MRI
BUYERS GUIDE

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The MRI Buyers Guidebook

This MRI Buyers Guidebook, developed by Amber Diagnostics, is designed to help you understand and address common concerns regarding MRI systems before you make a big investment. This document contains all the information you need in regards to MRI costs, parts, types, site planning, maintenance, and more. Our goal is to ensure you have a convenient reference at hand, giving you the knowledge and confidence to go forth in purchasing your MRI system.

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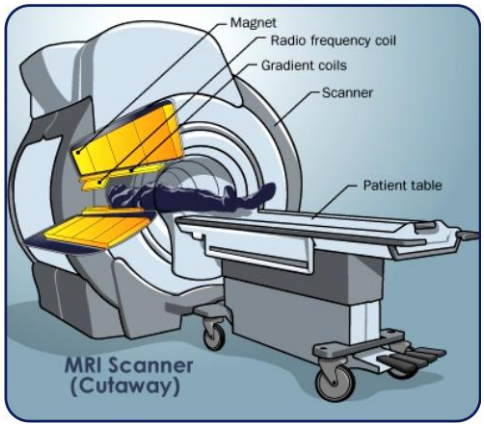
Magnetic Resonance Imaging (MRI)

On July 3, 1977, an event took place that would forever change modern medicine; it was the first MRI exam ever performed on a human being! Though it took almost five hours to produce just one image, Dr. Raymond Damadian, a physician and scientist, and fellow colleagues labored for seven long years to do what many said could not be done. Today there are thousands of MRI scanners in the country with images being produced in seconds as opposed to hours.



An MRI scanner is often used to diagnose conditions such as tumors, developmental issues, damage caused by stroke, suspected breast cancer, and chronic conditions such as Multiple Sclerosis. Physicians can also gain information though an MRI about changes and injuries to the spinal column and vertebrae, the joints, and the structure of the heart muscle, as well as detect problems in many internal organs. The benefit of an MRI compared to an X-ray is that it is much more detailed, it can view more then just bones and joints, and it can produce three-dimensional images allowing the body to be viewed from many angles.

The "magnetic" in Magnetic Resonance Imaging, is the most important feature of the system. The strength of the magnet is vital, and is rated using a unit of measure known as a tesla (T). Another unit of measure commonly used with magnets is the gauss (1 tesla = 10,000 gauss). The magnets commonly used today are in the 0.5T to 2.0T range. Compared with the Earth's 0.5-gauss magnetic field, you can see how incredibly powerful these magnets are. Magnetic fields greater than 2T have not been approved for use in medical imaging, though much more powerful magnets are used in research. As we get further in the guide book, you will learn more about the magnets.

The Future of MRI

MRI is a field with a virtually limitless future; research and improvements are ongoing in this field. Magnets, typically making MRI systems heavy, are getting lighter with each new generation; and systems are becoming more patient friendly, allowing heavier patients and claustrophobic patients to get tested with more comfort than before.

Predicting the future of MRI is speculative at best, but there is no doubt it will be exciting for those in the field, and very beneficial to the patients.

Preparation for an MRI Scan

It is apparent almost everyone gets apprehensive before getting an MRI. This document is useful to help patients prepare and relax prior to their examination. Print a copy for your patients too.

MRI is the method of choice for the diagnosis of many types of injuries and conditions to the brain, spine, or joints. An MRI provides an unparalleled view inside the human body, with an extraordinary level of detail compared with any other imaging modality. The only other way to see inside the body any better is to cut it open (ready for that MRI now?). It may be an uncomfortable process, but the vast benefits of an MRI can certainly outweigh the few drawbacks of claustrophobia, noisy machines, and sitting still for extended periods of time.

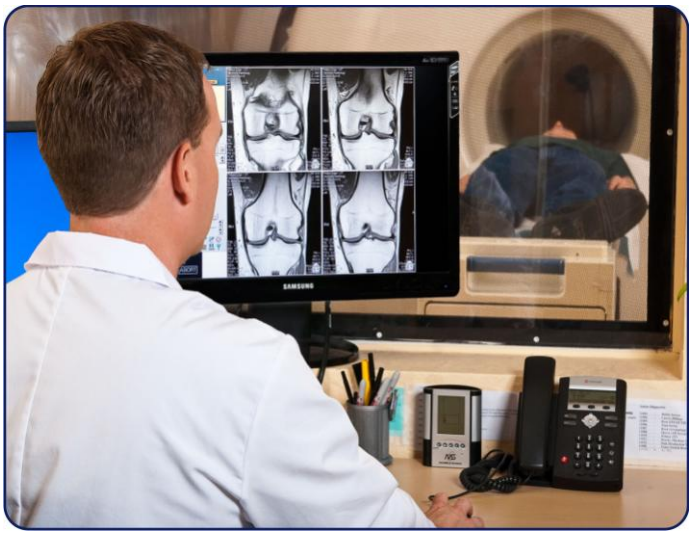
Very little preparation is needed for an MRI. Be sure to eat and drink normally, and continue to take usual medications. Under certain conditions, there may be dietary restrictions requested by the physician in cases when the MRI requires a contrast agent, sedation or anesthesia, or other special considerations.

Keep in mind, patients will be asked to change into a gown and remove all accessories, glasses, dentures, hearing aids, prosthetic devices, and other metallic objects. It is best to keep them at home if possible. Also, avoid wearing any makeup as makeup may contain metal filaments.

It is also crucial to inform the staff if there is any metal in the body that cannot be removed such as pacemakers, heart valves, surgical staples and wires, insulin pump, etc. If patients were metal workers at some point, or had a piece of metal penetrate the eyeball, it is important to inform the doctor of this. Most facilities prefer not to image pregnant women, as there has not been enough research conducted in terms of biological effects on a developing fetus. The final decision of whether or not to scan a pregnant patient is made on a case-by-case basis.

What to Expect During and After the Scan

Prior to scans, patients are encouraged to use the restroom as scans can take an extended period of time. A trained MRI professional will help position the patient on the scanner bed. Whether or not the patient goes in head first or feet first, as well as how far in they will go, is determined by the type of exam. Once the body part to be scanned is positioned in the exact center of the magnetic field, the scan can begin.



All a patient must do when the exam begins is relax and lie as still as possible. Take a few deep breaths before going in, and choose music that is calming if offered headphones. Patients are able to talk to a member of the staff via a two way intercom system throughout the scan.

Patients may also have a companion stay in the scanning room. Parents are especially encouraged to be in the room with their children during the scan.

Immediately following the exam, all normal activities and diet may be resumed. There are no known biological hazards to humans from being exposed to the strength of magnetic fields used in medical imaging today. The fact that MRI systems do not use ionizing radiation is a comfort to many patients. MRI contrast materials also have a very low incidence of side effects.

Just remember, MRI scans are painless and harmless. Try practicing some relaxation techniques before the exam since the key to completing an MRI successfully and comfortably is to relax.

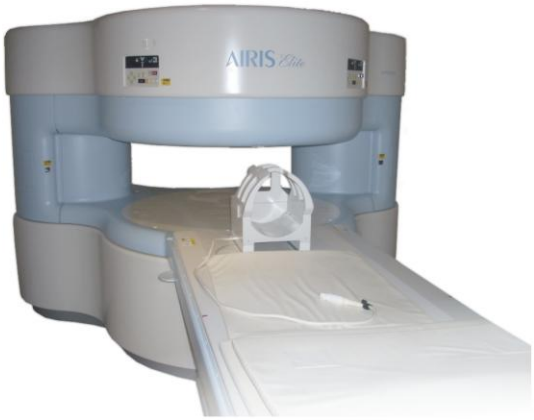
TYPES OF MRI SCANNERS

Like most products on the market, MRI machines and scanners are not all the same, nor are they manufactured by the same company. The most common top name brands for MRI scanners are **Philips, Hitachi, Siemens** and **GE**. Types of MRI scanners can also be differentiated by their magnetic field strength or tesla (T), and by construction or orientation such as open, closed or upright. A closed machine is a smaller, narrower tube and provides the best images. An open MRI machine is open on three sides, making it more comfortable for the patient. The upright MRI is very useful when the physician needs to see the effects of weight bearing on the body.

High-field MRI Scanners.

High-field MRI scanners, typically identified as closed MRI scanners, are the preferred type for physicians. These scanners use a magnet strength that can range from 0.5T up to 3.0T. A 1.5T provides great image quality, fast scan times, and the capability to evaluate how certain structures in the body function.

The 3.0T MRI scanner, double the strength of the 1.5T, is ideal for visualizing very fine detail such as brain and heart vessels. However, these closed machines can be uncomfortable for claustrophobic patients and can only handle patients who weigh no more than three hundred pounds.



Low-field MRI Scanners.

Low-field MRI scanners, typically known as open MRI scanners, have a range of 0.2T-0.5T. With an open MRI, scanners have decreased image quality since the magnet is not traveling around the whole body, and require a longer scan time compared to high-field MRI scanners. Open MRI machines are not meant to perform high end applications.

These scanners are especially useful for people who are claustrophobic or unable to have a closed MRI scan due to weight restrictions or body circumference. It has also been used as a marketing tool for hospitals, physicians, and imaging centers with the intention to attract additional patients and referring doctors.

Standup/Upright MRI Scanners.

Stand-Up MRI scanners are useful for those who are unable to lie down or who have conditions where the body part needs to be visualized while standing, bending or sitting. This type of scanner is best used for the spine and joints, where weight-bearing is necessary.

It is also beneficial for those who suffer from claustrophobia, and in some cases, has the capability to perform flexion and extension studies.

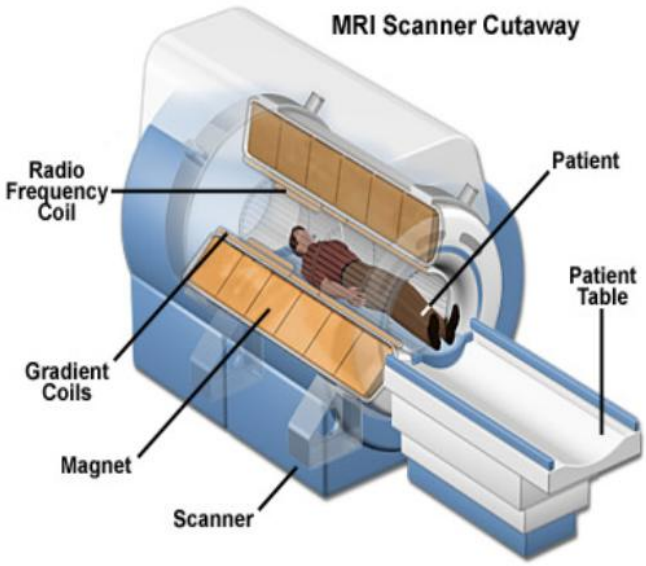
MRI MAGNETS

The biggest and most important component in an MRI system is the magnet, and the strength of the magnet is vital. A homogeneous magnetic field of incredible strength and stability is critical for high-quality imaging. There are three basic types of magnets used in MRI systems:

• **Resistive magnets** consist of many windings or coils of wire wrapped around a cylinder (or bore) through which an electric current is passed. This generates a magnetic field, which will die out if the electricity is shut off. These magnets are lower in cost to construct, but require a tremendous amount of electricity to operate because of the natural resistance of the wire. The electricity can get expensive when higher power magnets are needed. To operate this type of magnet above the 0.3-tesla level would be quite costly.

• **Permanent magnets** are just that…permanent. Its magnetic field is always there and always on full strength, so maintaining the field requires no cost. The major drawback is that these magnets are extremely heavy – up to several tons. A stronger field would require a magnet so heavy it would be difficult to construct. Though permanent magnets are getting smaller these days, they are still limited to low field strengths.

• **Superconducting magnets** are by far the most commonly used in MRI systems. They are similar to resistive magnets in that the coils of wire with a passing current of electricity create the magnetic field. The important difference is that in a superconducting magnet, the wire is continually bathed in liquid helium at 452.4 degrees below zero. (Yes, patients are surrounded by a substance that cold! Of course it is very well insulated by a vacuum.) This unbelievably cold temperature causes the resistance in the wire to drop to zero, dramatically reducing the electrical requirement for the system and making it much more economical to operate. Superconductive systems are still very expensive, but they can easily generate 0.5T to 2.0T fields, allowing for much higher-quality imaging.



Another type of magnet found in every MRI system is called a **gradient magnet**. There are three gradient magnets inside the MRI machine, which are extremely low strength compared to the main magnetic field. The main magnet immerses the patient in a stable and very intense magnetic field, and the gradient magnets create a variable field.

They are arranged in a particular style inside the main magnet so when they are rapidly turned on and off in a specific manner, they alter the main magnetic field. What this means is that you can pick exactly which area you want a picture of, and the machine does not need to be moved around to get an image from a different direction, the machine can manipulate everything with the gradient magnets.

Which MRI Is Right For My Business?

With technology constantly evolving, buyers want to make sure they have the latest and greatest. But unlike smart phones and tablets, it's not always about following the hype when it comes to MRI scanners. MRI scanners are growing increasingly complex, and as a result, buyers now have more decisions to make when selecting a scanner. It is no longer simply a choice of whether to opt for an open or closed system; you must know what type of studies you plan to perform and which MRI capabilities will help optimize your results.

Additionally, distributors or vendors can overwhelm users with a combination of marketing fact and fiction, making the process even more confusing. Prior to purchasing, buyers are urged to take the time to study their needs and the offering of the vendors. Beware of offers that seem too good to be true, because they usually always are.

The Basics

Buying any capital medical equipment is a big decision, and an even bigger investment. So how do you know which MRI to purchase? The standards for the medical industry are the 0.5T, 1.0T and 1.5T. Before finalizing an MRI type, consider these aspects:

I. What is the patient load?
ii. What is your budget in terms of initial equipment purchase and maintenance cost?
iii. Is your site an IDTF, physician owned hospital, or research center?
iv. Observe the geographical area to determine how many facilities in the area are already performing MRI scans, the population in the area, and how many physicians, neurologists, neurosurgeons and orthopedic surgeons are in this area.

Answering these questions can help you logically conclude which scanner is the best investment for your particular business; and help you avoid long-standing financial difficulties and feasibility problems. It is always wise to think through the desired types of exams and the referring physician population to be served. These factors will certainly govern the number and types of dedicated surface coils required for the machine.

Magnet Choice

The heart of an MRI system is the magnet; and image quality and strength of the magnet are very important. Generally, high-field scanners (1.5 Tesla magnets) are regarded as the best magnet strength with higher quality images and easier marketing capabilities. Higher field magnets exhibit thinner slices with much shorter imaging times, and can be used to perform more exhaustive patient studies. Low to mid-field scanners (0.25 to 0.5 Tesla magnets) are more cost-effective than high field scanners, typically have a zero life cycle magnet, and do not require the need for liquid helium.

They also tend to me more patient-friendly as well. About 10 - 15% of the worldwide volume in MR units falls into the low-field range (this includes permanent and resistive magnets). To compare and choose between high-field and low to mid-field scanners ultimately depends on your needs, capability, and budget. There is no need to purchase high-field if it does not fit your overall plan; and do not settle for less if you know you have a high volume of patients.

RF Subsystems

All modern MR systems should utilize digital RF technology to control complex RF wave signals and pulses. When buying your MRI system, be sure to ask for this feature. If purchasing a new system, look for Quadrature versus Linear Phased Array Technology. The benefits and flexibility provided by Quadrature Phased Array may even change MR image acquisition practices over the next few years.

Gradient Subsystems

Many buyers automatically assume that bigger is better, and base their selection on the highest gradient amplitude available. This misconception overlooks how the gradients are used and how they are applied in clinical cases. Gradient amplitude governs the system's ability to set apart spatial location - covering field of view, slice thickness, and matrix of acquisition. Gradient coils are essentially resistive magnets that adjust the main magnetic field for the function of creating images. The big gradients are not meant for every clinical site, regardless of what is being said. It is a good idea for the buyer to look for systems that can be upgraded to higher slew rate gradients for the future.

Computer Subsystem

Early generations of MR Systems used customized computers and array processors to run the systems and process images. With the change in the computer and electronics industry, operator consoles today include touch screens and specialized displays. The buyer should look for a work station-like environment utilizing easily attached and easily upgradeable components, and find the computer and array processor capability to keep up with the data stream coming from the acquisition module of the equipment. A system which is well balanced will allow for a smooth operation and an upgrade path in the design, which in turn increases the security of investment in the MR system.

Purchase of an MR system is complex and can cause anxiety during the process and remorse after the acquisition. Buyers should take the time to evaluate systems on the basis of their needs, a match to the budget, and a company that will stand behind the equipment for the entire life cycle.

Use the chart below to help you better differentiate between your choices.

Advantages and Disadvantages with Various Types of MRIs.

Type of MRI	Field Strength	Advantages	Disadvantages
Open or Upright MRI (Fonar Upright, Siemens Magnetom Open)	0.2T to 0.5T	On/off switch, Low initial cost Reasonably good quality images, Patient friendly	Heavy and high power consumption, Low field strength Not fit for high-end imaging and special applications
Permanent Magnet (Hitachi Airis Elite)	0.3T to 0.7T	Easy maintenance, Low power consumption, Patient friendly, Can complete most clinical routine work	Low field, Cannot be turned off, Not able to perform high-end applications
Superconducting (Philips Achieva 3T, Siemens Avanto 1.5T, Hitachi Echelon 1.5T)	0.5T to 3T	High field applications, High homogeneity, Ideal for thin slices and high end applications such as functional imaging & spectroscopy	High initial and running costs (expensive cold heads & service contracts), High power consumption (24-hour working AC needed), Can quench, Frequent helium fill
Superconducting Open, Hybrid (Hitachi OASIS 1.2T, Philips Panorama 1T)	0.6T to 1.5T	Decent quality images, Mid-field applications, Open access	Expensive, Heavy, High power consumption, Requires helium use

Remember, prior to sealing the deal on an MRI scanner, you also need to consider space configurations. The site planning process is quite possibly the most important step in successfully implementing a new or refurbished system. Customers must analyze and understand every angle around the field, from properly storing chillers to identifying ferromagnetic materials.

Used vs. New Medical Equipment

When we hear the word “used” or “refurbished”, often times we think of something old, and nonfunctional. But with rising costs in virtually every industry out there, it is just too expensive to always buy new. With medical imaging equipment, there is a lot of money that can be saved in purchasing used machines.

While there is no harm in questioning used medical equipment, especially when using it for a high volume of patients, bear in mind that secondary equipment does not make procedures less effective.

Buying used or refurbished radiology equipment is certainly a cost-effective strategy that can get the same job done on patients for a lower cost. When buying second hand medical equipment, be sure to consider whether it will meet the quality standards and guidelines for the future. If done properly, a pre-owned piece of equipment will work as if it were brand new.

Used / Refurbished MRI Systems

Since MRI scanners do not possess many moveable parts like other imaging systems, it is very unlikely for the machine to experience extensive damage. For an MRI in particular, unless it is broken, burned, or quenched, there is no need to refurbish.

An MRI typically hits the refurbishment process when the coldheads have aged and needs replacement or the absorbers need to get changed out. Other changes consist of more minor cosmetic restorations such as paint, coils, pad replacements, etc. Aside from these components, there are no major differences between the used and refurbished MRI.

Remember, a used device refers to equipment that is sold “as-is”. There are no changes or fixes made to the product. A refurbished machine usually has some work done to it, be it a paint job, a quick replacement, or an extensive repair. Regardless, neither is considered “new”. For any reason, whether it is a surplus of machines or a decline in business, a medical company may decide to sell equipment that is perfectly functional. Even if the MRI machine has barely been touched, it is no longer considered new, and becomes secondary. This also means a very good piece of equipment is now on the market for a low price.

Risks Involved with Purchasing

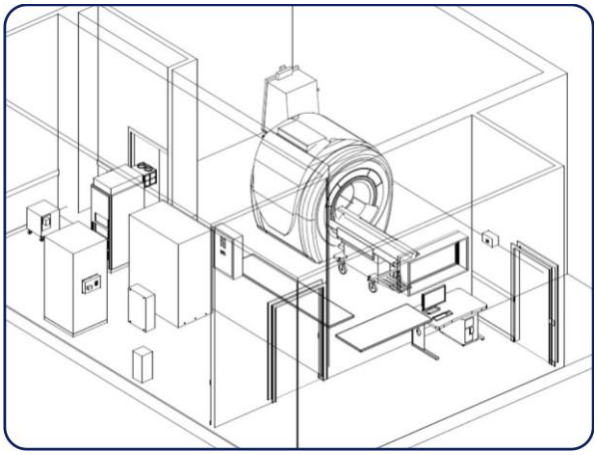
As with any investment - new, used or refurbished - you always want to buy with a trusted source that guarantees quality. Since MRIs are used on patients, it is extremely important to make sure the seller is reputable and technicians are first-class. Also, know exactly what's included in the terms; get a copy from your provider listing the refurbishments and the coverage of the warranty.

Since there is very limited or no warranty at all with used medical equipment, asking to perform an inspection prior to the purchase and getting opinions from other buyers could also be helpful. Many used and refurbished machines undergo inspections, repairs (if needed), and even testing to ensure it is operational and will meet quality standards.

In essence, so long as you are working with a reliable seller and have done your research, the benefits will certainly outweigh the financial risks of buying used imaging equipment.

Proper Site Planning for Your MRI System

Before you accept that steal of a deal on an MRI scanner, think about space. Room configurations require careful planning; and you must also prepare for site inspections that can ultimately result in delays and extra costs if not done properly. To help mitigate these hassles, a carefully designed plan by a qualified professional specifying equipment placement, plumbing, electrical runs, heating/cooling units, and potential safety measures should be composed for all MRI site locations.



The ultimate goal for most imaging sites is to ensure high system performance standards, comfortable patient handling, professional working environment, and sufficient storage space.

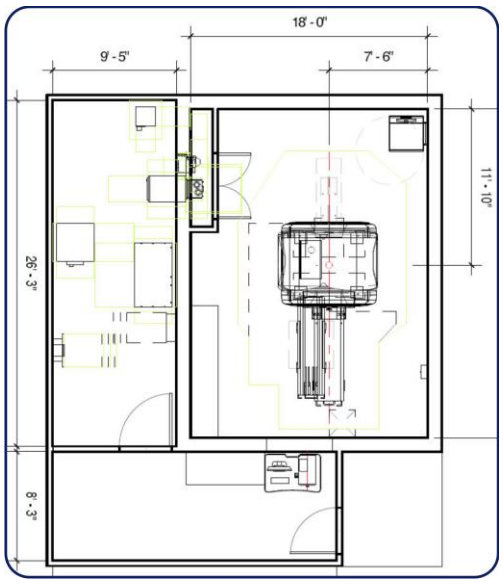
Below is a fundamental overview of key site planning points for fixed, open, and mobile MRI units to help you reach that goal efficiently.

Site Planning for a Fixed High Field MRI

To maximize performance for your MRI, the facility must consider precise project planning starting from the initial site selection and design through the final delivery and installation. Magnetic fringe fields, RF shielding, specified ceiling heights, minimal noise levels, cryogen storage, and adequate venting for cryogen exhaust are typical examples of the special considerations to be made when implementing a high-field MRI scanner.

Site Layout. A thorough drawing and evaluation of the proposed MRI location, as well as communication with all that are involved (from planning to installation), should begin early in the process.

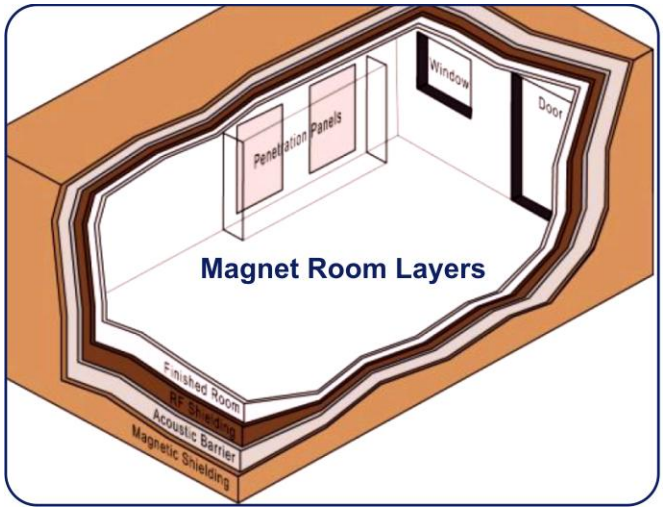
When selecting an MRI site, two most important planning considerations are the fringe field and the need for a site free from ambient RF electrical noise. The site plans should clearly indicate the location of the magnet isocenter and its surroundings to configure the workstation, RF coil storage cabinet, liquid cooling cabinet, helium gas exhaust pipe, patient support, operator's table, and more.

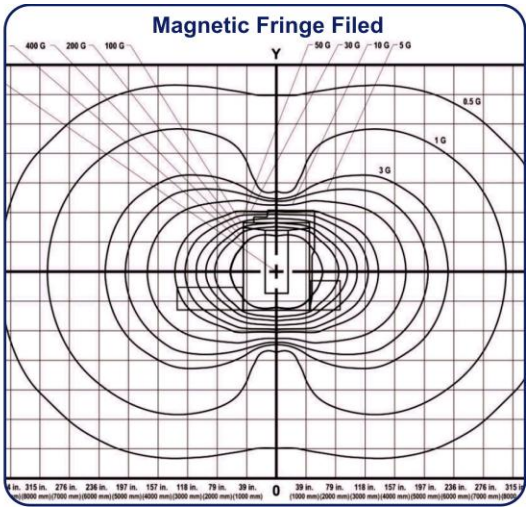


Specific ceiling heights are required as well, especially in the exam room (exam room suspended ceiling and exam room RF ceiling) and access route. As for flooring, carpet is not encouraged due to dust build up, risk of static shock, sanitary issues, and other service hassles. Rather, think of a thin, vinyl tile floor for the rooms.

RF shielding.
All users and vendors of MR imaging agree that radiofrequency shielding is necessary for proper operation of the MRI system. RF shielding is required because of the interference that is present between various sources of noise and the MR detection coil, as well as external ambient RF waves that can degrade MRI image quality. Shielding in the magnet room typically consists of copper or aluminum sheets with RF shielded doors and windows.

Shielding must be insulated from all grounds, and all electrical lines into the RF room must be routed through RF filters. All electrically non-conductive supply lines such as oxygen into the RF room must be routed through RF sealed wave guides provided by the RF vendor. Finally, for pressure equalization, the RF door should open to the outside of the RF room. The RF shield must be tested before and after magnet placement.





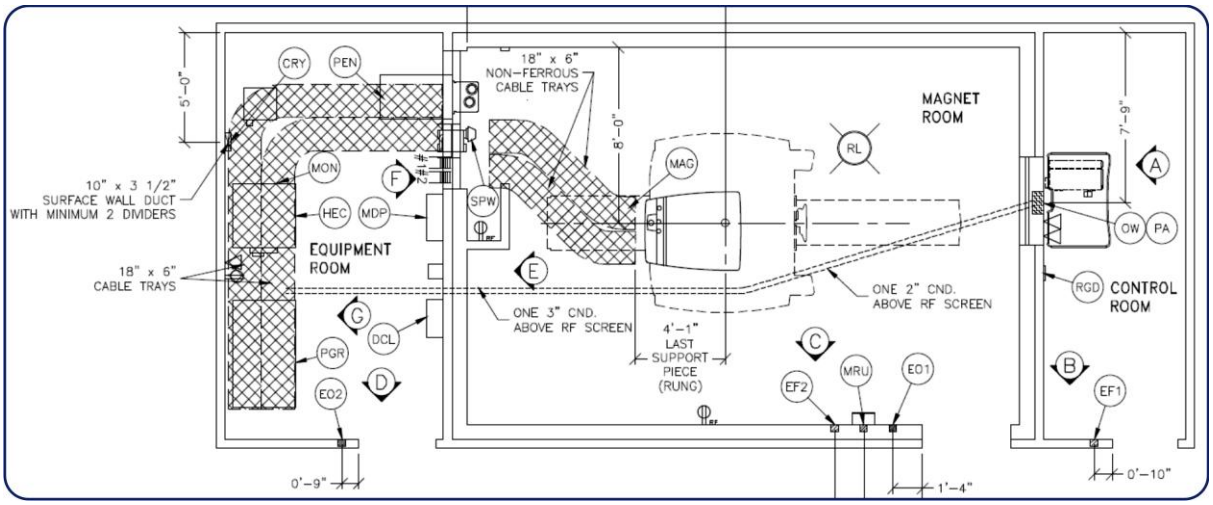
Magnetic shielding.
The magnet's fringe field and ferromagnetic objects are of primary concern when selecting an MRI site. The field outside the magnet bore extends in all directions and frequently goes beyond the boundary of the MR imaging room - this area is referred to as the fringe field region. Fringe fields can be substantially decreased through the use of magnetic shielding; since fringe fields are 3-dimensional, areas on the floors above and below the imaging facility may also need shielding. Other ways to control fringe fields is securing the magnet area with locked entrances to keep out unauthorized personnel, and preventing inadvertent introduction of potentially hazardous metallic objects.

Consequently, a detailed knowledge of a magnet's fringe field and its relationship to surrounding equipment and activities is an essential part of site planning and installation. While protecting your own credit cards, computers, cameras, and more from the magnetic fringe fields, caution should be taken to protect the magnetic field as well. The presence of ferromagnetic material such as wheel chairs, stretchers, oxygen tanks, AC chillers, vehicles, elevators, lift trucks, and electric railway systems can adversely affect the uniformity and homogeneity of the magnetic field.

Protect the magnetic field from potential damage by knowing the location and amount of steel shielding, large ferrous objects and structures, external vibrations or shocks, and moving objects within and outside the building. Tolerable distances from the center of the magnet will depend on magnet field strength and shielding design.

Facility environment.
Heating, ventilation, and air conditioning requirements concern all rooms, especially the scan room, and must be maintained 24 hours a day, seven days a week. Each room is recommended to have a dedicated control and sensor to monitor and adjust the air. Energy such as liquid and gaseous helium dissipated in the examination room should be removed by an additional air exhaust system, whereas gradient coil heat dissipation should be removed via liquid cooling of the gradient coil.

The magnet room exhaust air should be installed a certain distance above the finished floor and not in the vicinity of the quench vent exhaust. It is important for fresh air intake systems to exhaust air directly out of the building, and must never blow directly onto the magnet or be deflected into another room. To ensure safety in the magnet room, oxygen monitoring should also be provided. Chilled water supply is required to the RCA cabinet 24 hours a day year round for the cold head and gradient systems. Chiller requirements include a minimum flow rate, a certain temperature, allowable temperature fluctuation, water pressure, acidity range, and water hardness.



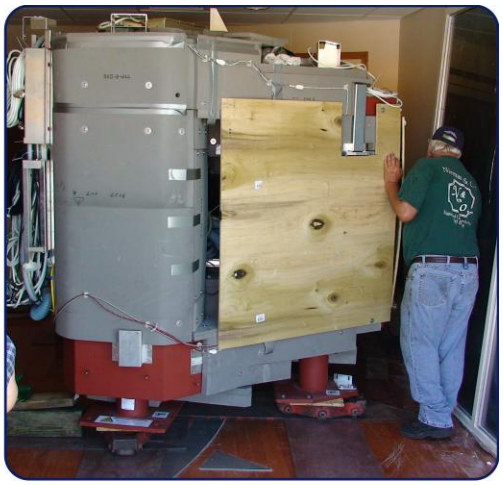
Electrical.
Construction for MRI sites needs to be performed in compliance with all applicable local and national electric codes (NEC) and regulations. Installing electrical power to meet the requirements of a higher power gradient package at the time of initial installation will reduce the cost to upgrade the system later.

Typically, an electrical contractor is responsible for supplying and installing the MRI sub-panel for the control room, the copper panel feeder with the required voltage level, all branch circuit wiring, safety disconnect, lighting and controls, grounding system, wireways, wiremolds, and installation of UPS system, if purchased.

A UPS is strongly recommended for areas with frequent lighting storms, power disruptions, and blackouts. In the event of an incident causing major loss of coolant (quench), a discharge pipe for the rapid removal of gas is necessary. Avoid light dimmers and fluorescent lighting ballasts within the magnet room.

Rigging.
Due to the weight of the components in an MRI system, a rigger should be hired (usually the responsibility of the customer, unless otherwise specified) to unload the magnet and deliver all MRI components. Prior to delivery, the rigger should become familiar with the site so they can approve the best delivery route, and take necessary precautions to protect the MRI equipment and the facilities.

When riggers are on site to remove the system from the truck and place it correctly inside the facility; the engineer should be on site to oversee the rig and connect the cold head to the choler and power supply to keep the system cool and avoid helium boil off. It also ideal to have the shielding company, electrician and HVAC contractors on site at the time to complete their tasks once the machine is in place (i.e., RF vendors can close up the shielding room, contractor can hook up chiller to the system, etc.) Once this is done, the system will have a helium fill, and the magnet will then be ramped and shimmed.



Room basics.
The MRI scan room should be located near the exterior of the building to help facilitate delivery. Be sure to exercise careful screening of those entering the room to ensure the magnet is not affected by certain objects such as electronic devices and pacemakers. The rooms should be functional and practical, allowing for strong visual and direct contact between the operator and patient.

The window between the magnet room and control room usually requires RF shielding, which is often two layers of copper screen or perforated sheet.

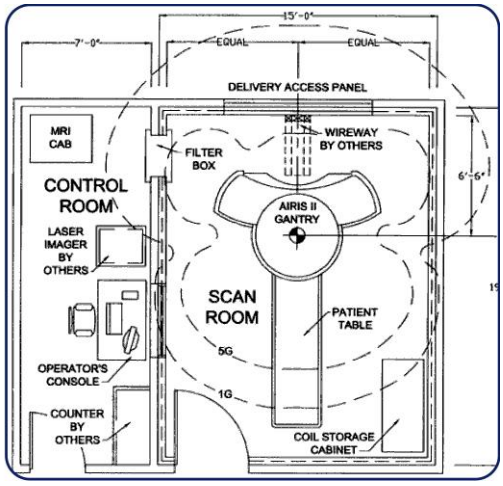
The control room should be sufficiently large to accommodate employee activities and provide service access to all the equipment. An office intercom should be located in the control room for the safety of the patient and the operator.

Site Planning for an Open Permanent MRI

Much like a high-field MRI, an open MRI requires proper site preparation, floor planning, RF shielding, power supply, magnet placement, rigging, and special components for the scan room and control room. However, the permanent magnet excludes the procedures required for placing a chiller on site.

Site preparation.

Prior to installation, coordinate with the architect, contractors, site planning specialists, and other personnel to thoroughly review and evaluate all aspects of the site. Your proposed MRI location should be designed with the isocenter as a reference point and to maintain consistency for planning purposes. Once the isocenter is identified, this will act as key for planning; it will reflect the location used during initial site qualification, all shielding references, and even for rigging.



Floor and structural plans.

For obvious reasons, the open MRI unit you have chosen should comfortably fit into the room you have chosen. The room itself should be functional and practical, allowing for strong visual and direct contact between the operator and patient. Access into the scan room should accommodate a stretcher; there should be sufficient space around the patient table for proper handling; and prep rooms, restrooms, and holding areas should be located near the scan room as well. While structural support is up to the customer, vinyl tile floor is recommended for the scan and control rooms. Carpet is not encouraged due to dust build up, risk of static shock, sanitary concerns, and difficulty moving equipment.

RF shielding.

An RF shielded room is required for proper operation of the MRI system, and the best way to set up proper shielding is to find a qualified RF vendor. The vendor should be selected prior to construction to ensure that the MRI scan room area is prepared properly. Once the vendor has completed the installation of the RF door, RF window, shim plates, electrical (EMI) filters, waveguides, and ground stud, be sure the vendor has a written confirmation of performing an RF verification test after system delivery, and a detailed drawing for you to present if requested by any authoritative individual.

Power supply.
Construction for MRI sites need to be performed in compliance with all applicable local and national electric codes (NEC) and regulations. Typically, an electrical contractor is responsible for supplying and installing the MRI sub-panel for the control room, the copper panel feeder with the required voltage level, all branch circuit wiring, safety disconnect, lighting and controls, grounding system, non-ferromagnetic wireways, wiremolds, and installation of UPS system, if purchased. A UPS is strongly recommended for areas with frequent lighting storms, power disruptions, and blackouts. Electrical power for lights and receptacles should derive from the same branch circuit as the MRI cabinet. Incandescent lighting is suggested for scan rooms; dimmers, halogen, fluorescent, or track lighting is discouraged.

Magnet placement.
With all MR systems, there is always concern regarding the affect on magnetically sensitive instruments, and the ferromagnetic materials in the area. A permanent magnet has a minimal fringe field, but needs careful preconstruction planning because of its tremendous weight. A magnetic fluctuation test must be performed at sites to assist in identifying possible sources of interference, and is needed for final site approval. When selecting a location to place the magnet, consider the location of the isocenter in relation to the following: fringe fields; any other modalities (CT, X-ray, Mammography, etc.); any large ferrous moving objects in immediate area (trains, subways); vehicular traffic including parking; electrical service such as elevators; and types of construction materials used in existing structures such as columns and cast iron pipes. Once the MRI is installed, the magnetic field is shimmed to counteract the affects of ferromagnetic objects around the magnet. Large ferrous objects such as metal file cabinets located near the MRI scan room should not be removed after shimming as introducing these objects to the magnetic field after shimming can affect image quality.

Rigging.
Due to the weight of the components in an MRI system, hiring a rigger to unload the magnet, uncrate, properly place the MRI, and deliver all MRI components is necessary. Prior to delivery, the rigger should become familiar with the site so they can approve the best delivery route and take necessary precautions to protect the MRI equipment. Be sure the access and delivery route for the magnet and all components is clear of obstructions. This also means to remove and protect any items along the delivery path that may be affected by the magnetic field such as computers, diskettes, credit cards, and more. Have a representative onsite at the time of delivery, and provide a secure storage area near the MRI control room for components until installation is complete. Equipment needed for proper maneuvering of the system include a crane for unloading the magnet, roller or air bags to move the magnet into place, and forklift to unload MRI components.

Scan room and control room.
The MRI scan room should be located near the exterior of the building to help facilitate delivery. Regardless of whether you dedicate a separate heating and AC unit for the scan room alone, the temperature in the scan room must be maintained 24/7 in order to achieve optimal and consistent image quality. It is important to make certain no direct air will blow onto the magnet. The control room should be sufficiently large to accommodate employee activities and provide service access to all the equipment. The control room should also contain a telephone with access to an outside line, as well as an office intercom for the safety of the patient and the operator.

Site Planning for a Mobile MRI

Mobile MRI units are typically constructed with the magnetic shielding and RF shielding in the walls of the scan room. However, proper site location and preparation is still imperative for successful operation. Other requirements to keep in mind include support pad, electricity, mobile grounding, telephone and data service, water supply, site clearance, and regulations.

Location.

When choosing a location for the mobile MRI unit, think of the setting and how it will affect the set up. For example, consider the impact of the magnetic field to the surrounding areas such as buildings and parking lots, the ventilation for generator airflow, and the effect of moving metal and vibrations. Keep in mind that moving metal objects near the magnet, such as high power lines, emergency vehicles, forklift trucks, helicopter landings, and automobile traffic can affect magnetic field homogeneity and degrade image quality. These objects should be held 9 to 12 feet from the unit. A firm, level surface is also required around the mobile unit for convenient access to the trailer, servicing the unit, proper handling of cryogens, and for patient lift operations and staircase.

Support Pads.

Whether you choose the minimum support pads or the recommended full pad, the support pad level is strictly enforced to avoid any difficulties in the MRI system operation. The support pad depth should be determined by a local contractor based upon weight distribution. As there are varying site conditions and local building codes, the actual pad design should be prepared by a licensed structural or architectural engineer. It is also suggested that non-ferrous reinforcement materials be used for pad reinforcement.

Electricity.

Electricity is essential in order to power the MRI system, HVAC system, and the chiller. The trailer's electrical system is hardwired on one end, and the free end of the cable has a connector attached for compatibility with the site's receptacle, typically a 480 volt, 3-phase receptacle. The facility is responsible for providing a matching receptacle.

As for connection of shore power, this should be performed by local, qualified electricians only. The shoreline is located in the rear skirt compartment and can be accessed from either the roadside or curbside. If power is lost to the unit, it is imperative that the generator be started to retain environmental controls.

Grounding.

The ground for the system should originate at the first access point of power into the facility, and be constant to the system power disconnect in the room. The ground wiring consists of copper wires the same size as the disconnect feeders. The unit must also have an earth driven ground rod within a certain distance of the hospitable power receptacle. A grounding cable must be connected between the grounding rod and the grounding pin of the power receptacle. A separate insulated grounding conductor should also be installed in the power distribution unit in accordance with local, state and national electric codes.

Telephone and data service.

The mobile units are supplied with telephone connections, data line connections, and connecting cables; and the customer is required to purchase and install the weatherproof phone outlets for use at the site. Any additional cables needed must also be purchased by the customer. Telephone and data services may vary, so be sure to confirm exact connections on the trailer. For example, the data line may require a standard RJ45 connector mounted in a weatherproof box, and phone lines may require a Hubbell PH6597 weatherproof outlet mounted in a Hubbell PH6619 weatherproof box. Data boxes and phone boxes should be located in the same general area.

Water supply.

The mobile MRI unit can be operated either with a water line connected and pressurized, or disconnected, providing tank is refilled as needed. The unit's water storage tank for the humidifier should always contain water to insure the specified humidity level remains consistent. In cold weather conditions, the site must provide a weather protected supply line to prevent pipe freeze. Finally, the facility must provide sanitary wastewater drainage that complies with locally applicable codes.

Site clearance.

Convenient means of entrance and exit for staff and patients must be provided by the mobile unit, with attention to swing and turn radii. Site clearance should be considered for all compartment doors, entrance doors and canopy doors. It is a good idea to understand the actual dimensions of the rearmost projections of your tractor to the centerline so you can verify your swing clearance. Sharp dips, curbs, bumps, and other road surface conditions can affect the mobile unit ground clearance. With turning requirements, the site must prepare adequate space to accommodate the turning radius. It is also essential to ensure the access route is clear of obstructions when the trailer is scheduled to arrive or depart.

Regulations.

Local, state, and national regulations may differ from site to site, so be sure to have the proper permits, meet the applicable codes, and have all the qualified personnel for labor. It is the responsibility of each site to ensure that these regulations are met and hinder any costs associated with the requirements. Although the MRI mobile system is most likely manufactured according to stringent quality engineering standards, it is wise to consult building code authorities well in advance of installation to avoid any unnecessary delays.

Since MRI technology is especially complex and sensitive, it is best to let an MRI specialist install, fine-tune, and maintain the system. Be sure to choose equipment suppliers, contractors, and other site planners that understand medical construction, and have extensive experience. Keep in mind that this is a general reference to get you on the right track, and not an official construction plan. Requirements may change without notice as systems evolve; site conditions, application requirements, customer preferences, equipment configuration, and federal, state, and local requirements can also significantly impact the design and layout. Physical specifications for different imaging systems are best obtained from their manufacturers.

MRI SITE PLANNING CHECKLIST

Use the following check list as a site planning reference for key aspects to consider when designating an imaging facility for an MRI.

PRIMARY MRI AREAS

- o Exam Room
- o Control Room
- o Equipment Room (power supplies and RF equipment)
- o Cryogen Storage
- o Reading Room

SECONDARY MRI AREAS

- o Quality Control and Service
- o Patient Preparation and Emergency Procedure Space
- o Restrooms
- o Reception and Waiting Area
- o Storage
- o Soiled and Clean Utility

ADDITIONAL AREAS (can be shared area or remote from the MRI)

- o Administrative and Conference Space
- o Additional Storage
- o Offices

MAGNETIC FIELD HOMOGENEITY PROTECTION

- o Amount of Steel Shielding at Location
- o Structural Iron and Steel
- o Symmetrical Location of Ferrous Structures or Objects
- o Moving Ferrous Objects (elevators, vehicular traffic, lift trucks, etc.)

ENVIRONMENTAL PROTECTION

- o Three Dimensional Survey of Magnetically Sensitive Devices & Equipment
- o Acceptable Distance from Center of Magnet
  (will depend on magnet field strength & shielding design)

RADIOFREQUENCY SHIELDING

- o Appropriate RF Shielding (based on site survey and OEM specifications)
- o Avoid Light Dimmers & Fluorescent Lighting Ballasts in Magnet Room

CONSTRUCTION & ACCESS

- o Equipment Transportation (access for unloading and installation)
- o Access for Cryogens & Cryogen Venting (normal and quench)
- o Floor Levelness & Ceiling Heights
- o Well Controlled Access to Magnet Room and Facility

FACILITY ENVIRONMENT

- o Air Conditioning (controlled temperature in scan room)
- o Electrical Supplies
- o Water Supply & Floor Drains
- o Chilled Water Supply
- o Fire Hazards and Safety (no sprinklers or non-ferrous extinguishers)
- o Housekeeping (no ferrous cleaning supplies)
- o Personnel Protection (metal detection routines are recommended)

MRI Maintenance

Understanding the functionality of the MRI system and the required service to continue optimal performance can be overwhelming. Just comprehending the physics of how the system produces a diagnostic image can be intimidating.

While some users may have the appropriate skill set in imaging equipment, it is most beneficial to seek help from a qualified professional to conduct monthly checks on MRI machines, making sure the systems are clean, properly working, and there are no RF leaks. MRI systems are complex and sensitive, not to mention pricey, so it's better to avoid the risk of further damage.

MRI Safety

Before we move further, it is important to establish an understanding of the safety factors for those in the presence of a strong magnet system. As discussed in the site planning section, strict precautions regarding metal objects must be adhered to for the safety of individuals as well as the MRI machine. For example, keys, scissors, stethoscopes and any other small objects can be pulled off the body at very high speeds, and fly toward the opening of the magnet where the patient is placed.

The more mass an object has such as oxygen tanks, patient stretchers, and heart monitors, the more dangerous it can be as the magnet attraction is much stronger. Patients and staff members should be thoroughly screened for metal objects and metal implants prior to entering the scan room.

Components

When looking at the requirements to maintain an optimal running MRI system, it is best to consider the system in several blocks, and focus on each component of the MRI. It is also important to understand how each block impacts one another. When a magnet system is first installed, a number of tests are typically performed to ensure optimal performance.

Once the MRI system is installed, daily quality checks are needed to monitor system performance. Since each manufacturer has their own proprietary approach based on the make and model, it is up to the user to understand the basis of performing specific tests, calibrations, and troubleshooting.

The MRI system obtains raw data through interpretation of RF information, and rooms must be shielded from all external RF signals. It should become a practice to inspect all areas of shielding. Inspect the door on a regular basis to ensure shielding elements are intact and surfaces are clean; and inspect the penetration panel to ensure no cable connections or shielding plates have become loose during service. RF leaks within the room can cause poor images, and costs valuable time tracing down and fixing the issue.

Magnet maintenance should focus on ensuring proper center frequency, maintaining proper shim to provide homogeneity of the image, ensuring proper cooling on the helium vessel, and overall mechanical condition. The primary focus is to make sure all screws are tight and no components or cables are loose. Remember, the magnet does not shut down and remains fully powered even when the system is not imaging.

Finally, bear in mind that while magnets may last forever, MRI software upgrades are frequent, as advancements are constantly occurring. Even if you don't have the latest upgrades, be sure your system is performing up to par and all the components are working cohesively.

Helium Services

The cost for helium has risen between 15% and 30% (based on regional demand), and is expected to continue increasing. With helium becoming scarce and prices going up, be sure to maintain a careful system monitoring for helium fills. Scheduling more frequent helium fills is a good idea in the event the shortage becomes massive and cryogen vendors cap the number of liters that can be dispensed in a single visit.

Damage & Warranty

Since MRI scanners do not possess many moveable parts like other imaging systems, it is very unlikely for the machine to experience extensive damage. For an MRI, in particular, there is typically no wear and tear unless it is broken, burned, or quenched. Other cosmetic damages that can be repaired include paint, coils, and pad replacements.

Make sure your equipment has a good warranty or service contract, and be sure you know when it expires. If your system does not come with warranty, be certain your vendors are reputable and knowledgeable so that they can direct you to qualified engineers when you experience problems with the machine.

MRI De-installation

While the cost of equipment is important when purchasing an MRI, it is only part of the equation. There are certainly other logistics involved including proper installation and deinstallation. MRI installation requires the coordination of many qualified specialists, and somewhere along the way, you may find yourself involved with an imperfect installation.

The Right Personnel

The most common source of substandard installations and disasters is that vendors do not know the importance of installations, or are not mindful of the essential needs in imaging projects. A complex imaging project like an MRI installation requires the coordination of many specialists in various construction and engineering fields, but there should also be an individual who understands how the entire project comes together to guarantee they get the job done right. Remember, there is a big difference between a general contractor who has built a lot of buildings and a general contractor who has built a lot of imaging centers. Be sure your team has specific experience with MRI machines and suites.

Avoiding Mishaps

Even if your relocation project has the proper budget planning, sometimes it's inevitable to eliminate all the problems that can occur during the course of such complicated imaging projects. Here are a few tips on minimizing your risks:

i.) It is not necessary to purchase your equipment from OEM's to get quality service. Find experienced planners, contractors, and a vendor with a knowledgeable, well-trained staff.

ii.) Stay on top of the project, and ask questions. Visit the project as often as possible and take the time to get to know your equipment, its history, and performance. Make sure the vendor knows you are monitoring the job. If you don't have sufficient knowledge of the project, find a local service engineer to inspect it, and report all speculations.

iii.) When purchasing the equipment, establish a contract specifying that the vendor is responsible for every aspect, from de-installation to operational start-up. Have someone involved in oversight that has prior experience with these projects.

iv.) Use the same service vendor for removal and reinstallation. If two different firms perform these services, problems with the installation will often lead to finger-pointing between the de-installers and installers. If you have a single vendor responsible, you can rest assured the vendor is focused on a smooth project that is completed in a timely and professional manner.

Rigging Costs

Due to the weight of the components in an MRI system, a rigger is hired to unload the magnet and deliver all MRI components. Cost of rigging depends on the weight of the magnet and the ease of moving the magnet to its designated location. (Remember, there are also varying local, state, and national costs depending on your geographic location). The weight of a magnet fluctuates based on each type of system. For example, permanent magnet MRI scanners are generally a bit heavier, and require more care while being moved.

Think about location in terms of where the magnet will be placed. Rigging contractors need to figure out how to move, turn and properly set up magnets based on surroundings (not just floor numbers). For example, while sometimes they may get lucky and easily maneuver the magnet through a spacious, empty parking lot, there may also be a situation where the crane may need to be set up on a busy street.

Each imaging equipment project has its own set of challenges. It is a complicated job with several parties involved. To guard against mishaps is to budget realistically, use experienced people with proven reputations, be willing to pay for quality services, demand accountability and risk sharing, and ask questions. If something does not quite add up, do not ignore it. Attentive planning along with these handy tips will ensure a smooth deinstallation project.

MRI Costs

More often than not, buying decisions are finalized based on cost and cost alone. And why shouldn't it be? Times are tough, and if you find a steal of a deal that fits your budget, you should jump on it. Here's the truth though: buying an MRI scanner is not cheap. While you can find great deals on used and refurbished medical equipment, it is a big investment when you add up equipment costs, constructions costs, and other service expenses such as inspection, installation, helium, and maintenance. Not to mention, the time required after your MRI is installed while you obtain all the necessary licenses, Medicare License, and HMO programs.

Cost management is the core business task when purchasing MRI equipment and putting up your imaging center, private office, clinic, or mobile unit. Buying an MRI that doesn't fit your overall business standard paired with unmanageable expenditures can pose a big threat on your practice. If you are still unsure of equipment, there are options to lease or rent machines. Though in time, the cost of leasing may surpass the cost of buying, it is still a good idea to look into the option if buying is too risky for you.

In addition to unpredictable construction costs, MRI equipment varies in cost as well, making it almost impossible to put a definite price tag on any one system. Scanners with more strength produce more detailed images, which will ultimately cost more. Standard 1.5 tesla MRI scanners can cost up to $1 million; of course that price is cut significantly when buying on the secondary market or with refurbished equipment. Other factors that play a key impact on price include the year equipment was manufactured, the specific model you desire, which coils are included in the machine, current system operating software, and gradient strength.

Since MRI equipment can be costly, the procedures in turn can also become quite costly. Providing an actual MRI can cost anywhere from $90 to $200* per procedure, depending upon which MRI procedure is performed, location of your testing facility, and reimbursements available to your imaging center or practice.

**Based on a volume of $300 per month.*

MRI Reimbursements

The reduced reimbursement rates for the equipment component of many MRI scans has certainly shifted the economic landscape. Typically, MRI costs are comprised of two parts: the Technical Fees and the Professional Fees. The technical fee, also known as the equipment fee, is the cost of the actual procedure itself.

The professional fee is associated with having the radiologist view images and interpret test results. An equipment charge may cost anywhere from $30 to $60, with a professional charge ranging from $50 to $100, depending on rates negotiated with your specific radiologist or radiologist group.

Reimbursement rates also differ based on insurance carrier and site of care. For Medicare in particular, the technical and professional components of procedures performed in an IDTF or physician's office is reimbursed under the Medicare Physician fee Schedule, a Medicare payment system which establishes payments based on resource costs associated with physician work, practice expense, and professional liability insurance. In the state of Florida, an average Medicare allowable is approximately $471.

Despite financial concerns due to declining reimbursement rates, a report titled "MR Market Outlook Study: Present Practice and Future Outlook, 2011-2013," describes how the MRI industry is emerging from the recent recession without permanent damage. The report also indicates that MRI has settled into a period of steady 3.2% annual utilization growth, and that a surge of MRI scanner sales is expected in the coming year.

Still Have Questions?

Though this guide book is intended to inform you on the foundations of buying an MRI system, we're pretty certain it must have raised other questions along the way as well.

We understand that even if you've done your homework on purchasing an MRI and read through this document, every situation is different. And since there is not always information readily available regarding your specific questions and concerns, we will be happy to direct you.

If you are not ready to purchase a machine just yet, give us a call anyway! We'll help you with your homework and planning process.

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