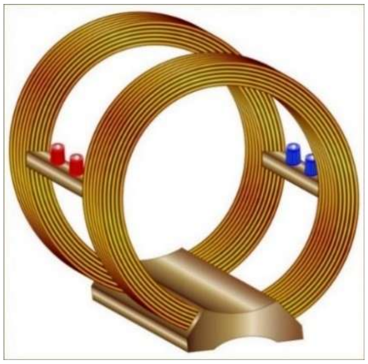

Image 4.1

Section 4.2 Passive Shielding

Passive shielding is done by installing ferromagnetic materials in the walls, ceilings, and floors. The ferromagnetic materials within these areas will redirect the magnetic field lines away from outside the room or where the magnetic flux is not desired. Passive shielding is used during the design and construction of the scanner room. These ferromagnetic materials installed in and around the room disrupt the fringe field and, if designed and installed correctly, can safely keep the fringe field within the confines of the scanner room. Image 4.2 shows some passive shielding being installed in a future MRI suite.

You do not have to limit passive shielding to the walls and ceilings. You can also use these barriers inside the room. Passive shielding can be expensive and extremely heavy if you are considering placing the shielding on anything other than ground level. Additional design and construction efforts must be regarded to accommodate the extra weight.

If the facility chooses to install passive shielding inside the walls, penetrations in the walls must also be limited or eliminated at all at these locations. This can also cause complications with the room's design if we consider plumbing, electrical, communication, or HVAC components that would usually be inside the walls.

Image 4.2

Section 4.3 Considerations When Designing Your MR Suite

Here are some crucial tips to help you save time and money while avoiding headaches during the designing process. Each step should be thoroughly evaluated before committing to a specific type of MR system or placement for this equipment.

Determine your needs: A detailed assessment of the patient population and the medical needs the MR system is designed to fulfill should be the first step in evaluating suitable locations for the MR system. If many inpatients or exceptional cases (e.g., pediatric, cardiac, stroke, critical care, or research patients) are expected, locating the facility within a radiology department or similar support service will reduce transportation costs while maximizing the availability of radiologists and ancillary medical services. If such instances are projected to account for fewer than 10% to 20% of total MR examinations, having them performed in an imaging facility can typically improve efficiency and throughput for routine outpatient scans.

Picture Archiving and Communications Systems (PACS) can solve problems with radiology coverage and image transfer in remote places. Also, parking, which is always a problem at hospitals, is easier to deal with in the outpatient setting.

On the other hand, stand-alone facilities usually necessitate duplication of reception and other personnel services. Medical supervision is required for the administration of the following drugs:

- Contrast agents
- Sedation
- Coverage for code blue and other comparable scenarios should also be examined.

The economic impact must be considered when picking an in-house vs a free-standing outpatient installation.

Educate yourself regarding new technology: In the past, the placement of the MR site was usually decided by the technical components of the system, particularly the magnet. Large magnetic fringe fields, bulky magnetic shields, hefty loads, and frequent cryogen delivery, for example, historically excluded numerous MR system sites that could have provided better access or operation.

On the other hand, advances in active shielding techniques now allow most MR systems to be used in practically any environment. Indeed, compared to low-field-strength "open" MR systems, current, "compact," high-field-strength MR systems are typically lighter and have smaller magnetic fringe fields. As a result, any claim that an MR system (high-field-strength or low-field-strength system) cannot fit into a specific location should be questioned until it is proven by at least two distinct manufacturers' sitting specialists.

Explore all reasonable alternatives: The sayings "Commit in haste, repent at leisure" and "Commit in haste, repent later" underline a vital point. It's important to remember that MR facilities often have a 10-year or longer practical and functional life. Additional efforts should be spent considering as many options as possible before committing to a specific MR system site location.

Anticipate future needs: At most MR facilities, the volume of MRI scans of the upper and lower extremities has surpassed that of head studies. As a result, it's probably a good idea to plan for a rise in MRI examination volume from non-traditional sources, including body studies, early stroke evaluation, cardiac, functional, therapy planning and evaluation, surgical pre-planning, spectroscopy, and so on. The MR system's installation site should be appropriately chosen.

Utilize vendor expertise: Some of the industry's most talented and experienced sitting talents work with the MR system suppliers. A review of suitable locations by citing experts from each supplier under consideration should be part of the MR system selection process. Allow them to be inventive and evaluate their abilities based on the depth of their research.

Distribute your risk: Once the MR system vendor has been chosen, it's an excellent idea to contractually bind the company to pay for any later adjustments to the site plans they may require and that they should have adequately noted during the review and approval of the final drawings.

4.3.1 Choice of Location

The location of the MR system is just as crucial as the type of MR system chosen. This is contingent on the appropriate assessment of numerous aspects. Considering all of these factors for each potential site necessitates meticulous planning. The procedure can be made more accessible by creating a matrix of issues. Each entry should be weighted by its relative importance. The following are some examples of typical categories and topics:

- **Patient access:** Is it easy for patients to get to the location? Is there appropriate access to wheelchairs and gurneys?
- **Convenience to the radiology department:** Can radiologists be contacted quickly for consultation or in the event of a code blue? Are radiologists available to oversee MRI contrast injections if proposed Medicare supervision regulations are implemented?
- **Environmental interference:** Is there any potential for electrical or mechanical interference? Are there any vibrational sources? Are there any significant moving metal masses near the location? Are there any massive metal constructions in the vicinity?
- **Structural support:** Is the current floor loading sufficient to support the system? What kind of seismic anchoring could be required?
- **Utility accessibility:** How much would it cost to supply appropriate power, cooling water, telephone service, and other essential utilities and services to the site?

4.3.2 Magnetic Fringe Field Considerations

The MR system's magnet generates fields inside and outside the device. Depending on field strength, system design, and the intrinsic system shielding strategy, the size of these fringe magnetic fields can vary dramatically. The following are some general types of potential issues:

- Interactions with cardiac pacemakers or implantable cardioverter-defibrillator devices may occur, leading them to malfunction and putting the patient or individual at risk.
- Blood flowing through a magnetic field can generate electrical potentials that complicate cardiac monitoring and cause arrhythmias or other abnormalities in heart function at very high fields.
- Within the patient or individual, ferromagnetic materials may move, causing harm.
- Tools, scalpels, pens, gas tanks, and other ferromagnetic objects carried into the MR system room can be accelerated into the magnet, causing damage to patients or MR system operators.
- The function of monitoring or diagnostic equipment in rooms near the MR system may be affected by magnetic fringe fields.
- Moving metal objects near the MR system can modify magnetic fringe fields, resulting in image quality differences.