ARCHITECTURAL SITE PLANNING GUIDE

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SECTION 1 INTRODUCTION

Information in this guide will assist you in designing the scan room area and also provide critical information to electricians, HVAC companies and other trades involved in the construction.

IMEDCO will provide the planner, the architect or the hospital with a complete set of drawings. These drawings are based on dimensional information from the site and on installation requirements from the system supplier.

To provide the architect design and planning information, this guide includes drawings with proposals and details of a typical installation using the most cost effective solutions. Of course other alternatives are usually possible and IMEDCO will work with you on specific problems imposed by local conditions. All IMEDCO planning drawings can also be provided in AutoCAD (.dwg files) upon request.

SECTION 2 THE MAGNET

THE MAGNET

Magnetic Resonance Imaging (MRI) is a modern diagnostic imaging technology for radiologists. The system uses echo principles to acquire data from the body of a patient, which a powerful computer then reconstructs to an anatomical image. No x-ray radiation is present.

The patient must be placed in a homogeneous magnetic field. Hydrogen nuclei (Protons) in the human body are excited with radio waves and during quiet periods their echo is transformed to an image on a video screen.

The very powerful magnet and the special environment that is required are critical factors that architects must take into account in the site layout. Understanding all the siting requirements will enable the architects and planners to design an effective and safe area for the MRI in the clinic or hospital setting.

The magnet is usually defined by its' field strength. It is quoted in TESLA and typically will vary in strength from 0.06 to 9.4 TESLA with the majority of magnets being 1.5/3.0T magnets. (Higher field strengths are more often used for research purposes.)

Magnets from 0.2 - 1.0 T are designed in one of two ways. The lower field strengths of this range are primarily designed using resistive (electro-) magnetic principles, which require a significant power source and a large cooling unit when in use. They do have the ability to be switched off when not in use. The higher end of this range is primarily designed with superconductivity technology. See next paragraph for explanation.

Magnets from 1.0 – 9.4 T are exclusively super conductive. Superconductivity is a phenomenon whereby certain materials lose their resistance to electrical currents at temperatures very near absolute zero (-274 degree Celsius). This is why the magnets are filled with liquid helium. They do not have the ability to be switched off when not in use.

SPECIAL SITING FACTORS

Weight is another factor to be considered. A magnet may be as light as 2.5 tons, or as heavy as 50 tons depending on its construction, field strength and the amount of shielding.

The magnetic field referenced earlier is measured inside the magnet bore, or in between the magnet halves in the open bore designs, which is where the patient is positioned. The field should be homogeneous or consistent throughout this area for peak image performance.

The fringe field is yet another factor that must be considered and understood. Like any magnet, the field lines, also known as flux, leave one pole of the magnet and travel to the other pole. These lines are imaginary and form a closed loop. These lines actually exist in three-dimensional form and are referred to as field plots. This field plot typically exists symmetrically in each dimension surrounding the magnet.

Magnetic Shielding may be necessary to limit the fringe field in certain sites. It may also be necessary to improve image quality by eliminating external disturbances.

To ensure safety of the patients, the technicians and the general public a controlled area must exist around the magnet. This area is defined by the position of the 5 Gauss (0.5 mT) line. Field strengths greater than 5 Gauss should not extend to any public area. Fences, access controlled doors, warning signs and places for safekeeping of magnetic materials, money and credit cards must all be considered.

Homogeneity of the field inside the magnet is important to obtain quality images. Moving and non-moving ferrous materials in close proximity such as reinforcing iron, columns, girders, elevators and cars all influence homogeneity. Their existence must be known and evaluated by the system manufacturer. It should be noted that certain disturbances can be corrected on the magnet by shimming, which can be accomplished by the manufacturer on site.

SECTION 3 MAGNETIC SHIELDING

MAGNETIC SHIELDING

As stated previously, magnetic shielding primarily protects the environment from the strong magnetic field and assures safety of the public. Each magnet possesses a distinctive magnetic field. Several approaches exist to reduce the extension of the fringe field, with the most common being Passive Shielding for the Room:

PASSIVE SHIELDING – MAGNET: OLDER GENERATION MAGNETS

Passive Shielding of the magnet is always done by the magnet manufacturer. Iron is placed on the magnet itself during magnet installation. Consideration must be given to the floor loading as the weight of the passively–shielded magnets may exceed 30 tons.

PASSIVE SHIELDING – ROOM:

Passive shielding may also be accomplished by placing iron around the walls of the room. The most common and effective shielding for these purposes is M-36 silicon steel because of its' inherent magnetic properties. There may be circumstances when the low-carbon, annealed plate is used for some unique siting situations. The amount of iron required on the various surfaces (walls, ceilings, floors) can be estimated by either the

magnet supplier or IMEDCO and the design submitted to the system manufacturer for final calculations and approvals.

ACTIVE SHIELDS – MAGNET: NEWER AND CURRENT GENERATION MAGNETS

These types of magnets are common today. They may weigh less than passive shield magnets; however there may be other trade-offs, which should be explained by the system manufacturer.

OTHER TYPES OF SHIELDING:

Some research systems utilizing squid devices (MEG) operate at very low magnetic field strengths. Such systems may not perform optimally because of magnetic field fluctuations caused by the changes of the earth's magnetic field or by vagabonding electrical current in the ground or building. In this case the magnetic shield must protect the device by attenuating these disturbances. A single or multi-layer shield built from special alloy with high permeability serves this purpose. IMEDCO has experience in providing these sophisticated protection devices.

SECTION 4 RADIO FREQUENCY (RF) SHIELDING

RF SHIELDING:

The majority of magnetic resonance systems require RF Shielding. The RF Shielding serves two purposes. The first purpose is to prevent radio wave emission from the MRI system from disturbing other electronic equipment in the clinic or nearby television and radio reception. The second purpose is to prevent external radio waves from entering the examination room and being picked up by the system coils and corrupting the image. Radio waves are especially harmful in the region of the so-called operating frequency. The value of this frequency is directly related to the field strength of the magnet. Typical field strengths and their operating frequencies are:

4.3 MHz	0.1T
9.8 MHz	0.23T
12.7 MHz	0.3T
15.0 MHz	0.35T
21.3 MHZ	0.5T
42.6 MHZ	1.0T
63.9 MHz	1.5T
85.2 MHz	2.0T
127.8 MHz	3.0T
200.0 MHz	4.7T
300.0 MHz	7.0T
400.0 MHz	9.4T
>400.0 MHz	>9.4T

There may be some specialty Research magnets greater than 4.7T that have much smaller bore sizes that can work without any RF Shielding.

A good RF Enclosure should attenuate radio waves between the minimum range of 1 MHz and 200 MHz. The attenuation factor should be at least 1:100,000 or expressed in decibels (dB) = 100. The attenuation factor at higher frequencies may be reduced somewhat, but typically a minimum 60-80dB reduction from 200 MHz to 700MHz is required.

IMEDCO's RF Enclosure is made from a copper foil wrapped over wood frames. These panels form a complete, totally airtight cubicle. All penetrations located inside or outside of this room need special attention.

All services entering the room, such as wires, gases, water and ductwork can only enter or leave the scan room enclosure if they pass through special filters or waveguides.

ELECTRICAL FILTERS:

Electrical filters must not only satisfy the attenuation requirements, but also must have minimum leakage current for patient safety. IMEDCO has been a leader in providing these types of filters, which carry the important certifications of U.L. and E.N.

HVAC FILTERS:

Special honeycomb filters are used for venting and air conditioning (HVAC). These must be non-magnetic and have minimal pressure drop. Honeycomb sizes up to 24" X 36" are available from IMEDCO.

SPRINKLER/MEDICAL GAS FILTERS:

Filters are required for all medical gases and sprinkler lines. All filters must be installed with provisions to maintain electrical isolation between the outside services and the shielded enclosure.

ACOUSTIC SHIELDING:

Acoustic noise generated by modern MR units still can exceed 120dB for certain scanning sequences. Often these systems are located near sensitive areas or neighboring tenants. Complete MRI suite design must take into account this potential problem. To help solve this critical issue IMEDCO has developed, and in some cases patented, an entire line of products that combine high performance RF and Acoustic attenuation. SilentSHIELDTM products from IMEDCO range from component (door and window) upgrades to total wall, floor and ceiling solutions. They address both airborne and structure borne noise transmission. Please refer to IMEDCO planning pamphlet ***RF Shielding and Soundproofing for Magnetic Resonance Imaging*** for further details.

SECTION 5 SITING CONSIDERATIONS

TYPICAL CONSIDERATIONS:

The following questions are typical of those that should be asked during the initial site analysis in order to determine the most feasible siting solution:

Is the floor strong enough to support the weight of a magnet?

Does the access for delivery of the magnet have adequate clearance and structure?

Can the floor and access path be reinforced?

Can the floor be recessed to accommodate the shield's floor cross-section such that there is minimal transition from the patient access entryway into the exam room?

Is the ceiling height adequate?

Can the air conditioning requirements be met?

Can the cryogen gases be safely vented?

Will existing iron masses or planned ferromagnetic structures disturb the magnetic field?

Moving masses are especially critical and can cause artifacts. Are elevators, cars or trains in close proximity?

Does the magnetic fringe field disturb the surrounding environment? Is additional magnet shielding necessary and possible?

It is advisable to layout the clinic in a way that patients cannot inadvertently enter high magnetic field areas. Can this recommendation become part of the architectural design?

Have all of the above concerns been discussed with the system supplier, the physicians, and the hospital planning department?
Are there rules for electrical, medical gases and sanitary installations? Do local guidelines for patient and operator safety exist?

Furthermore, are there restrictions imposed by national building codes that must be considered?

Is it necessary to provide increased levels of acoustic attenuation in the RF Enclosure, in the surrounding walls and ceiling areas?

What is the usage planned for areas surrounding the scan room, including floors above and below?

What is the structural make-up of the surrounding floors, ceilings and walls?

What is the published Lp value (noise level) of the MRI magnet?

Is RF-Acoustic (RFA) Shielding recommended for this site?

SECTION 6 CONSTRUCTION DETAILS

THE ENCLOSURE:

Unless specified as required by the equipment manufacturer, IMEDCO uses copper, the ideal material for long-term RF performance. The entire enclosure consists of a series of copper panels that are bolted together using lag screws to maintain a constant pressure at the seams. This modular construction allows for quick installation and easy access/egress of the magnet through a large custom opening pre-designed in the walls or ceiling. In addition, the entire enclosure (except for the floor) can be relocated, and is suitable for upgrade. IMEDCO is able to build an enclosure to any size and shape, should building constraints or aesthetics so demand. The basic enclosure now comes with a lifetime performance warranty.

THE FLOOR:

IMEDCO recommends an exam room layout which utilizes a depressed floor if possible. This will avoid a ramp that otherwise might be necessary to meet door threshold, and provide a smooth entry for patient beds and helium dewars.

The recommended depression depends upon the configuration of the main entry door or steel requirements.

Factors such as door-swing direction, RF door design type (Fingers vs. Pneumatic seal method), sub-flooring materials and magnetic shield steel requirements can create a need for recesses that can range from 3/4" to 2.0".
The surface of the concrete slab must be smooth, flat and level within ±1/8" over the entire room area. The slab must be dry and cured adequately to support the weight of the magnet at the time of installation of the RF shield. When IMEDCO arrives, the concrete slab will be sealed with moisture barrier and dielectric, which may restrict or slow the drying process.

The floor consists of several layers. It is important to provide an effective dielectric and durable barrier for moisture that otherwise might affect the underside of the copper floor RF Enclosure and create a direct ground to the structure. Grounding is a very critical concern for every magnet supplier and all RF Enclosures must demonstrate 100% isolation prior to any electrical, med gases, sprinkler connections are allowed. Every magnet vendor has specific protocol that must be followed during the construction process.

The copper is then protected by installing a specially formulated high density, water resilient composite board, a cement board product or a cementitious grout. All IMEDCO sub-flooring surfaces covering the copper are approved by flooring contractors and ready for final finish application.

Special considerations must be taken into account where anti-static or conductive vinyl floor tiling is required. Contact your magnet vendor Product Specialist to understand how these types of finish flooring comply with their recommendations.

In situations where structure borne acoustic noise is a concern, IMEDCO is capable of providing its SilentSHIELDTM floor. Although design varies to meet each individual site's specific requirements, this patented floor system may incorporate up to a 3" thick stainless steel plate weighing approximately 4500 lbs. and specially engineered elastomers to absorb structural energy generated by the MRI system.

THE WALLS:

The walls of the RF Enclosure are made from self-supporting wood frames. They are built to the required room height and shape, and are designed to be installed a minimum of 2" from the parent wall surface. The parent walls are recommended to be finished on the interior face, providing for enhanced acoustic performance and/or compliance to local building codes.

With some exceptions, the walls will typically contain the HVAC, electrical, medical gas, and sprinkler filters. The architect and the magnet supplier will specify location and details, and the general contractor will provide structural wall openings as detailed in the IMEDCO-issued construction drawings.

IMEDCO's standard product includes wood furring installed 16" on center around the entire interior perimeter walls of the RF enclosure. Interior drywall is typically installed by the general contractor, but IMEDCO can provide and install interior finishes. The RF panel is filled with a sound deadening rated insulation to provide thermal and acoustic performance. All IMEDCO wood frame members and furring are coated at the factory with a UL-listed, Class A flame retardant.
In situations where airborne acoustic noise is a concern, IMEDCO is capable of providing its SilentSHIELDTM walls which, in conjunction with properly designed parent walls, are capable of providing up to 80dB STC/R'w.

MRI System generated noise may be quite loud and sound dampening and acoustical construction techniques should be considered. IMEDCO has detailed and tested a number of parent wall/RF wall combinations and is able to predict total wall acoustic performance. IMEDCO is willing to share with architects and planners its extensive experience in RFA shielding.

IMEDCO DOORS

IMEDCO currently offers two primary door types for its' North American customers. Standard clear passage is 4' x 7' and can be offered with a variety of plastic laminate surfaces to match any finish schedule.

SILENTSHIELD™

This RF Door entry system door has a conductive brass frame, with special contact fingers. These fingers are recessed into a protected alcove along the sides and top of the door. The fingers along the bottom of the door are attached with screws by a brass faceplate. The entire finger system of the door can be quickly and easily replaced (if required) by the customer. For proper performance, the frame must be cleaned after construction is complete and every 6 to 8 weeks thereafter to provide maximum performance.

As a standard feature, IMEDCO offers its patented SilentSHIELDTM RF door which addresses the ever present airborne noise issue by providing a minimum 40dB STC/R'w, among the highest in the industry. The design from IMEDCO has been installed in over 7,500 shields around the world

The door comes standard with a roller latch mechanism released by a simple push/pull motion on the oversized polished stainless steel handle and a deadbolt door lock to restrict unauthorized access to the scan room. An optional Magnetic Lock with keypad controls is available as an option.

PNEUMATIC SEAL II

This RF Door entry system door has a conductive stainless steel frame, with an inflatable seal covered with a copper braided mesh to ensure both an effective RF seal and provide a unique controlled entry system. The airflow is simple and straight forward and has no special valves built behind the slab or the frame that may be difficult to access should there be any air-flow blockage within the valves. The "quick release/inflate" (<1 second) seal can be controlled and provide secured access via a programmable keypad, card reader with a micro-shipped card/fob, or a keyed push button switch. Controls inside and outside are backed up by emergency release buttons for control; malfunction or emergencies. Any power outage will release the RF Seal unless the control box and the compressor are placed on emergency generator circuits, which would keep the door secured.

This product comes with a special compressor that is normally positioned in the equipment room.

OTHER DOOR DESIGNS

- Sliding Single/Double Leaf RF Doors for intra-operative Magnet suites
- Swinging Double Leaf Doors
- Custom size Doors for special applications

Contact IMEDCO for information on your special entry needs.

THE WINDOW:

The IMEDCO High Visibility Technician Window comes in two standard sizes, offering nominal clear views of 3' high by either 4' or 5' wide. Custom size windows can be manufactured to any size, but may require mullions and/or a framing network to maintain the clear, non-distorted view with no Moiré patterns.

As a standard feature IMEDCO offers its' SilentSHIELDTM window, which has been certified to provide a minimum 40dB STC/R'w, This can be especially important for the MRI Technician who must reside at the window during all scanning procedures. A special RF Window certified to provide an STC/R'w of 50+ dB is available as an option.

THE CEILING:

The RF ceiling is built in a similar fashion to the walls. It is normally suspended from the structural room ceiling using dielectric isolators. A minimum of 4" is required from the bottom of the lowest obstruction to the top of the RF cage. The RF cage ceiling weighs 2.5 lbs/ft2. This does not include the weight of the suspended ceiling, electrical components, HVAC ductwork, or magnet cabling.

In situations where airborne acoustic noise is a concern, IMEDCO is capable of providing its' SilentSHIELDTM ceiling which in combination with a properly constructed parent ceiling, is capable of attenuating up to 80dB STC/R'w.

In situations where structural borne acoustic noise is a concern, IMEDCO is capable of providing its' SilentSHIELDTM ceiling; a fully self-supported ceiling with no physical connection to the floor above.

SEISMIC COMPLIANCE:

Given the increased emphasis by Architects and Structural Engineering firms on meeting local Seismic Compliance, IMEDCO has developed a number of RF Enclosure designs that are engineered to meet Seismic Design Criteria Class C and Class D. These packages include full PE analysis and Stamped Drawings. Contact IMEDCO for more information.

WAVEGUIDES:

All services required inside the scan room must enter through a waveguide provided by IMEDCO. A waveguide is a device that blocks RF-waves but allows passage of non-ferrous materials, including air, water and medical gases.

HONEYCOMBS:

Honeycomb waveguide air vents are used for HVAC purposes. IMEDCO recommends the use of standard sizes, but custom sizes up to 24″ x 36″ can be accommodated. IMEDCO provides dielectric for proper installation of interior and exterior ductwork to the RF shield. Standard HVAC sizes are as follows:

12″ x 4″	18″ x 18″
12″ x 12″	24″ x 8″
12″ x 18″	24″ x 24″
12″ x 24″	

BRASS/STAINLESS PIPE:

Plastic or rubber hoses may be used to carry fiber optics, meds or airlines may liquids or gases through brass or stainless steel pipe waveguides. This type of waveguide does not require a dielectric.

Pipe networks carrying medical gas or sprinkler services into the scan room must also pass through a brass pipe waveguide, but require a dielectric. When applicable, IMEDCO is responsible for this dielectric.

IV LINE WAVEGUIDES INTEGRATED INTO RF DOOR ENTRY:

IMEDCO has designed a method of allowing up to four (4) IV lines to be safely passed thru the RF Door Entry without having to be disconnected from the patient and the injector or portable anesthesia device. This type waveguide is particularly well-suited for Children's Hospital patients and intensive care patients.

QUENCH NETWORK:

Super-conductive MR units require a quench network to evacuate the liquid helium in emergency situations to the exterior of the building. IMEDCO provides a stainless steel quench waveguide sized to specification of magnet manufacturer and installed in accordance with the various site planning guidelines. IMEDCO complies with MRI manufacturer guidelines with respect to emergency vent packages.

ELECTRICAL FILTERS:

These filters are used to provide electricity for lighting and power outlets into the exam room. Other filters are required for signal leads to oxygen monitors, nurse call system, fire alarms and other miscellaneous devices. IMEDCO assures patient safety in providing filters with very low leakage currents and IMEDCO complies with all local electrical codes.

FERROUS METAL DETECTORS (FMD):

Safety recommendations made by the Federal Guidelines Institute (FGI) and major Accreditation Agencies have now included use of Ferrous Metal Detection usage in the MRI departments. IMEDCO is proud to be associated with Kopp Development, an established and innovative leader in this field and provider of the FerrAlert™ series of products and FMD devices. Their unique capabilities include pinpoint location of ferrous objects, unique features that minimize any "alarm fatigue" issues and the latest in incident recording via their FILM option. To best utilize these products, IMEDCO has the ability to integrate these products at the entrance to Zone IV actually in the RF door frame. Our collaborative efforts has resulted in the most streamlined and effective Zone IV entry package on the market. Contact IMEDCO for more information.

SECTION 7 ARCHITECTURAL DETAILS – IMEDCO STRUCTURAL COMPONENTS

ARCHITECTURAL DETAILS:

The attached details will assist the Architect in the planning and designing of the layout for compatibility of an IMEDCO Enclosure.

A formal set of drawings will be generated by IMEDCO for the architect showing site specifics, with respect to structural details upon formalization of the contracts. These drawings will be submitted for verification to the architect prior to the creation of IMEDCO production drawings and the release of fabrication of the Enclosure.

IMEDCO reserves the right to change specifications and details without notice. ***Therefore please contact IMEDCO to verify the current revision of the details provided.***

SECTION 8 MINIMUM SITING REQUIREMENTS

VERIFICATION OF SITE READINESS:

Installation of the IMEDCO RF Enclosure will be started only after the customer has confirmed in writing, and two weeks in advance of the installation start date, that the site is ready for inspection and that site conditions are accordance with IMEDCO Construction drawings that were approved by the GC and the architect during the submittal process. Additionally the following will also need to be verified:

RF STRUCTURAL FLOOR:

The foundation slab has a moisture content of no greater than 8% and the floor is flat, level within ±1/16" per 3ft. and 1/8" overall.

PROTECTED WORK ENVIRONMENT:

The Scan, Computer, and Operator room must be weatherproofed. This shall include the magnet access opening, cryogen exhaust vent, and any other enclosure penetrations. The working temperature will be maintained at a minimum of 65 degrees Fahrenheit. All above areas will be finished and clean of debris to prevent damage to the materials.

ELECTRICAL POWER:

110VAC (20 Amp) and 220VAC (40 Amp) service (for some magnetic shielding designs), single phase power and sufficient lighting must be available within 10 Ft of the area.

MATERIAL DELIVERY ACCESS:

A reasonably close unloading or docking area and delivery route to the construction and assembly area must be provided. The General Contractor shall provide one (1) drywall and one (1) flat cart to assist in the unloading process.

TOOL AND MATERIAL STORAGE:

The customer shall provide a clean, dry and lockable storage area, minimum 16' x 20' in size, in the vicinity of the scan room. This is to assure proper staging of RF Enclosure materials and tools. Installation tools may remain on-site until magnet delivery.

INSTALLATION SCHEDULE:

The installation has to be done without interruption. The General Contractor may be requested to provide two (2) 8' ladders for IMEDCO use during installation.

INTERRUPTION OR ADDITIONAL WORK:

Any breaks in the installation of additional work not included in our quotation, due to an unfinished site or a site not finished in accordance to our specification will be subject to the following surcharges:

Standard rate, straight time 8hr/day Monday – Friday, 1st shift
$80.00 Hourly rate per man waiting/traveling/working time

- 2nd shift rate, straight time 8hr/day Mon. – Fri. will be billed at 1.1 x Std. rate.
- Overtime rate, Saturday, hours beyond 40 in a week or beyond 8 in a day will be billed a minimum of 8 hours at 1.5 x Std. rate.
- Holiday rate, Sunday or holidays. Work conducted on these days will be billed a minimum of 8 hours at 2.0 x Std. rate.

$275.00 Daily Field rate for expenses per man including hotel vehicle, per diems (Special rates may apply in some metropolitan areas.)

MAGNET DELIVERY:

IMEDCO will return to close and certify RF Enclosure following magnet delivery.