GE Healthcare

MR Safety Guide

Operator Manual

GE Medical Systems, LLC, doing business as GE Healthcare

MR Safety Guide
Operator Manual, English
2381696-100 (07/2012) Rev.13

Applicable Regulations and Standards

Medical Device Directive

These products conform with the requirements of council directive 93/42/EEC concerning medical devices, when they bear the following CE Mark of Conformity:

CE 0459

Manufacturer

Refer to your operator manual for the manufacturer's address.

This equipment generates, uses, and can radiate radio frequency energy. The equipment may cause radio frequency interference with other medical and non-medical devices and radio communications. To provide reasonable protection against such interference, the:

GE MR System

complies with emissions limits for (Group 2, Class A) Medical Devices as stated in EN 60601-1-2. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment is found to cause interference (which may be determined by turning the equipment on and off), the user (or qualified service personnel) should attempt to correct the problem by one or more of the following measures:

- reorient or relocated the affected devices;
- increase the separation between equipment and the affected device;
- power the equipment from a source different from that of the affected device; and/or
- consult the point of purchase or service representative for further suggestions.

The manufacturer is not responsible for any interference caused by using interconnect cables that are not recommended or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

Do not use devices that transmit RF Signals (cellular phones, transceivers, or radio controlled products) in the vicinity of this equipment as they may cause performance outside the published specifications. Keep the power to these types of devices turned off when near this equipment.

The medical staff in charge of this equipment is required to instruct technicians, patients, and other people who may be around this equipment to fully comply with the above requirement.

Immunity/Emissions Exceptions: Note the exceptions from the EMC test results. Check with the business EMC engineer for this information.

In accordance with the international safety standard IEC 60601-1, this system is:

- a Class I device
- acceptable for Continuous Operation
- having ordinary protection against ingress of water (IPX0)

- type B and BF applied parts
- is not for use in the presence of flammable anesthetics.

CAUTION

This symbol indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Contact an authorized representative of the manufacturer for information concerning the decommissioning of your equipment.

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Chapter 1: Introduction to MR Safety Guide

The MR Safety Guide presents the concepts necessary to successfully complete the working safely process. Before using your system, familiarize yourself with the purpose and design of this manual.

About this manual

About this manual

This section explains the purpose and design of this operator manual. It is an introduction to the manual, providing information on the purpose, prerequisite skills, organization, format, and graphic conventions that identify the visual symbols used throughout the manual.

The manual does not identify components or features that are standard or purchasable options. **Therefore, if a feature or component included in the manual is not on your system, it is either not available on your system configuration or your site has not purchased the option**.

Safety information

Please refer to the **MR Safety chapter**. The MR Safety chapter describes the safety information you and the physicians must understand thoroughly before you begin to use the system. If you need additional training, seek assistance from qualified GE Healthcare personnel.

The equipment is intended for use by qualified personnel only.

This manual should be kept with the equipment and should be readily available at all times. It is important for you to periodically review the procedures and safety precautions. **It is important to read and understand the contents of this manual before attempting to use this product.**

Federal Law restricts this device to sale, distribution, and use by or on the order of a physician.

Safety notices

The following safety notices are used to emphasize certain safety instructions. This manual uses the international symbol along with the danger, warning, or caution message. This section also describes the purpose of an Important notice and a Note.

DANGER

Danger is used to identify conditions or actions for which a specific hazard is known to exist that will cause severe personal injury, death, or substantial property damage if the instructions are ignored.

WARNING

Warning is used to identify conditions or actions for which a specific hazard is known to exist that may cause severe personal injury, death, or substantial property damage if the instructions are ignored.

CAUTION

Caution is used to identify conditions or actions for which a potential hazard may exist that will or can cause minor personal injury or property damage if the instructions are ignored.

Coil CAUTION

Coil Caution is used to identify conditions or actions for which a potential hazard of crossing or looping coil cables may exist that will or can cause minor personal injury or property damage if the instructions are ignored.

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Pinch Point CAUTION

Pinch Point Caution is used to identify conditions or actions that will or can cause personal injury.

Important indicates information where adherence to procedures is crucial or where your comprehension is necessary to apply a concept or effectively use the product.

Note provides additional information that is helpful to you. It may emphasize certain information regarding special tools or techniques, items to check before proceeding, or factors to consider about a concept or task.

Troubleshooting tips provide information that allow you to investigate the resolution of some type of problem, locate the difficulty, and make adjustments to solve the problem

Purpose of this manual

This manual is written for health care professionals (namely, the MR technologist) to provide the necessary information relating to the proper operation of this system. The manual is intended to teach you the system components and features necessary to use your MR system to its maximum potential. It is not intended to teach magnetic resonance imaging or to make any type of clinical diagnosis.

Prerequisite skills

This manual is not intended to teach the principles of magnetic resonance imaging. It is necessary for you to have sufficient knowledge to competently perform the various diagnostic imaging procedures within your modality. This knowledge is gained through a variety of educational methods, including clinical working experience, hospital-based programs, or classes offered by many college and university Radiologic Technology diagnostic imaging programs.

Pop-up windows

Pop-up message windows require an acknowledgement typically by clicking ***OK***. Always click ***OK*** to acknowledge the message.

If there are multiple floating window on the screen, click on the window title to bring it in front or close the window in front to access the windows that is behind it.

Graphic conventions and legends

This manual uses special conventions for images and legends to make it easier for you to work with the information. The table below describes the conventions used when working with menus, buttons, text boxes, and keyboard keys.

Table 1-1: Graphic conventions

Example	Description
UI conventions	Blue text indicates a link to another topic.
Select	Select an option in a check box or radial button and selecting a tab.
Press **Enter**	Press a hard key on the keyboard.
Press and hold **Shift**	Press and holding down a hard key on the keyboard.
Click ***Viewer***	A button label or Interface button name that you actively click. If there is a reference to a button label that is not actively clicked, it is not displayed as bold or italic.
In the Spacing field...	The name of field in which you can select or type text.
Type **supine** in the Patient Position text box	Text you enter into a field box followed by pressing the Enter key on the keyboard.
Select ***Sort > Sort by date***	The pathway of selecting option(s) in a pull-down menu.
Ctrl X simultaneously	Press and hold the Control button on the keyboard and simultaneously press the X button on the keyboard. Ctrl is the abbreviation used for the Control keyboard button, and ALT is the abbreviation used for the Alternative keyboard.
"message"	A system message prompt is in quotations.
Cancel/Close	Cancel/Close typically closes a screen without executing the changes on the screen. The instructions to Cancel/Close are typically not included in procedures in this manual.

Table 1-2: Mouse controls conventions

Operator manual instruction	Mouse action
Click	Click the left mouse button to select a button or icon.
Right-click	Click the right mouse button.
Middle-click	Click the middle mouse button.
Click and drag	Click and hold the left mouse button down while dragging the cursor to the desired location.
Right-click and drag	Click and hold the right mouse button down while dragging the cursor to the desired location.
Middle-click and drag	Click and hold the middle mouse button down while dragging the cursor to the desired location.
Double-click	Click the left mouse button twice in rapid succession.
Triple-click	Click the left mouse button three times in rapid succession.

Chapter 2: Safety

This section presents the concepts necessary to successfully complete the working safely process. Specifically, you need to understand:

Introduction

The MR Safety Guide contains information applicable to several MR system configurations. A topic heading, a note, or other wording indicates information that is applicable to a specific system configuration.

This chapter focuses on the visible and invisible sources of hazard and concern in the magnetic resonance (MR) imaging environment and emphasizes the need to work safely. To ensure safe operation of your scanner, you must understand several components of your imaging system. This chapter provides brief guidelines for working in a magnetic field, key concepts regarding the patient alert system, as well as magnet, quench, radio frequency (RF), laser light, metal sliver, acoustic, peripheral nerve stimulation (PNS), and equipment hazards. It contains the step-by-step instructions to help you learn how to:

- Eliminate Magnet Hazards
- Respond to Emergencies
- Check the Cryogen Levels
- Handle Contact with Liquid Cryogens

 This chapter contains important safety information that you and the physician must understand thoroughly before using the system.

INTRODUCTION

Safety Information

The Magnetic Resonance Imaging (MRI) system uses a magnet, which can have a field strength several thousand times greater than that of the earth's magnetic field. The magnetic field surrounding the magnet may present a hazard to personnel and equipment within the immediate area. Therefore, the magnetic field safety information described in this chapter is very important. You and your physician must understand it thoroughly before you begin to use the system. You can find additional safety information throughout your Operator Manual and Learning and Reference Guide CD-ROM. If you need additional training, seek assistance from qualified General Electric (GE) Healthcare personnel.

Make sure your training guides are readily available at all times. Review the procedures and safety precautions periodically. Through Magnetic Resonance (MR) safety education, careful planning, and diligent upkeep of your MR facility, a safe environment can be provided for both patients and personnel.

For any hazardous incident or system malfunction related to the use of the GE Healthcare MR Scanner please use the following contact methods:

If Serviced by GE Healthcare: Please contact your Field Service Engineer to report out on the incident.

If third party serviced: Please contact your third party Field Service Engineer and have them send a manufacturers notice to:

Complaint Handling Unit Manager

GE Healthcare

3200 N Grandview Blvd WT-893

Waukesha, WI 53188

If the user is self servicing the GE Healthcare MR Scanner please provide the following information:

- System type
- System ID
- Date of incident
- Description of incident
- Contact Information (facility, address, contact name, title, and telephone numbers)

Locate the contact number on your scanner or visit GE Healthcare on the web http://www.gehealthcare.com/contact/contact_details.html and locate the appropriate telephone number for your location. In the US please us: 1-800-437-1171.

INTRODUCTION

User Training

GE Healthcare provides a purchasable training program in Milwaukee for new system operators. You may arrange to participate through your local sales representative. In addition, GE Healthcare provides purchasable on-site training by an MR Applications Specialist. GE Healthcare advises that anyone who operates the system should attend this session after reading the Operator Manual, Learning and Reference Guide, and related training materials.

GE Healthcare strongly recommends that physicians who prescribe studies and review images on the MR system, attend at least two full days of professional meetings dealing with MR imaging each year. Such meetings include the Radiological Society of North America (RSNA), the Society for Magnetic Resonance in Medicine (SMRM) and the American Roentgen Ray Society (ARRS). In addition, MR system user groups present symposia and workshops throughout the year that provide additional learning opportunities.

The healthcare facility is responsible for training outside emergency personnel (e.g., fire department and other outside emergency personnel) not to bring any ferrous fire-fighting equipment, including axes, ferrous stretchers, or oxygen tanks into the magnet room. Be sure to show such outside emergency personnel where the Emergency Magnet Rundown switch is located.

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INTRODUCTION

Product identification labels

Product identification labels (ratings) can be found on the tops and sides of the cabinets, the rear of monitors, and other exterior surfaces on the equipment. Such product labels alert you to specific hazards and the level of hazard importance. The labels may also contain messages that communicate the specific hazard, the probable consequence of involvement with the hazard, and how the hazard can be avoided. In the event you are unable to identify these labels, contact your service personnel.

One or more of the product identification labels in Table 2-1 may be on your system or peripheral equipment. Please familiarize yourself with the labels that apply to your particular system.

Table 2-1: Warning symbols

Label	Description (typical use)
	Warning: Hand crushing
	Warning: Hot surface
	Warning: Magnetic field
	Warning: Voltage (barriers, points of entry)
	Warning: General sign
	Warning: laser beam
	Warning: non-Ionizing radiation

Table 2-2: Prohibited symbols

Label	Description (typical use)
	Prohibited: do not obstruct
	Prohibited: no access for unauthorized persons
	Prohibited: do not touch - hazardous voltage
	Prohibited: no metallic articles
	Prohibited: no metallic implants*
	Prohibited: no pacemakers*
	Prohibited: do not loop cable

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

Table 2-3: Mandatory symbols

Label	Description (typical use)
	Mandatory: instruction manual
	Mandatory: maintenance instructions
	Mandatory: refer to instructions
	Mandatory: wear ear protection

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Table 2-4: Manufacturer information symbols

Label	Description (typical use)
	Manufacturer
	Date of manufacture
	Model reference
	Serial number

Table 2-5: Patient comfort symbols

Label	Description (typical use)
	Patient comfort lighting
	Patient comfort ventilation (fan)

Table 2-6: Environmental symbols

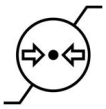
Label	Description (typical use)
	Atmospheric pressure limitation
	Temperature limitation
	Humidity limitation

Table 2-7: PAC[1] symbols

Label	Description (typical use)
	Respiratory bellows port. Either label may be on your system.
	ECG leads port. Either label may be on your system.
	Peripheral gating port. Either label may be on your system.
	Patient alert port. Either label may be on your system.

Table 2-8: MR safety symbols

Label	Description (typical use)
 or	MR safe
	MR Conditional
	MR unsafe

[1] Physiological Acquisition Control

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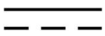
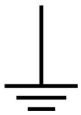
Table 2-9: Product identification symbols

Label	Description (typical use)
	Alternating current (rating plate, terminals)
	Direct current (rating plate, terminals)
	Three-phase alternating current
	Earth (ground terminals)
	Protective earth (ground terminals)
	Equipotentiality (terminals)
	Voltage (components, points of entry)
	Main power on (main disconnect/power switch)
	Main power off (main disconnect/power switch)
	Power on (only for a part of equipment)
	Power off (only for a part of equipment)
	Emergency stop
	Fast stop
	Class II equipment (double insulated) (ratings)
	Type B Applied Part (ratings, AP connections)

Label	Description (typical use)
	Type BF Applied Part
	Non-ionizing electromagnetic radiation (ratings)
	Attention – Consult accompanying documents
	CAUTION – Static Sensitive (Electrostatic discharge (ESD) susceptible parts)
	Laser Radiation (laser devices)
	Table mass in Kg. without the patient

INTRODUCTION

Indications for use

The indications for use for each specific system type can be found in the your MR Operator Manual.

CAUTION

These devices are limited by federal law to investigational use for indications not in the “Indications for Use” statement for a specific system type. Under federal law, these devices should only be used for the functions set forth in the “Indications for Use” statements.

WARNING

Read the *full prescribing information* on the contrast media label before use of contrast media. Use contrast media only in accordance with Indications and Usage as described in full prescribing information.

INTRODUCTION

Restrictions on use

CAUTION

Federal law restricts the sale, distribution, and use of this device to or on the order of a physician.

CAUTION

Do not load non-system software onto the system computer.

WARNING

The MR system is not designed to provide information for clinical stereotactic use. The spatial accuracy obtainable with your MR system may not be adequate for stereotactic procedures and can vary depending on the patient, the pulse sequence used, and the system itself. It is therefore recommend that MR images not be used for stereotactic applications.

WARNING

Electrically conductive stereotactic devices may lead to high localized SAR. Excessive transmit power may result from interactions between the structure and the transmit coil. In addition, improper padding between the patient and any conductor may lead to excessive localized heating.

Clinical stereotactic use refers to being used in localization for surgical procedures.

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INTRODUCTION

Instructions for use

The 2nd amendment to IEC 60601-2-33 assumes that because no chronic effects from exposure to MR fields are known, worker safety limits are the same as for patients. However, it is prudent to minimize worker exposures.

Workers must prevent ferromagnetic materials from entering the magnet room. Ferrous projectile hazards are a major safety concern. Note that some materials that are initially non-magnetic may become magnetic when subjected to a static magnetic field over a period of time. Motion in static magnetic fields (especially near large spatial field gradients) may induce metallic tastes, vertigo, nausea, and possibly flashes of light (magneto-phosphenes). These motion effects are considered to be non-hazardous, provided they do not cause the worker to fall.

Time-varying gradient magnetic fields may induce peripheral nerve stimulation if the worker intercepts sufficient time-varying flux. Peripheral nerve stimulation is non-hazardous unless it causes the worker to injure himself when startled by the effect. Field plots of the maximum time-varying gradient |B| workers could experience outside the magnet bore is shown in the figure below.

Figure 2-1: Maximum Magnitude Gradient Magnetic Field from three Simultaneous Axes at the Patient Bore Radius (worker exposure is limited to these levels as a function of z).

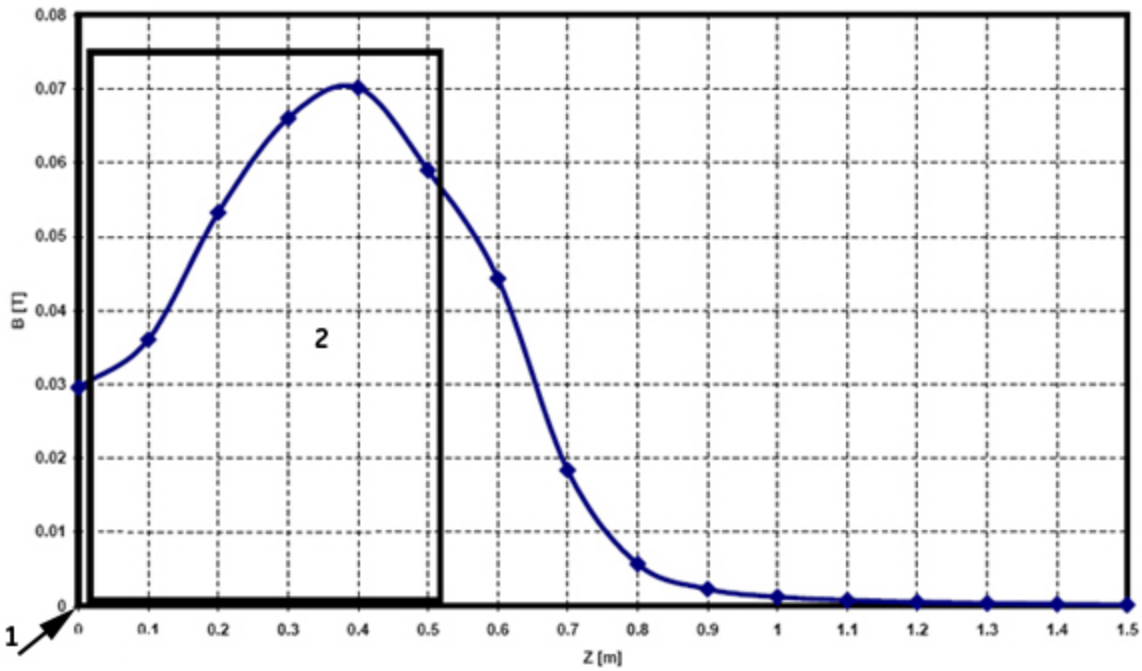

Table 2-10: Image legend

#	Description
1	Isocenter
2	Magnet from isocenter to front

Radio frequency fields at sufficiently high levels may cause heating. Outside the magnet bore the radio frequency fields rapidly decay. Let B1 be the magnetic field strength of the radio frequency magnetic field. A plot of the square B1 normalized to its value at isocenter is shown in figure below. At most B1 at isocenter may produce the whole-body Specific Absorption Rate (SAR) limit. If as much of the body were exposed outside the bore then the graph below shows the scale factor for each Z location. This is a very conservative estimate of SAR since the total flux into the body is likely to be much smaller.

Figure 2-2: Plot of the Square of B1 Normalized to Isocenter for the Body Birdcage Coil on Axis.

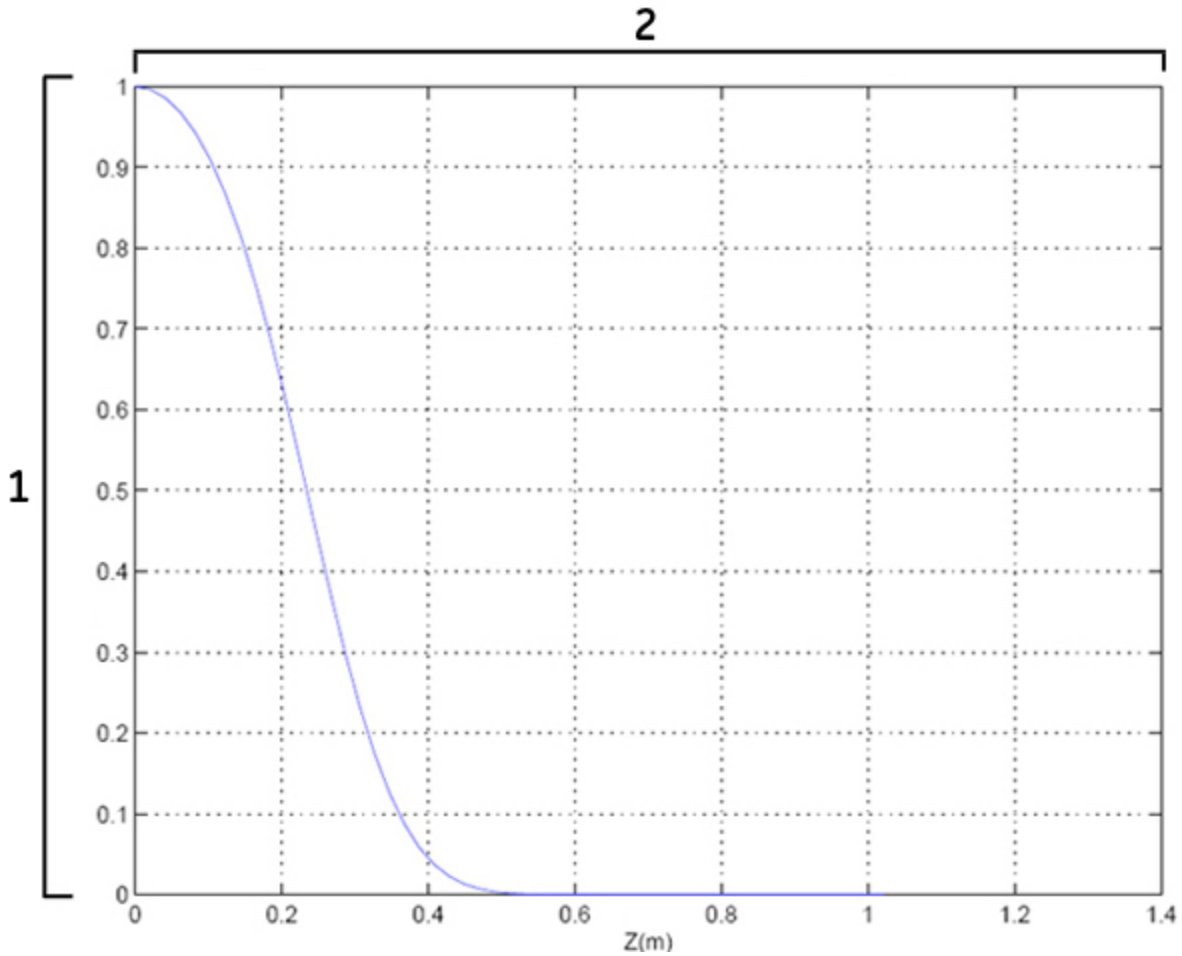

Table 2-11: Image legend

#	Description
1	Square of B1 normalized to isocenter.
2	Square of B1 normalized to isocenter for body birdcage coil on axis.

INTRODUCTION

Contraindications for use

Contraindications for use statement

In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

- **MR Safe**: For patients with implants that are labeled as MR Safe, consult the implantable device's labeling.
- **MR Conditional**: For patients with implants that are labeled as MR Conditional, consult the implantable device's labeling.
- **MR Unsafe**: Patients with implantable devices that are MR Unsafe are contraindicated.

If the level of MR compatibility is not known, then an implantable device should be considered MR Unsafe.

MR environment safety terminology

The MR Environment Safety Terminology is intended to help explain labeling matters for medical devices and other items that may be used in the MR environment to ensure the safe use of MR technology.

Terminology for defining the safety of items in the MR environment is provided in ASTM F2503 Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment. FDA recommended using the terminology MR Safe, MR Conditional, and MR Unsafe, defined in ASTM F2503 (FDA guidance document, "Establishing Safety and Compatibility of Passive Implants in the Magnetic Resonance (MR) Environment Document").

Definitions

MR safe: An item that poses no known hazards in all MR imaging environments.

With this terminology, MR safe items are non-conducting, non-metallic, and non-magnetic items, such as a plastic Petri dish. An item may be determined to be MR safe by providing a scientifically based rationale rather than test data.

MR Conditional: An item that has been demonstrated to pose no known hazards in specified MR environment with specified conditions of use. Field conditions that define the MR environment include static magnetic field strength, spatial gradient, time rate of change of the magnetic field (dB/dt), RF fields, and specific absorption rate (SAR).

Additional conditions, including specific configurations of the item (e.g., the routing of leads used for a neurostimulation system), may be required.

MR Unsafe: An item that is known to pose hazards in all MR environments.

MR unsafe items include magnetic items such as a pair of ferromagnetic scissors.

ASTM standard F2503 also describes how MR Safe, MR Conditional and MR Unsafe device Icons are to be used for MR labeling of implants and devices. For details see **MR safety labels.**

CAUTION

Safe scanning of patients with MR Conditional devices or implants may be complex. Health care professionals that scan patients with MR Conditional devices or implants should consult the implant or device manufacturer for instructions with respect to safety guidelines.

WARNING

Scanners are not designed to regulate SAR and dB/dt for levels other than the IEC NORMAL MODE (WB SAR <= 2 W/kg, head SAR <= 3.2 W/kg and dB/dt <= 80% of the mean nerve stimulation limit) and IEC FIRST MODE (WB SAR <= 4 W/kg, head SAR <= 3.2 W/kg and dB/dt <= 100% of the mean nerve stimulation limit. No other limits are enforced.

WARNING

The magnetic field of the MR system can cause a ferrous implant (e.g., surgical clip, cochlear implant, intracranial aneurysm clip etc.) or prosthesis to move or be displaced, resulting in serious injury. Patients and MR workers should be screened for implants and those individuals with implants should, in general, not enter the scan room. For patients and MR workers with implants that are labeled as "MR Safe" or "MR Conditional", consult the implantable device's labeling and the technical information about the MR system.

Prostheses should be removed before scanning to help prevent injury.

WARNING

The tests commonly employed to determine MR Conditional implant heating safety (standard, ASTM F2182, ASTM.org), require quadrature excitation. Heating results for non-quadrature excitation (such as parallel transmit, dual drive, or elliptical drive) are unknown.

For patients with MR Conditional implants or devices, applying Preset or Optimized RF Drive Modes may violate the MR Conditional specifications.

When scanning patients with MR Conditional implants, check with GEHC to ensure your system has quadrature transmit.

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MR safety standards

In most countries the MR safety standard IEC 60601-2-33 provides safety limits for MR exams, for ventilation, and for occupational exposure of MR workers. The International Electrotechnical Commission (IEC) developed a widely-used MR safety standard. The IEC MR safety standard is three-tiered. The NORMAL OPERATING MODE is for routine scanning of patients. The operator must take a deliberate action (usually an ACCEPT button) to enter the FIRST CONTROLLED OPERATING MODE. This mode provides higher scanner performance, but requires monitoring of the patient. Finally, there is a SECOND CONTROLLED OPERATING MODE used only for research purposes under limits controlled by an Investigational Review Board (IRB).

The scanner employs a whole body gradient system whose IEC 60601-2-33 compliance volume is:

- a cylinder with axis coinciding with the magnet axis and with a radius of 0.20 meters, for cylindrical magnets, or
- a volume bound by planes parallel to the magnet poles and separated by a distance of 0.40 meters, for vertical-field magnets.

Table 2-12: IEC safety limits

Operating mode	Whole body SAR (W/Kg)	Head SAR (W/Kg)	Partial body SAR (W/Kg)	Local head/trunk SAR (W/Kg)	Local extremity SAR (W/Kg)	Short term SAR (W/Kg)	dB/dt (% mean PNS)
IEC Normal Mode	2	3.2	$= \left(10 - \frac{8M_{exposed}}{M_{patient}}\right)$	10	20	3 x long term	80% PNS
IEC 1st Controlled Operating Mode	4	3.2	$= \left(10 - \frac{6M_{exposed}}{M_{patient}}\right)$	10	20	3 x long term	100% PNS
IEC 2nd Controlled Operating Mode	IRB Limit	IRB Limit	IRB Limit	IRB Limit	IRB Limit	IRB Limit	IRB Limit

Local SAR is averaged over the worst-case 10 g. Short term SAR is averaged over 10 s. SAR limits are reduced if temperature can exceeds 24 degrees C or if humidity exceeds 60%. Hearing protection (only earplugs have been validated) with NRR >/= 29 dB to reduce the A-weighted root-mean-squared sound pressure level below 99 dB(A) shall be used. IEC 60601-1 limits surface contact temperatures to 41 degrees C.

SAFETY STANDARDS

IEC EMC compliance

Per IEC 60601-1-2 Edition 2.1 Medical Electrical Equipment needs special precautions regarding Electro Magnetic Compatibility (EMC) and needs to be installed and put into service according to the EMC information provided in the following tables. The tables below provide details about the level of compliance and provide information about potential interactions between devices.

Portable and mobile RF communications equipment can affect Medical Electrical Equipment.

WARNING

The MR System may be interfered with by other equipment, even if that other equipment complies with CISPR EMISSION requirements.

WARNING

The MR System should not be used adjacent to or stacked with other equipment; if adjacent or stacked use is necessary, the MR System should be observed in order to verify normal operation in the configuration in which it will be used.

WARNING

The MR System should be used only in a shielded location named as the Magnet Room. Magnetic and RF Shielded Room requirements defined in Pre-Installation Manual.

WARNING

The use of accessories, transducers and cables other than those specified, with the exception of transducers and cables sold by GE Healthcare or replacement parts for internal components, may result in increased emissions or decreased immunity of the MR system.

Adhering to the recommendations provided herein for the interaction of the MR System with other electrical devices within the electromagnetic environment may not eliminate all the disturbances, however, the system will maintain its essential performance by continuing to acquire, display, and store quality diagnostic quality images safely.

Table 2-13: Guidance And Manufacturer's Declaration – Electromagnetic Emissions

The MR System is intended for use in a typical health care electromagnetic environment specified below. The customer or the user of the MR System should assure that it is used in such an environment.		
Emissions Test	**Compliance Level**	**Electromagnetic Environment - Guidance**
RF emissions CISPR 11	Group 2	The MR system must emit electromagnetic energy in order to perform its intended function. Nearby electronic equipment may be affected.
RF emissions CISPR 11	Class A	The MR system is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Not Applicable	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Not Applicable	

Table 2-14: Guidance And Manufacturer's Declaration – Electromagnetic Immunity

The MR System is intended for use in a typical health care electromagnetic environment specified below. The customer or the user of the MR System should assure that it is used in such an environment.			
Immunity test	**IEC 60601 test level**	**Compliance Level**	**Electromagnetic environment – guidance**
Electrostatic discharge (ESD) IEC 61000-4-2	±6 kV contact ±8 kV air	±6 kV contact ±8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 61000-4-4	±2 kV for power supply lines ±1 kV for input/output lines	±2 kV for power supply lines ±1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	±1 kV line(s) to line(s) ±2 kV line(s) to earth	±1 kV differential mode ±2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5% UT (>95% dip in UT) for 0,5 cycle 40% UT (60% dip in UT) for 5 cycles 70% UT (30% dip in UT) for 25 cycles	Not applicable	Mains power quality should be that of a typical commercial or hospital environment. If the user of the MR System requires continued operation during power mains interruptions, it is recommended that the MR System be powered from an uninterruptible power supply or a battery.
	<5% UT (>95% dip in UT) for 5 sec.	<5% UT (>95% dip in UT) for 5 sec.	
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.
NOTE UT is the a.c. mains voltage prior to application of the test level.			

Table 2-15: Guidance And Manufacturer's Declaration – Electromagnetic Immunity

The MR System is intended for use in a typical health care electromagnetic environment specified below. The customer or the user of the MR System should assure that it is used in such an environment.			
Immunity test	**IEC 60601 test level**	**Compliance Level**	**Electromagnetic environment – guidance**
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz	3 Vrms	Portable and mobile RF communications equipment should be used no closer to any part of the MR System, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. Recommended separation distance. $d = 1,2\sqrt{P}$ $d = 1,2\sqrt{P}$ 80 MHz to 800 MHz $d = 2,3\sqrt{P}$ 800 MHz to 2.5GHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey[a] should be less than the compliance level in each frequency range[b]. Interference may occur in the vicinity of equipment marked with the following symbol: 
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2,5 GHz	3 V/m	

NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

a: Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the MR System issued exceeds the applicable RF compliance level above, the MR System should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the MR System.

b: Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

Table 2-16: Recommended Separation Distances between portable and mobile RF communications equipment and the MR system

The MR System is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the MR System can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the MR System as recommended below, according to the maximum output power of the communications equipment.			
Rated maximum output power of transmitter W	**Separation distance according to frequency of transmitter stated in meters**		
	150 kHz to 80 MHz $d = 1,2\sqrt{P}$	80 MHz to 800 MHz $d = 1,2\sqrt{P}$	800 MHz to 2.5GHz $d = 2,3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.37	0.37	0.74
1	1.17	1.17	2.33
10	3.69	3.69	7.38
100	11.67	11.67	23.33
For transmitters rated at a maximum output power not listed above, the recommended separation distance d in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer. NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies. NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			

SAFETY STANDARDS

Temperature and humidity specifications

System Suite

Use the specifications listed in the tables in Spatial magnetic field data for designing your HVAC (heating, ventilation, and air conditioning) system. Proper insulation and moisture barrier should be installed within the environmental controlled space (e.g. area above drop ceiling) for humidity, condensation, and temperature control.

To help prevent a patient from feeling uncomfortably warm during a scan, make sure the magnet room temperature does not exceed 69.8.F (21.C) maximum. For Discovery MR750 3.0T systems, if the scan room temperature exceeds 75.2°F (24°C), then the SAR is automatically derated, which means that the current scan parameters may trip the SAR monitor.

Table 2-17: Temperature and humidity specifications

Area	Temperature		Humidity	
	Range °F (°C)	Change °F/Hr (°C/Hr)	Range%	Change%/Hr
Equipment Room at Inlet to Equipment	59-89.6* (15-32)*	5 (3)**	30-75*	5
Temperature in equipment room only for Optima MR360 and Brivo MR355	59-82.4 (15-28)*	5 (3)	30-75*	5
Magnet Room	59-69.8 (15-21)	5 (3)	30-60*	5
Operator's Control Room	59-89.6* (15-32)*	5 (3)	30-75*	5

Note

* Non-condensing humidity with 50% nominal at 65.F (18.3.C).

** Room temperature gradient specification applies from floor to height of top discharge of equipment cabinets.

Table 2-18: Discovery MR750 3.0T Temperature And Humidity Specifications

Area	Temperature		Humidity	
	Range °F (°C)	Change °F/Hr[1] (°C/Hr)	Range%	Change% /Hr[2]
Equipment Room at Inlet to Equipment	59-89.6 (15-32)	5 (3)	30-70	5
Magnet Room	59-69.8 (15-21)	5 (3)	30-60	5
Operator's Control Room	59-89.6 (15-32)	5 (3)	30-70	5

Note

[1] Operating temperature gradient limits shall be between -5F (-3C) degrees C/hour and 5F (3C) degrees C/hour when averaged over 1 hour.

[2] Operating humidity gradient limits shall be between -5% RH/hour and 5% RH/hour, when averaged over 1 hour.

MRCC Operating Environment

The MR Common Chiller (MRCC) operating environment specifications do not apply to Discovery MR750 3.0T systems.

The MRCC is designed to be located external to the building and may be used or be transported in environments meeting the following specifications.

- Ambient Temperature: -22 °F (-30°C) to 110°F (43°C)
- Humidity: 5-100%

Magnetic field basics

Though it is generally accepted that no published evidence exists supporting cumulative or long-term negative effects of EMF[1] exposure, it is advisable for pregnant MR workers to exercise extra precaution in limiting their exposure as much as possible. The existence of local regulations establishing upper limits for MR workers may not apply to pregnant MR workers, although no epidemiological evidence exists supporting negative effects of EMF exposure on the health of a pregnant worker or her fetus. The User is responsible for determining whether local or country legislation may exist establishing occupational limits for exposure to EMF. If such limits exist it is the User's responsibility to ensure they are being observed.

To ensure safe operation of your system, for both you and your patient, you must understand several components of your MR system. Your MR system includes the following magnetic fields:

- Static Magnetic Field (the magnet)
- Gradient Magnetic Fields (the gradients)
- Electromagnetic Fields (the RF)

The following definitions are used throughout Magnetic Field Basics section. Not all modes of operation apply to all GEHC MR scanners.

- **Normal Operating Mode (Clinical Mode):** mode of operation of the MR equipment in which none of the outputs have a value that may cause physiological stress to patients.
- **First Level Controlled Operating Mode:** mode of operation of the MR equipment in which one or more outputs reach a value that may cause physiological stress to patients, which needs to be controlled by medical supervision.
- **Second Level Controlled Operating Mode:** mode of operation of the MR equipment in which one or more outputs reach a value that may produce significant risk for patients, for which explicit ethical approval is required (i.e., a human studies protocol approved to local requirements).

[1] Electro Magnetic Field

MAGNETIC FIELDS

Static magnetic fields

The main magnet is a stable and very intense magnetic field.

Note that the MR magnet is always on even when the system is not acquiring scan data. The only exception to this is if service has ramped down the magnet or it has been quenched.

The main safety issues regarding the static magnetic field include the potential for biological effects, the potential for attraction of ferromagnetic objects, and the potential for a quench of the cryogens.

The MR system static magnetic field may be classified under several modes:

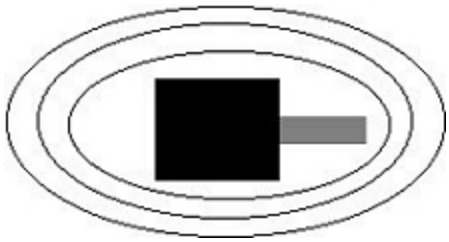
- Normal: the normal operating mode, admissible for all individuals.
- First Level: controlled operating mode, admissible for patients on whom a medical decision was made ensuring they can handle the increased static magnetic field.
- Second Level: controlled operating mode, approval of an IRB or Human Ethical Committee required, with the static field limit explicitly stated.

Table 2-19: Static magnetic field

Mode	System
</= 2T for Normal Mode	0.7T /1.5T
> 2T </= 4T for First Level Mode	3.0T
> 4T for Second Level Mode	N/A

A magnet produces invisible lines of force that extend beyond the magnet that are called the fringe field. The size of the fringe field depends on the strength of the magnet and whether or not it is shielded. Active and inactive shielding are used to reduce or tighten the fringe field.

Figure 2-3: Fringe field



CAUTION

For some patients or MR workers, rapid movement of the head while in the magnetic field may cause dizziness, vertigo, or a metallic taste in their mouth. None of these motion effects are considered to be hazardous, provided they do not cause the worker to fall.

It is recommended that the patient and the MR worker endeavor to remain still while in the region of high static magnetic field. The MR worker should always vacate the area of the static magnetic field when duties do not require otherwise.

The tesla to gauss conversion is 1 tesla = 10,000 Gauss.

The magnetic field exerts force on susceptible materials and biomedical implants and can create hazards. There are two critical zones: the Security Zone and the Exclusion Zone. Each zone has specific restrictions regarding people and materials.

WARNING

It is your responsibility to ensure permanent creation of the Security Zone and the Exclusion Zone and to establish rules for access. Ensure occupational exposure to static magnetic field complies with local requirements.

MAGNETIC FIELDS

Security zone

The Security Zone is the magnet room and the walls of the magnet room.

Figure 2-4: Security Zone

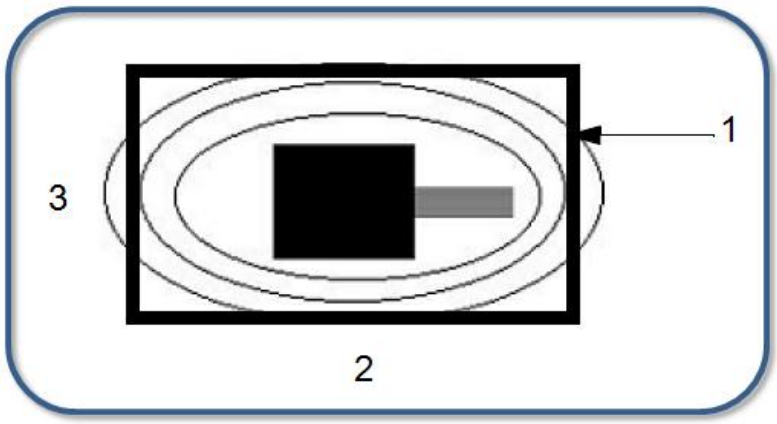


Table 2-20: Image legend

#	Description
1	Magnet room
2	Room length = 21 feet (6.4 m)
3	Room width = 13 feet (3.96 m)

Static magnetic field plots for siting (rule of thumb - assumes no ferromagnetic materials) may be found at:
http://www.gehealthcare.com/company/docs/siteplanning.html#mr

NOTE: The figure above states the approximate minimum room size for the 0.7T OpenSpeed, 1.5T EXCITE, and 3.0T systems, including Signa and MR750 systems. Consult your GE System Pre-Installation Manual for specific dimensions of your system and additional magnetic field plot information.

The 3.0T VH/i system approximate minimum room requirements are 17 feet x 28 feet. Consult your GE System Pre-Installation Manual for specific dimensions of your system and additional magnetic field plot information.

Optima MR360 and Brivo MR355 systems approximate minimum room requirements are 18.7 feet x 10.9 feet (5.7m x 3.3m). Consult your GE System Pre-Installation Manual for specific dimensions of your system and additional magnetic field plot information.

IMPORTANT!: You need to understand the meanings of ferromagnetic and ferrous substances or items:

- A substance that is ferromagnetic has a large positive magnetic susceptibility. (Example: Iron.)
- An item that is ferrous can posses intrinsic magnetic fields and react strongly in an applied magnetic field. (Examples: Iron, nickel, and cobalt.)

The attractive force of the magnetic field in the Security Zone can cause ferromagnetic items to become projectiles and contraindicated biomedical implants to fail. In short, ferromagnetic items and contraindicated biomedical implants are NOT allowed in the Security Zone.

The MR System operates with a highly sensitive RF receiving front end to be able to capture the signal of an object scanned. The Magnet Room part of the MR System installation provides the RF isolation to reduce the interference from electrical devices outside the shielded location.

It is possible that any device that functions with active electronic circuitry may potentially interfere the operation of the MR System if such device is introduced inside the Magnet Room even though the device does not have an intentional RF Transmitter. Extreme EMC measures must be taken into account in the design and manufacturing of an electrical device if such device is intended to operate inside the Magnet Room.

A device that may potentially interfere the MR System if introduced inside the Magnet Room are those containing active electronics. Some examples include: Switching Mode Power Supply (SMPS), microprocessor, Digital Signal Processors, analog to digital converters, LCD displays, keypad controllers, motors, battery operated devices.

WARNING

The Security Zone warning sign must be posted on the entrance to the magnet room to alert personnel to the high magnetic field and warn not to bring ferromagnetic objects into the magnet room.

WARNING

Ensure that the Security Zone complies with your local statutory requirements.

Security Zone Warning sign

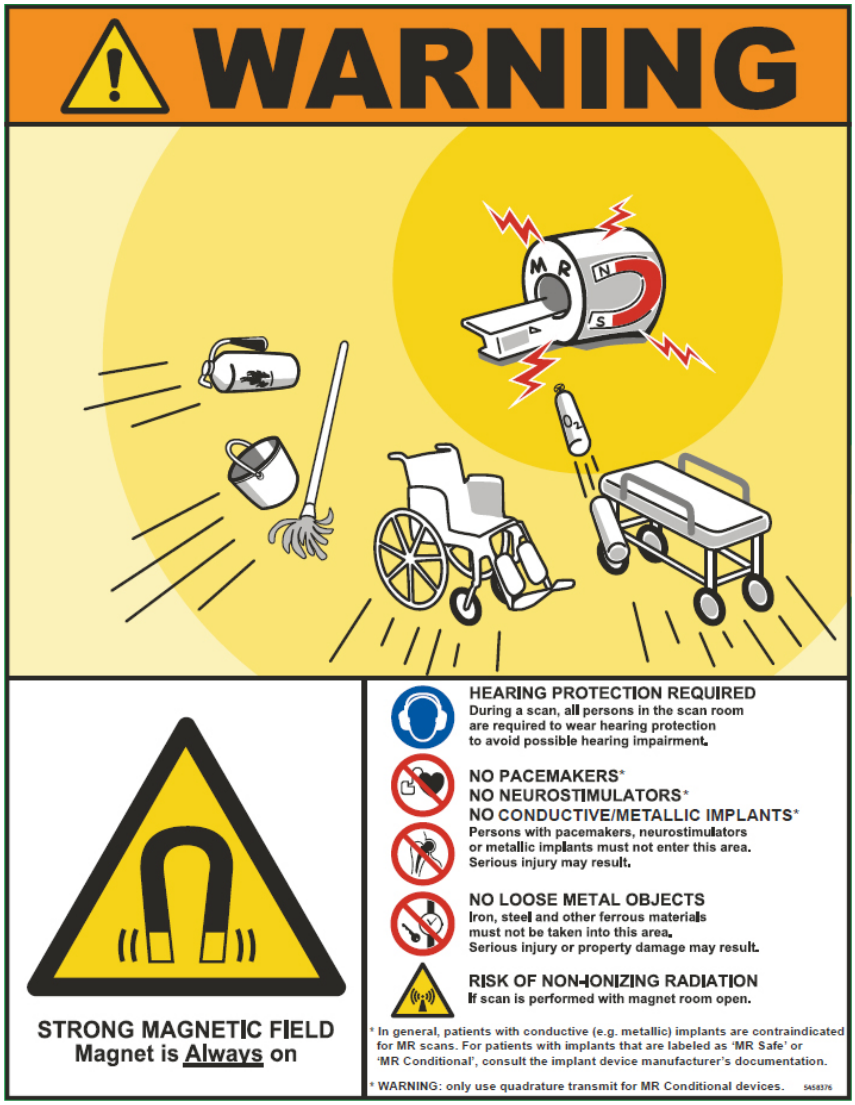
The Security Zone Warning Sign alerts personnel and patients of the following:

- Strong magnetic field
- Hearing protection: During a scan, all persons in the scan room are required to wear hearing protection to avoid possible hearing impairment.
- No pacemakers*
- No neurostimulators*
- No conductive/metallic implants*
  - Persons with pacemakers, neurostimulators or metallic implants must not enter this area. Serious injury may result.
- No loose metal objects: Iron, steel and other ferrous material must not be taken into this area. Serious injury or property damage may result.
- Risk of non-ionizing radiation: If a scan is performed with the magnet room open.

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

Figure 2-5: Security zone warning sign



Your system may have a slight variation of this sign.

3.0T Security Zone warning sign

3.0T EXCITE magnets have a specialized Security Zone warning sign to distinguish the 3.0T magnet from a lower magnetic field.

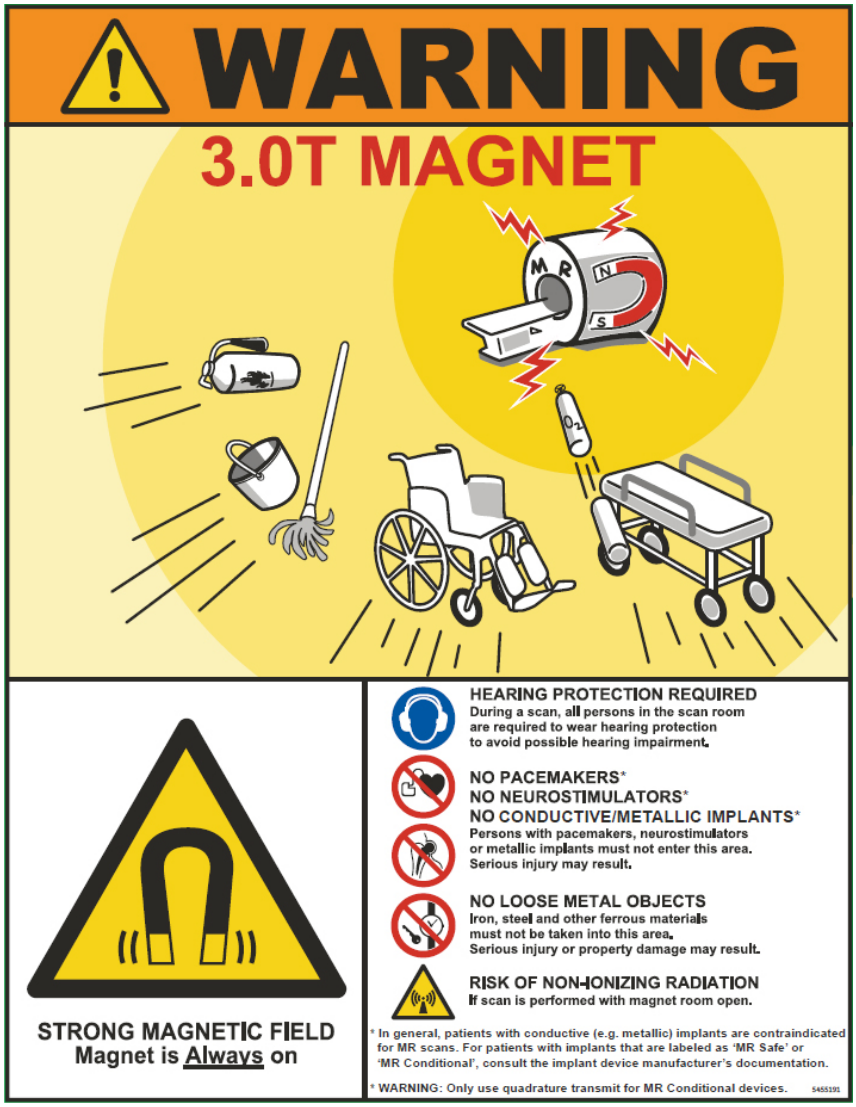
The Security Zone Warning Sign for 3.0T EXCITE magnets alerts personnel and patients of the following:

- Strong magnetic field
- Hearing protection: During a scan, all persons in the scan room are required to wear hearing protection to avoid possible hearing impairment.
- No pacemakers*
- No neurostimulators*
- No conductive/metallic implants*
  - Persons with pacemakers, neurostimulators or metallic implants must not enter this area. Serious injury may result.
- No loose metal objects: Iron, steel and other ferrous material must not be taken into this area. Serious injury or property damage may result.
- Risk of non-ionizing radiation: If a scan is performed with the magnet room open.

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

Figure 2-6: Security zone warning sign for 3.0T magnets



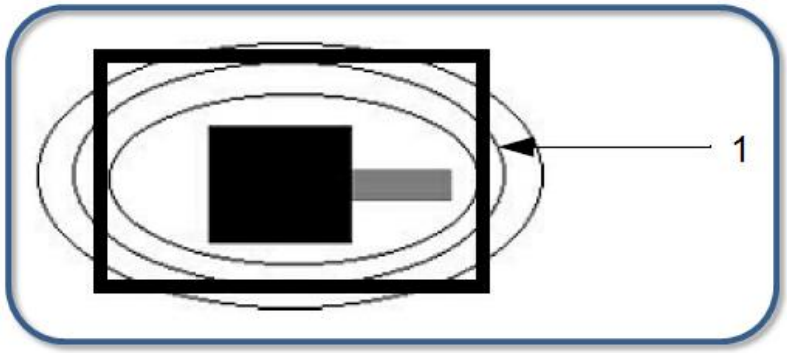
Your system may have a slight variation of this sign.

MAGNETIC FIELDS

Exclusion zone

The Exclusion Zone begins at the 5-gauss line. Magnetic shielding may, however, restrict the 5-gauss line to the magnet room, making the security and the exclusion zone the same

Figure 2-7: Exclusion Zone, 1 = 5 gauss line



Static magnetic field plots for siting (rule of thumb - assumes no ferromagnetic materials) may be found at:

http://www.gehealthcare.com/company/docs/siteplanning.html#mr

All personnel should be aware of the gauss line and actively screen the changing conditions of the environment. There are gauss lines and equipment that must remain outside certain limits. Consult your GE Service Engineer to know where these gauss lines are located in your facility.

WARNING

The Exclusion Zone warning sign must be posted at the 5 gauss boundary. Locate and read the Exclusion Zone signs at your facility.

Exclusion Zone Warning sign

The Exclusion Zone Warning Sign alerts personnel and patients of the following:

- Strong magnetic field
- No pacemakers*
- No neurostimulators*
- No conductive/metallic implants*
  - Persons with pacemakers, neurostimulators or metallic implants must not enter this area. Serious injury may result.

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

Figure 2-8: Exclusion zone warning sign

Your system may have a slight variation of this sign.

WARNING

Ensure that the Exclusion Zone complies with your local statutory requirements.

MAGNETIC FIELDS

Biological effects

The static magnetic field strengths used by your MR system are within the guidelines provided by the United States Food and Drug Administration (FDA) for clinical imaging. However, there are several cautions that need to be understood:

CAUTION

Minimize the time spent near the magnet. Spend only the time necessary to attend to the needs of the patient.

CAUTION

MR scanning has not been established as safe for imaging fetuses or infants. Carefully compare the benefits of MR versus alternative procedures before scanning to control risk to the patient. A physician needs to decide to scan pregnant or infant patients.

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MAGNETIC FIELDS

Ferromagnetic objects

Ferromagnetic objects brought within close proximity of the static magnetic field can become projectiles, which could cause harm to someone standing between the object and the magnet. The force of attraction between a magnet and a ferromagnetic object is determined by the magnetic field strength (fringe field), the magnetic susceptibility of the object, its mass, its distance from the magnet, and its orientation to the field.

Use only non-ferrous oxygen tanks, wheelchairs, gurneys, intravenous (IV) poles, ventilators, etc. in the magnet room. Be sure anyone who has access to the MR suite is aware that only non-ferrous items are allowed in the magnet room. Make them aware that policies and procedures are in place for bringing medical devices and other equipment into the magnet room.

In addition to the projectile hazard, the static magnetic field can cause ferromagnetic objects within the patient (e.g., surgical clips, prostheses) to move, thus possibly causing harm. Electrically, magnetically, or mechanically activated implants can become dysfunctional due to the static magnetic field. If these devices are life-supporting, harm could result.For medical devices that are labeled as MR Safe or MR Conditional consult the device manufacturer's documentation.

WARNING

The attractive force of the magnetic field of the MR system can cause ferrous objects to become projectiles that can cause serious injury. Post the security zone warning sign on the entrance to the magnet room and keep all hazardous objects out of the magnet room. If a ferromagnetic object has become attached to the magnet, contact GE Service for assistance.

WARNING

To help prevent patient or operator injury, do not bring ferrous materials such as battery operated devices into the magnet room.

WARNING

To help prevent patient or operator injury, do not bring ferrous oxygen bottles into the magnet room.

CAUTION

Common hospital equipment, which often have ferrous battery packs, such as patient monitoring, and life supporting devices, may be adversely affected when in proximity to the magnetic field or image quality may be affected by the presence of this equipment.

CAUTION

The only GE supplied tools recommended for use inside the Security zone are the phantoms supplied with your system.

WARNING

Electrical discharges between conductive devices and the MR coils can startle or burn the patient and possibly cause the patient to injure himself/herself. To help avoid such reactions, do not place metal objects (e.g., limb braces, traction mechanisms, stereotactic devices, etc.) in the MR magnet.

WARNING

The fringe field can cause injury by interfering with the normal operation of biomedical devices.

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MAGNETIC FIELDS

Spatial magnetic field data

MR environment safety terminology

The MR Environment Safety Terminology is intended to help explain labeling matters for medical devices and other items that may be used in the MR environment to ensure the safe use of MR technology.

Terminology for defining the safety of items in the MR environment is provided in ASTM F2503 Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment. FDA recommended using the terminology MR Safe, MR Conditional, and MR Unsafe, defined in ASTM F2503 (FDA guidance document, "Establishing Safety and Compatibility of Passive Implants in the Magnetic Resonance (MR) Environment Document").

Definitions

MR safe: An item that poses no known hazards in all MR imaging environments.

With this terminology, MR safe items are non-conducting, non-metallic, and non-magnetic items, such as a plastic Petri dish. An item may be determined to be MR safe by providing a scientifically based rationale rather than test data.

MR Conditional: An item that has been demonstrated to pose no known hazards in specified MR environment with specified conditions of use. Field conditions that define the MR environment include static magnetic field strength, spatial gradient, time rate of change of the magnetic field (dB/dt), RF fields, and specific absorption rate (SAR).

Additional conditions, including specific configurations of the item (e.g., the routing of leads used for a neurostimulation system), may be required.

MR Unsafe: An item that is known to pose hazards in all MR environments.

MR unsafe items include magnetic items such as a pair of ferromagnetic scissors.

ASTM standard F2503 also describes how MR Safe, MR Conditional and MR Unsafe device Icons are to be used for MR labeling of implants and devices. For details see **MR safety labels.**

CAUTION

Safe scanning of patients with MR Conditional devices or implants may be complex. Health care professionals that scan patients with MR Conditional devices or implants should consult the implant or device manufacturer for instructions with respect to safety guidelines.

WARNING

Scanners are not designed to regulate SAR and dB/dt for levels other than the IEC NORMAL MODE (WB SAR <= 2 W/kg, head SAR <= 3.2 W/kg and dB/dt <= 80% of the mean nerve stimulation limit) and IEC FIRST MODE (WB SAR <= 4 W/kg, head SAR <= 3.2 W/kg and dB/dt <= 100% of the mean nerve stimulation limit. No other limits are enforced.

WARNING

The tests commonly employed to determine MR Conditional implant heating safety (standard, ASTM F2182, ASTM.org), require quadrature excitation. Heating results for non-quadrature excitation (such as parallel transmit, dual drive, or elliptical drive) are unknown.

For patients with MR Conditional implants or devices, applying Preset or Optimized RF Drive Modes may violate the MR Conditional specifications.

Magnet information

This information is provided to comply with IEC 60601-2-33 clause 6.8.3 bb.

The peak main magnetic field (B_0), peak gradient of the main magnetic field (grad(B_0)), and the peak force product (main magnetic field times the peak gradient of the main magnet field [B_0 grad(B_0)]) and their spatial locations are provided in cylindrical coordinates centers at magnet isocenter.

Note that peak accessible values typically occur (see figure below) at or near the magnet covers (shroud) in a patient accessible area. To find the magnet type used with your system, contact your GE field service engineer.

Definitions

- Peak main magnetic field (B_0), maximum magnetic field magnitude at patient accessible locations.

  For solenoid magnets these values typically lie on circles with radius R from the axis of the magnet on both the front and the back of the magnet at ±Z from isocenter.

- Peak gradient of the main magnetic field (grad(B_0)).

  The peak gradient of the static magnetic field, B_0, is the maximum rate of change of the main magnetic field magnitude along any direction at a patient accessible location. For solenoid magnets these values typically lie on circles with (see table and figure below) radius R from the axis of the magnet on both the front and the back covers of the magnet at ± Z from isocenter.

Note that the strength of time-varying gradients are small and not relevant to magnetic force considerations.

- Peak force product (B_0 grad(B_0)).

  The peak force product is the maximum product of B_0 and grad(B_0) at accessible locations. Note that maximum forces and torques will occur at this location. Only values in a patient accessible area with magnet covers in place are given in the table below. For solenoid magnets (see figure below) these values typically lie on circles with radius R from the axis of the magnet on both the front and the back of the magnet at ± Z from isocenter.

- Locations

  Defined in cylindrical coordinates, (Z, R) with (Z=0, R=0) being magnet isocenter apply to both the front and back of the magnet (see table and figure below). For solenoid magnets the same maximum values occur at R, ± Z for all angles, i.e., the same peak values form a circle with radius R at ±Z.

- Translational Force

  Force acting to move the center of mass of an object. Ferromagnetic objects in non-uniform magnetic fields experience translational forces.

- Torque

  A pair of opposite forces some distance apart acting to rotate an object without changing the position of the center of mass. Asymmetrically-shaped ferromagnetic objects (such as needle-shaped objects) experience torques in magnetic fields.

Figure 2-9: Magnet location of fringe-field maximum. Spatial locations of peak fields accessible to patients. The origin of the cylindrical coordinates is magnet isocenter. Cylindrical coordinates locate points a radius R from the magnet axis (centerline) and a distance z from isocenter on axis.

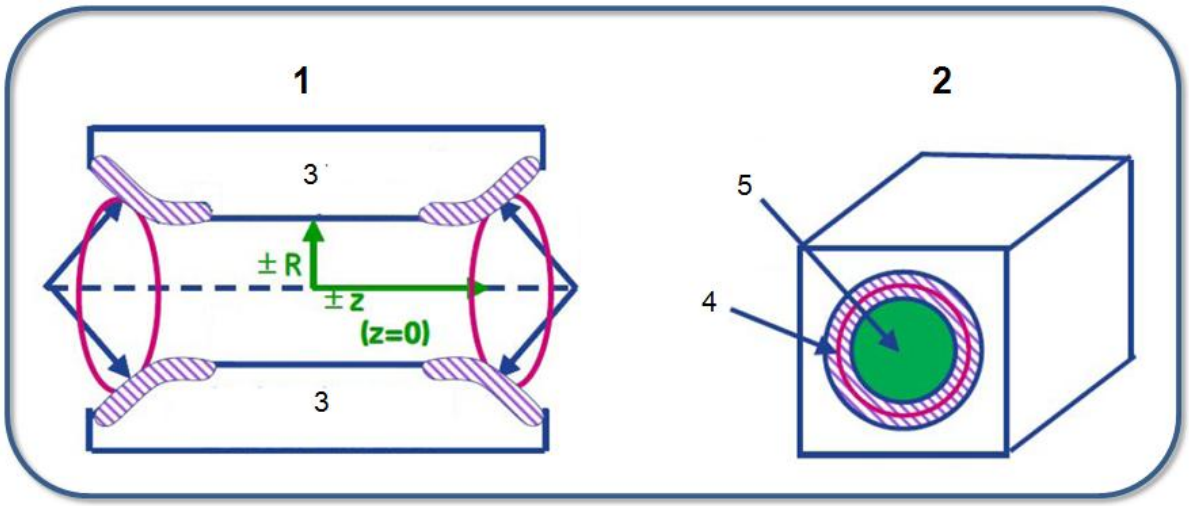


Table 2-21: Image legend

#	Description
1	Side cut-away view of magnet.
2	Front view of magnet.
3	Cylindrical magnet and cover (shroud).
4	Peak B Peak grad (B) Peak B* grad (B) Typically, peak B, peak grad (B), and peak B*grad(B) are close to the magnet covers in a patient accessible area and are symmetric for rotations about the long axis of the magnet (equal fields for (Z,R) along a circle centered on axis). The peak values are in the shaded regions. Specific locations (R.Z) are identified in table below.
5	Patient bore.

Spatial Magnetic Field

Maximum forces and torques on ferromagnetic objects depend on the force product.

Forces and Torques

Spheres of uniform ferromagnetic material experience translational forces near magnets, but no torque.

For example, the magnetic force on a soft iron sphere is its weight multiplied by 31.2 times B_0(grad(B_0)).

- Asymmetric ferromagnetic objects (for example long cylinders) may experience both translational forces and torques. For such objects the translational force can be orders of magnitude lower than those related to torque.
- Magnetic translational force depends on the force product (B0 grad(B0)) with the maximum force occurring for the maximum force product.
- Torques increase with $(B_0)^2$ and depend on angle from B_0 and shape.
- MR compatibility investigators have reported the maximum static magnetic fringe field gradient in the past as a safety criterion. For each maximum the maximum values, the spatial locations

(cylindrical coordinates (Z,R)), and the values of the other (typically non-maximum) parameters are given below for GE magnets.

The table below contains coordinates for and values of maximum B_0, maximum grad(B_0), and maximum B_0(grad(B_0)). MR compatibility investigators have reported the maximum static magnetic fringe field gradient in the past as a criterion for MR compatibility though the force product actually determines translational force on ferromagnetic objects. The maximum field values (shown with red borders), the spatial locations (in cylindrical coordinates (z,R)), and the values of the other (typically non-maximum) parameters are given below for GE magnets

Useful unit conversions

- 1 T/m = 100 G/cm
- 1 G/cm = 0.01 T/m
- 1 T^2/m = 10^6 G^2/cm
- 1 G^2/cm = 10^{-6} T^2/m

Peak static spatial gradients on patient accessible areas table

See figure above for explanation of R and Z. If you are not sure of your system configuration, consult your service engineer.

GEM enclosure

Figure 2-10: GEM magnet cover

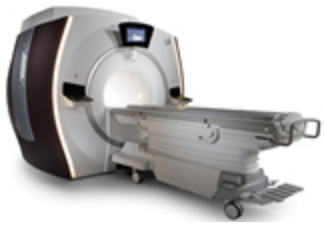


Table 2-22: GEM enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
3.0T 3TLC	70 XRMW	Peak B	0.35	0.64	3.9	7.2	28.2
		Peak Gradient	0.51	0.92	1.8	12.4	22.6
		Peak Product	0.36	0.73	3.6	10.7	38.7
1.5T DVw	70 XRMW	Peak B	0.36	0.62	2.1	6.1	12.8
		Peak Gradient	0.51	0.78	1.5	12.4	18.8
		Peak Product	0.51	0.78	1.5	12.4	18.9

DV enclosure

Figure 2-11: DV magnet cover

Table 2-23: DV enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
3.0T G3	60 XRMB	Peak B	0.31	0.63	3.6	4.7	16.9
		Peak Gradient	0.43	0.89	2.3	13.1	30.2
		Peak Product	0.40	0.86	2.6	12.1	31.9
1.5T LCC	60 XRMB	Peak B	0.31	0.60	1.9	2.8	5.2
		Peak Gradient	0.37	0.84	1.2	5.8	7.1
		Peak Product	0.32	0.76	1.5	5.2	8.1
1.5T DVw	70 XRMW	Peak B	0.36	0.62	2.1	6.0	12.7
		Peak Gradient	0.56	0.78	1.4	11.9	16.7
		Peak Product	0.53	0.78	1.5	11.5	17.1

HDx enclosure

Figure 2-12: HDx magnet cover

Table 2-24: HDx enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
3.0T G3	60 TRM	Peak B	0.31	0.61	3.6	3.6	12.8
		Peak Gradient	0.50	0.91	2.1	14.9	30.7
		Peak Product	0.35	0.77	3.3	11.9	39.3
1.5T LCC	60 BRM	Peak B	0.32	0.63	1.9	3.4	6.5
		Peak Gradient	0.39	0.81	1.4	7.4	10.5
		Peak Product	0.37	0.77	1.6	6.9	11.3
1.5T LCC	60 TRM	Peak B	0.31	0.61	1.9	2.9	5.4
		Peak Gradient	0.38	0.83	1.3	6.5	8.3
		Peak Product	0.34	0.76	1.6	5.9	9.5

Vibrant enclosure

Figure 2-13: Vibrant magnet cover

Table 2-25: Vibrant enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
1.5T LCC	60 TRM	Peak B	0.32	0.63	1.9	3.4	6.5
		Peak Gradient	0.39	0.81	1.4	7.4	10.5
		Peak Product	0.37	0.77	1.6	6.9	11.3

OpenSpeed enclosure

Figure 2-14: OpenSpeed magnet cover

Table 2-26: OpenSpeed enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
0.7T HFO	Flat	Peak B	0.58	0.23	1.5	16.3	22.7
		Peak Gradient	0.59	0.23	1.5	25.2	34.6
		Peak Product	0.59	0.23	1.5	25.2	34.6

Wide open enclosure

Figure 2-15: Wide open magnet cover

Table 2-27: Wide open enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
3.0T G3	60 TRM	Peak B	0.32	0.63	3.6	4.7	17.0
		Peak Gradient	0.48	0.91	2.2	14.5	31.1
		Peak Product	0.38	0.83	2.9	12.4	36.0
1.5T LCC	60 BRM	Peak B	0.32	0.62	1.9	3.6	6.9
		Peak Gradient	0.40	0.80	1.5	7.9	11.8
		Peak Product	0.39	0.78	1.6	7.7	12.5
1.5T LCC	60 TRM	Peak B	0.31	0.62	1.9	3.3	6.2
		Peak Gradient	0.37	0.81	1.4	6.3	8.6
		Peak Product	0.34	0.76	1.6	6.0	9.4

Horizon wide enclosure

Figure 2-16: Horizon wide open magnet cover

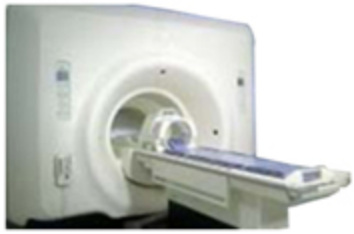


Table 2-28: Horizon wide open enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
3.0T 3T94	55 CRM	Peak B	0.31	0.71	3.4	1.9	6.5
		Peak Gradient	0.42	1.07	2.4	9.1	21.9
		Peak Product	0.41	1.03	2.7	8.3	22.7
1.5T magni-shield	60 BRM	Peak B	0.31	0.67	1.7	1.3	2.3
		Peak Gradient	0.43	1.09	0.9	6.1	5.4
		Peak Product	0.38	0.86	1.6	3.8	5.9
1.5T magni-shield	55 CRM	Peak B	0.32	0.71	1.7	1.8	3.1
		Peak Gradient	0.43	1.08	0.9	4.9	4.4
		Peak Product	0.38	0.86	1.6	3.8	5.9

Horizon enclosure

Figure 2-17: Horizon magnet cover

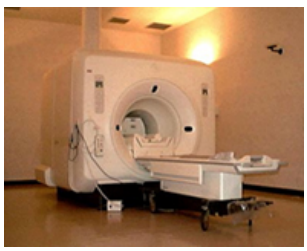


Table 2-29: Horizon enclosure peak static spatial gradients on patient accessible areas

Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)*grad(B) (T^2/m)
1.5T LCC	60 BRM	Peak B	0.31	0.61	1.9	3.0	5.6
		Peak Gradient	0.44	0.86	1.1	6.6	6.9
		Peak Product	0.31	0.73	1.6	4.6	7.5
1.5T CX	60 BRM	Peak B	0.31	0.61	1.9	3.0	5.5
		Peak Gradient	0.42	0.87	1.1	6.2	6.5
		Peak Product	0.31	0.75	1.6	4.9	7.6
1.5T LCC	55 CRM	Peak B	0.29	0.62	1.8	2.7	4.9
		Peak Gradient	0.44	0.86	1.1	6.6	7.0
		Peak Product	0.36	0.80	1.4	6.1	8.5
1.5T CX	55 CRM	Peak B	0.29	0.62	1.8	2.6	4.7
		Peak Gradient	0.42	0.86	1.1	6.5	7.3
		Peak Product	0.36	0.80	1.4	6.2	8.8
1.5T S5	60 BRM	Peak B	0.31	0.62	1.8	1.9	3.4
		Peak Gradient	0.39	0.89	1.3	5.1	6.3
		Peak Product	0.36	0.82	1.5	4.7	7.0
1.5T S4	60 BRM	Peak B	0.31	0.64	1.8	1.8	3.2
		Peak Gradient	0.44	1.10	0.6	7.1	4.0
		Peak Product	0.37	0.85	1.5	5.0	7.4
1.5T S3	60 BRM	Peak B	0.31	0.67	1.7	1.4	2.5
		Peak Gradient	0.44	1.11	0.8	7.4	5.7
		Peak Product	0.37	0.86	1.6	3.8	6.1
1.5T S2	60 BRM	Peak B	0.31	0.67	1.7	1.4	2.5
		Peak Gradient	0.39	0.90	1.5	4.1	6.1
		Peak Product	0.38	0.87	1.6	4.0	6.3
1.5T S5	55 CRM	Peak B	0.30	0.63	1.8	1.9	3.3
		Peak Gradient	0.39	0.88	1.3	5.1	6.6
		Peak Product	0.36	0.82	1.5	4.7	7.0
1.5T S4	55 CRM	Peak B	0.30	0.65	1.8	1.9	3.3
		Peak Gradient	0.44	1.10	0.6	7.1	4.2
		Peak Product	0.38	0.85	1.5	5.0	7.4
1.5T S3	55 CRM	Peak B	0.32	0.72	1.8	2.0	3.4
		Peak Gradient	0.44	1.10	0.8	7.6	6.3
		Peak Product	0.44	1.10	0.8	7.6	6.3
1.5T S2	55 CRM	Peak B	0.32	0.72	1.8	1.9	3.3
		Peak Gradient	0.40	0.90	1.5	4.2	6.1
		Peak Product	0.38	0.87	1.6	4.2	6.5

OrthOne and MSK Extreme 1.0T system

Table 2-30: OrthOne and MSK Extreme 1.0T peak static spatial gradients on patient accessible areas

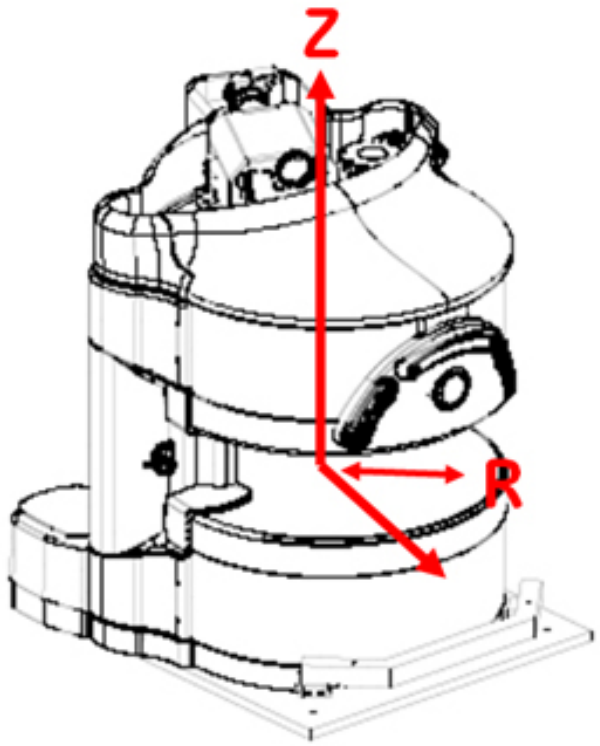
Field Name	Patient bore type	Parameter	Radial Location R(m)	Location along Z(m)	B(T)	Grad(B) (T/m)	max(B)* grad(B) (T^2/m)
OrthOne and MSK Extreme 1.0T w/18cm RF coil	18 cm RF coil	Peak B	0.13	0.22	1.4	26.6	37.5
		Peak Gradient	0.15	0.24	1.1	100.2	113.3
		Peak Product	0.15	0.24	1.3	94.5	121.9

Magnetic Field Plots

Static magnetic field plots for siting (rule of thumb - assumes no ferromagnetic materials) may be found at: http://www.gehealthcare.com/company/docs/siteplanning.html#mr

HFO Static Spatial Gradients In Patient Gap with Various Radii

Figure 2-18: HFO Peak Gradient Fields in patient gap



Coordinate system for field and gradient where Z is in the B0 direction, R is the radius, and the origin is isocenter.

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Table 2-31: Peak gradient field in the patient gap. Note that gradients are symmetrical about negative and positive values of Z, so negative Z values are not explicitly shown.

Peak gradient location		Gradient (T/m)	Peak gradient location		Gradient (G/cm)
Z (m)	Radius (m)		Z (cm)	Radius (cm)	
0.000	0.690	2.95	0.0	69.00	295.0
0.050	0.693	3.32	5.0	69.25	331.7
0.100	0.718	4.25	10.0	71.75	424.9
0.150	0.723	6.22	15.0	72.25	621.8
0.200	0.738	11.21	20.0	73.75	1121.2
0.225	0.740	17.91	22.5	74.00	1791.4

MAGNETIC FIELDS

Static spatial gradients on concentric cylinders

The static magnetic field might cause forces or torques on some devices near the magnet. The following table shows the maximum magnetic field (B0), the spatial rate of change of the magnetic field (grad(B0)), and the product of the magnetic fields and its rate of change (B0*grad(B0)) for infinitely long cylinders concentric with the patient bore. This information may be of use in evaluating risk assuming patients are confined to the cylinder bounds. Note that higher values of these parameters exist on the magnet bore covers (see above).

For example, find the peak static gradient field in the 70 cm bore for a MR450w (DVw) GEM system.

- First find that the maximum peak gradient on the magnet covers (from the above table) is 12.4 Tesla/m (1240 gauss/cm). This peak occurs at a radius of 0.510 m of axis and a z location 0.783 m from isocenter (typically on the magnet covers. Some risk managers consider this information adequate for determining risk from static spatial gradients.
- Some risk managers may limit the patient to regions contained by cylinders concentric with the patient bore. They may use the table below to find that the maximum spatial gradient in the bore is 6.7 Tesla/m (which may be written as 670 Gauss/cm). The peak spatial gradient in the patient bore is located on the 70 cm cylinder surface at z = 0.68 m from isocenter. The user then evaluates the risk from the device manufacturer's MR Conditional Labeling, from the characteristics of the scanner, and from other information such as patient history. In this case the static gradient is about half the maximum value on the magnet cover.

Figure 2-19: Static spatial gradients at various radii

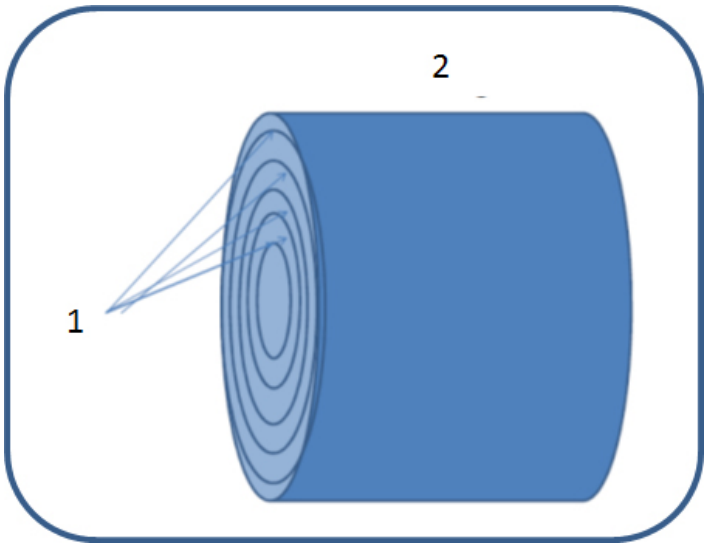

Table 2-32: Image legend

#	Description
1	Concentric cylinders
2	Magnet

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Table 2-33: Concentric cylinder data table 1

Field magnet	Item	On patient Z axis		on 20 cm Diameter Cylinder surface		on 30cm Diameter Cylinder surface		on 40cm Diameter Cylinder surface	
		Peak	R,Z (m,)	Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)
3.0T 3TLC	Bo (T)	3.0	(0.000,0.250)	3.0	(0.100, 0.358)	3.0	(0.150,0.460)	3.0	(0.200,0.530)
	Gradient (T/m)	5.1	(0.000,0.880)	5.3	(0.100,0.880)	5.6	(0.150,0.880)	6.2	(0.200,0.845)
	BxG (T2/m)	10.6	(0.000,0.790)	11.3	(0.100, 0.785)	12.3	(0.150,0.765)	14.0	(0.200,0.785)
3.0T G3	Bo (T)	3.0	(0.000,0.225)	3.0	(0.100, 0.325)	3.0	(0.150,0.450)	3.0	(0.200,0.535)
	Gradient (T/m)	5.0	(0.000,0.900)	5.2	(0.100, 0.885)	5.5	(0.150,0.880)	6.0	(0.200,0.880)
	BxG (T2/m)	12.2	(0.000,0.810)	11.4	(0.100,0.789)	12.2	(0.150,0.800)	14.0	(0.200,0.805)
3.0T 3T94	Bo (T)	3.0	(0.000,0.275)	3.0	(0.100,0.390)	3.0	(0.150,0.460)	3.0	(0.200,0.545)
	Gradient (T/m)	4.3	(0.000,1.090)	4.4	(0.100,1.088)	4.6	(0.150,1.080)	4.8	(0.200,1.098)
	BxG (T2/m)	8.7	(0.000,0.970)	9.0	(0.100,0.963)	9.4	(0.150,0.985)	10.1	(0.200,0.975)
1.5T DVw	Bo (T)	1.5	(0.000,0.270)	1.5	(0.100,0.366)	1.5	(0.150,0.460)	1.5	(0.200,0.520)
	Gradient (T/m)	2.6	(0.000,0.840)	2.8	(0.100,0.820)	3.0	(0.150,0.815)	3.3	(0.200,0.780)
	BxG (T2/m)	2.9	(0.000,0.730)	3.1	(0.100,0.756)	3.3	(0.150,0.745)	3.9	(0.200,0.745)
1.5T LCC	Bo (T)	1.5	(0.000,0.230)	1.5	(0.100,0.374)	1.5	(0.150,0.465)	1.5	(0.200,0.525)
	Gradient (T/m)	2.7	(0.000,0.840)	2.8	(0.100,0.836)	3.0	(0.150,0.810)	3.3	(0.200,0.805)
	BxG (T2/m)	2.8	(0.000,0.770)	3.0	(0.100,0.763)	3.3	(0.150,0.775)	3.8	(0.200,0.745)
1.5T Cx	Bo (T)	1.5	(0.000,0.230)	1.5	(0.100,0.367)	1.5	(0.150,0.460)	1.5	(0.200,0.530)
	Gradient (T/m)	2.7	(0.000,0.85)	2.8	(0.100,0.837)	3.0	(0.150,0.825)	3.2	(0.200,0.815)
	BxG (T2/m)	2.8	(0.000,0.600)	3.0	(0.100,0.746)	3.3	(0.150,0.750)	3.8	(0.200,0.745)
1.5T S5	Bo (T)	1.5	(0.000,0.320)	1.5	(0.100,0.384)	1.5	(0.150,0.460)	1.5	(0.200,0.530)
	Gradient (T/m)	2.5	(0.000,0.900)	2.6	(0.100,0.919)	2.7	(0.150,0.870)	2.9	(0.200,0.895)
	BxG (T2/m)	2.6	(0.000,0.820)	2.7	(0.100,0.791)	2.9	(0.150,0.810)	3.3	(0.200,0.800)

Field magnet	Item	On patient Z axis		on 20 cm Diameter Cylinder surface		on 30cm Diameter Cylinder surface		on 40cm Diameter Cylinder surface	
		Peak	R,Z (m,)	Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)
1.5T S4	Bo (T)	1.5	(0.000,0.210)	1.5	(0.100,0.364)	1.5	(0.150,0.465)	1.5	(0.200,0.540)
	Gradient (T/m)	2.5	(0.000,0.920)	2.6	(0.100,0.924)	2.7	(0.150,0.910)	2.9	(0.200,0.925)
	BxG (T2/m)	2.6	(0.000,0.830)	2.7	(0.100,0.842)	2.9	(0.150,0.815)	3.2	(0.200,0.825)
1.5T S3	Bo (T)	1.5	(0.000,0.260)	1.5	(0.100,0.344)	1.5	(0.150,0.480)	1.5	(0.200,0.565)
	Gradient (T/m)	2.0	(0.000,0.970)	2.1	(0.100,0.990)	2.2	(0.150,0.970)	2.3	(0.200,0.940)
	BxG (T2/m)	2.3	(0.000,0.895)	2.4	(0.100,0.889)	2.5	(0.150,0.885)	2.7	(0.200,0.875)
1.5T S3 magna-shield	Bo (T)	1.5	(0.000,0.260)	1.5	(0.100,0.344)	1.5	(0.150,0.481)	1.5	(0.200,0.564)
	Gradient (T/m)	2.1	(0.000,1.004)	2.2	(0.100,0.990)	2.3	(0.150,0.973)	2.4	(0.200,0.990)
	BxG (T2/m)	2.3	(0.000,0.895)	2.4	(0.100,0.889)	2.5	(0.150,0.893)	2.8	(0.200,0.884)
1.5T S2	Bo (T)	1.5	(0.000,0.261)	1.5	(0.100,0.384)	1.5	(0.150,0.496)	1.5	(0.200,0.568)
	Gradient (T/m)	2.0	(0.000,0.988)	2.1	(0.100,0.978)	2.2	(0.150,0.968)	2.3	(0.200,0.931)
	BxG (T2/m)	2.2	(0.000,0.890)	2.3	(0.100,0.880)	2.5	(0.150,0.867)	2.7	(0.200,0.868)

Table 2-34: Concentric cylinder data table 2

Field Magnet	Item	On patient Z axis		on 50cm Diameter Cylinder surface		on 55 cm Diameter Cylinder surface		on 60cm Diameter Cylinder surface		on 70cm Diameter Cylinder surface	
		Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)
3.0T 3TLC	Bo (T)	3.0	(0.000,0.250)	3.1	(0.250,0.580)	3.2	(0.275,0.595)	3.3	(0.300,0.610)	3.5	(0.350,0.635)
	Gradient (T/m)	5.1	(0.000,0.880)	7.0	(0.250,0.845)	7.5	(0.275,0.800)	8.3	(0.300,0.825)	10.7	(0.350,0.770)
	BxG (T2/m)	10.6	(0.000,0.790)	16.9	(0.250,0.755)	18.9	(0.275,0.790)	22.4	(0.300,0.740)	31.5	(0.350,0.740)
3.0T G3	Bo (T)	3.0	(0.000,0.225)	3.1	(0.250,0.585)	3.2	(0.275,0.600)	3.2	(0.300,0.620)	3.5	(0.350,0.640)
	Gradient (T/m)	5.0	(0.000,0.900)	6.7	(0.250,0.830)	7.7	(0.275,0.825)	7.9	(0.300,0.805)	10.4	(0.350,0.755)
	BxG (T2/m)	12.2	(0.000,0.810)	16.4	(0.250,0.800)	19.3	(0.275,0.790)	21.9	(0.300,0.765)	32.7	(0.350,0.750)
3.0T 3T94	Bo (T)	3.0	(0.000,0.275)	3.0	(0.250,0.600)	3.1	(0.275,0.620)	3.1	(0.300,0.640)		
	Gradient (T/m)	4.3	(0.000,1.090)	5.2	(0.250,1.090)	5.5	(0.275,1.085)	5.8	(0.300,1.075)		
	BxG (T2/m)	8.7	(0.000,0.970)	11.1	(0.250,0.975)	11.8	(0.275,0.985)	12.6	(0.300,0.995)		
1.5T DVw	Bo (T)	1.5	(0.000,0.270)	1.6	(0.250,0.565)	1.6	(0.275,0.580)	1.7	(0.300,0.595)	1.9	(0.350,0.610)
	Gradient (T/m)	2.6	(0.000,0.840)	3.8	(0.250,0.755)	4.2	(0.275,0.755)	4.7	(0.300,0.760)	6.7	(0.350,0.680)
	BxG (T2/m)	2.9	(0.000,0.730)	4.9	(0.250,0.735)	5.8	(0.275,0.725)	7.0	(0.300,0.685)	11.8	(0.350,0.660)
1.5T LCC	Bo (T)	1.5	(0.000,0.230)	1.6	(0.250,0.570)	1.6	(0.275,0.590)	1.7	(0.300,0.600)		
	Gradient (T/m)	2.7	(0.000,0.840)	3.7	(0.250,0.820)	4.1	(0.275,0.790)	4.6	(0.300,0.750)		
	BxG (T2/m)	2.8	(0.000,0.770)	4.7	(0.250,0.750)	5.5	(0.275,0.740)	6.5	(0.300,0.720)		
1.5T Cx	Bo (T)	1.5	(0.000,0.230)	1.6	(0.250,0.570)	1.6	(0.275,0.585)	1.7	(0.300,0.600)		
	Gradient (T/m)	2.7	(0.000,0.85)	3.8	(0.250,0.810)	4.2	(0.275,0.775)	4.6	(0.300,0.775)		
	BxG (T2/m)	2.8	(0.000,0.600)	4.7	(0.250,0.715)	5.5	(0.275,0.700)	6.5	(0.300,0.715)		
1.5T S5	Bo (T)	1.5	(0.000,0.320)	1.6	(0.250,0.575)	1.6	(0.275,0.595)	1.6	(0.300,0.615)		
	Gradient (T/m)	2.5	(0.000,0.900)	3.3	(0.250,0.850)	3.5	(0.275,0.845)	3.7	(0.300,0.830)		
	BxG (T2/m)	2.6	(0.000,0.820)	3.9	(0.250,0.795)	4.4	(0.275,0.780)	4.9	(0.300,0.775)		
1.5T S4	Bo (T)	1.5	(0.000,0.210)	1.5	(0.250,0.595)	1.6	(0.275,0.620)	1.6	(0.300,0.630)		
	Gradient (T/m)	2.5	(0.000,0.920)	3.3	(0.250,0.890)	3.4	(0.275,0.885)	3.7	(0.300,0.860)		
	BxG (T2/m)	2.6	(0.000,0.830)	3.8	(0.250,0.795)	4.2	(0.275,0.810)	4.7	(0.300,0.775)		

Field Magnet	Item	On patient Z axis		on 50cm Diameter Cylinder surface		on 55 cm Diameter Cylinder surface		on 60cm Diameter Cylinder surface		on 70cm Diameter Cylinder surface	
		Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)	Peak	R,Z (m,m)
1.5T S3	Bo (T)	1.5	(0.000,0.260)	1.5	(0.250,0.626)	1.5	(0.275,0.645)	1.6	(0.300,0.665)		
	Gradient (T/m)	2.0	(0.000,0.970)	2.5	(0.250,0.930)	2.7	(0.275,0.925)	2.9	(0.300,0.910)		
	BxG (T2/m)	2.3	(0.000,0.895)	3.1	(0.250,0.860)	3.4	(0.275,0.855)	3.7	(0.300,0.840)		
1.5T S3 magna-shield	Bo (T)	1.5	(0.000,0.260)	1.5	(0.250,0.623)	1.5	(0.275,0.643)	1.6	(0.300,0.663)		
	Gradient (T/m)	2.1	(0.000,1.004)	2.6	(0.250,0.973)	2.7	(0.275,0.935)	2.9	(0.300,0.922)		
	BxG (T2/m)	2.3	(0.000,0.895)	3.1	(0.250,0.860)	3.4	(0.275,0.851)	3.8	(0.300,0.858)		
1.5T S2	Bo (T)	1.5	(0.000,0.261)	1.5	(0.250,0.625)	1.6	(0.275,0.650)	1.6	(0.300,0.665)		
	Gradient (T/m)	2.0	(0.000,0.988)	2.6	(0.250,0.942)	2.7	(0.275,0.922)	2.9	(0.300,0.900)		
	BxG (T2/m)	2.2	(0.000,0.890)	3.2	(0.250,0.832)	3.4	(0.275,0.865)	3.9	(0.300,0.831)		

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MAGNETIC FIELDS

Cryogen and quench concerns

With superconductive MR systems, another concern related to the static magnetic field is a quench of the cryogens. A superconductive magnet uses cryogens to super-cool the electrical conductor that creates the magnetic field. Temperatures as low as -269°C (-452°F) are achieved to create the proper environment within the magnet. A quench, which is a sudden boil-off of the entire volume of cryogenic liquid, causes a rapid loss of the static magnetic field.

Liquid Cryogen Hazards

Cryogens come in large vacuum containers called dewars. Liquid helium is generally used for cooling purposes, although some service procedures also require liquid nitrogen. Nitrogen dewars weigh from 400 to 500 pounds when full. Helium dewars weigh from 700 to 800 pounds. In addition to large dewars, there may be smaller helium gas cylinders present. This helium gas is used to fill the magnet to proper cryogen levels. Special considerations should be observed when dealing with cryogens.

CAUTION

Leaking helium or nitrogen gas will displace oxygen. The ambient air oxygen concentration may then be insufficient for human respiration. The limit of the air oxygen concentration should meet national laws or regulations.

CAUTION

The following information defines the proper handling of cryogens.

- Dewars and cylinders should not be tipped or heated, nor should the valves be tampered with.
- The cryogens boil off as they cool the magnet wires and must be replenished periodically by qualified personnel. The rate of boil-off should be monitored by checking the cryogen level meter found on the system cabinet.
- Contact with the cryogenic liquids or gas could result in severe frostbite; care should be taken when in proximity to these substances. The wearing of protective clothing is essential during all work in conjunction with liquefied cryogens. Such clothing consists of:
  - Safety gloves
  - Work gloves
  - Face shield
  - Laboratory coat or overalls (cotton or linen)
  - Non-magnetic safety shoes
- Dewars should be stored in a well-ventilated area. Cryogens could be accidentally released in gaseous form, resulting in an asphyxiation hazard.
- All dewars and gas cylinders must be non-magnetic.
- Gas cylinders should be stored upright and secured to the wall with a chain with the metal protective top in place. (If a cylinder falls over or the valve is knocked off, the container may act like a rocket; a full cylinder has enough power to penetrate walls.)
- Because the cylinder's metal cap may be magnetic, the cap should always be removed before bringing the cylinder into the magnet room.

- If possible, all personnel should stay out of the magnet room when a qualified service engineer is filling cryogens in the magnet. If personnel must be present, they must wear proper gloves, a face shield, and ear protectors.
- A qualified service engineer should be present any time cryogens are transported within the hospital or added to the magnet.
- It is crucial that ventilation and cryogenic systems be kept in good repair and checked regularly to ensure proper functionality.
- Flammable materials must not be brought near the cryogen containers.
- You are responsible for establishing and following a procedure, in accordance with your local and federal requirements (in the US: OSHA 29 CFR 1910.36), that includes possible evacuation of the MRI area, if flammable materials are identified near cryogenic gases. If grease, oil, or other combustible material is present in the vicinity of the containers, the escape of cryogenic gases can lead to the formation of a potentially combustible liquid due to liquefaction of air and concentration of oxygen.

Quench vent failure hazards

Quenches are indicated by a loud noise, warning message, or the tilting of an image on the display screen. A quench is a hazard only if the vent fails, which would result in the release of white clouds of cryogen vapor into the magnet room. This would present a potential asphyxiation hazard to both the patient and personnel. It is critical to have a well-planned method to quickly evacuate the patient and personnel from the magnet room should a quench occur.

WARNING

In the unlikely event of a quench and vent failure, a procedure needs to be in place to evacuate the patient and all personnel from the magnet room. Failure to follow these precautions can result in serious injury (e.g., asphyxiation, frostbite, or injuries due to panic).

The table below lists the decay times for the 1.5T system to reach 20 mT and the 3.0T systems to reach 50 mT in the case of a quench or the Emergency Magnet Rundown switch is activated.

Table 2-35: Examples of system decay time to reach 20 mT for 1.5T systems and 50 mT for 3.0T systems

System	Decay time (seconds)
0.7T	120
1.5T	120
1.5T wide bore	60
3.0T VH/i	30
3.0T EXCITE	100
3.0T wide bore	60

Gradient magnetic fields

Gradient magnetic fields produce rapidly changing magnetic fields during scanning. Gradients turn on and off very rapidly to spatially encode the MR signal during a scan. High frequency gradient amplitudes switched very quickly (high dB/dt) may cause nerve stimulation at periphery of body due to induced currents in nerves. Because a current can be induced in any conductive material lying on or near the patient's body, a potential biological hazard exists. The greater the rate of change of the magnetic field (dB/dt, slew rate), the larger the induced current. The muscles, nerves, and blood vessels of the human body are all conductive materials.

WARNING

Ensure occupational exposure to time varying magnetic field caused by the gradients complies with local requirements.

GRADIENT MAGNETIC FIELDS

Calculate maximum gradient output

Let d be the total duration of the gradient ramp (minimum to maximum) or the period of a sinusoidal waveform divided by π. Let f be a fraction (0.8 for Normal Mode or 1 for First Mode). Let c be the chronaxie time in microseconds. Let d|B|/dt_0 be the rheobase (rb, infinite ramp duration) value of the time varying gradient magnetic field. Gradient output may be expressed by the following equation;

Maximum gradient output on a cylinder of 0.2 m radius may be found from equation and table below. f is the fraction of the mean stimulation threshold, rb is the infinite ramp duration mean PNS threshold, c is the rheobase value (ramp duration where the mean threshold is 2*rb), and d is the gradient ramp duration.

$$\left(\frac{d|B|}{dt}\right)_{limit} = f\left(\frac{d|B|}{dt}\right)_0\left(1+\frac{c}{d}\right)$$

Table 2-36: Rheobase and chronaxie constants for various gradient coils

	rb (T/s)	C (µs)
BRM*	23.7	370
CRM	25.2	558
TRM Zoom	29.1	354
TRM WB	23.7	370
XRMB	23.4	334.3
XRMw	20	360

*BRM gradient used in Optima MR360 and Brivo MR355 systems

Related topics

Contraindications for use

GRADIENT MAGNETIC FIELDS

Gradient output limits

Safety parameter levels approved for the Second Controlled Operating Mode are set by the Investigational Review Board (IRB) or other human studies boards. For Gradient Output these levels are measured as a percentage of the mean peripheral nerve stimulation threshold (PNS).

CAUTION

Continuous patient observation and contact are required in all modes of operation. Medical Supervision is required in the First or Second Level controlled operating modes.

The MR system gradients are capable of operating under several modes:

- Normal: the normal operating mode, admissible for all individuals.
- First Level: controlled operating mode, admissible for patients on whom a medical decision was made ensuring that they can handle the increased gradient output effects or increased SAR. Limits for increased gradient output and SAR are based on current scientific literature related to safety.
- Second Level: controlled operating mode, admissible for customers with Investigation (ethical studies) Review Board (IRB) clearance and with a proprietary license agreement with GE. IRB review must include explicit approval of the percentage PNS threshold.

The appearance of the operating interface changes on the basis of: whether the system is operating in clinical or research mode, the governing standard (typically the International Electrotechnical Commission (IEC)). The table below lists system operating modes and associated threshold limits.

Product maximum gradient output

The table below gives d|B|/dt for the maximum magnitude values of the vector sum of the field components generated by each of the three GRADIENT UNITS simultaneously at the published peak gradient strength and peak slew rate. The values are in terms of d|B|/dt at various diameters (in meters) from the gradient coil axis. The diameters include 0.2 m, 0.4 m, and the bore diameter minus 0.1 m. The values include no peripheral nerve stimulation limits.

Table 2-37: Maximum d|B|/dt on cylinders of various diameters at the product slew rate

max d|B|/dt [T/s]	D= 0.2 (m)	D = 0.4 (m0	D = 0.45 (m)	D = 0.5 (m)	D = 0.6 (m)
BRM (Signa HDx, Cx 1.5 T BRM, MR360, 60 cm bore, Lx, Excite, HD, and S5)	59.1	84.5	N/A	111	N/A
CRM (CRM, 55 cm bore, Lx, Excite, HD)	64.4	98	113	N/A	N/A
TRM zoom (TwinSpeed, 60 cm bore, Lx, Excite, HD)	60.1	87.1	N/A	111.5	N/A
TRM whole body (TwinSpeed, 60 cm bore, Lx, Excite, HD)	40.8	58.2	N/A	75	N/A
XRMb (3T MR750, 60 cm bore, DV)	94.7	129.1	N/A	161.9	N/A
XRMw (1.5 T MR450w, 3 T MR750w. 70 cm bore, DV)	52.2	70.8	N/A	N/A	118.6

CAUTION

Gradient output may be controlled by Local Approval.

Table 2-38: IEC gradient output limits

Operating mode	PNS Limit
Normal	80% mean nerve stimulation threshold
First Level (controlled mode)	100% of the mean nerve stimulation threshold. Requires you to click the [Accept] button to proceed when the Normal mode dB/dt or SAR limits are exceeded, but Second Level mode has not yet been reached.
Second Level (controlled mode)	Requires research key and IRB or Human Ethical Committee approval of the research to be conducted.

GRADIENT MAGNETIC FIELDS

Peripheral nerve stimulation

The concern from time-varying gradient fields is to prevent cardiac stimulation and ventricular fibrillation. Cardiac stimulation in the most sensitive population percentile requires at least 39 times as much energy as is produced by at peak gradient amplitude of 0.05 Tesla/meter and Slew Rate of 200 Tesla/meter/sec.

Regulatory bodies use avoidance of painful nerve stimulation to limit gradient output with an adequate safety margin. Painful nerve stimulation typically occurs at approximately double the mean stimulation perception threshold. Some discomfort is experienced about 1.5 times the mean PNS threshold, see figure below.

Peripheral nerve stimulation (PNS) problems are not of concern on systems compliant with IEC 60601-2-33 Normal or First Controlled Operating Modes. The IEC limits PNS to 80% of the mean threshold in Normal Mode (where stimulation should be rare) and 100% for the First Mode (where non-painful stimulation is expected in about half the patients).

If the patient can not tolerate PNS, change to Normal Mode to eliminate the problem. Otherwise change to a lower slew rate pulse sequence to continue scanning the patient. MR workers may experience similar sensations if they are in or very near gradient coils during active scanning.

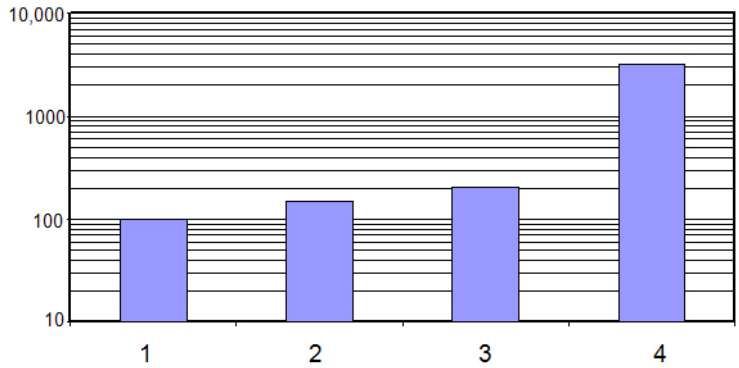
The Anterior/Posterior (A/P) (=Y) gradient axis typically has the lowest stimulation threshold. So it is prudent to keep the gradient waveform most likely to stimulate (the gradient waveform with the highest slew rate for the longest total ramp time) on a physical axis other than Y.

You should remain in constant contact with the patient, especially in the FIRST CONTROLLED MODE, to ensure that the patient does not feel painful stimulation (or high localized heating).

The figure below displays a graph of the relative mean threshold (vertical axis) and discomfort stimulation levels (horizontal axis) where relative means are for perception (100), discomfort (1000), and pain (10,000).

- 1 = threshold
- 2 = uncomfortable
- 3 = intolerable
- 4 = 1% cardiac

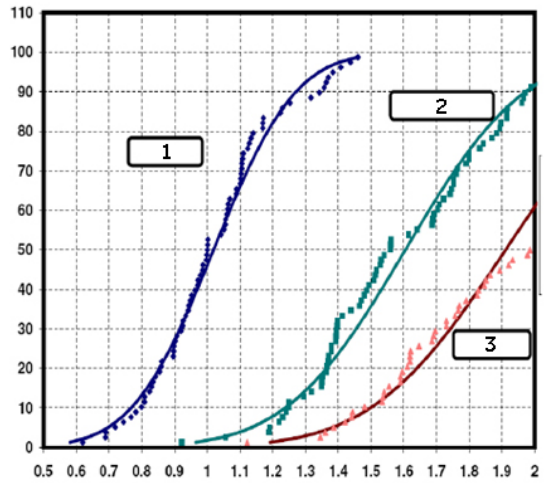
Figure 2-20: Relative mean threshold and discomfort stimulation levels



The distribution of those experiencing PNS is illustrated in the figure below; three curves where the horizontal axis is the normalized level and the vertical axis is the% probability of PNS. The curves represent the following:

- 1 = threshold
- 2 = uncomfortable
- 3 = intolerable

Figure 2-21: PNS probability. X axis = Fraction of the Mean Threshold (100% PNS). Y axis = Population percentile.



CAUTION

To reduce the possibility of PNS, make sure the patient's hands are not clasped or touching and that their feet are not crossed. Either or both of which could form a conductive loop.

CAUTION

Due to the rapid rate of change of the magnetic fields (dB/dt) used during some scans, a percentage of patients may experience a non-hazardous tingling or touch sensation. The **PNS probability graph** indicates the type of sensations caused at different percentages of the mean nerve stimulation threshold. Note that stimulation is relatively rare in NORMAL MODE (x-axis=0.8), but occurs about 50% of the time in the FIRST MODE (x axis=1). If this sensation is bothersome or uncomfortable to the patient, stop the scan. Change to NORMAL MODE to continue scanning the patient. The MR worker may experience similar sensations if remaining within the gradient field during active scanning.

CAUTION

There is a possibility that mild peripheral nerve stimulation (PNS) may be induced in the MR worker when that person is exposed to the gradients when the system is operating in the First Level Controlled Operation Mode. The MR worker should remain outside the magnet room during scanning in this Mode except when circumstances dictate otherwise.

CAUTION

Peripheral nerve stimulation is not harmful. The potential for inducing peripheral nerve stimulation is kept within limitations. The MR system is limited from operating above 80% of the PNS threshold in the NORMAL Mode (100% of the mean PNS threshold in the First Mode) by the software (unless the system is in Second Controlled Mode). The point at which 50% of a population experiences PNS is the PNS threshold. PNS has been described as a light "touching" sensation felt on various areas of the skin surface. These areas vary depending upon which gradient axis is in use. Some common

areas for the sensations are the bridge of the nose, arms, chest, and upper buttock/abdomen. Hands clasped together increase the potential for stimulation by approximately 65%. The potential for PNS is low, but it exists for all sequences in all gradient configurations.

 Please report all complaints of patient discomfort that may be associated with PNS during MR examinations (e.g., muscle twitches, tingling sensations, or headaches) to GE Healthcare. See **Safety information** for contact information.

GRADIENT MAGNETIC FIELDS

Acoustic noise

Another potential safety issue associated with gradient switching is the loud noise. The rapid alternations of currents within the gradient coils cause the coil assemblies to vibrate against their mountings, thus generating a loud resonant noise. The acoustic noise produced during scanning can exceed 99 dBA in the bore.

WARNING

The sound level at the operator's console should be limited to comply with local rules.

WARNING

Hearing protection is required for all people, including the MR worker, in the magnet room during a scan to prevent hearing impairment. Acoustic levels may exceed 99 dBA. Patient hearing protection with a noise reduction rating (NRR) of 29 dB or better is required to reduce acoustic level below 99dBA. The A-weighted RMS sound pressure level is measured according to section 26e and 26g of IEC 60601-2-33: 2002.

CAUTION

All personnel should be trained on the proper use of hearing protection.

- Special attention should be utilized to protect the hearing of neonates, premature infants, and any other condition that does not allow for hearing protection to be applied.
- Patients with increased anxiety may have a lower acceptance to sound pressure (e.g., newborns, infants, young children, elderly, and pregnant women and the foetus).
- Anesthetized patients have less then normal protection against high sound pressure. Hearing protection should not be omitted.
- Typical operator console noise levels are below 60 dBA, so hearing protection is generally not required at the operator console. However, it is important to ensure the sound level complies with all local regulations.
- In some countries, legislation exists that limits employee exposure to noise levels. Ensure compliance with your local regulations by providing additional hearing protection to MR workers for use in the magnet room where required.
- If a music sound system is in use by the patient during scanning, the music sound system must provide > 29dB NRR of attenuation. All hearing protection devices must provide > 29dB NRR of attenuation.

Encourage the routine use of earplugs to prevent problems associated with acoustic noise during MR procedures. GE Healthcare offers disposable ear protection of various noise reduction ratings. These can be ordered through the GE accessories catalog. The table below, describes the available types of disposable ear protection.

Table 2-39: Disposable ear protection

Description	dB
E8801BA EAR Disposable Foam Earplugs	29
E8801BB EAR Taperfit2 Foam Earplugs	32
E8801BC Max-Lite Foam Earplugs	30

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 Since the acoustic noise of the OpenSpeed system does not exceed 92.2 dBA, ear protection is not required, but is recommended.

Electromagnetic fields

The Radio Frequency (RF) field is an oscillating electromagnetic field. Pulses of RF energy are used to generate the signal, which cause tissues to absorb RF power. Under certain conditions, this may cause tissue heating. The amount of heating depends on several factors, such as patient size and pulse sequence timing. RF heating of tissues is greatest at the periphery of the skin. The Specific Absorption Rate (SAR) is the estimated amount of heat dose received by the patient. This value is expressed as watts of power per kilogram of the patient's body weight.

MR frequencies for Multi-Nuclear Spectroscopy (MNS)

Figure 2-22: MR frequencies in MHz for Multi-Nuclear Spectroscopy (MNS) nuclei at 1.5T and 3.0T

	1.5 Tesla		3.0 Tesla	
Nucleus	Min Freq MHz	Max Freq MHz	Min Freq MHz	Max Freq MHz
^{15}N	6.450	6.496	12.899	12.993
^{17}O	8.621	8.690	17.242	17.380
^{2}D	9.772	9.834	19.544	19.669
^{29}Si	12.657	12.743	25.314	25.486
^{13}C	16.008	16.113	32.016	32.227
^{23}Na	16.849	16.956	33.697	33.912
^{129}Xe	17.672	17.916	35.345	35.833
^{11}B	20.428	20.562	40.855	41.124
^{7}Li	24.744	24.901	49.488	49.803
^{31}P	25.787	25.970	51.574	51.941
^{3}He	48.519	48.827	97.037	97.654
^{19}F	59.895	60.396	119.790	120.791
^{1}H	63.658	64.063	127.316	128.126

ELECTROMAGNETIC FIELDS

Tissue heating

Before the patient is scanned, the computer estimates the level of heating and compares it to the predetermined exposure limits. If the scan is expected to exceed these limits, the system then adjusts the scan parameters before starting the scan. The complete estimate is based in part on patient weight. Therefore, take care to enter the patient's weight correctly to prevent excessive RF exposure or scan abortion.

When patient temperature is not changing, typical skin temperatures are about 33 °C while core temperatures are about 37 °C. Patients dissipate metabolic heat at the same rate it is generated so there are no skin or core temperature changes. Humans subjected to significant radio frequency power deposition (i.e., significant SAR) will normally attempt to dissipate the additional heat load through vasodilatation of skin blood vessels permitting skin to approach core temperature. This action typically causes the skin to flush (turn red) and enables the body to dissipate heat more rapidly. This skin flushing is a normal response to significant radio frequency power deposition. Skin reddening or to a lesser degree the report of a warming sensation without reddening regardless of the method it was created (SAR, Contact, Metal, etc) is not hazardous if it clears in a few hours.

Patient comfort module

A sensor located in the bore of the magnet monitors bore temperature. The sensor posts appropriate messages in the System Status Display area of the monitor (upper left portion of the monitor) that notify you when the magnet bore wall is becoming warm. The temperature inside the magnet room should be set at less than 70°F and the bore fan should be turned on at all times to keep air flowing inside the bore of the magnet.

Thermal hazards

The increase in tissue temperature caused by RF exposure depends on a variety of factors associated with the thermoregulatory system of the individual and the surrounding environment. Thermoregulatory is the ability of the body to maintain regulated heat capacity levels. Observe the following warnings concerning tissue heating:

WARNING

RF power deposition can heat the patient's tissue if delivered faster than the patient's tissues can dissipate the generated heat. The amount of tissue heating depends on the patient's weight, type of pulse sequence, timing factors, number of slices, SAR, and the use of imaging options such as saturation. Power deposition will typically be lower when the NORMAL MODE is selected for SAR. FIRST MODE for SAR offers higher performance but also higher power deposition.

WARNING

A rise in body temperature can be a hazard to a patient with reduced thermoregulatory capacity and increased sensitivity to raised body temperature. These can be caused by pre-existing conditions, such as cardiac impairment that has reduced circulatory function, hypertension, diabetes, old age, obesity, fever, pregnancy, or an impaired ability to perspire. A patient with these complications must be carefully monitored at all times. Consider scanning with NORMAL MODE for SAR for patients that may not tolerate the higher levels.

CAUTION

The MR worker who remains in the scan room during a study could be subject to tissue heating caused by RF energy exposure. Care should be taken to limit the time the MR worker remains in the scan room during a study.

WARNING

RF can also raise the magnet bore temperature and cause thermal stress; medical conditions can reduce a patient's ability to cope with external temperature increases. If the temperature continues to rise, the scan stops until temperature within the bore is lowered. When the sensor detects temperatures that may cause patient discomfort, the system posts the following messages on the screen or in the error log:

- "The patient comfort level is warmer than normal."
- "The patient may be uncomfortable during the scan."
- "The bore cooling system or magnet room temperature may not be normal."
- "Further increases in temperature will inhibit scanning."

When the temperature drops to a comfortable level, the message is cleared from the screen. If the temperature continues to rise, a second message appears on the screen:

- "Scan inhibited. Patient comfort sensor trip."

To facilitate a return to scanning, make sure the patient fan is ON, room temperature is normal, 21°C (70°F), and air flow through the bore is unobstructed.

When the magnet opening temperature decreases, the system posts this message:

- "New scans can be initiated, but the patient comfort level is still warmer than normal."

CAUTION

All patients should be monitored for increased temperature during the scan acquisition. If the patient reports discomfort due to warming, stop the scan. Patients should be provided with the hand-held Patient Alert bulb prior to scanning. The patient should be instructed to communicate any concerns through the intercom or by activating the Patient Alert bulb.

CAUTION

RF heating can be caused by:

- Damp clothing
- Contact of body or extremities against the RF transmit coil surface, contact with metal, tattoos or metallic eyeliner, contact with other body parts
- Formation of loops with RF receive coil cables and ECG leads
- The use of non MR-compatible ECG electrodes. Never use ECG electrodes past their expiration date.

- Scanning with a unconnected receive coil or other cables in the RF transmit coil during the examination.
- ECG leads not compatible with MR. MR leads have very high impedances that limit current to below the level of concern.

CAUTION

Extra attention should be utilized when scanning patients who are unconscious, sedated, or may have loss of feeling in any body part (temporary or permanent paralysis). They may not be able to alert you to RF heating.

CAUTION

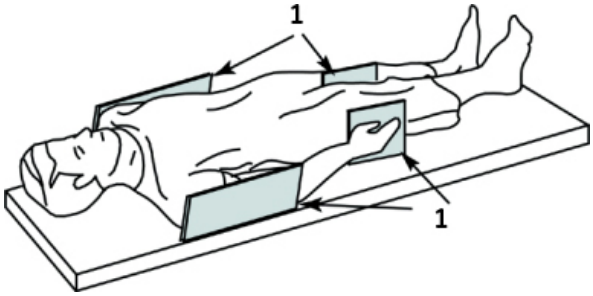
The coil selected should match the coil that is connected. When scanning with a transmit/receive only coil, DO NOT scan using the body coil (or use the Body coil configuration) at any time. Using the body coil can cause RF heating and could result in patient burns. In addition, scanning with the body coil can damage the transmit/receive only coil, requiring the coil to be unusable and returned to the factory for service.

ELECTROMAGNETIC FIELDS

Contact point heating

Patient positioning can affect the safety of the scan procedure. To help prevent a patient burn from closed loops formed by the following examples: clasped hands, by hands touching the body, from thighs contacting, the patient's breasts contacting the chest wall over a small area, etc., insert non-conducting pads at least 0.25 inches thick between touching parts and between the patient and the bore wall and the patient and any coils or conductors.

Figure 2-23: Patient positioned with non-conducting pads (1)



Observe the following warnings concerning contact point heating to protect patients from excessive heating or burns related to induced currents during MR procedures:

WARNING

RF can cause localized heating at contact points between the patient/bore and patient/RF coil resulting in discomfort or burns.

WARNING

RF can cause localized heating at contact points between adjacent body parts when a loop is formed. Such localized heating can result in discomfort, or burns. This could occur when a patient's hands are touching or when a female patient's breasts are compressed to her chest. Use pads between body parts to avoid creating a loop with adjacent body parts.

WARNING

Place appropriate non-conductive padding between the patient and the bore wherever a portion of the body may come into contact with the magnet opening.

WARNING

Always place appropriate non-conductive padding between the surface coil and the patient's skin to prevent burn injuries.

WARNING

For shoulder imaging, always place appropriate non-conductive padding between the patient's opposite shoulder or a portion of the patient's body and the bore wherever a portion of the body or opposite shoulder comes into contact with the bore.

CAUTION

RF can cause localized heating at patient contact points. Wet diapers or incontinence products have the same electrical properties as human tissue. All patients with diapers, including adults, should have dry diapers on prior to the start of the scan. If the patient reports discomfort due to warming, stop the scan.

ELECTROMAGNETIC FIELDS

Conductive material heating

Another potential hazard related to the RF field is the heating of implants, devices, and objects of conductive (e.g. metallic) compositions that may cause temperature changes during an MR examination. The induced currents in the conductive (e.g. metallic) objects may cause them to get so hot that they can actually cause burns in adjacent tissues. Therefore, it is very important to determine each patient's work history and thoroughly screen for any accessories containing conductive material.

Observe the following warnings concerning conductive material heating to protect patients from excessive heating or burns related to induced currents during MR procedures:

WARNING

Eye makeup that contains metal flakes can cause eye and skin irritation during MR scanning. Instruct patients to wash off removable makeup before the exam to avoid the risk of eye injury. Before scanning, warn patients with permanent eyeliner or other metallic ink tattoos about the risk of skin irritation and instruct them to get prompt medical attention if they experience severe discomfort following an MR exam.

WARNING

Metal fragments/slivers can deflect and/or heat in a magnetic field, damaging surrounding tissues. Patients thought to have metallic fragments in the eye should receive an eye exam to detect and remove any metal fragments that could deflect and damage the eye.

WARNING

Jewelry, even 14-karat gold, can heat and cause burns. RF can heat (even non-ferrous) metal and cause burns.

WARNING

Medicinal products in transdermal patches may cause burns to underlying skin.

WARNING

The use of MR non-compatible stereotactic frames and RF blankets is not recommended.

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ELECTROMAGNETIC FIELDS

Specific Absorption Rate (SAR) limits

It is necessary to measure the RF absorption in tissues since RF exposure cannot be measured by the system. Energy dissipation through absorption by the body can be described in terms of Specific Absorption Rate (SAR). SAR is a rate, meaning it is a measure of the amount of RF power absorbed per unit of mass of an object in watts per kilogram (W/kg). There are several types of SAR, listed in the table below, that must be understood.

Table 2-40: SAR definitions

SAR type	Definition
Whole body	SAR averaged over total patient body mass over any six-minute period for Body and Receive Only surface coils, which use body transmit.
Partial body	SAR averaged over the exposed mass in the coil averaged over any six-minute period.
Head	SAR averaged over the mass of the patient's head over any six-minute period.
Extremity	SAR averaged over the estimated mass of the patient's extremity over any six-minute period for small volume and Transmit/Receive coils.
Short term	The SAR averaged over any 10-second period.

The MR system SAR operating modes:

- **Normal:** the normal operating mode, admissible for all individuals.
- **First Level:** controlled operating mode, admissible for patients on whom a medical decision was made ensuring they can handle the increased SAR effects. Increased SAR levels are based on current scientific literature related to safety.
- **Second Level:** controlled operating mode, admissible for customers with a propriety license agreement with GE and with Investigational Review Board clearance for the investigational protocol. IRB review must include explicit approval of the SAR limits.

CAUTION

When the system is operating in research mode, you are presented an interface to modify pulse sequence internal parameters. If one chooses to modify certain internal pulse sequence parameters like the pulse sequence repetition time, there is a risk of running the pulse sequence at a Specific Absorption Rate (SAR) higher than the regulatory limits. You are advised NOT to modify any internal pulse sequence parameters through Research Options, unless you are certain that by doing so, you are not violating or bypassing safety limits or other local requirements which are otherwise in place.

CAUTION

Continuous patient observation and contact is required in all modes of operation. Medical Supervision is required in the First or Second Level controlled operating modes.

CAUTION

SAR may be controlled by Local Approval.

WARNING

The magnet room temperature shall not be more than 21°C per the manufacturer's requirements and the relative humidity shall not be more than 60%. Temperatures above 21°C and humidity above 60% could result in lowering the system SAR limit.

The derating temperature is 25°C for relative humidity less than 60%. For each 10% increase of the relative humidity in excess of 60%, the temperature is reduced by 0.25°C, e.g., 24°C at 100% relative humidity.

For each degree of environmental temperature that exceeds the SAR-derating temperature, the whole-body SAR limit is reduced by 0.25 W/kg until the SAR is 2 W/kg or 0 W/kg for the First Level controlled operating mode or for the Normal mode, respectively.

WARNING

The RF power monitor and SAR limitations help prevent excessive RF exposure to the patient; SAR values are calculated based on the patient's weight. To help avoid injury, enter the patient's correct weight to set operating limits and prevent excessive RF exposure.

WARNING

The SAR algorithms for the MR systems calculate SAR values and set a limit on the number of slices/echoes per second in order to limit RF power deposition. The power monitor and SAR algorithm limit SAR, regardless of the patient weight or pulse sequence used. SAR limits are conservatively estimated from worse-case patient positioning as a function of weight.

The legacy power monitor module limits the RF amplifier output power thus limiting the patient SAR in case of a catastrophic failure. This module monitors peak power based on the patient's weight, duty cycle, and pulse sequence parameters. The peak power limits prevent you from using incorrect patient weights.

WARNING

The average power monitor and SAR algorithm limit SAR based on patient weight and RF transmit coil used. SAR limits are conservatively estimated from worse case patient positioning as a function of weight. The power monitor limits the RF power, which in turn limits the patient SAR to within controlled limits over time.

Pulse sequence SAR predictions (estimated SAR) are based on patient weight at the worst-case landmark. To minimize nuisance power monitor trips caused by patient-to-patient variability, pulse sequence predicted SAR is the mean plus 1.96 standard deviations (typically the normalized standard deviation is about 18% at the worst-case landmark). The expected worst-case nuisance trip rate is approximately 2.5%. If you experience a significant number of power trips above the 2.5% frequency, please consult your local field service representative. The power monitor measures actual power and limits SAR appropriately. The power measuring accuracy of the power monitor is about +/-12%.

Errors in patient weight do not result in excessive SAR. Low patient weight entries result in power monitor trips below the SAR limit. High patient weight entries result in fewer slices/images per unit time than would have been permissible.

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SAR limits

The MR system's RF power monitor helps prevent excessive RF exposure due to equipment failure. Since the monitor protects the patient, it must be operational at all times, even when a scan is not in progress. If it detects an equipment failure, it immediately disables the RF system. This system must be repaired or adjusted by qualified service personnel.

Table 2-41: SAR operating limits

System	Normal mode (W/kg)	First level (W/kg)	Second level (W/kg)
0.7T	Head = 3.2 Body = 2.0	N/A	N/A
1.5T	Head = 3.2 Body = 2.0	Head = 3.2 Body = 4.0	Head > 3.2 Body > 4.0
3.0T	Head = 3.2 Body = 2.0	Head = 3.2 Body = 4.0	Head > 3.2 Body > 4.0*

*When operating in the Second Level controlled operating mode, you need to click the [Scan Modes] button from the Rx Manager and click [NO] to monitor SAR. This is only available when Research mode is available. This disables the SAR slice limitations of the MR system, but not the slice limitations or SAR monitoring of the 3.0T system power monitor. When the Research mode is enabled, a [Monitoring Parameters] button is available. Clicking this button allows the researcher to enter an IRB approved SAR limit for the research scans to be performed. The system automatically returns to Normal operation for the next examination or can be manually returned to Normal operation by clicking the [Go to Clinical] button from within the [Monitoring Parameters] button.

The IEC also allows Short Term limits that allow a higher Short Term SAR for 10 second periods of time. These limits are 3 times higher than the 6 minute limitations per IEC guidelines. This allows short term bursts of RF energy for very short scans.

For example, the Body SAR limit is 2.0 W/kg over 6 minutes and the 10 second average is subsequently 6.0 W/kg averaged over 10 seconds. This would allow a scan of 4.0 W/kg to run for up to 3 minutes, since running at 2 times the long term limit can only run for half the time to equal the same average over the full 6 minutes.

Patient acceptance of High SAR scanning can be increased by giving the patient breaks to cool down, providing light clothing, and limiting room temperature to 18 ± 3 °C, and by maximizing air flow.

Maximum B1rms for Transmit Body Coils and Transmit Head Coils

The following table provides a bound for maximum B1rms (in micro-tesla) for body transmit coils and head transmit coils at 1.5 T and at 3 T. Values are shown for the limits at 1.5 T and for the 3 T 94 magnet for the head transmit coil and for the body transmit coil with the patient's umbilicus at isocenter. Also shown are the limits for other 3 T products for the head transmit coil and for the body transmit coil when the patient's umbilicus is at isocenter and when the patient's chin is in isocenter in the body transmit coil.

Table 2-42: B1rms limit (μT)

Coil	1.5T	3.0T	3.0T 94
Body Coil Umbilicus Landmark	3.6	2.5	3.6
Body Coil Chin Landmark	N/A	3.6	N/A
Head Coil	7.2	7.2	7.2

Clinical hazards

Maintaining good patient contact and education can help reduce patient anxiety reactions and clinical scanning hazards in the MR environment and during procedures.

CAUTION

Continuous patient observation and contact are required in all modes of operation.

You need to be aware of the conditions and risks associated with the following:

- High-Risk Patients
- Scanning Hazards

CLINICAL HAZARDS

High risk patients

Several conditions are associated with high-risk patients, who may be at a greater risk of developing complications during an MR examination. Observe these warnings and be prepared to manage the needs of such patients during the examination.

WARNING

Patients with the following conditions are at the greatest risk of complications during MR scanning:

- Patients likely to develop seizure or have claustrophobic reactions.
- Greater than normal potential for cardiac arrest.
- Patients who are unconscious, heavily sedated, or confused and patients with whom no reliable communication can be maintained.

WARNING

Patient screening is required for patients who are going to be imaged on an MR scanner.

Some patients may experience feelings of fear or claustrophobia when undergoing an MR procedure. This could be related to the confining conditions of the magnet, the length of the examination, the acoustic noise, or the temperatures within the bore of the magnet. Discuss the procedure with the patient and be prepared to manage the needs of the patient during the examination.

CAUTION

The confining conditions of the MR system can precipitate claustrophobia in some patients. To prevent injuries due to panic, provide instructions and comfort the patient as needed to alleviate anxiety.

WARNING

Since direct observation from the operator's console can be partially obscured by the magnet enclosure, be sure to more closely monitor these types patients at all times to quickly identify and respond to medical emergencies. In some cases, emergency personnel should remain with the patient or be on standby alert to help prevent serious complications or death.

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CLINICAL HAZARDS

Scanning hazards

During scan set-up, acquisition, and conclusion, be aware of the following scanning hazards:

WARNING

Do not use Projection Images for localization.

WARNING

Do not use 3D views only to perform voxel value, distance, angle, or area measurements. Always refer to 2D baseline views.

CAUTION

Measurements are more reliable when done on 2D views. Always check on the 2D reformatted views where exactly the points have been deposited.

CAUTION

Most multiple-channel receive only coils are designed to function best with adult patients. For smaller patients using the multiple-channel receive only coil the patient positioning is critical for optimal image quality. For small patients use appropriate non-conductive padding to place patient anatomy of interest in the center of the coil.

For example, the HDHead coil is a multiple-channel receive only coil. Use appropriate non-conductive padding to place the patient's head in the center of the coil.

CAUTION

Make sure the patient connected IV lines, oxygen tubing, urinary catheters, and any other tubing and cables are long enough to allow full travel of the system and will not become entangled, pinched, or pulled.

CAUTION

Following the exam, your patient may need assistance when getting off the table. After lying in a prone position for a length of time, your patient may experience light-headedness upon sitting up.

CAUTION

If the magnet room door is open, the scan cannot be started. If the scan is already in process and the door is opened, the scan will pause. Close the door and press resume.

If the magnet room door is opened when attempting to start a scan, close the door and try again.

International regulations require the system to function in this manner.

CAUTION

Always base evaluations on all images in the data set and on the clinical history. Information from only a single image should not be used to evaluate a patient.

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Equipment hazards

There are also general equipment concerns in the MR environment. Make sure you are familiar with your MR equipment and the accessory equipment manufacturer's guidelines and precautions. Specifically, you need to be aware of the hazards associated with the following MR equipment:

- Laser Alignment Lights
- Cables and Equipment Connections

Also observe the following general equipment hazards:

WARNING

The MR staff must consult the GE Pre-installation Manual before installing any furniture or making any changes in the scan room. Failing to do so may hinder the servicing of the scanner and present a dangerous safety hazard to the service engineer.

CAUTION

Using equipment that is damaged or has been compromised, can put the patient and/or operator at risk of injury.

CAUTION

The MR system applications run on equipment that includes one or more hard disk drives, which may hold medical data related to patients. In some countries, such equipment may be subject to regulations concerning the processing of personal data and the free circulation of such data. It is strongly recommended that access to patient files be protected from all persons not in medical attendance.

CAUTION

Any application of physiological monitoring and sensing devices to the patient shall be made under the clinical staffs direction and is the clinical staff's responsibility. Use only MR-compatible devices. Devices with conductors or ferromagnetic parts may introduce safety concerns. For medical devices that are labeled as MR Safe or MR Conditional consult the device manufacturer's documentation.

EQUIPMENT HAZARDS

Laser alignment lights

The MR systems use semiconductor laser alignment lights for patient land marking. This type of alignment light casts a thin red light on the patient for the purpose of positioning and land marking. The laser lights can cause eye injury. The figures below display the safety labels for laser products and are located near the laser alignment light. Labels such as these provide safety information about laser radiation.

Figure 2-24: Laser safety label

Figure 2-25: Chinese laser safety label for Brivo MR355 and Optima MR360

Figure 2-26: Chinese laser safety label for other MR systems

Your system may have a slight variation of these labels.

The eyes must be protected from laser radiation. The patient needs to be instructed to close their eyes when landmarking and the laser light is turned on. Exposing eyes to the laser alignment lights may result in eye injury.

CAUTION

Exposing eyes to laser alignment lights may result in eye injury.

- Do not stare directly into the laser beam.
- Instruct patients to close their eyes to avoid eye exposure to the alignment light.

- Closely monitor all patients and prevent them from accidentally staring into the beam. Do not leave the laser beam on after you position the patient.

Figure 2-27: Laser aperture warning label

The 3.0T VH/i imaging systems do not contain laser lights. Therefore, these hazards do not apply.

EQUIPMENT HAZARDS

Cables and equipment connections

Various equipment and accessories are used in the MR environment for specific types of examinations that include cables and require connections to the MR system or the patient.

To avoid trip hazards, you should install yellow and black trip hazard indicator covers over any cables routed on the ground of the equipment room.

WARNING

The following general warnings should be followed when using cables and accessory connection equipment:

- For medical devices that are labeled as MR Safe or MR Conditional consult the device manufacturer's documentation.
- Use only GE or GE-authorized accessory coils, cables, monitoring and gating equipment that is labeled as compatible with MR equipment. Failure to restrict the use of such equipment not labeled for MR applications may result in patient burns or other injuries.
- Use only accessories, coils, and cables that are in good condition. If you suspect that an accessory is not in good condition, discontinue its use and contact your GE Service Engineer.
- Auxiliary devices indicated as compatible with MR equipment may still cause patient injuries if the instructions for use are not explicitly followed. Never use equipment unless it is accompanied by the use instructions.
- Remove unplugged surface coils or unused accessory devices from the magnet bore; a patient burn can result.
- RF can heat non-compatible surface coils/gating cables, damaged surface coils/gating cables, surface coils that are not properly plugged in, and improperly routed cables can cause burns.
- The use of cable-connected surface coils, the original peripheral gating probe (consult your GE Service Engineer for questions), or electrocardiogram (ECG) gating accessories for patient scanning can result in localized heating, leading to a burn or fire if proper scan preparation is not followed. The cables often extend into the high intensity region of the RF field and it is possible that induced electrical currents in the cables may cause arcing.
- Always bring the cable directly out of the magnet bore with no slack. Place cables under the cushion whenever possible to separate the cable from the patient.
- Keep the length of cable in the bore to a minimum. Avoid bending the cable 180° and route the cables out of the bore in the most direct way.
- Route cables through the center of the magnet bore. Place cables under the cushion whenever possible to separate the cable from the patient. Routing near the sides of the bore increases the likelihood of cable heating (from induced currents).
- Do not cross or loop cables. Arcing and patient burns could result.

In addition to the warnings above, there are specific warnings related to Cardiac Gating Equipment and Accessory Coils you need to understand to maintain a safe MR environment.

Cardiac gating equipment

Electrocardiogram (ECG) gating may be performed in an MR environment to monitor critically ill patients or for an MR triggering technique to synchronize the MR scan acquisition with the patient's heart beat. Only MR-compatible electrodes should be used in the MR environment to ensure patient safety. For medical devices that are labeled as MR Safe or MR Conditional consult the device manufacturer's documentation.The ECG triggering feature on the system should only to be used for cardiac gating and must not be used for

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patient monitoring. When using an ECG triggered MR technique, it is important to use only GE recommended disposable electrodes and compatible leads.

WARNING

Observe the following warnings when using ECG or peripheral gating:

- The MR cardiac gating feature is intended for use solely in acquiring MR images using cardiac gating/triggering, not for physiological monitoring. The patient's condition may not be reflected, resulting in improper emergency treatment.
- Do not use monitoring equipment when conductors are in the bore and touching the patient; burns can result.
- Do not use leads with broken shields or exposed conductors. Only use accessories in good condition. If you suspect that an accessory is not in good condition, discontinue its use and contact your GE Service Engineer.
- Check to see that the cardiac or peripheral gating cable does not pass under or near the surface coil or surface coil cable.
- Check to see that only the peripheral gating sensor touches the patient. Keep cables from coming in contact with the patient.
- Do not use equipment that has not been specifically tested and approved for use in the environment of a MR system.
- Physiological monitoring and sensing devices should be used solely under the operators direction and it is their responsibility to ensure patient safety.

WARNING

Do not use waveforms for physiological monitoring. Patient condition may not be reflected, resulting in improper treatment.

WARNING

Do not use expired or dried electrodes. They do not properly conduct the signal, which can lead to image degradation, create intermittent triggering, and can cause burns to the patient.

Accessory coils

It is important you familiarize yourself with the operating instructions for each accessory coil used in your MR environment. Follow the recommended guidelines and precautions by the manufacturer.

WARNING

Observe the following warnings when using surface coils:

- Do not use surface coils with exposed coils or damaged insulation. Skin contact with metal conductors can cause burns.
- Do not allow the surface coil cable to touch the patient; patient burns can result. Use a thermal resistant material or pad to keep the cable from touching the patient.
- When using the 1.5T Breast Coil, make sure the patient's back and arms do not touch the magnet bore. Use thermal resistant material or padding between the patient and the magnet to prevent burns that could be caused by patient contact with the interior of the magnet bore.

Clinical screening

To avoid potential health hazards in the MR environment, personnel and patient screening procedures should be established in your imaging facility. Every person working or entering the magnet room or adjacent rooms with a magnetic field needs to be instructed about the dangers. This should include all MR workers, maintenance, service, and cleaning personnel, as well as the local fire station team.

All MR workers need careful assessment prior to engaging in operation of the MR system. Additionally, all patients undergoing the MR examination need careful assessment prior to the procedure. Screening helps identify anything that might create a health risk or interfere with MR imaging. It also assists you in determining if the patient has any specific needs or limitations. Additionally, if another person accompanies the patient undergoing the MR examination, they should be screened and managed in the same manner as the patient. The aim of screening is to safely obtain high-quality images so an accurate diagnosis can be made. Maintaining a controlled and safe environment can be achieved by careful questioning patients, visitors/family members and all personnel.

 Screen each patient thoroughly for pertinent medical history and conditions that contraindicate scanning before initializing an examination. If proper scanning can not be performed, postpone MR examinations until the screening can be completed.

A documented screening procedure should be followed by a review of the completed form and a verbal conversation to verify the form information and provide the patient time to express his or her questions or concerns. The review and discussion should be conducted by MR safety-trained personnel to ensure there is no miscommunication about the MR safety issues.

A written screening form must be completed each time a patient is to have an MR examination. Even if the patient undergoing previous MR examinations and/or has completed the screening form previously, does not assure the patient another safe examination.

CLINICAL SCREENING

Screening form

A comprehensive, printed screening form should be used to assess the patient and document the information. The form can be customized for your MR suite and might consists of three sections:

- Section 1: General Information
- Section 2: Hazardous Items Checklist
- Section 3: Magnet Room Pre-Entry Checklist

WARNING

Patient screening is required for patients who are going to be imaged on an MR scanner.

General information

Section 1 of a patient screening form contains general information concerning patient demographics and the patient's medical and work history. Relevant patient-related information is valuable for obtaining current medical conditions and information on prior diagnostic studies that may be helpful in evaluating the patient's state.

Determining the patient's work history is important for those who work in machine shops or similar environments. These individuals may have small metal slivers or fragments of steel embedded in their eyes. If metal fragments are suspected, the patient should receive an eye examination to detect and remove hazardous materials before scanning.

Section 1 of a screening form also contains questions needed to help identify high-risk patients, i.e., those with conditions posing higher risk of complications during the MR exam. Questions explore risks due only to the condition of the patient (e.g. elevated risk of seizure or cardiac arrest) and also those due to the elevated SAR possible when operating in First Level Controlled Mode (e.g. for patients with compromised thermoregulatory capacity.)

MR workers may be at risk if previous occupational, recreational or other life experiences have resulted in the accidental implantation of metallic substances, such as slivers or fragments. Page 2 of the patient screening form should be completed by each MR worker to ensure the magnetic field does not pose a hazard to their well-being.

This section also contains questions for female patients concerning matters that may affect the MR examination. Pregnant patients must be identified before they are permitted to undergo an MR procedure. A physician should carefully compare and discuss the risks and benefits of the MR examination versus alternative procedures before scanning to control risk to the patient.

Hazardous items checklist

The Hazardous Items Checklist, in section 2 of a patient screening form, is valuable in identifying various implants and devices that may be hazardous to the patient undergoing the MR examination. Items that may produce image artifacts, can also be detected through this section of the screening process.

Some patients, including those suffering from forms of dementia, may not be aware of having a pacemaker. On such patients, palpate the upper torso and abdomen to make sure no pacemaker is present. Pacemakers may be implanted in any of several locations in the chest and abdomen. Pacemaker lead wires are sometimes left in place after removal of the pacing mechanism. The wires can induce current, producing heat during the MR procedure. Therefore, checking for lead wires is also important.

The best way to ensure a metal-free environment is to have patients change into patient examination attire. The checklist also includes items the patient may externally possess. Do not limit your inspection to only ferrous objects alone. Even non-ferrous items, such as gold jewelry, can heat during a scan and burn a

patient. Make sure the patient removes all of these objects. In addition, be sure to check small children for safety pins and snaps on diapers or undershirts.

Section 2 of a form also contains an anatomical figure of the human body for patients to mark the location of objects they have inside or on their body. This information can be useful in determining the approximate area of objects that may be hazardous or produce artifacts.

Magnet room pre-entry checklist

The last section of a screening form lists metal or magnetic-sensitive items with which the patient can not enter the magnet room. Ensure the patient removes the checked items prior to magnet room entry. Also obtain signatures to document the person who completed and reviewed the screening form.

CLINICAL SCREENING

MR compatibility

Review the following information related to spatial magnetic field data:

- Contraindications for use
- Spatial magnetic field data

A device is labeled as MR Conditional if it has been demonstrated to pose no known hazards in a specified MR environment with specified conditions of use. Field conditions that define the MR environment include static magnetic field strength, static spatial gradient, time rate of change of the magnetic field (dB/dt), RF fields, specific absorption rate (SAR), and coil to be used. Additional conditions, including specific configurations of the item (e.g., the routing of leads used for a neurostimulation system), may be required.

WARNING

The attractive force of the magnetic field of the MR system can cause ferrous objects to become projectiles, which can cause serious injury. Post the Security Zone warning sign on the entrance to the magnet room and keep all hazardous objects out of the magnet room.

WARNING

GE shall not be responsible for assessing the proper function of any device. The user of the device must consult the device manufacturer to ensure the device is MR Safe or MR Conditional. Then the user must ensure the MR Conditions are met. Finally, the user must determine what is appropriate.

DANGER

Devices compatible at one field strength, such as 1.5T, may not be compatible at another field strength, such as 3.0T. Prior to patient scanning, confirm with the device manufacturer that the device is compatible at your field strength.

Patient emergencies

You must become very familiar with the location and proper use of certain emergency buttons and releases should an emergency occur in the MR environment. Advanced planning and being accustomed to your site's procedures and surroundings are necessary to ensure a safe environment.

Before you begin any scanning procedure, explain the use of the Patient Alert System to your patient. Make sure he or she understands its purpose and use. Remember that implants, pacemakers, and ferromagnetic life-support systems cannot be brought into the magnet room.*

Be sure to closely monitor patients with a increased potential for cardiac arrest or claustrophobia, or patients who are unconscious or extremely ill. Always maintain visual contact with the patient. Be familiar with your site's predetermined location outside the magnet room where you can transfer patients if it becomes necessary for emergency personnel to intervene.

The figure below displays a general layout of an MR magnet room. You should always be able to maintain visual contact with your patient from the operator's console.

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

Figure 2-28: Magnet room layout

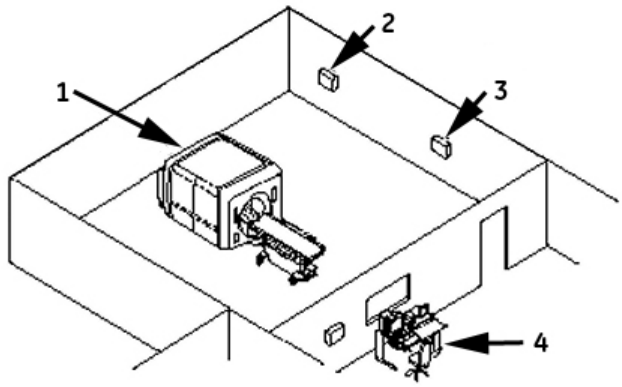

Table 2-43: Magnet room layout image legend

#	Description
1	Magnet and magnet enclosure
2	Oxygen monitor remote sensor (optional)
3	Emergency magnet rundown
4	Operator's console

Emergency medical procedures

Your site should define and implement specific procedures to follow in case of a medical emergency. These procedures should take account of the existence of the magnetic field. For example, they should instruct how to use the **Table Transport Emergency Release** to remove a patient rapidly from the magnet's influence. Other product features useful in an emergency are described on the pages following.

PATIENT EMERGENCIES

Patient alert system

Your MR system has a Patient Alert system that enables the patient to alert you at the console by squeezing a bulb.

Figure 2-29: Patient alert system

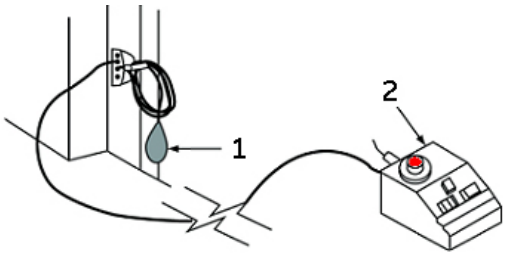

Table 2-44: Patient alert system image legend

#	Description
1	Patient alert bulb
2	Control box

Squeezing the Patient Alert bulb causes the control box to light up and emit an audible signal. A switch on the control box allows you to set the signal for intermittent or constant light and sound.

Your MR system also has an intercom system that enables you to maintain verbal contact with the patient throughout the examination.

CAUTION

Provide all patients with the Patient Alert bulb. This can be especially important for procedures that require the concerted attention of the technologist/operator at the MR or Advantage Workstation (AW) operator console, e.g., BrainWave sequences.

CAUTION

THIS PRODUCT CONTAINS NATURAL RUBBER LATEX WHICH MAY CAUSE ALLERGIC REACTIONS.

The black Patient Alert bulb and the Respiratory bellows contain latex. If the patient is aware of a sensitivity/allergy to latex or if the patient is unsure and concerned about the possibility of an allergic reaction, cover the bulb or the bellows with a towel, cloth, or plastic bag to shield the patient from the latex.

The gray Patient Alert bulb is made of PVC and does not contain natural rubber latex.

PATIENT EMERGENCIES

Emergency stop

The **Emergency Stop** button is located on the keyboard and on both the right and left sides of the magnet enclosure. This function cuts off electrical power from equipment located in the magnet room that may present a hazard to the patient in an emergency situation.

You can press the **Emergency Stop** button to stop a scan in a patient emergency situation. To quickly recover from an Emergency Stop situation, you can press the **Reset** button. You should not be afraid to press the **Emergency Stop** button because it may shut the system down for an extended length of time. This is not required to shut down the magnet coldhead.

Figure 2-30: Emergency Stop button

The **Emergency Stop** button disables the following systems:

- RF
- Gradient power supply
- Magnet room unit
- Table and patient support subsystem

WARNING

The Emergency Stop button does not remove the magnetic field, turn off the computer cabinets, operator's console, or camera.

PATIENT EMERGENCIES

Emergency off

The **Emergency Off** button is located on the wall next to all computer equipment and next to the MR magnet room doors. It removes ALL electrical power from ALL components of the system, including any power sources from uninterrupted power supply (UPS) devices.

The **Emergency Off** button not only stops a scan in a patient emergency, but also in the event of a serious equipment fault or hazards such as fire/water in the vicinity of the MR equipment. The entire MR system is to be turned OFF except for the static magnetic field and the magnet rundown unit used to shut down the magnetic field.

Figure 2-31: Emergency Off button

Use this button only in a major emergency in the computer or MR magnet room. For example, use this button when you notice fire, sparks, or loud noises not associated with normal operation of the system.

To restore power after emergency stop, the main circuit breaker must be reset before rebooting the system. Always contact a service engineer before restoring power.

WARNING

The Emergency Off button does not turn off the magnetic field. To avoid personal injury or equipment damage, do not bring any ferromagnetic equipment into the magnet room. Assume that equipment is magnetic unless it is clearly labeled otherwise.

PATIENT EMERGENCIES

PDU power off

The PDU Power Off button turns off power to system components other than the Magnet Rundown Unit, cryogen compressor, scan room lights, chillers and magnet cryogen monitor. Typically, service uses this power off switch and the MR customer does not.

Figure 2-32: PDU power off button

Figure 2-33: PDU power off button for value products

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PATIENT EMERGENCIES

Magnet rundown

The Magnet Rundown operates as follows and is located inside the magnet room:

- Rapid reduction of the magnetic field in about two minutes
- Boil-off of cryogens, accompanied by loud hissing sound
- Several days of down time to replace the cryogens

Figure 2-34: Magnet rundown unit

WARNING

The Magnet Rundown should only be used to free someone pinned to the magnet or to remove a large ferromagnetic object captured by the magnetic field when injury to persons is imminent. A controlled magnet rundown should be performed by a GE Service Engineer in non-emergency situations.

PATIENT EMERGENCIES

Table transport emergency release

In an emergency, the patient cradle can be manually pulled out of the magnet. Refer to your specific product operator manual for details on cradle emergency release.

On some systems, hold and rotate the release handle and then pull the cradle, to move the patient all the way out to the home position. The figure below displays the cradle release handle on movable 1.5T and 3.0T tables.

Figure 2-35: Cradle release handle, 1.5T and 3.0T tables

The figure below displays the cradle release handle on 0.7T OpenSpeed table.

Figure 2-36: Cradle release handle, 0.7T Open*Speed* tables

With a GEM system table, grasp the handle and squeeze the lever to pull the cradle to the end of the table.

Figure 2-37: Squeeze lever to pull cradle to end of table

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The patient table for Brivo MR355 System and one configuration of the table for Optima MR360 System are fixed tables, which means that the tables are permanently fixed to the magnet. Neither table has docking pedals or an emergency table release lever. Therefore, it cannot be detached from the magnet.

The Optima 360 detachable patient table can be lowered and raised. In the event that the patient needs emergency medical treatment outside the scan room, the emergency table release lever and the undock pedal are used to quickly move the patient and table outside the scan room.

With a Brivo MR355 or Optima 360 table, hold and rotate the release handle and then pull the cradle, to move the patient all the way out to the home position.

Figure 2-38: Cradle release handle, 1.5T and 3.0T tables

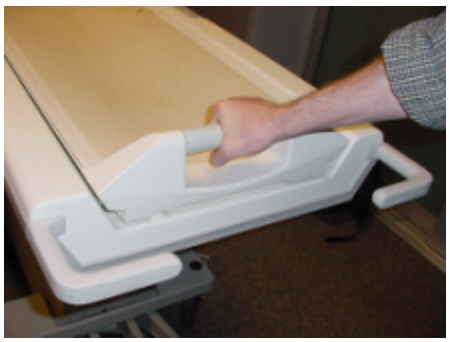


Figure 2-39: Cradle label

The patient table of the Open*Speed* system is permanently fixed to the magnet system and has lateral swing movement. A non-ferrous gurney should always be placed outside the magnet room for emergency patient transportation.

CAUTION

The Open*Speed* table should only be swung with the patient off the table. If you are pivoting the table for the examination, move the table prior to positioning your patient.

The 1.5T and 3.0T patient tables can be detached from the magnet system. The tables can also be lowered and raised. In the event that a patient needs emergency medical attention during the scanning session, use the undock pedal or the emergency table lever release for quick transportation of patients outside the magnet room.

Figure 2-40: Undock pedal at foot of table

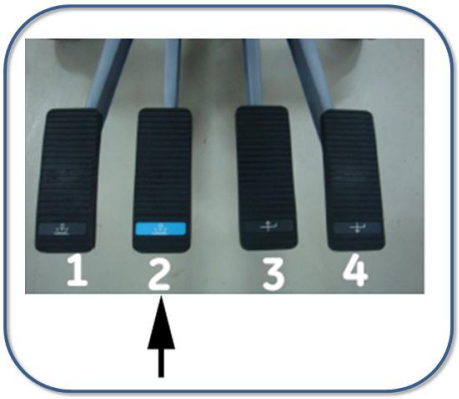
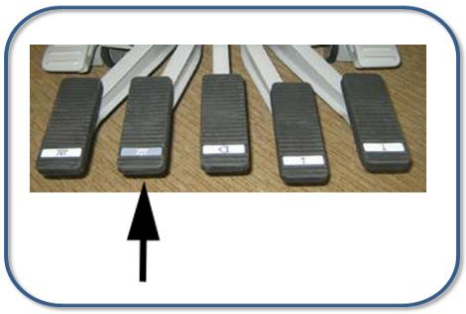


Figure 2-41: Discover undock pedal at foot of table



The Table Transport Emergency Release is used in the event the undock pedal on the patient transport does not function.

Figure 2-42: Table transport emergency release

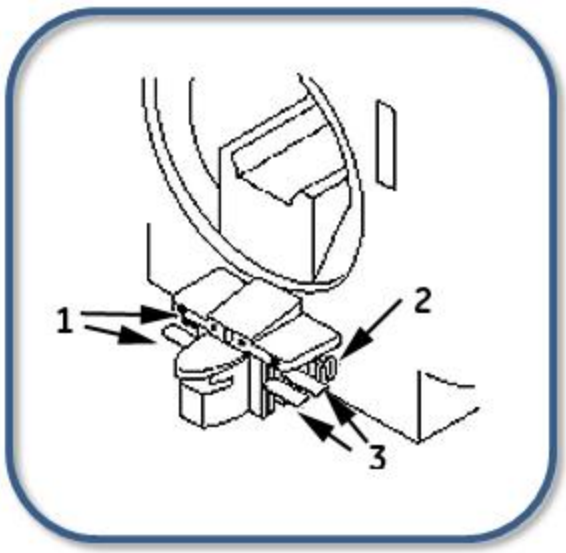


Table 2-45: Transport emergency release image legend

#	Description
1	Up/down pedals
2	Transport/emergency release lever
3	Up/down pedals

To release the transport with the emergency release:

- Make sure the cradle is fully retracted from the magnet bore at the home position.
- Grasp the handle on the red lever and pull straight out to release the table.

Scan and Display introduction

This section includes additional warnings and cautions for the following areas:

Scan and equipment

- BrainWave paradigm
- CD/DVD handling
- Dielectric pads
- IDEAL Imaging Option
- IV pole
- MR Conditional
- MR-Touch
- Multi-echo FGRE/FSPGR
- Patient orientation
- Patient transfer
- Patient weight
- Post-contrast scans
- Prescan
- Radiation oncology table top
- GEM coil

Display or post processing

- Add/Subtract images
- Applications
  - VIBRANT Flex and LAVA Flex
- Imaging Option
  - IDEAL
- FuncTool
- Volume Viewer
  - Annotation
  - Filter Floaters
  - Measurements
  - Reformat
  - Threshold

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ADDITIONAL WARNINGS AND CAUTIONS

Scan

This section contains additional scan warnings and cautions.

BrainWave paradigm

WARNING

When creating paradigms, if you do not create a unique paradigm number, paradigm string, and paradigm name/filename, the Brainwave Hardware may fail to communicate with BrainWaveRT. After editing paradigms, always be sure BrainWave communication with the clinical software is intact.

CD/DVD handling

CAUTION

To avoid image loss, never touch the recording surface of a recordable CD (CD-R). Handle the disk only by the outer edge or central hole. Do not place it face down on a hard surface. Fingerprints or scratches will make the disk unusable.

Dielectric pads

CAUTION

Do not use the dielectric pads together with sharp objects. Refer to the Dielectric Material Safety Data sheet for further information.

IDEAL Imaging Option

CAUTION

Make sure that the FOV includes all anatomy. Phase wrap will cause water/fat signal swap.

IV pole

Pinch Point CAUTION

Do not move the patient into the magnet with the MR table's IV pole in use. To avoid any pinch points from the MR table's IV pole, remove the IV pole from the table, store it, and use a non-ferrous free standing IV pole.

MR Conditional

WARNING

Susceptibility artifacts, such as those related to MR Conditional metal implants, will result in incorrect 3D Geometry Correction. Please carefully verify images.

WARNING

If the calibration scan covers a region containing MR Conditional metal implants, the calibration images are expected to have distortion and signal void artifacts. Therefore, PURE and ASSET images that have MR Conditional metal present should not be used for post processing.

WARNING

FuncTool fusion does not function reliably if MR Conditional metal implants are present and a reference image other than the original image is used. FuncTool Fusion should not be applied on series if the image area includes MR Conditional metal implants. Strong B0 and B1 distortion caused by MR Conditional metal implants will cause image distortion and signal void in images. Reference images may have different level of distortion (e.g., MAVRIC SL versus non-MAVRIC SL) with functional series, and mis-registration will occur.

WARNING

Due to the strong magnetic field disturbance in a region containing metal, do not use the RF Drive Mode parameter: Optimized.

WARNING

Do not use the PURE[1] image filter when acquiring scans in the vicinity of metallic implants or devices. Signal distortion effects are not predictable and will result in incorrect images.

WARNING

The tests commonly employed to determine MR Conditional implant heating safety (standard, ASTM F2182, ASTM.org), require quadrature excitation. Heating results for non-quadrature excitation (such as parallel transmit, dual drive, or elliptical drive) are unknown.

For patients with MR Conditional implants or devices, applying Preset or Optimized RF Drive Modes may violate the MR Conditional specifications.

[1] Phased array UnifoRmity Enhancement

CAUTION

Safe scanning of patients with MR Conditional devices or implants may be complex. Health care professionals that scan patients with MR Conditional devices or implants should consult the implant or device manufacturer for instructions with respect to safety guidelines.

MR-Touch

CAUTION

When setting up an MR-Touch exam, to avoid entanglement of the Patient Driver tube with the patient's neck, always orient the driver so that the tube is routed towards the patient's feet.

CAUTION

MR Touch has only been evaluated for use on adults. There is insufficient information to establish the safety and effectiveness of MR Touch for use on pediatric patients.

WARNING

Never place the active acoustic driver in the magnet scan room.

WARNING

To avoid tripping over the tubing, route the tubing on the side of the table that is opposite the scan room door.

Coil CAUTION

There is a potential hazard of crossing or looping coil cables that may exist, which will or can cause minor personal injury or property damage if the instructions are ignored.

Multi-echo FGRE/FSPGR

CAUTION

Measurement of relaxation time by Multi-Echo FGRE/FSPGR is very sensitive to the result of gradient shim (Auto-Shim) in the slice direction. Auto-Shim with shim-volume setting is recommended.

CAUTION

It is possible that FuncTool results of the calculated T2* and R2* values have an error with acquisitions that have a large slice number value

Patient orientation

WARNING

Ensure that the Patient Position selection matches the actual patient orientation. Making a selection that does not match the patient's actual position results in incorrectly annotated and/or rotated images, possibly resulting in improper medical treatment.

Patient transfer

CAUTION

The arm boards are not to be used as a seat or shelf. The arm board is not designed as a weight bearing device and there is a possibility for failure and the patient or load falling.

.

CAUTION

Following the exam, your patient may need assistance when getting off the table. After lying in a prone position for a length of time, your patient may experience lightheadedness upon sitting up.

Patient weight

CAUTION

The patient's weight determines the SAR. Entering a weight more than the actual patient weight could potentially harm the patient. Patient weight is not pulled with the other patient information from the ConnectPro worklist. You must manually enter the weight.

Post-contrast scans

WARNING

Do not use BRAVO to image a post contrast series. If the T1 shortening of contrast corresponds to the null point of an enhancing lesion, contrast enhancement will be suppressed.

WARNING

Do not use 3D IR-Prep SPGR to image a post contrast series. If the T1 shortening of contrast corresponds to the null point of an enhancing lesion, contrast enhancement will be suppressed.

Prescan

CAUTION

Auto prescan is used to calibrate the flip angle and to accurately estimate SAR levels. Do not manually adjust the transmit gain for GRE, SPGR, FGRE, FSPGR and FIESTA scans since excessive SAR may result if the TG is set too high. Using Auto prescan rather than manual prescan insures that accurate SAR limits are used.

Radiation oncology table tops

Pinch Point CAUTION

Do not use the arm boards at a height above horizontal. Due to the increased width needed for the flat top and lok-bar, there is a possibility for collision and a pinch hazard if the arm boards are used above the horizontal plane.

CAUTION

Do not use the coil positioning braces for a hand hold when getting the patient on the table, or as a handle for moving the table around. This feature is not designed as a weight bearing device, and could fall or break.

Pinch Point CAUTION

When moving the Express GEM cradle in and out of the magnet bore, keep the patient's and your hands away from pinch points. Place the patient's hands on the top of the thighs or above the head to avoid pinch points during positioning.

GEM coil

CAUTION

Never use an incompatible legacy coil with the GEM table. The curved bottom of the coil placed on the flat surface of the GEM table can lead to patient injury.

CAUTION

When using the AA with the PVA in a feet-first orientation, be sure to run the AA cable over the center housing of the PVA, pull it taut, and secure it to the PVA clip to prevent the AA cable from becoming warm.

CAUTION

The Anterior Array may not fit in the bore on patients with large torsos. To avoid injuring the patient or damaging the coil, watch carefully as the table moves into the bore. Stop advancing the table if the Anterior Array comes into contact with the top of the bore.

CAUTION

Do not carry any of the coil components by the cable. Damage to the coil component may occur. The coil may not work if damaged.

CAUTION

The coil contains sensitive electronic components that may become damaged. Do not spray or pour cleaning solution directly onto the coil. Do not submerge the coil in any solution. Under no circumstances should the coil be placed into any type of sterilizer.

CAUTION

Do not place a coil directly on the table surface over the GEM PA area. Be certain that the pads are on the table before using a coil. For example, only place the wrist coil on the table surface with the pads in place. Placing a coil directly on the PA area of the GEM table results in coil-to-coil contact, which can result in poor image quality.

CAUTION

RF can cause localized anterior coil warming when it is positioned close to the top of the bore. Place non-conductive padding between the coil and the bore in order to keep the coil positioned away from the bore wall.

CAUTION

Ensure that no hair or fabric is caught between the components. Failure to comply may cause artifacts and decreased image quality.

CAUTION

Do not pick up or carry the Head Component by the mirror attachment. To avoid damaging the coil, pick up and carry the Head Component using two hands on the bottom of the coil.

CAUTION

Users should place a service call any time the coil is dropped or mishandled. A GE Service Representative should inspect the coil after it has been dropped or mishandled to ensure it is safe to use.

CAUTION

Looped cables may cause RF coupling and degrade the scan performance of the coil. Do not cross or loop cables.

Pinch Point CAUTION

To avoid injuring the patient or damaging the coil, watch carefully for pinch points as the table moves into the bore. Stop advancing the table if the patient or any part of the coil comes into contact with the bore.

WARNING

Do not use accessories (e.g. pads or straps) that have not been specifically tested and approved for use in the MR environment. Use of non-approved accessories may result in patient burns or injuries or image degradation. Even auxiliary devices labeled as compatible with MR equipment are capable of causing injury if the manufacturer's instructions are not followed.

WARNING

Electric shock may occur if the coil is attached to the system during cleaning or when it is still wet. Detach coil connector from the scanner before attempting to clean the coil. Do not touch connectors with bare fingers. Never press sharp objects against connector surface. Do not reattach connector after cleaning until the coil has dried completely.

WARNING

Electric shock hazard. No user serviceable parts. Refer service to qualified service personnel.

WARNING

All coil components must be plugged in when they are in the scanner. This includes coil components that should be plugged into the system and coil components that should be plugged into another coil component. Leaving components unplugged can damage the coil, or cause harm to the patient.

WARNING

Do not allow the coil cables to touch the patient. Use a thermal resistant material or pad to keep the cable from touching the patient. Failure to comply may cause patient burns.

WARNING

Prior to patient placement in the coil, assure that any breached or compromised patient skin surfaces that come in contact with the coil have been adequately bandaged or covered.

ADDITIONAL WARNINGS AND CAUTIONS

Display

This section contains additional warnings and cautions related to image display and post processing.

Add/Subtract images

CAUTION

Since "COMB" series contain images resulting from a combination of images from different locations in the patient's body, the absolute anatomical coordinates accompanying these series (shown both in the Browser and on the displayed images) are not accurate. Only relative geometric measurements (i.e. distance, angle, or area) are accurate.

Applications

VIBRANT, VIBRANT-Flex and LAVA-Flex

CAUTION

Images labeled as water may include signal from fatty tissue, and images labeled as fat may include signal from water. This error may occur in regions of high magnetic field variation, in spatially isolated tissue, due to patient or tissue motion, due to phase wrap artifacts, due to TE values beyond recommended limits, and/or in images with low signal-to-noise ratios. The presence of fat tissue in images labeled as water, or vice versa, may occur within single images or throughout an in entire stack of slices. By default, both sets of images (labeled fat and labeled water) will be reconstructed and inserted into the database for review. Proper calibration and center frequency selection will reduce the occurrence of this error. Complete elimination of this error may not be possible and thus interpretation of MR images must be completed by trained personnel.

WARNING

It is possible that a spatial distortion can be seen on 3D data sets, especially in the lateral-most VIBRANT images. The distortion can be demonstrated in sagittal versus axial data sets. There is a potential risk for lesion localization misregistration during biopsy procedures, which could result in a re-biopsy of the patient.

Imaging Option

IDEAL

CAUTION

Images labeled as water may include signal from fatty tissue, and images labeled as fat may include signal from water. This error may occur in regions of high magnetic field variation, in spatially isolated tissue, due to patient or tissue motion, due to phase wrap artifacts, and/or in images with low signal-to-noise ratios. The presence of fat tissue in images labeled as water, or vice versa, may occur within single images or throughout an in entire stack of slices. By default,

both sets of images (labeled fat and labeled water) will be reconstructed and inserted into the database for review. Proper calibration and center frequency selection will reduce the occurrence of this error. Complete elimination of this error may not be possible and thus interpretation of MR images must be completed by trained personnel.

FuncTool

CAUTION

Care should be taken when using quantitative measures of cerebral blood flow from 3DASL in clinical populations. Differences in CBF values may be seen when the same subject is scanned on different systems and coils. Diagnostic and treatment decisions should not be based solely on these absolute values.

WARNING

Do not use 3D views only to perform voxel value, distance, angle, or area measurements. Always refer to 2D baseline views.

CAUTION

Diffusion Tensor images attempt to characterize behavior of water molecules in imaged tissue. Therefore, fiber tracking representation actually displays algorithmically predicted water molecule direction. These displays may be only representative of the actual white matter anatomy. A trained neuro radiologist is required to make the association between the rendered tract display and the actual patient's anatomy.

CAUTION

Failure to place the ROI as described will negatively impact the output measurement.

CAUTION

Always click ***Compute*** again to re–compute the functional maps after making changes to the input parameters. The changes are not taken into account automatically.

WARNING

Under no circumstances should the pixel value from saved functional maps be used by any software applications that rely on Hounsfield values. This applies, in particular, to dose computation software applications.

CAUTION

It is possible that FuncTool results of the calculated T2* and R2* values have an error with acquisitions that have a large slice number value

Volume Viewer

Annotation

CAUTION

When saving images for diagnostic purposes, always make sure the patient name is displayed on all views.

Filter floaters

WARNING

Floater filtering removes all 3D objects from the displayed 3D volume that have a size equal to or smaller than the selected filter size. Before applying a filter, make sure that the selected filter size will not result in removing pathologies or other essential anatomical structures.

Measurements

CAUTION

Measurements are more reliable when done on 2D views. Always check on the 2D reformatted views where exactly the points have been deposited.

CAUTION

Post processing results may be affected by the presence of MR Conditional implants. Consider the following related to post-processing MAVRIC SL images on your MR[1], PACS[2] or AW[3] systems:

If an image includes susceptibility artifact, such as from MR Conditional metal implants, measurements made on the image may be incorrect due to distortion of actual physical locations.

CAUTION

Distance, angle, and area measurements are valid only if all trace segments are longer than the inter-slice distance.

[1]Magnetic Resonance. The absorption or emission of electromagnetic energy by nuclei in a static magnetic field after excitation by a suitable RF pulse.
[2]Picture Archiving Communications System
[3]Advantage Workstation

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Reformat

WARNING

A curved VOI can introduce distortion in the shape of objects. To prevent misinterpretation of the shape of an object, always verify the cursor position by correlation with the baseline and reformatted views.

Threshold

WARNING

The use of thresholding for the building of the 3D model excludes all voxel values outside the selected range from the 3D model. Before applying the threshold(s), make sure that the selected threshold settings will not result in removing pathologies or other essential anatomical structures from the 3D model.

System maintenance

Maintaining a controlled environment also involves routine preventative maintenance checks by the service engineer and site personnel. Careful planning and diligent upkeep of an MR facility can provide a safe environment for both patients and employees. Your system requires maintenance at specific service intervals in which many of the maintenance checks should be performed by a qualified service engineer. There are several checks you can perform. Be aware of required maintenance and the personnel responsible for meeting each requirement.

After-sale service of MR systems under GE warranty or service-contract shall be done by GE engineers or GE-assigned qualified people.

GE makes available, on request, such information as circuit diagrams and component lists to assist your technical personnel in the repair of equipment classified by GE as repairable. Where there are no user serviceable parts, adhere to this warning and refer service to qualified service personnel.

WARNING

Electric shock hazard. No user serviceable parts. Refer service to qualified service personnel.

WARNING

When installing and maintaining the products, follow lockout and tagout procedures, and adhere to MR safety requirements, high voltage and radio frequency prevention requirements. If these instructions are ignored, damage to the equipment and patient/personnel injury can result.

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SYSTEM MAINTENANCE

General cleaning

Background cleaning should be done by site personnel (e.g., technologists or housekeeping personnel) unless otherwise indicated in the following maintenance schedules.

Inspect pads for peeling or cracking. To prevent a biohazard, replace cracked or peeling pads before using.

Cleaning tips:

- To clean most accessories, use nothing stronger than alcohol or a mild soap-and-water solution.
- Use hydrogen peroxide to remove bloodstains.
- Open-cell sponges are coated with canvas to allow better durability and reliability. These sponge covers allow disinfection using only a 1:10–1:100 water dilution of 5.25%–6.15% sodium hypochlorite (common household bleach). Bleach concentrations greater than 10% or other disinfectants may discolor or compromise the fabric.

CAUTION

To avoid possible damage to equipment, do not use solutions containing amines, strong alkalis, esters, iodine, aromatic or chlorinated hydrocarbons, or ketones. Do not use autoclaves or the industrial washers and dryers found in most hospitals or professional laundry services.

SYSTEM MAINTENANCE

Exhaust fan

The magnet (RF-shielded) room exhaust fan, vent, and duct system are intended to evacuate the magnet room of cryogenic gas at the MR product specified rate. Over time, the exhaust fan system may become blocked with lint, hair, and other air-borne particles. It is important for personnel safety reasons that the exhaust fan system (vent, exhaust fan, ducts, etc.) be kept clean to make sure the exhaust fan system operates properly and exhausts cryogenic gas to an outside area.

In the unlikely event of a magnet quench or a cryogen gas leak, it is important that this exhaust fan system performs at or above the specified airflow to remove the cryogen gas from the magnet room. The magnet room exhaust fan and air inlet must be sized for a minimum of 1200 CFM (34 m3/minute) and minimum of room 12 air exchanges per hour. The minimum air flow and air exchange rate for mobile, transportable, and relocatable systems are different from those for fixed sites and varies depending on the type of site. Any blockage or obstruction could prevent the exhaust fan system from providing the required airflow. If the exhaust fan system fails to operate at or above specification, accumulation of dangerous levels of helium or nitrogen within the RF screen room could occur.

It is important that this exhaust system vent be cleaned regularly as part of the normal room cleaning. Regular customer inspection, cleaning, and testing of the exhaust fan system (vent, exhaust fan, ducts, etc.) are needed to make sure all equipment and parts of the system are always in good working order and able to perform to specification. It is recommended the exhaust fan system be cleaned and inspected annually to make sure the specified air flow rate can be met and thus ensures proper performance.

SYSTEM MAINTENANCE

Maintenance services

The planned maintenance (PM[1]) services prescribed in the PM schedules represent the current manufacturer's recommendations. Specific customer requirements and/or your site environment may necessitate more or less frequent intervals for PM service. An agreement to perform PMs less frequently than these recommendations can be made with the understanding that a reduction of system performance may result.

The PM service schedules in the **Maintenance Service** Schedules, list all the PM procedures and the frequency they should be completed by qualified service personnel. There are different schedules for each system type.

You should perform the maintenance services shown in the table below.

Table 2-46: Operator services

Item	Required maintenance	Service interval
General	Clean Check the table emergency release.	4 months 4 months
Patient cradle and pads	Check for cleanliness of pads and clean the inside of the cradle.	Daily
Patient table	Check the table alignment and proper operation.	6 months
Coils, pads, and straps	Clean with non-abrasive cleanser. Clean coil anti-skid pads with water and mild detergent only.	Daily
Coils and coil cables	Check for defects or damage, worn cable or exposed wires.	Daily
Image quality	Perform quality assurance and functional checks.	As recommended

[1]Planned Maintenance

SYSTEM MAINTENANCE

Magnet Rundown Unit test procedure

Use the following steps every week to test the Magnetic Rundown Unit. If any test fails, immediately contact your service engineer.

Figure 2-43: Magnet Rundown Unit

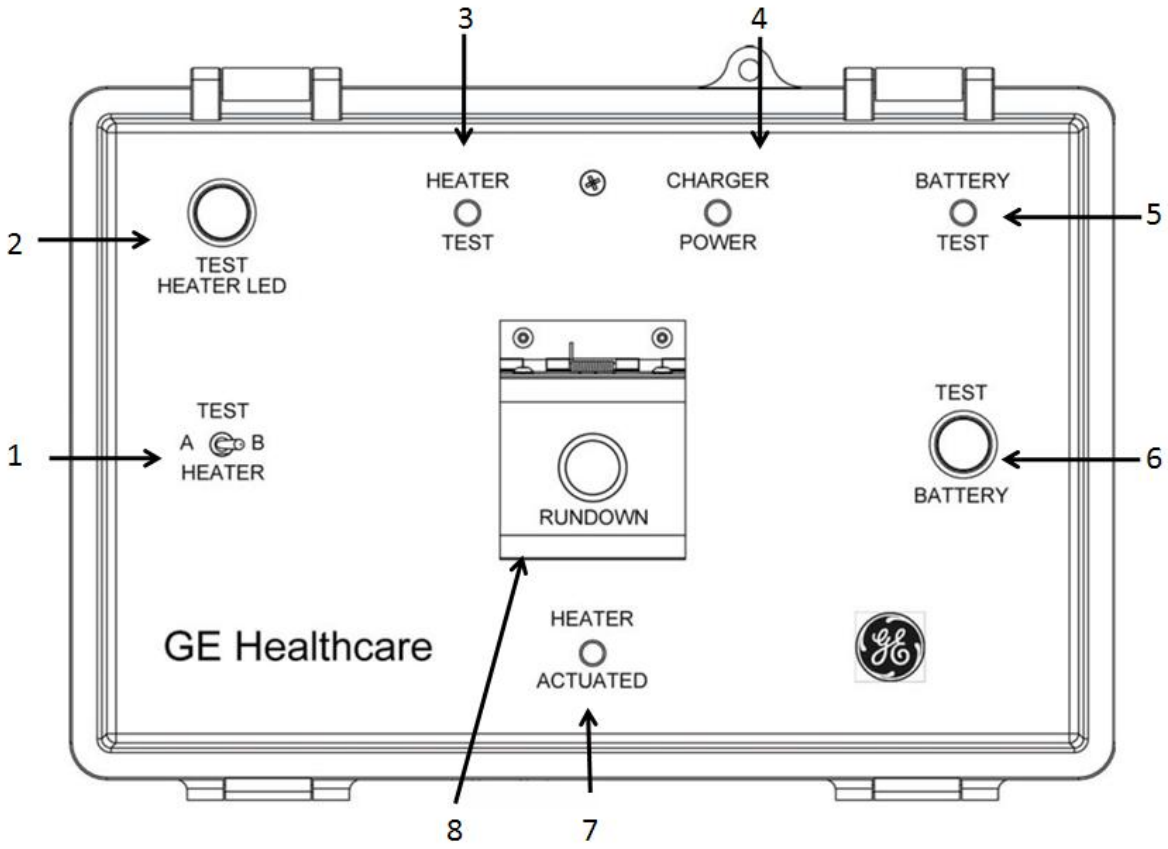


Table 2-47: Image legend

#	
1	TEST HEATER switch
2	TEST HEATER LED button
3	HEATER TEST light
4	CHARGER POWER LED
5	BATTERY TEST LED
6	TEST BATTERY button
7	HEATER ACTUATED LED
8	RUNDOWN button

1. Verify that the green CHARGER POWER LED (4) is illuminated.

- If test 1 fails, the MRU has only 11 days until it won't be able to quench the magnet when needed. If the Charger light is not illuminated, immediately call GE Service to schedule service

repair.

2. Depress and hold the TEST BATTERY button (6) for 15 seconds. The green BATTERY TEST LED (5) should light and remain lit while the TEST BATTERY switch is depressed.

   - If test #2 fails, you cannot quench the magnet when needed. Immediately call your service engineer.

3. Place the TEST HEATER toggle switch (1) in the A position. The green HEATER TEST (3) should illuminate.

   - If, when the TEST HEATER toggle switch is in either the A or B position and HEATER TEST (3) does not illuminate, then press the TEST HEATER LED button (2) to verify HEATER TEST (3) is functional.

   - If test #3 fails, you may not be able to quench the magnet when needed. Immediately call your service engineer.

4. Place the TEST HEATER toggle switch (1) in the B position. The green HEATER TEST (3) should illuminate.

   - If test #4 fails, you may not be able to quench the magnet when needed. Immediately call your service engineer.

Magnet quench

Pressing the big red RUNDOWN button (8) at any time will quench the magnet. Do not press the big red RUNDOWN button unless you want to quench the magnet.

Procedures introduction

This section provides the step-by-step instructions for working safely in a magnetic field environment. Specifically, it describes how to:

- Eliminate Magnet Hazards
  - **Protect the security and exclusion zones**
  - **Screen patients and personnel**
- **Prepare the patient**
- **Protect the patient from RF burns**
- **Protect the patient's eyes and ears**
- Respond to Emergencies
  - **Patient emergencies**
  - **Equipment or environmental emergencies**
  - **Magnet emergencies**
  - **Quench with vent failure**
- **Check the Cryogen Levels**
  - Systems with a helium level meter
  - Systems with a magnet monitor unit
- **Handle contact with liquid cryogens**

IMPORTANT!: You should understand the following definitions before continuing:

- A substance that is ferromagnetic has a large positive magnetic susceptibility, meaning it is very easily magnetized (example: Iron).
- An item that is ferrous can posses intrinsic magnetic fields and become a projectile in an applied magnetic field (examples: Iron, nickel, and cobalt).

PROCEDURES

Protect the security and exclusion zones

It is vital to have supervised and controlled access within the MR environment to keep it safe from ferromagnetic items and to guard against accidents, injuries, or damage to MR systems. Keep in mind that even a paperclip inside the bore of the magnet can cause image artifacts or a patient burn. All personnel should be aware of the following important steps.

1. Keep the door to the MR environment and the magnet door closed.
   - The doors should not be held open for other people or propped open.
   - Only essential personnel should be allowed to enter the magnet room.
2. Limit and monitor access to the MR environment and magnet room.
   - Personnel trained in MR safety should be present at all times during the operation of your MR facility to ensure that no unaccompanied or unauthorized individuals are allowed to enter the MR environment or magnet room.
   - Personnel trained in MR safety are also responsible for performing thorough screening of patients and other individuals before allowing them to enter the magnet room.
3. Supervise non-MR personnel when working in the magnet room.
   - Everyone who needs to enter the MR environment on a regular or periodic basis should be educated regarding the potential hazards related to the magnetic field.
4. Prominently display the Security and Exclusion Zone warning signs to make all individuals and patients aware of the risks associated with the MR system.
   - The Security Zone sign must be posted on the entrance to the magnet room.*
     - These signs warn patients about the strong magnetic field and stresses the presence that no pacemakers, metallic implants, neurostimulators, or loose objects are allowed.
   - The Exclusion Zone sign must be posted at the 5 gauss boundary.*
     - This sign warns against the strong magnetic field and stresses the presence of no pacemakers, metallic implants, or neurostimulators.

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

5. Test all items for ferromagnetic properties before taking them into the magnet room.
   - Use a hand magnet to test items.
6. Remove ferrous items from the immediate vicinity of the magnet room.
   - This can reduce the chance that someone might carry a ferrous item into the magnet room.
   - Replace ferrous items that must remain in the vicinity of the magnet room with non-ferrous versions whenever possible.
7. Tag ferrous items that remain at the facility so that all personnel know the item cannot be taken into the magnet room.
   - Tag all ferrous items with the same label to be consistent in identifying items that are not to be in the magnet room.

8. Do a pocket check before entering the magnet room.
   - Check for loose metal objects, such as keys, and remove.
9. Keep the magnet door in sight at all times.
   - When working in the magnet room, do not stand between the door and the magnet or turn your back to the door.
10. Do not turn your back on the patient or anyone else in the magnet room.

PROCEDURES

Screen patients and personnel

For your safety and the safety of the patient, an MR safety-trained health care worker at your facility should carefully screen for hazards before patients and personnel enter the Exclusion Zone. All personnel must be aware of and comply with your facility's screening procedure.

WARNING

Patient screening is required for patients who are going to be imaged on an MR scanner.

1. Use a Patient Screening form routinely before bringing patients or other personnel into the Exclusion Zone.
   - Thoroughly review all safety information and considerations before starting a scan with patients that have an MR Conditional implant. In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. For patients with implants that are labeled as MR Safe or MR Conditional consult the implant device manufacturer's documentation.
   - Every patient, individual, and employee must be carefully screened prior to admission to the magnetic field. Refer to the **Screening form** topic.
2. Review the completed screening form and evaluate the individual prior to entry.
   - Identify circumstances that contraindicate admission to the Exclusion Zone or items that need to be removed before entering the Security Zone.
   - In addition to safety issues, metal objects or materials containing metal may distort the magnetic field and detract from the image quality.
3. Discuss the items on the screening form with the patient or other individual.
   - Verbally interview the patient to verify the information on the form and ensure the patient understands each question he/she is answering.
   - Allow discussion of any question or concern that the patient may have.
4. Examine all patients with diapers or incontinence products, including adults, should have dry diapers on prior to the start of the scan.
5. Examine or X-Ray patients who are at risk for metal eye slivers.
   - Serious injury may occur as a result of movement or heating of the metallic foreign body as it is attracted by the magnetic field of the MR system.
   - Follow your departmental clinical screening policy.
6. Require that patients change clothes.
   - Provide clothes without metallic fasteners and pockets.
   - Patients should not wear shoes into the magnet room as they may have collected metal on the soles.
7. Instruct the patient to wash off non-permanent make-up.
   - Follow the precautions for patients with permanent make-up such as permanent eyeliner, which can cause tissue heating.
8. Keep metal out of the bore.*
   - A metal-free bore prevents burns and image artifacts.

*In general, patients with conductive (e.g. metallic) implants are contraindicated for MR scans. Some implantable devices have been labeled as MR Conditional under certain operating conditions. MR Safe implants will have the MR Safe symbol in their implant documentation.

When evaluating whether to proceed with MR scanning on patients with such implants, consult the implantable device's labeling.

PROCEDURES

Prepare the patient

Some patients undergoing an MR procedure may experience feelings of fear, anxiety, or claustrophobia. The following techniques may help reduce or eliminate these sentiments. Use the following techniques for all patients, even if your patient does not exhibit signs of fear or claustrophobia. Larger patients can feel anxious due to a confined feeling in the magnet. Degradation of image quality can also occur. Verify that the patient's weight does not exceed the table weight limit as defined in your MR system's documentation. Consult your system operator manual for details.

1. For safety reasons, patients must be thoroughly screened prior to scan preparation.
   - Screen for pertinent medical history and conditions that contraindicate scanning.
   - If proper screening cannot be performed, postpone the MR examination until screening can be done.
   - Review **Contraindications for use** before scanning the patient.
2. Determine scan protocol and enter the patient's information in advance.
   - This saves time during the preparation for the procedure so the patient is not left waiting for the examination to begin.
3. Provide the patient an information booklet to read.
   - Educating the patient concerning specific aspects of the MR examination is an effective way to prepare for the situation and explain what is about to happen.
4. Have the patient use the restroom prior to the examination.
   - Fewer interruptions during the scanning procedure can help you stay on schedule and keep the patient focused on holding still during the examination.
5. Examine all patients with diapers or incontinence products, including adults, to make sure the patient has dry diapers and dry clothing on prior to the start of the scan.
6. Discuss the procedure with the patient.
   - The length of the examination
   - What can be seen during the examination
   - What can be heard during the examination
   - What can be felt during the examination
7. Transfer the patient to the MR table.
   - Refer to your specific MR system operator manual for patient transfer details.

CAUTION

Position the patient's limbs, hair, and clothes completely on the table to avoid risk of injury when the table is moving.

8. If the patient was transported into the magnet room via the MR table and the IV pole connected to the table is in use, once the table is docked, replace the MR table's IV pole with a non-ferrous free-standing IV pole.

Pinch Point CAUTION

Do not move the patient into the magnet with the MR table's IV pole in use. To avoid any pinch points from the MR table's IV pole, remove the IV pole from the table, store it, and use a non-ferrous free standing IV pole.

9. Let the patient see the MR system while you explain the features of the bore.
   - Soft lighting
   - Good ventilation
   - A microphone and speaker to enable the patient to hear and be heard at all times
10. Demonstrate the use and function of the Patient Alert System.
    - This system is patient-activated and allow the patient to signal for assistance during a scan.
11. Explain the use of straps. See your system operator manual for details.
12. Ensure the patient is comfortable.
    - Use sponges and wedges to relieve pressure points and support the body in the correct position.
    - Ask if a blanket is needed while being aware that once the scan begins, a blanket may increase patient warming.
13. Explain the need for **hearing protection**.
    - Use recommended earplugs (>/= 29dB NRR) to minimize the noise from the gradient magnetic field.
    - Alternatively, use recommended MR-compatible headphones (>/= 29dB NRR) to provide relaxing music to the patient and minimize the noise.
14. Stress the need for cooperation to attain a diagnostic study.
    - It is extremely important the patient not move during the examination.
15. Stay in constant verbal and visual communication with the patient throughout the examination.
    - Some patients may require the physical presence of an family member or nurse in the magnet room.
16. See the following procedures for details regarding:
    - **Protect the patient from RF burns**
    - **Protect patient's eyes and ears**
    - **Patient emergencies**

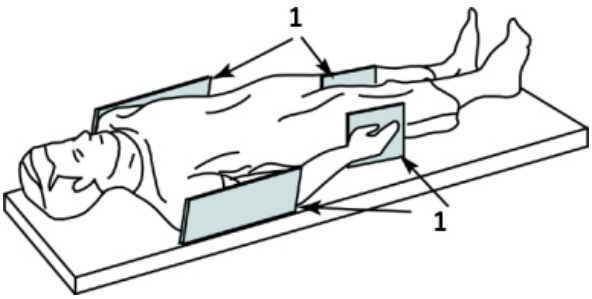
PROCEDURES

Protect the patient from RF burns

All personnel should be aware of several factors to protect a patient from burns and peripheral nerve stimulation. The following steps should be observed by all personnel that position patients for scanning.

1. Remove any accessory devices from the bore of the magnet that are not required for the procedure.
   - This includes any unplugged electrically conductive materials such as surface coils, cables, etc.
2. Examine all patients with diapers or incontinence products, including adults, to make sure the patient has dry diapers on prior to the start of the scan.
3. Position the patient to prevent direct contact between the patient's skin and the bore of the magnet or an RF surface coil.
   - Before connecting halves of a split coil, take care that the patient's body (for example, ear, jowl, neck, finger, hand, etc.) is not trapped or pinched by coil parts.

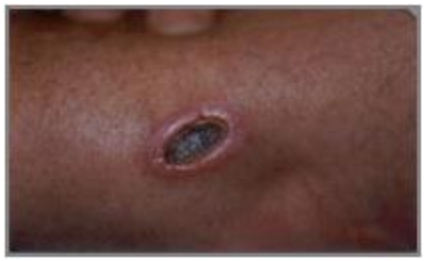
Figure 2-44: Patient positioned with non-conducting pads (1)



- Use additional pads to immobilize the patient and make them comfortable.
- Preventing patient warming is one of the most important safety measures you must take into consideration as you prepare a patient for an MR exam. Appropriate RF padding and proper patient positioning are the most effective means of preventing injury related to RF heating. The following are a few golden rules to remember as you position and pad your patients:
  - Only use GE-approved RF padding.
  - Use non-conductive padding that is at least 0.25 inches (0.635 cm) thick between the patient's skin and the magnet bore.
  - Appropriate padding must be used EVERY time without exception
  - Sheets and gowns are not a substitute for approved RF padding.
  - Never allow your patient’s skin to come in direct contact with the scanner bore or any surface coil or cable.
  - Never allow skin-to-skin contact.
  - If a patient does not fit in the MR scanner bore with the required padding, another modality should be used to scan the patient.
- While some of these rules may seem a little tough to follow at times, remember that RF injury, which can in extreme cases include burns such as the one you see below, can happen very quickly and your patient may not have time to warn you in time to prevent an injury.

Patient padding

Figure 2-45: Elbow RF burn



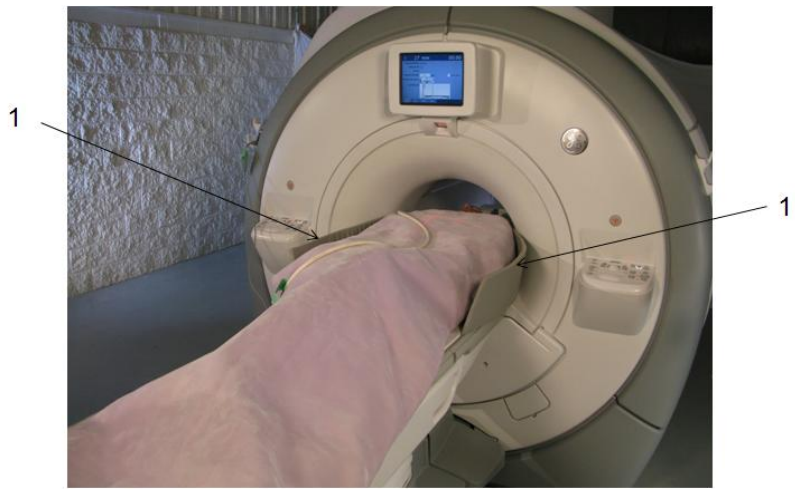
- The following are a tips that will assist you in properly positioning and applying RF padding to your patients. Should you need more information on prevention of patient warming than what is provided here, refer to your surface coil and refer to Tissue Heating in this manual. If you need help beyond the documentation please do not hesitate to reach out to your local Applications Specialists.

Whole body padding

Although the photos are from a Discovery system, the safety padding guidelines apply to all MR systems.

- An important consideration when padding your patients is that you will need to double check the position of the pads once the patient is in the bore. Table movement may dislodge padding and expose skin to the scanner bore.

Figure 2-46: Padding between patient and bore. 1 = bore pads



- Notice that padding is positioned not only at the patient's sides to prevent their arms from touching the bore, but that padding is also placed between the hands and thighs and between knees and ankles to prevent forming conductive loops.

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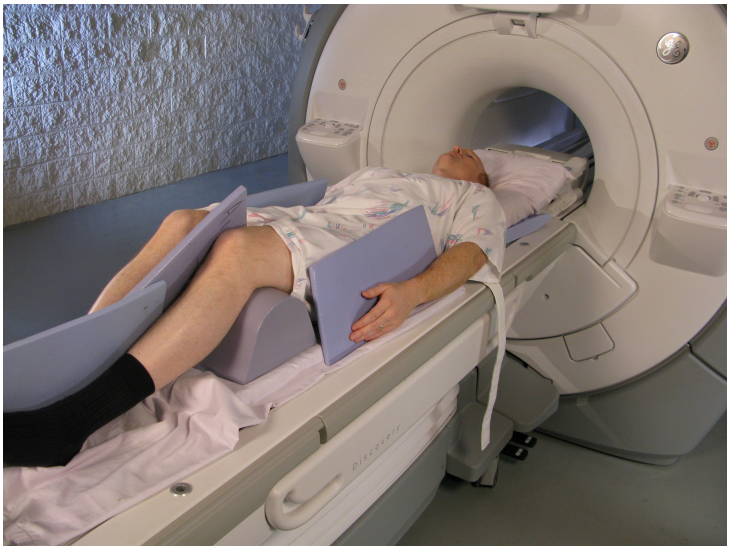
Figure 2-47: Patient padding

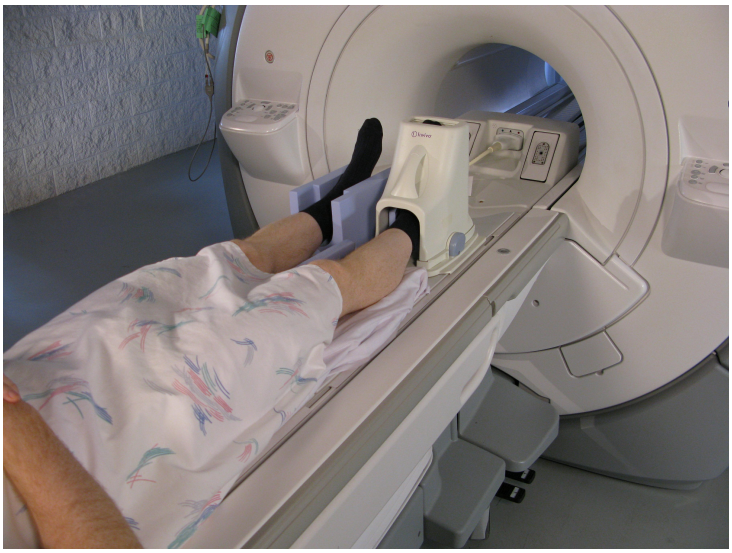


Surface coil padding

Although the photos are from a Discovery system, the safety padding guidelines apply to all MR systems.

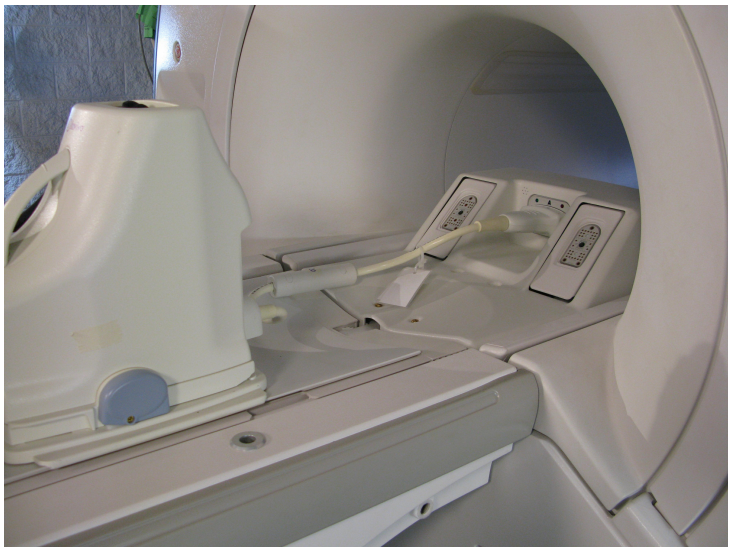
- Padding with a surface coil presents different challenges from a patient RF padding perspective.
  - First rule of thumb is to remember to use all manufacturer provided padding to prevent motion and the patient's skin from coming in contact with the coil, and to also use additional padding if appropriate to secure an opposing extremity to prevent contact with the coil which could also lead to burns or motion artifacts.
  - Just as with the whole body RF padding demonstration, you'll need to make certain that the patient's skin does not come into contact with the scanner bore and that padding is placed between the hands and thighs to prevent conductive loops.

Figure 2-48: Extremity padding



- A final safety consideration for surface coils is to ensure that the patient does not come into contact with the coil cable, therefore you may need to use additional RF padding to protect the patient.
  - Care should also be taken to ensure the cable is not looped in the bore and that it is routed down the center of the scanner bore.

Figure 2-49: Coil cable with no loop

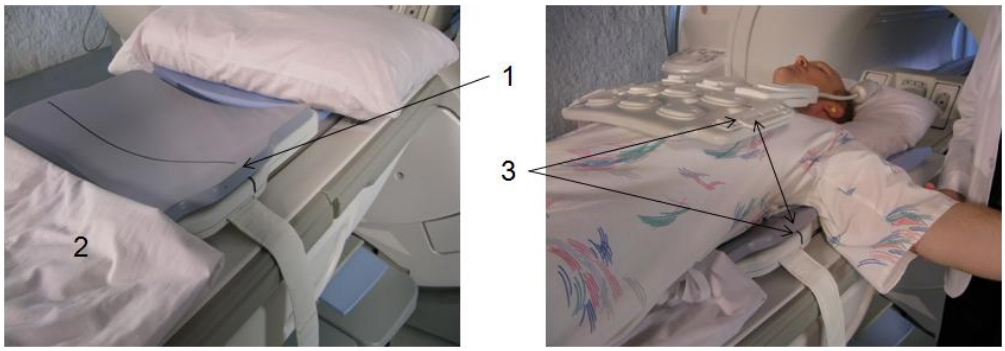


Cardiac coil padding

Although the photos are from a Discovery system, the safety padding guidelines apply to all MR systems.

- Follow your basic padding recommendations to prevent contact with the scanner bore and prevent conductive anatomical loops, but there are a couple of additional steps you'll need to take to ensure patient safety
  - The cardiac coil does not require additional RF padding to be placed between the patient and the anterior coil component, but you should use the manufacturers pad on the posterior component of the coil for patient RF protection. You should also cover the patient with their gown before placing the anterior component of the coil and make certain both the anterior and posterior elements are in alignment.

Figure 2-50: 1 = coil pad aligned with coil, 2 = sheet to cover pad, 3 = anterior and posterior coil elements aligned



  - Secure the coil snugly, but comfortably with the straps.

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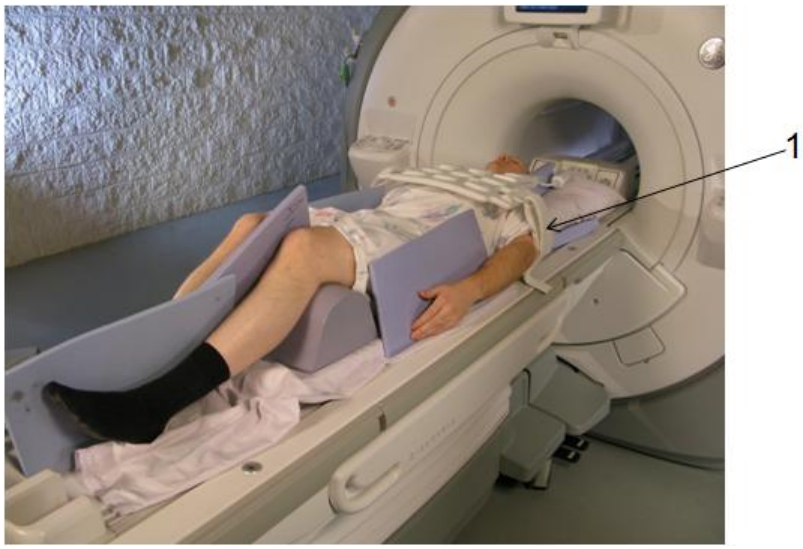
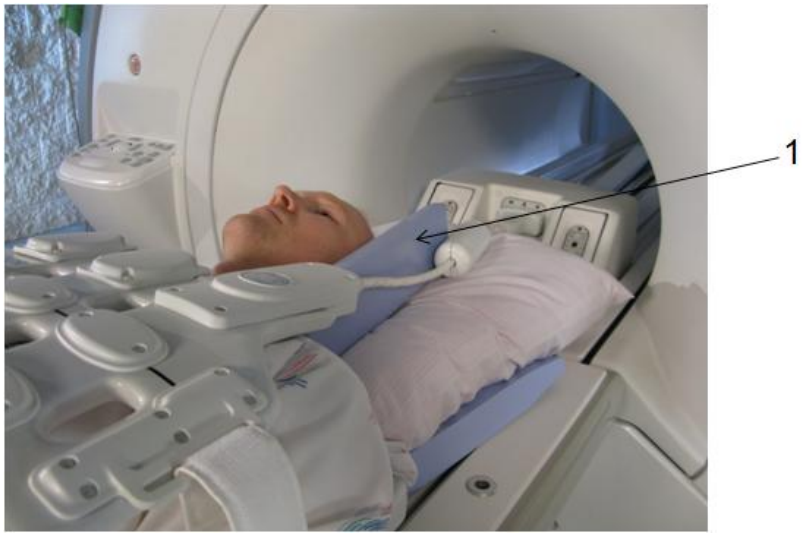
Figure 2-51: Coil secured with straps



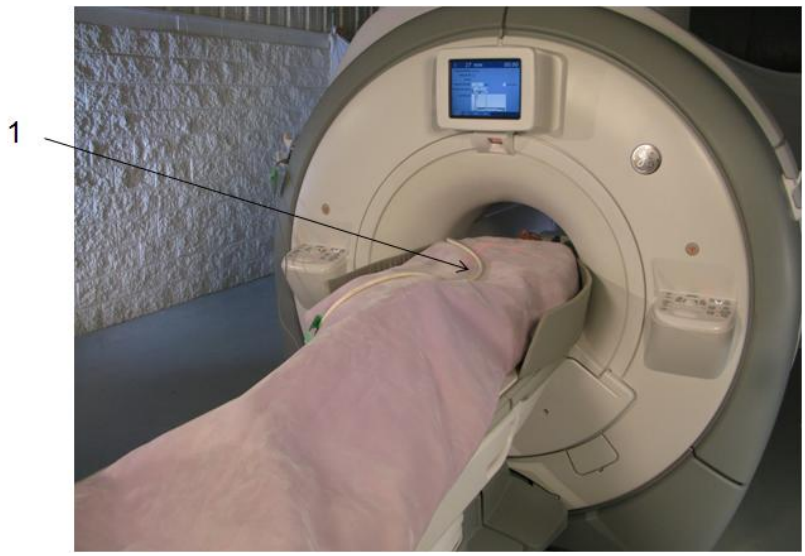
- As is the case of all surface coils ensure that the cables do not come in contact with the patient and that they are not looped and routed down the center of the bore. As you can see there is significantly more cable that we need to isolate from the patient, so be sure to use as much padding as needed.

Figure 2-52: 1 = Pad placed between cable and patient skin



- If you are using the cardiac coil, it's likely you are also using the ECG leads and cable. The rules for the ECG cable are the same as the coil cable. Route the ECG cable down the center of the bore, do not loop the ECG cable and do not allow it to come in contact with the coil cable.

Figure 2-53: 1 = ECG cable with no loops



4. Only use approved RF coils that are not damaged.
   - Labels such as the one in the figure below, provide warnings about working with RF coils.

Figure 2-54: Warning label

   - Before using the coil, check the integrity of the electrical insulation of the components or accessories of the device.
5. Keep electrically conductive material that must remain in the magnet bore from directly contacting the patient by placing insulation between the conductive material and the patient.
   - Place a clean cotton sheet over the coil and comfort pad so the patient's skin does not come in contact with the coil or the comfort pad.
6. Position RF cables down the center and directly out of the bore, without looping or crossing the cables.
   - Use the cable holders provided to route the cables so there are no loops in any cables in the magnet. Cable holders are located on both side of the cradle near the edges. Use the appropriate gating cable for surface coil imaging.
   - Use only MR system recommended monitoring equipment, ECG leads, wires, electrodes, and other components and accessories.

- For medical devices that are labeled as MR Safe or MR Conditional consult the device manufacturer's documentation.
- Follow all instructions for the proper operation of physiologic monitoring or other equipment provided by the manufacturer of the device.

7. Test the patient intercom.
   - Make sure that the patient can hear you and you can hear the patient.
8. Enter the correct patient weight.
   - Correct weight entries maximize performance and help prevent excessive RF exposure.
9. Turn on the bore light and fan.
   - Lights turned on inside the bore can help alleviate feelings of claustrophobia.
   - A fan inside the magnet bore provides adequate air movement for the patient. Keep the fan on at all times.
10. Show the patient how to use the Patient Alert System.
    - Patients experiencing uneasiness or concern can squeeze the Patient Alert bulb.
    - When the Patient Alert bulb is squeezed, an alarm emits a signal to you.
11. Respond to bore temperature direction messages throughout the procedure.
    - The temperature messages are located in the message window on your console.
    - If the patient reports feeling warm, discontinue the procedure.

PROCEDURES

Protect the patient's eyes and ears

During scanning gradients produce noise that can exceed 99 dBA in the bore. Hearing protection is required to prevent hearing impairment. Patients must close his or her eyes when the alignment light is on during positioning. Follow these guidelines to ensure proper eye and ear protection for your patient.

1. Provide the patient with hearing protection.
   - Earplugs or a headphone system with stereo music. For details, see Acoustic Noise
     - Earplugs reduce the intensity of the sound, while allowing your patient to hear normal conversations.
     - Headphone systems soften acoustic noise, but may impede verbal communication with patients while the system is operating.

Table 2-1: Disposable ear protection

Description	dB
E8801BA EAR Disposable Foam Earplugs	29
E8801BB EAR Taperfit2 Foam Earplugs	32
E8801BC Max-Lite Foam Earplugs	30

WARNING

Hearing protection is required for all people in the magnet room during a scan to prevent hearing impairment. Acoustic levels may exceed 99 dB(A)

IMPORTANT!:Since the acoustic noise of the OpenSpeed system does not exceed 92.2 dBA, ear protection is not required, but is recommended.

2. Make sure that the hearing protection device is worn properly.
   - Earplugs should be comfortable for the patient and inserted fully. Pliable earplugs compress when they are rolled between the fingers and conform to the ear after they are inserted.
   - The headphone system should be audible and comfortable for the patient.
3. Instruct the patient to close his or her eyes when the alignment light is on.
   - The Laser Alignment Lights for patient positioning can cause eye injury.
   - 3.0T VH/i systems do not use semiconductor laser alignment lights for patient land marking, therefore this only applies to 0.7T, 1.5T. and 3.0T EXCITE systems.

CAUTION

Turn off the laser light after positioning the patient.

PROCEDURES

Patient emergencies

Dealing with patient emergencies requires special planning in the MR environment because of the magnetic field. Certain equipment used for resuscitation does not function in a magnetic field, and ferrous items can become projectiles. If a patient needs emergency medical attention during the scanning session, follow these guidelines:

1. Press ***Emergency Stop*** on the operator's console or magnet enclosure.
   - The scan aborts.
   - The power disables the patient-handling and scan-related equipment.
2. Notify emergency personnel, if necessary.
   - Since ferromagnetic life support and related equipment cannot be brought into the magnet room, it must await the patient outside the magnet room.
3. Quickly bring the patient out of the magnet bore. Refer to your specific product operator manual for details on cradle emergency release.
4. If you have an OpenSpeed, Brivo MR355, or Optima MR360 fixed table systems, continue with step 5. Otherwise, move the side rails of the transport into the vertical position then, continue with step 7.
   - The side rails help prevent the patient from rolling off the side of the patient table and provide a handrail for the patient to hold.
   - The side rails also provide you a handrail as you guide the table during movement.
5. Move a non-ferrous gurney next to the magnet table.
6. Move the patient from the table to the gurney and continue with step 8.
7. Undock the transport.
   - Use the undock pedal at the foot of the table or emergency release handle at the head of the table.
8. Keep the patient on the gurney or transport and remove the patient from the magnet room as quickly as possible.
   - It is important to have an assigned emergency area outside of the magnet room where you can take a patient so that the emergency team can use the necessary equipment.
9. Follow your facility's emergency protocol.

WARNING

The Emergency Stop button does not remove the magnetic field, turn off the computer cabinets, operator's console, or camera.

PROCEDURES

Equipment or environmental emergencies

If you experience a serious equipment fault (system overheating, smoke, or odor associated with the system) or hazards such as fire/water in the vicinity of the MR equipment, you may need to perform a system shutdown with the Emergency Off button. The entire MR system is turns OFF with this button, except for the static magnetic field and the Magnet Rundown Unit used to shutdown the magnetic field.

Use this procedure to perform an emergency shutdown on your system during an equipment or environmental emergency.

1. Press the ***Emergency Off*** button located on the wall next to the computer equipment or next to the magnet room door.
   - This stops power to the magnet room, removing all electrical power from all components of the system.
   - This button also removes any power sources from UPS devices.
2. Evacuate the patient.
   - Follow the guidelines in the Patient Emergencies procedure.
3. Evacuate the MR suite.
   - Follow your facility's emergency protocol.
4. Call the fire department, if appropriate.
   - When the fire department arrives, evaluate the need for an emergency MRI magnet quench.
   - If the firefighters need to take ferromagnetic equipment into the MRI magnet room, quench the magnet.
5. Contact a service engineer before restoring power.
   - To restore power after an Emergency Off, the main circuit breaker must be reset before rebooting the system.
6. After service has examined the system, document the correct cause of the emergency.
   - Keeping the events documented allows you to reference this information in the future and may help prevent similar incidents.

WARNING

The Emergency Off button does not turn off the magnetic field. To avoid personal injury or equipment damage, do not bring any ferromagnetic equipment into the magnet room. Assume that equipment is magnetic unless it is clearly labeled otherwise.

PROCEDURES

Magnet emergencies

In addition to patient and equipment emergencies, magnetic field emergencies can also occur. Examples of magnetic field emergencies include instances where the presence of the magnetic field may cause injury or harm, if someone is pinned between the magnet and ferromagnetic object. All personnel should be familiar with how to respond to magnet emergencies.

A magnet rundown results in several days of downtime and may jeopardize your magnet. Your facility needs to define the specific circumstances that would require a magnet rundown so that no one makes an expensive mistake.

Use this procedure to perform an emergency magnet rundown on your system during a magnetic field emergency.

1. Press the Magnet Rundown button located in the magnet room.
   - This results in a rapid reduction of the magnetic field in about two minutes.
   - There is a boil-off of cryogens, accompanied by loud crackling and hissing sounds.
   - Expect several days of downtime to replace the cryogens.
2. Evacuate the patient and all other personnel from the magnet room.
   - Follow the guidelines in the Patient Emergencies procedure.
3. Evacuate the magnet room.
   - Follow your facility's emergency protocol.

IMPORTANT!: Plan and rehearse for a magnet rundown that results in venting of cryogen vapor into the magnet room.

Do not activate the Magnet Rundown switch during practice.

WARNING

The Magnet Rundown should only be used to free someone pinned to the magnet or to remove a large ferromagnetic object captured by the magnetic field when injury to persons is imminent. A controlled magnet rundown should be performed by a GE Service Engineer in non-emergency situations.

PROCEDURES

Quench with vent failure

A magnet quench can result in the release of cryogen vapor into the magnet room if the vent fails; white clouds of vapor appear in the magnet room. Cryogens released during a quench can cause asphyxiation, frostbite, or injuries due to panic. Magnet quenches are indicated by a loud noise, warning message, or the tilting of an image on the image screen. It is critical to have a well-planned method to quickly remove the patient and all personnel from the magnet room if a quench should occur.

Use this procedure in case of a sudden cryogen release into the magnet room.

1. Do not panic.
   - Staying calm helps you remain focused so you are able to safely remember and follow your planned method of action.
2. Using the intercom, tell the patient to stay calm and remain on the table.
   - Tell the patient that someone will be in shortly to offer assistance.
3. Turn on the magnet room exhaust fan.
   - Some systems vent automatically and there is no fan to turn on.
4. Prop open the door between the operator room and hallway or if in a mobile unit, open the door to the outside.
   - This promotes air circulation.
5. Prop open the door to the magnet room.
   - If helium is venting in the room, the magnet room door may not open.
   - If the door cannot be opened, slide open the window between the console and magnet rooms, or if needed, break the window to the magnet room to relieve pressure.
6. Enter the magnet room and help the patient exit.
   - If a gurney or wheelchair is needed to remove the patient, make sure it is a non-ferrous type.
   - When exiting, stay near the floor where the oxygen will be and immediately exit the magnet room.
7. Evacuate all personnel from the area until the air is restored to normal.

PROCEDURES

Check cryogen levels

Systems with a Helium Level Meter

It is very important to check and record the helium level. Sufficient helium is necessary to avoid accidental quench. If the helium levels fall below 60%, or the level your service engineer says is acceptable, contact a service engineer immediately.

Use this procedure to check cryogen levels.

1. Turn on the Helium Meter power switch.
   - This switch is located at the system cabinet.
2. Press Update on the system cabinet.
   - An updated reading of the helium level posts.
3. Record the percent of helium reading.
   - Keep a logbook to record readings daily.
   - It is crucial that cryogenic systems be checked regularly to be sure they are properly functioning.
4. Turn off the Helium Meter power switch when complete.

Systems with a Magnet Monitor Unit

It is very important to check and record the helium level. Sufficient helium is necessary to avoid accidental quench. If the helium falls below 60%, or the level your service engineer says is acceptable, contact a service engineer immediately.

Use this procedure to daily check cryogen levels of a system with a Magnet Monitor Unit.

1. Locate the magnet monitor, which is typically in the equipment room. Push the sample button on the Magnet Monitor Unit and hold it for approximately 10 seconds.
   - An updated reading of the helium level posts.
2. Record the He Level value when it displays on the monitor.
   - The reading also toggles to the magnet pressure. Monitor any change in pressure. Normal pressure is between 3.9psi and 4.1psi.
   - Keep a logbook to record readings daily.
   - It is crucial that cryogenic systems be checked regularly to be sure they are properly functioning.
3. If the alarm LED is illuminated, contact your service engineer.

PROCEDURES

Handle contact with liquid cryogens

Since the cryogen gasses are odorless, tasteless, and colorless, it is particularly important to have specific procedures in place to avoid frostbite if there is ever an accident in which the liquid or gaseous cryogen contacts human skin. Such procedures should be established and made readily available to all personnel.

Use this procedure immediately in the unlikely event that someone comes in contact with a liquid cryogen.

1. Promptly flush the area with large volumes of tepid water.
   - Tepid water is 105° to 111°F or 41° to 46°C.
   - For cold burns, immerse affected area in tepid water for at least 15 minutes.
2. Calm the victim.
3. Avoid aggravating the injury.
   - Do not rub or massage the affected parts of the body.
4. Cover the area with a sterile dressing.
   - You may also use a clean sheet if the exposed area is large.
   - This protects the area from further trauma.
5. Consult a physician immediately.
   - Maintain the affected area at normal body temperatures until a physician arrives.

PROCEDURES

Safety review

Table 2-48: Safety review table

Situation	Procedure
Fire, sparks, a loud noise or other emergency condition in the magnet room not associated with normal operation of the system.	Press an **Emergency Off** button, either in the computer equipment room or at the magnet room door. Remove the patient from the magnet room.
Magnet quench, indicated by a loud noise, warning message, dense white vapor with vent failure, helium meter dropping considerably or the tilting of an image on the image screen. Oxygen monitor is activated indicated by a loud sound.	Evacuate the patient and personnel from the magnet room and close the magnet room door. Follow your site's overnight procedure. All helium vapor should automatically be vented outside of the magnet room.
Magnetic-field emergency, e.g., a person pinned between the magnet and a ferromagnetic object.	Press the Magnet Rundown button in the magnet room. Remove the patient from the scan room.
Fire, sparks or a loud noise, indicating a severe system malfunction in the computer equipment room.	Press an Emergency Off button, either in the computer equipment room or at the magnet room door. Remove the patient from the magnet room.
Fire or severe condition relating to the power distribution unit (PDU) or service outlets.	Press an Emergency Off button, either in the computer equipment room or at the magnet room door. Remove the patient from the magnet room.
Overtemp indicator lights up at the remote power panel (RPP) or at the PDU, and an error message appears on the scan console's System Status Display area.	Remove the patient from the magnet room. Check the PDU vent for obstructions. If the vent is obstructed, or if the overtemp light or message remains on, perform a system shutdown and then press an Emergency Off button, either in the computer equipment room or at the magnet room door.
Patient needs medical attention.	Press the Emergency Stop button on the console or magnet and remove the patient from the magnet room.
Hydraulic failure of the table.	Make certain the cradle is fully retracted on the transport (the home position) before undocking the transport. Keep all personnel (including patients) away from any spill. Keep patients on the table until safe transfer is possible. Check for oil leaks and if any exist, clean them up to prevent anyone from slipping on the oil. If the table latch is stuck and the table cannot be removed, pull the Table Transport Emergency Release. Remove the table from clinical use until it is repaired.
Imaging functions are lost without warning.	Follow your facility's emergency procedures during this type of occurrence.


In all cases, notify a GE Service Engineer as soon as possible.

The ACR Guidance Document for Safe MR Practices may be found at ACR.org. GE does not necessarily endorse the document, but provides the reference for information.

MR compatibility test guidelines

Introduction

This section document describes a set of specifications and standards that can be used to evaluate the Magnetic Resonance (MR) compatibility of hand-held, non-electronic equipment used in conjunction with the MR system.

MR compatibility standards

The American Society for Testing and Materials, International (ASTM) has developed the following MR compatibility standards (and are developing more):

- F1542 Specification for the Requirements and Disclosure of Self-Closing Aneurysm Clips
- F2052 Test Method for Measurement of Magnetically Induced Displacement Force on Medical Devices in the Magnetic Resonance Environment
- F2119 Test Method for Evaluation of MR Image Artifacts from Passive Implants
- F2182 Measurement of Radio Frequency Induced Heating Near Passive Implants During Magnetic Resonance Imaging
- F2213 Measurement of Magnetically Induced Torque on Medical Devices in the Magnetic Resonance Environment
- F2503 Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment

These may be ordered online at http://www.astm.org.

PM service schedules

Specific customer requirements and/or your site environment may necessitate more or less frequent intervals for PM[1] service. An agreement to perform PMs less frequently than these recommendations can be made with the understanding that a reduction of system performance may result.

To further enhance productivity, the PM procedures have been divided into four types:

- Type 1 – Safety and Regulatory
- Type 2 – Image Quality
- Type 3 – Other (System not available for patient scans)
- Type 4 – Other (System available for patient scans)

The PM matrices list all the PM procedures and the frequency they should be completed, according to schedules listed below. The schedules indicate the procedures that are performed during each visit. They also show the type (1 - 4) for each procedure. The services should be completed at the indicated intervals and should be performed only by qualified service personnel.

Four/year PM schedule

- A = 0 to 3 months
- B = 4 to 6 months
- C = 7 to 9 months
- D = 10 -12 months

Six/year PM schedule

- A = 0 to 2 months
- B = 3 to 4 months
- C = 5 to 6 months
- D = 7 to 8 months
- E = 9 to 10 months
- F = 11 to 12 months

There are different service schedules for each system type:

- **0.7T Service Schedule**
- **1.5T Service Schedule for HDx and HDx prior systems**
- **3.0T Service Schedule for HDx and HDx prior systems**
- **HDxt 1.5T and 3.0T Service Schedule**
- **Optima MR360 and Brivo MR355 System Service Schedule**
- **MR750, MR450 and MR450w Service PM schedule**

[1]Planned Maintenance

SERVICE SCHEDULE

Discovery MR750 3.0T and MR450 1.5T and Optima MR450w 1.5T

The Discovery MR750 3.0T, MR750w, MR450 1.5T, and Optima 450w PM[1] service schedule lists all the PM procedures and the frequency they should be completed according to schedules A -D.

- A = 0 to 3 months
- B = 4 to 6 months
- C = 7 to 0 months
- D = 10 to 12 months

To further enhance productivity, the PM procedures have been divided into four types:

- Type 1 – Safety and Regulatory
- Type 2 – Image Quality
- Type 3 – Other (System not available for patient scans)
- Type 4 – Other (System available for patient scans)

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

[1] Planned Maintenance

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Table 2-49: Discovery MR750 3.0T and MR 450 1.5T and Optima 450w PM Schedule

Subsystem	PM check performed	Test purpose	A	B	C	D
Image Quality						
Patient Handling	Laser Light Alignment	Check	X	X	X	X
Image Quality	DQAII Calibration	Adjust		X		X
IBIS	Patch Update	Adjust	X	X	X	X
Image Quality	SPT (PM Mode)	Check	X	X	X	X
Image Quality	LVShim (PM Mode)	Check	X	X	X	X
Image Quality	EPI White Pixel (PM Mode)	Check	X	X	X	X
IBIS	PM Check	Check	X	X	X	X
Magnet Room						
Magnet Room	Oxygen Monitor Operation (Option)	Safety			X	
Magnet Room	PAC Leakage Current Test	Safety			X	
Magnet Room	Cardiac Gating Cable	Safety		X		X
Magnet Room	Patient Blower and Filter	Check	X	X	X	X
Magnet Room	Pneumatic Patient Alert System	Safety		X		X
PGR Cabinet						
PGR Cabinet	Inlet Filters	Clean	X	X	X	X
RF Power	UPM Functional Check	Safety				X
Patient Handling						
Patient Handling	General Checks	Safety		X		X
Patient Handling	Hydraulic Fluid Check	Check				X
Heat Exchanger						
Heat Exchanger	Check fluid levels and top off	Check	X	X	X	X
Heat Exchanger	HEC Coolant Deionization	Replace			X	
Heat Exchanger	HEC Filter Check	Check		X		X
PDU						
Teal PDU	Emergency Off & Stop Circuits/Indicator	Safety			X	
Teal PDU	LightsLeak Sensor Functionality Check	Safety			X	
Computer						
GOC	Set time	Check	X		X	
GOC	Clean dust	Clean	X		X	
Computer System	T-File Cleanup	Clean		X		
Computer	Storelog/File Clean up	Clean		X		

Subsystem	PM check performed	Test purpose	A	B	C	D
System						
Computer System	Review Overnight Diag Results	Check	X	X	X	X
Computer System	One-Wire Diagnostic	Check		X		
Options Cabinet						
BrainWave	Clean filters on BrainWave Lite PC (Option)	Clean		x		x
Magnet						
Magnet & Cryogens	Inspect Cryogen Vent	Check			X	
Magnet & Cryogens	Test GE Magnet Rundown Unit (MRU)	Safety	X	X	X	X
Magnet & Cryogens	Inspect SH1 System (Replace Adsorber every 20K hours)	Replace		X		X
Magnet covers	Inspect for discoloration the inside of the bore and the front and back of the magnet	Check	X			
Secondary PEN Wall						
Penetration Panel	Body Coil Air Filter	Clean		X		X

SERVICE SCHEDULE

0.7T

The 0.7T PM[1] service schedule lists all the PM procedures and the frequency they should be completed within a 3-month time frame, according to the following schedule, which results in services completed four times per year:

Four/year PM schedule

- A = 0 to 3 months
- B = 4 to 6 months
- C = 7 to 9 months
- D = 10 -12 months

To further enhance productivity, the PM procedures have been divided into four types:

- Type 1 – Safety and Regulatory
- Type 2 – Image Quality
- Type 3 – Other (System not available for patient scans)
- Type 4 – Other (System available for patient scans)

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

[1]Planned Maintenance

Table 2-50: 0.7T PM Schedule

Item	Type	A	B	C	D
Magnet Room					
Check Oxygen Monitor operation/installation date	1	X			
Perform Physical Acquisition Controller (PAC) Leakage Current test	1			X	
Check magnet room radio frequency (RF) integrity with correlated noise	3	X	X	X	X
Check cardiac gating cable	1	X		X	
Check patient blower and filter	3	X	X	X	X
Check pneumatic Patient Alert System	1	X			X
RF					
Check RF cabinet fans and filters	4	X	X	X	X
Perform Power Monitor functional checks	1		X		
Check RF output power	1	X	X	X	X
Patient Handling					
Check table operation	1	X	X	X	X
Check emergency release of cradle	1		X		X
Check patient transport casters and armboard set screws	1	X	X	X	X
Check brake pedal cable and brake operation	1		X		X
Check table gas shocks	1		X		X
Check table/cradle level	3			X	
Clean lightweight cradle wheels	3			X	X
Replacement of gas shocks (every 2 years)	3		X		
Gradients					
Check Gradient Cabinet fans and filters	4	X	X	X	X
Check eddy current compensation	2	X	X	X	X
Check gradient cables connection and support	3		X		
Check gradient calibration	2	X	X	X	X
PDU					
Check PDU Module in GRFD Cabinet emergency off and stop circuits	1			X	
Inspect PDU power connections	3			X	
Operator Workspace for OpenSpeed					
Check computer fans and clean air intake grills	3	X	X	X	X
Clean workstation mouse and videocam lens	3		X		X
Set Silicon Graphics, Inc. (SGI) system clock	4	X	X	X	X
Operator Workspace for OpenSpeed Excite					
Clean disk space by entering the following in a c-shell: storelog	4	X	X	X	X
Adjust the time from Guided Install	4	X	X	X	X
Clean dust of global operator console	3	X	X	X	X
General System					

Item	Type	A	B	C	D
Check system cabinet fans and clean filters	4	X	X	X	X
Check and delete error/message log/T-test files	3	X	X	X	X
Check shim	2	X	X	X	X
Check SNR	2	X	X	X	X
Check cabinet inlet air temperature	4	X	X	X	X
Check PM supplies	4			X	
Update Configuration File in Site Log Book	4		X		X
Perform Site Restoration - Check the Daily Quality Assurance (DQA) phantom, remove GE test scans, and check cabinet doors and covers	3	X	X	X	X
Check laser alignment lights	1	X	X	X	X
3M Laser Camera					
Check laser camera fans	3	X	X	X	X
Clean and vacuum laser camera interior	3		X		
Clean laser camera suction cups	3	X	X	X	X
Clean laser camera transport plate/docking unit	3	X	X	X	X
Run laser camera cleaning film	3	X	X	X	X
Clean laser camera exterior	4		X		
Check laser camera air shock pressure					
(Mobile systems only)	4		X		
Replace laser camera external docking unit switches	3	X			X
Magnet and Cryogens					
Check Magnet Monitor Connectivity	4	X	X	X	X
Calculate cryogen boil-off rates	4	X	X	X	X
Monitor Magnet Thermal Performance	4	X	X	X	X
Evaluate cryogen delivery schedule (If applicable)	4		X		X
Evaluate helium transfill efficiency	4		X		X
Verify cryogen meter calibration	4	X			
Inspect cryogen vent	1		X		
Test GE Magnet Rundown Unit (MRU)	1	X	X	X	X
Inspect GE MRU	1		X		
Check drip pan for fluid build-up	3		X		X
Inspect Sumitomo system (Replace adsorber every 20,000 hours)	3			X	
Replace Desiccant Pack in water flow meter	3	X	X	X	
Inspect flow meter for Magnet Monitor	3	X	X	X	X
SCC Cabinet					
Check air inlets, water temperature, and water flow	3	X	X	X	X

SERVICE SCHEDULE

HDxt 1.5T and 3.0T

The HDxt PM service schedule lists all the PM[1] procedures and the frequency they should be completed. There are four PMs per year.

Four/year PM schedule

- A = 0 to 3 months
- B = 4 to 6 months
- C = 7 to 9 months
- D = 10 -12 months

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

[1] Planned Maintenance

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Table 2-51: HDxt 1.5 and 3.0T PM schedule

Subsystem	Type	A	B	C	D
Image Quality					
Alignment Light Check	IQ	X	X	X	X
Patch Update		As applicable	As applicable	As applicable	As applicable
DQA-II Calibration	IQ	X			
LVShim	IQ	X	X	X	X
Eddy Current Check	IQ	X	X	X	X
Coherent Noise	IQ	X	X	X	X
Signal to Noise Check	IQ	X	X	X	X
Spike Noise Check	IQ	X	X	X	X
16-channel switch diagnostic	IQ	X	X	X	X
Perform Save Info	N/A	X	X	X	X
PM Check	IQ	X	X	X	X
Magnet Room					
Oxygen Monitor Operation	Safety	X			
Cardiac Gating Cable	Safety	X	X	X	X
Patient Blower and Filter	Check	X	X	X	X
Pneumatic Patient Alarm System	Safety		X		X
Inspect Front Cover Cable Take-up	Check				X
PAC Leakage Current Test	Safety			X	
RF/System Cabinet					
Fan and Filter for SRFD	Clean	X	X	X	X
Fan and Filter for MKS	Clean	X	X	X	X
Check RF Output Power	Check	X	X	X	X
Check/Clean Filters in RFS Cabinet	Clean		X		
Power Monitor Check	Check				X
Patient Handling					
Patient Table Checks	Safety	X	X	X	X
Lite Patient Transport	Safety	X	X	X	X
Signa OR - compatible table	Safety	X	X	X	X
Signa Oncology Patient Transport Table	Safety	X	X	X	X
Gradient					
Fans and Filters	Clean	X	X	X	X
Check Fluid Levels and valve of Heat Exchanger	Clean	X		X	
CFT-150 System maintenance	Check		X		X
Lytron System maintenance	Check		X		X
Mobile Hx System maintenance	Check		X		X

Subsystem	Type	A	B	C	D
Gradient cable / PDU Connections & Support	Check			X	
PDU					
Emergency Off & Stop Circuits/Indicator Lights	Safety	X		X	
Clean PDU Air intake	Clean			X	
TAC Cabinet - TRM Systems only					
Filter Replacement	Check	X	X	X	X
Clean Inlet Screen	Clean			X	
Solenoid Valve Replacement	Replace			X	
Vacuum Check	Check				X
Computer					
Storelog	Check	X	X	X	X
Clean dust, set time	Clean		X		X
BrainWave cabinet					
Clean the Filters on Brainwave Lite PC	Clean		X		
Integrated Patient Comfort Module (ICPM) Chilled Air Blower (CAB) (3.0T Option)					
Check Cabinet Filter and Condenser	Clean		X		X
Magnet					
Verify Magnet Monitor Calibration	Check		X		
Test GE Magnet Rundown Unit (MRU)	Safety	X	X	X	X
Inspect GE MRU	Safety		X		
Inspect cryocooler systems	Check	X		X	
Inspect Cryogen Vent	Check	X			

SERVICE SCHEDULE

1.5T for HDx and HDx prior systems

The 1.5T PM[1] service schedule lists all the PM procedures and the frequency they should be completed within a 2-month time frame, according to schedules A - F. This results in services completed six times per year.

Six/year PM schedule

- A = 0 to 2 months
- B = 3 to 4 months
- C = 5 to 6 months
- D = 7 to 8 months
- E = 9 to 10 months
- F = 11 to 12 months

To further enhance productivity, the PM procedures have been divided into four types:

- Type 1 – Safety and Regulatory
- Type 2 – Image Quality
- Type 3 – Other (System not available for patient scans)
- Type 4 – Other (System available for patient scans)

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

An asterisk (*) indicates the procedure should be performed during every site visit.

[1]Planned Maintenance

Table 2-52: 1.5T system PM schedule

Item	Type	A	B	C	D	E	F
Magnet Room							
Check Oxygen Monitor operation/installation date	1	X					
Inspect front cover and cable take-up	3						X
Inspect for discoloration the inside of the bore and the front and back of the magnet	1	X					
Perform Physical Acquisition Controller (PAC) Leakage Current test	1			X			
Check magnet room radio frequency (RF) integrity with correlated noise	3	X		X		X	
Check cardiac gating cable	1	X		X	X		X
Check patient blower and filter	3	X	X	X	X	X	X
Check pneumatic Patient Alert System	1	X			X		
RF							
Check RF cabinet fans and filters	4	X	X	X	X	X	X
Check Erbtec blower output	3	X	X	X	X		
Perform Power Monitor functional checks –RF/Penetration cabinet	1					X	
Perform Power Monitor functional checks – RF/Penetration II cabinet	1					X	
Perform Power Monitor functional checks – RF/Power Distribution Unit (PDU) cabinet	1					X	
Check RF output power	1	X	X	X	X	X	X
Patient Handling							
Check emergency release of cradle and patient transport	1	X	X	X	X	X	X
Check patient transport docking and alignment	3		X		X		X
Check patient transport casters, armboard set screws, and bumper strips	1	X	X	X	X	X	X
Check patient transport caster locks	1	X			X		
Check cradle longitudinal drive clutch	1		X		X		X
Check patient transport hydraulic filter	3			X			X
Clean lightweight cradle wheels	3	X			X		
Check foot pedal spring installation date	3	X					
Gradients							
Check Gradient Cabinet fans and filters	4	X	X	X	X	X	X
Check eddy current compensation	2	X	X	X	X	X	X
Check gradient cables connection and support	3		X				
Check gradient calibration	2	X	X	X	X	X	X
Check fluid level and valve of heat exchanger	3	X		X		X	
Check water chiller for gradient coil cooling	3	X		X		X	
Check pump motor lubrication	4	X					
PDU							
Check Standard PDU fans and filters	4		X		X		X
Check Standard PDU emergency off and stop circuits/indicator lights	1			X			

Item	Type	A	B	C	D	E	F
Inspect Standard PDU and power connections	3			X			
Check PowerTech and/or Transtector	3	X			X		
Check Compact PDU fans and filters	4		X		X		X
Check Compact PDU emergency off and stop circuits/indicator lights	1			X			
Inspect Compact PDU and power connections	3			X			
Check PDU Module in RF and Advance Control Gradient Driver (ACGD)/PDU Cabinet emergency off and stop circuits	1			X			
Inspect ACGD Cabinet PDU power connections	3			X			
Computer (Horizon 5.X)							
Check Operator Console (OC) and Independent Console (IC) computer fans and clean air intake grills	3	X	X	X	X	X	X
Clean OC/IC DAT drive	4	X	X	X	X	X	X
Check OC/IC console power supply fan	3	X	X	X	X	X	X
Clean and vacuum OC/IC console interior	3	X					
Operator Workspace (8.X and 9.X)							
Check computer fans and clean air intake grills	3	X	X	X	X	X	X
Clean workstation mouse and videocam lens	3	X			X		
Set Silicon Graphics, Inc. (SGI) system clock	4	X	X	X	X	X	X
Operator Workspace (Excite, HD, HDx)							
Clean disk space by entering the following in a c-shell: storelog	4	X	X	X	X	X	X
Adjust the time from Guided Install	4	X		X		X	
Clean dust of global operator console	3	X		X		X	
General System							
Check system cabinet fans and clean filters	4	X	X	X	X	X	X
Check and delete error/message log/T-test files/save info	3	X	X	X	X	X	X
Check shim	2	X	X	X	X	X	X
Check SNR	2	X	X	X	X	X	X
Check cabinet inlet air temperature	4		X		X		X
Check PM supplies	4		X				
Update Configuration File in Site Log Book	4		X			X	
Verify PM completion on van equipment							
(Mobile systems only)	4	X			X		
Perform Site Restoration - Check the Daily Quality Assurance (DQA) phantom, remove GE test scans, and check cabinet doors and covers	3	X	X	X	X	X	X
Check modem							
(United States sites only)	3	X	X	X	X	X	X
Check laser alignment lights	1	X	X	X	X	X	X
Review System Health Report	4	X	X	X	X	X	X
3M Laser Camera							

Item	Type	A	B	C	D	E	F
Check laser camera fans	3	X	X	X	X	X	X
Clean and vacuum laser camera interior	3		X			X	
Clean laser camera suction cups	3	X	X	X	X	X	X
Clean laser camera transport plate/docking unit	3	X	X	X	X	X	X
Run laser camera cleaning film	3	X	X	X	X	X	X
Clean laser camera exterior	4		X			X	
Check laser camera air shock pressure							
(Mobile systems only)	4		X			X	
Replace laser camera external docking unit switches	3	X			X		
Twin Accessory Cabinet (TAC)							
Filter replacement	4	X	X	X	X	X	X
Tip seal replacement	3						X
Clean inlet screen	3						X
Solenoid valve replacement	3						X
Magnet and Cryogens							
Check cryogen levels (Phone site for information)	4	*	*	*	*	*	*
Calculate cryogen boil-off rates/record compressor run times (Phone Site for information)	4	*	*	*	*	*	*
Evaluate cryogen delivery schedule (If applicable)	4	X	X	X	X	X	X
Evaluate helium transfill efficiency	4	X	X	X	X	X	X
Verify cryogen meter calibration - GE Magnets	4	X					
Verify cryogen meter calibration - Oxford Magnets	4	X					
Inspect cryogen vent	1		X				
Test Magnet Emergency Rundown Unit (ERU)	1	X	X	X	X	X	X
Inspect Magnet ERU	1		X				
Test GE Magnet Rundown Unit (MRU)	1	X	X	X	X	X	X
Inspect GE MRU	1		X				
Check and empty collection bottles (GE S-One and Oxford magnets only)	3	X	X	X	X	X	X
Inspect Cryogenics Technics, Inc. (CTI) system (Oxford magnets only)	3		X			X	
Record cryostat pressure and flow rates (GE magnets only)	3	X	X	X	X	X	X
Inspect Leybold system (Replace adsorber every 24,000 hours) (GE magnets only)	3	X		X		X	
Inspect Balzers system (Replace adsorber every 26,000 hours) (GE magnets only)	3	X		X		X	
Inspect Sumitomo system (Replace adsorber every 20,000 hours)	3	X		X		X	
Perform Oxford mobile specific inspections	3			X			X
Inspect Oxford water cooled power supply valve	3	X					
Check/replace Equipment Diagnostic Monitor (EDM) battery	3	X					
Change Desiccant Pack water flow meter	3	X		X		X	

SERVICE SCHEDULE

3.0T for HDx and HDx prior systems

The 3.0T PM[1] service schedule lists all the PM procedures and the frequency they should be completed within a 2-month time frame, according to schedules A - F. This results in services completed six times per year.

Six/year PM schedule

- A = 0 to 2 months
- B = 3 to 4 months
- C = 5 to 6 months
- D = 7 to 8 months
- E = 9 to 10 months
- F = 11 to 12 months

To further enhance productivity, the PM procedures have been divided into four types:

- Type 1 – Safety and Regulatory
- Type 2 – Image Quality
- Type 3 – Other (System not available for patient scans)
- Type 4 – Other (System available for patient scans)

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

An asterisk (*) indicates the procedure should be performed during every site visit.

[1]Planned Maintenance

Table 2-53: 3.0T HDx and HDx prior systems service schedule

Item	Type	A	B	C	D	E	F
Magnet Room							
Inspect front cover and cable take-up	3						X
Inspect for discoloration the inside of the bore and the front and back of the magnet	1	X					
Perform Physical Acquisition Controller (PAC) Leakage Current test	1			X			
Check magnet room radio frequency (RF) integrity with correlated noise	3	X		X		X	
Check cardiac gating cable	1	X		X	X		X
Check patient blower and filter	3	X	X	X	X	X	X
Check pneumatic Patient Alert System	1	X			X		
RF							
Check RF Cabinet fans and filters	4	X	X	X	X	X	X
Check RF output power	1	X	X	X	X	X	X
Patient Handling							
Check emergency release of cradle and patient transport	1	X	X	X	X	X	X
Check patient transport docking and alignment	3		X		X		X
Check patient transport casters and armboard set screws and bumper strips	1	X	X	X	X	X	X
Check patient transport caster locks	1	X			X		
Check cradle longitudinal drive clutch	1		X		X		X
Check patient transport hydraulic filter	3			X			X
Clean lightweight cradle wheels	3	X			X		
Check foot pedal spring installation date	3	X					
Gradients							
Check Gradient Cabinet fans and filters	4	X	X	X	X	X	X
Check eddy current compensation	2	X	X	X	X	X	X
Check gradient cables connection and support	3		X				
Check gradient calibration	2	X	X	X	X	X	X
Check fluid level and valve of heat exchanger	3	X		X		X	
Check water chiller for gradient coil cooling	3	X		X		X	
Check pump motor lubrication	4	X					
PDU							
Check PDU module in ACGD/PDU Cabinet emergency off and stop circuits	1			X			
Inspect PDU power connections	3			X			
Operator Workspace (with Octane computer)							
Check computer fans and clean air intake grills	3	X	X	X	X	X	X
Clean workstation mouse and videocam lens	3	X			X		
Set Silicon Graphics, Inc. (SGI) system clock	4	X	X	X	X	X	X
Operator Workspace (HD and HDx)							
Clean disk space by entering the following in a c-shell: storelog	4	X	X	X	X	X	X

Item	Type	A	B	C	D	E	F
Adjust the time from Guided Install	4		X		X		X
Clean dust of global operator console	3		X		X		X
General System							
Check system cabinet fans and clean filters	4	X	X	X	X	X	X
Check and delete error/message log/T-test files	3	X	X	X	X	X	X
Check shim	2	X	X	X	X	X	X
Check SNR	2	X	X	X	X	X	X
Check cabinet inlet air temperature	4		X		X		X
Check PM supplies	4		X				
Update configuration file in Site Log Book	4		X			X	
Perform site restoration - Check Daily Quality Assurance (DQA) phantom, remove GE test scans, and check cabinet doors and covers	3	X	X	X	X	X	X
Check modem	3	X	X	X	X	X	X
Check laser alignment lights							
Not applicable for 3.0T VH/i	1	X	X	X	X	X	X
Review System Health Report	4	X	X	X	X	X	X
Accessory Cabinet (ACC)							
Clean filter	4	X	X	X	X	X	X
Perform Power Monitor functional check	1						X
Magnet and Cryogens							
Check cryogen levels	4	*	*	*	*	*	*
Calculate cryogen boil-off rates/record compressor run times	4	*	*	*	*	*	*
Evaluate cryogen delivery schedule	4	X	X	X	X	X	X
Evaluate helium transfill efficiency	4	X	X	X	X	X	X
Verify cryogen meter calibration							
(GE magnets only)	4	X					
Inspect cryogen vent	1		X				
Test GE Magnet Rundown Unit (MRU)	1	X	X	X	X	X	X
Inspect GE (MRU)	1		X				
Record cryostat pressure and flow rates							
(GE magnets only)	3	X	X	X	X	X	X
Inspect Sumitomo Heavy Industry (SHI) system	3	X		X		X	

SERVICE SCHEDULE

Optima MR360 and Brivo MR355 System

Optima MR360 and Brivo MR355 System Service Schedule lists all the PM[1] procedures and the frequency they should be completed according to schedule A - D.

- A = 0 to 3 months
- B = 4 to 6 months
- C = 7 to 0 months
- D = 10 to 12 months

To further enhance productivity, the PM procedures have been divided into four types:

- Type 1 – Safety and Regulatory
- Type 2 – Image Quality
- Type 3 – Other (System not available for patient scans)
- Type 4 – Other (System available for patient scans)

CAUTION

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

[1]Planned Maintenance

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Table 2-54: Optima MR360 and Brivo MR355 system service schedule

Subsystem	PM check performed	Type	A	B	C	D
Image Quality						
Alignment Light Check	IQ	2	X	X	X	X
Patch update (Service contract customers only)	Software	3	X	X	X	X
DQA Tool II	IQ	2	X	X	X	X
LVShim	IQ	2	X	X	X	X
Grafidy3	IQ	2	X	X	X	X
Coherent Noise	IQ	2	X	X	X	X
Signal to Noise Check	IQ	2	X	X	X	X
Spike Noise Check	IQ	2	X	X	X	X
PM Check (Service Contract						
PM Check (Service Contract Customers Only)	IQ	2	X	X	X	X
Magnet Room						
Oxygen Monitor Operation	Safety	1	X			
Patient Blower & Filter	Check	3	X	X	X	X
Pneumatic Patient Alert System	Safety	1		X		X
System Cabinet						
Power Monitor Check	Check	3				X
Cabinet FAN & Water Line	Check	3	X	X	X	X
Driver Module Lite Functional						
Driver Module Lite Functional Check	Check	3		X	X	X
Cabinet Monitor Functional Check	Check	3		X		X
Clean Inlet Filter	Check	4	X	X	X	X
Gradient Cable Connection Check	Check	3			X	
DC Power Check	Check	3		X		X
PHPS Lite Functional Check	Check	3		X		X
MCS/LCS Coolant Level Check	Check	4	X	X	X	X
Patient Handling						
Patient Table Checks	Safety	1	X	X	X	X
System Cooling Unit and BRM Chiller						
Check Fluid levels and Valve of Heat Exchanger	Clean	3		X		X
Replace Lytron Pump for 4KW	Clean	3				X
PDU						
Emergency Off & Stop Circuits/Indicator Lights	Safety	1	X	X	X	X
Computer						
Storelog	Check	4	X	X	X	X
Clean Dust. Set time	Check	3		X		X
Magnet						

Subsystem	PM check performed	Type	A	B	C	D
Test GE Magnet Rundown Unit (MRU)	Safety	1	X	X	X	X
PAC Leakage Current Test	Safety	1			X	
Inspect Cryocooler Systems	Check	3	X		X	
Inspect Cryogen Vent	Check	3	X			
Verify Cryogen Meter Calibration	Check	4		X		

China RoHS label directive

Signa 1.5T & 3.0T Systems

The following product pollution control information is provided according to SJ/T11364-2006 Marking for Control of Pollution caused by Electronic Information Products.

This symbol indicates the product contains hazardous materials in excess of the limits established by the Chinese standard SJ/T11363-2006 Requirements for Concentration Limits for Certain Hazardous Substances in Electronic Information Products. The number in the symbol is the Environment-friendly Use Period (EFUP), which indicates the period during which the toxic or hazardous substances or elements contained in electronic information products will not leak or mutate under normal operating conditions so that the use of such electronic information products will not result in any severe environmental pollution, any bodily injury or damage to any assets. The unit of the period is "Year".

In order to maintain the declared EFUP, the product shall be operated normally according to the instructions and environmental conditions as defined in the product manual, and periodic maintenance schedules specified in Product Maintenance Procedures shall be followed strictly.

Consumables or certain parts may have their own label with an EFUP value less than the product. Periodic replacement of those consumables or parts to maintain the declared EFUP shall be done in accordance with the Product Maintenance Procedures.

This product must not be disposed of as unsorted municipal waste, and must be collected separately and handled properly after decommissioning.

Signa HD & HDx 1.5T & 3.0T Systems, Signa HDi 1.5T System, Discovery MR750 3.0T, Discovery MR450 1.5T and Optima MR450w

Table 2-55: Table of hazardous substances' name and concentration.

Component name	Hazardous substances' name					
	(Pb)	(Hg)	(Cd)	(Cr(VI))	(PVBB)	(PBDE)
Magnet	X	O	O	X	O	O
Patient Table	X	O	O	X	O	O
Systems Cabinet	X	O	X	X	O	O
Coils	X	O	O	X	O	O
Global Operating Console (GOC)	X	O	X	X	O	O
Chiller	O	O	O	O	O	O
Accessories (Uninterruptable Power Supply)	X	O	X	X	X	X
LCD Monitor	O	X	O	O	O	O

O: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006

Data listed in the table represents best information available at the time of publication.

Applications of hazardous substances in this medical device are required to achieve its intended clinical uses, and/or to provide better protection to human beings and/or to environment, due to lack of reasonably (economically or technically) available substitutes.

Signa HDe 1.5T, Optima MR360 and Brivo MR355 Systems

Table 2-56: Table of hazardous substances' name and concentration.

Component name	Hazardous substances' name					
	(Pb)	(Hg)	(Cd)	(Cr(VI))	(PVBB)	(PBDE)
Magnet	X	O	O	X	O	O
Patient Table	X	O	O	X	O	O
Systems Cabinet	X	O	X	X	X	X
Coils	X	O	O	X	O	O
Global Operating Console (GOC)	X	O	X	X	O	O
Chiller	O	O	O	X	O	O
Accessories (Uninterruptable Power Supply)	O	O	O	O	O	O
LCD Monitor	O	X	O	O	O	O

O: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006

Data listed in the table represents best information available at the time of publication.

Applications of hazardous substances in this medical device are required to achieve its intended clinical uses, and/or to provide better protection to human beings and/or to environment, due to lack of reasonably (economically or technically) available substitutes.

Glossary

3

3D multi slab
An image mode used in Time-of Flight vascular imaging for acquiring multiple overlapping 3D slabs.

3DASL
3D Arterial Spin Labeling

9

90° Pulse
A pulse that rotates the magnetization vector 90° from longitudinal static magnetic field direction. This converts the longitudinal agnetization into transverse magnetization.

A

A
Anterior

AA
Anterior Array

AB
Adapter Block

ABB
Adapter Block Bridge

ACPC
Anterior Commissure - Posterior Commissure

ACR
American College of Radiology

ACT
Active

ADC
Apparent Diffusion Coefficient

AIF
Artery Input Function

ART
Acoustic Reduction Noise

Artifact
An error in the reconstructed image that does not correspond to the patient. There are three major forms of artifacts that can occur in MR imaging and contribute to poor image quality: geometric distortion, inhomogeneous signal intensity, and spurious signal.

ARW
Arrhythmia Rejection Window

ASPIR
Adiabatic Spectral Inversion Recovery

Asymmetric Echo
An echo whose peak, at TE, is not centered in the sampling window. Also called fractional echo or partial echo.

Asymmetric Field of View (AFOV)
1. An FOV in which the vertical and horizontal dimensions are not equal. Simular to the rectangular FOV selected. 2. An imaging enhancement activated by choosing one of two FOV options: square pixel or variable FOV. Asymmetric FOV is useful for any scan which has anatomy smaller than the FOV in the phase direction. See FOV and square pixels.

Available Imaging Time (AIT)
In cardiac gating, the time during which data can be collected by the MR system.

Average Flow
A Flow Analysis measurement. Summation of voxel values in a given flow region (ml/min), reflecting the volume per minute passing through the defined flow region of a specified cardiac phase or cycle.

Average Velocit
A Flow Analysis measurement. Flow Q (expressed in cm3/sec) divided by the cross-sectional area A (expressed cm2) of a vessel: V = Q/A (cm/sec); 1/2 Vmax for laminar flow.

Averaging
A SNR-enhancing technique in which the same MR signal is added up, and then the sum is divided by the number of signals acquired.

AW
Advantage Workstation

AWS
Auto Water Suppression optimization

B

BAT
Bolus Arrival Time

BF
Blood Flow relative

Bipolar Flow-Encoding Gradients
Two gradient pulses of identical shape, but opposite polarity. Used in order to encode velocities as changes of phase, as used in Phase Contrast angiography.

BOLD
Blood Oxygen Level Dependent

BPM
Beats Per Minute. The average heart rate as shown by the cardiac waveform display.

BRAVO
BRAin VOlume Imaging

BREASE
BREAst Spectroscopy Examination

BSP
Blood SuPpression

BV
Blood Volume relative

C

C
Cervical

Cardiac Phase Images
Images demonstrating different times or phases within a cardiac cycle.

CBF
Cerebral Blood Flow

CD
Compact Disc

CD-R
Compact Disc-Recordable

CD-ROM
Compact Disc - Read Only Memory

CEMRA
Contrast Enhanced Magnetic Resonance Angiography

CIET
Clinical Image Extraction Tool

Cine
Generated images for dynamic views of anatomy such as the heart. This option employs retrospective gating techniques and a Gradient Echo pulse sequence.

CNR
Contrast-to-Noise Ratio. Ratio of the absolute difference in intensities between two regions to the level of fluctuations in intensity due to noise.

Collapsed
A Maximum Intensity Projection (MIP), also called Maximum Pixel Projection (MPP) from TOF magnitude images, or PC weighted-phase images. The collapsed image is the MIP in the slice

direction.

COMB
Combine

Complex Difference
A flow reconstruction type for Phase Contrast Vascular Imaging providing control of the Slab Dephasing Gradient and Phase Correction. Complex Difference reconstructions have the Dephase Gradient off and Phase Correction on.

Contrast Resolution
An image function providing the ability to differentiate anatomical density differences with respect to surrounding anatomical regions.

Coronal
The horizontal plane along the longitudinal axis of the body dividing it into anterior (front) and posterior (back) halves.

COSMIC
Coherent Oscillatory State acquisition for the Manipulation of Imaging Contrast

CSF
Cerebral Spinal Fluid

CSI
Chemical Shift Imaging

CV
Control Variable

D

DAQA
Daily Automated Quality Assurance

Decubitus Position
Describes the position of a patient lying on the left or right side.

Diastole
The period between the end of the T-wave and the beginning of the R-wave in the cardiac cycle. Also called ventricular filling.

DICOM
Digital Imaging and COmmunications in Medicine

DQA
Daily Quality Assurance

DTI
Diffusion Tensor Imaging

DVD
Digital Versatile Disc

DVD-R
Digital Versatile Disc-Recordable

DWI
Diffusion Weighted Imaging

Dynamic-Range Compression
A method of enhancing Phase Contrast image quality by applying a projection Dephasing Gradient to suppress signal from stationary tissues.

E

eADC
enhanced Apparent Diffusion Coefficient

ECG
ElectroCardioGram

Echo Rephasing
Re-establishment of spin phase coherence, accomplished via a 180 degree RF pulse or gradient switching.

EDR
Extended Dynamic Range. An imaging enhancement that uses 32-bit processing instead of the conventional 16-bits to improve SNR.

Effective R-R interval (RR)
The inverse of bpm (Beats per Minute) measured in msec: RR = 60,000 divided by bpm.

Effective TR
The average repetition time, or TR, in cardiac gating. Measured as the number of RR intervals between successive excitations of a particular slice location - e.g., RR, 2xRR, 3xRR, 4xRR.

Effective value
A typical or average value - for example, effective TR. Since you can not control your patients heart rate, you can not control true TR in a gated study. You can control the effective TR by telling the system not to trigger at every beat.

EMF
Electro Magnetic Field

EPI
Echo Planar Imaging

ESP
Echospace

ETL
Echo Train Length. The number of 180° refocusing pulses played out during one TR period.

Even-Echo Rephasing
Rephasing of moving spins on symmetric, even echoes (e.g., 2, 4, or 6) in Multi-Echo sequences.

F

Fat/Water Suppression (F/W)
An imaging enhancement technique that suppresses signal within the imaging volume from either fat or water by applying a frequency-selective saturation pulse.

FC
Flow Compensation

FID
Free Induction Decay. The measurable magnetic resonance signal that occurs as the transverse magnetism, produced by the application of the 90° pulse, decays toward zero.

First-Order Phase Correction
Phase errors in a Phase Contrast image can be modeled as a linear shading across the image in the x and y direction. In first order Phase Correction, the slopes of the x and y shading are determined to reduce the shading.

FLAIR
FLuid Attenuated Inversion Recovery

Flip Angle
Flip angle is the rotational angle of the magnetization vector produced by a RF pulse relative to the longitudinal axis of the static magnetic field. Flip angle adjusts contrast.

Flow Analysis
A flow reconstruction type for Cine-PC and 2D PC providing control of the Slab Dephasing Gradient and Phase Correction. Flow Analysis reconstructions have the Dephase Gradient off and Phase Correction off.

Flow Axis
Flow Axis: The orthogonal axis (S/I, R/L, A/P) for which flow has been encoded in a flow image.

Flow Encoding
A technique used in MR to measure or display motion such as blood flow within vessels.

Flow-Related Enhancement
A process by which the signal intensity of moving fluids, like blood or CSF, can be increased compared with the signal of stationary tissue. Occurs when unsaturated, fully magnetized spins replace saturated spins between RF pulses.

fMRI
functional Magnetic Resonance Imaging

FOV
Field Of View. The area of the anatomy being imaged, usually expressed in centimeters. FOV image size is a function of the acquisition matrix

FOV Center
The center of a scan image, which is ideally located at the magnet's isocenter.

FPS
Frames Per Second

Fractional Echo
A feature instructing the system to collect just part of the data it normally would. Reduces susceptibility and flow artifacts.

Fractional NEX
A feature instructing the system to use about half or exactly three-quarters of the phase encoding acquired in conventional imaging. Decreases scan time significantly.

Free Induction Decay (FID)
The measurable magnetic resonance signal that occurs as the transverse magnetism, produced by the application of the 90° pulse, decays toward zero.

Frequency
The scanning direction associated with the frequency gradient. Usually corresponds to the image's long axis.

FRFSE
Fast Recovery Fast Spin Echo

FRFSE-XL
Fast Recovery Fast Spin Echo eXel

FSE
Fast Spin Echo

FSE-XL
Fast Spin Echo eXcel

FTMRA
Fluoro Trigger Magnetic Resonance Angiography

FTP
File Transfer Protocol

G

Gating
An MR technique for imaging rapidly moving anatomy such as the heart. Uses equipment such as a standard electrocardiograph to trigger data acquisition.

GEM
GEMatrix

GMN (Gradient Moment Nulling)
The application of gradients to correct phase errors caused by velocity, acceleration or other motion. First-order gradient nulling is the same as Flow Compensation.

Gradient Momen
In MR angiography, the first moment describes a gradient's effect on the phase of a spin with constant velocity; the second moment, its effect on spins experiencing acceleration; the third moment, its effect on spins experiencing jerk.

GRASS
Gradient-Recalled Acquisition in the Steady State

GRE
Gradient Echo

GSPS
Gray Scale Presentation State

GVF
Gamma Variate Fit

Gx
Symbols for MR gradients. Subscripts indicate the spatial direction of each gradient.

Gy
Symbols for MR gradients. Subscripts indicate the spatial direction of each gradient.

Gz
Symbols for MR gradients. Subscripts indicate the spatial direction of each gradient.

H

HD
High Definition

HIPAA
Health Insurance Portability and Accountability Act

HIS
Hospital Information System

HNU
Head Neck Unit

HR
Heart Rate

HTML
HyperText Markup Language

I

I
Inferior

IA
Infusion Angiography

IDEAL
Iterative Decomposition of Water and Fat With Echo Asymmetry and Least-Squares Estimation

INo
Image Number

InRX
In prescription

INRX
In prescription

Intersequence Delay
The time between each image in the cardiac cycle.

Intravoxel Spin-Phase Dispersion
A loss of phase coherence and therefore, signal intensity that can result when a wide spectrum of flow velocities exist, when higher orders of motion like acceleration are present, or when there are minor variations in magnetic field homogeneity.

IP
Internet Protocol

IR
Inversion Recovery. A pulse sequence that inverts the magnetization and then measures the recovery rate as the nuclei return to equilibrium. This rate of recovery depends on T1.

iROC
in-Room Operator Console

IROC
In-Room Operator Console

Isocenter
The point at which the three gradient planes cross.

Isochromats
Spins sharing the same phase and frequency at a given point in time.

Isometric Contraction
The time immediately after the R-wave when the heart prepares for contraction but does not change in volume.

IT
Information Technology

IVI
Interactive Vascular Imaging

J

J-Coupling
Also called Spin-Spin Coupling. The interaction between multiple lines and nuclei. When this interaction takes places the nuclei split their energy levels according to J (the spin-spin coupling constant).

L

L
Left

LAVA
Liver Acquisition with Volume Acceleration

LED
Light Emitting Diode

LIC
Legacy Image Converter

LIP
Left to right, Inferior to superior, Posterior to anterior

LPCA
Low Profile Carriage Assembly

LR
Lower Right

M

Magnetic Resonance Imaging (MRI)
The creation of images using the magnetic resonance phenomenon. The current application involves imaging the distribution of hydrogen nuclei (protons) in the body. The image brightness in a given region usually depends jointly on the spin density and the relaxation times. Image brightness is also affected by motion such as blood flow.

Magnetic Resonance Signal
The electromagnetic signal (in the radio frequency range) produced by the precession of the transverse magnetization of the spins. The rotation of the transverse magnetization induces a voltage in the coil. This voltage is amplified by the receiver.

Magnetic susceptibility
In electromagnetism, the magnetic susceptibility is the degree of magnetization of a material in response to an applied magnetic field. The intensity of magnetization, I, is related to the strength of the inducing magnetic field, H, through a constant of proportionality,k, known as the magnetic susceptibility. I = kH.

MDE
Myocardial Delayed Enhancement

MID
Multiple Image Display

MIP
Maximum Intensity Projections. A technique for producing multiple projection images from a volume of image data (i.e., 3D volume or a stack of 2D slices). The volume of image data is processed along a selected angle and the pixel with the highest signal intensity is projected onto a two-dimensional image.

MOD
Magnetic Optical Disk

MPH
MultiPHase

MPR
Mullti Planar Reformat

MPS
Manual PreScan

MR
Magnetic Resonance. The absorption or emission of electromagnetic energy by nuclei in a static magnetic field after excitation by a suitable RF pulse.

MR Conditional
An item that has been demonstrated to pose no known hazards in specified MR environment with specified conditions of use. Field conditions that define the MR environment include static magnetic field strength, spatial gradient, time rate of change of the magnetic field (dB/dt), RF fields, and specific absorption rate (SAR). Additional conditions, including specific configurations of the item (eg, the routing of leads used for a neurostimulation system), may be required.

MR safe
An item that poses no known hazards in all MR imaging environments. With this terminology, MR safe items are non-conducting, non-metallic, and non-magnetic items, such as a plastic Petri dish. An item may be determined to be MR safe by providing a scientifically based rationale rather than test data.

MR unsafe
An item that is known to pose hazards in all MR environments. MR unsafe items include magnetic items such as a pair of ferromagnetic scissors. ASTM standard F2503 also describes how MR Safe, MR Conditional and MR Unsafe device Icons are to be used for MR labeling of implants and devices.

MRA
Magnetic Resonance Angiography

MRCP
Magnetic Resonance Cholangiopancreatographies

MRS
Magnetic Resonance Spectroscopy

MSMP (Multi-Slice
Multi-slice, multi-phase cardiac gating pulse sequence that produces images at multiple heart locations and several different cardiac phases at each location.

MSSP (Multi-Slice
Multi-slice, single-phase cardiac gating pulse sequence that produces images at multiple heart locations, each at a different phase of the cardiac cycle.

MTT (SVD
Mean Transit Time with standard deviation

Multi-Phase)
Multi-slice, multi-phase cardiac gating pulse sequence that produces images at multiple heart locations and several different cardiac phases at each location.

N

NEX
Number of EXcitations. The number of times a pulse sequence is repeated in a given acquisition.

NTP
Network Time Protocol

O

OEM
Original Equipment Manufacturer

OSF
Over Sampling Factor

P

P
Posterior

PA
Posterior Array

PAC
Physiological Acquisition Control

PACS
Picture Archiving Communications System

PC
Phase Contrast

PD
Protoon Density

PDF
Portable Document Format

PD-weighted
Proton Density-weighted

PFO
Patent Foreman Ovale

PFOV
Phase Field of View

PG
Peripheral Gated

Phase Encoding
The act of localizing an MR signal by applying a gradient pulse to alter the phase of spins before signal readout.

PIU
Percent Integral Uniformity

PJN
Projection

PL
Post Labeling

PM
Planned Maintenance

PPM
Parts Per Million

PPS
Performed Procedure Step

PRESS
Point RESolved Spectroscopy

PROBE
PROton Brain Exam

PROBE-P
PROton Brain Exam - PRESS

PROBE-S
PROton Brain Exam-Steam

PROC
Processed

Projection Dephasing Gradient
A gradient applied to diminish signal from stationary tissues in thick slab 2D Phase Contrast angiography.

PROPELLER
Periodically Rotated Overlapping ParallEL Lines with Enhanced Reconstruction

PROSE
PROstate Spectroscopy Examination

PROSP
Prospective

PSCD
PreSCannD

PSD
Pulse Sequence Database. A series of RF and gradient pulses and the intervals between them used in conjunction with gradient magnetic fields to produce magnetic resonance images.

Pulse Length or Width
The duration of a pulse, expressed in milliseconds.

PURE
Phased array UnifoRmity Enhancement

PVA
Peripheral Vascular Array

PW
Perfusion Weighted

PXE
Paradigm Presentation Engine

Q

QC
Quality Control

R

R
Right

RAS
Right, Anterior, Superior

RBw
Receive Bandwidth

RCA
Right Coronary Artery

rCBF
relative Corrected Blood Flow

rCBV
relative Blood Volume

Readout Gradient
A gradient pulse, applied when an MR signal is collected, used for frequency encoding.

Refocusing
The re-establishment of phase coherence via gradient or RF pulse. See Echo Rephasing, Gradient Echo, and Gradient Moment Nulling.

Relaxation Time
The time required for 63% of the nuclei to revert to their original state in the magnetic field after the RF pulse is turned off.

Rephasing Gradient
A gradient applied in the opposite direction of a recent selective excitation pulse, in order to correct for gradient-induced phase shifts.

RF
Radio Frequency. The frequency (intermediate between audio and infrared frequencies) used in magnetic resonance systems to excite nuclei to resonance.

RF Pulse
A burst of RF energy which, if it is at the correct Larmor frequency, will rotate the macroscopic magnetization vector by a specific angle, dependent on the amplitude and duration of the pulse.

RFA
Reduced Flip Angle

RFMT
Reformat

RIS
Radiology Information System

rMTT
relative Mean Time to Transit

ROI
Region Of Interest

R-R Interval
That part of an ECG waveform representing the heart's electrical activity showing the time between the peak of one R-wave and the peak of the next one. Each R-R interval represents the length of one cardiac cycle.

RTIA
Real Time Interactive Acquisition

RTSAR
Real Time Specific Absorption Rate

RxD
Prescribed

S

S
Superior

SAR
Specific Absorption Rate refers to the Radio Frequency power absorbed per unit of mass of an object (Watts/kg). Absorption of RF energy may result in increased tissue temperature.

SAT
SATuration Pulse. A slice-selective RF pulse applied, often followed by a Dephasing Gradient, to saturate spins and therefore minimize their signal. Used, for example, to minimize signal from flowing blood in the slice direction.

Saturatio
Repeated application of radio frequency pulses in a time that is short compared to the T1 of the tissue, producing incomplete realignment of the net magnetization with the static magnetic field.

Scan Time
The amount of time needed to acquire data.

SCIC
Surface Coil Intensity Correction

SCP
Service Class Provider

SCU
Service Class User

Single-Phase)
Multi-slice, single-phase cardiac gating pulse sequence that produces images at multiple heart locations, each at a different phase of the cardiac cycle.

Slice Select
The scanning direction associated with the slice-select gradient. Usually corresponds to the direction of the scanning range.

SLIP
Spatial LIPid Suppression

SNo
Series Number

SNR
Signal-to-Noise Ratio. The ratio of signal amplitude to noise - i.e., the amplitude of signal emitted by the patient's protons, divided by the amount of patient noises and electronic noise inherent in any electronic instrument.

Spatial Encoding
A method by which data is collected in order to formulate a three-dimensional image in a two-dimensional plane.

SPGR
SPoiled Gradient Echo

Spoiler Pulse
A gradient pulse applied to dephase spins and to minimize or eliminate residual signal.

SPS
Scheduled Procedure Step

SPT
Software Performance Test

SR
Structured Report

SSAVE
Screen Save

SSFP
See Steady State Free Precession. 1. A Gradient Echo pulse sequence designed for acquiring T2-weighted images in 3D mode. 2. A condition achieved by repeatedly exciting an MR sample with phase-coherent RF pulses at a repetition rate (TR) which is shorter than T2.

SSRF
Spectral Spatial Radio Frequency

STEAM
STimulated Echo Acquisition Mode

STIR
Short TI Inversion Recovery

SwiFT
Switch on the Fly Technique

T

T1
The characteristic time constant for the magnetization's return to the longitudinal axis after being excited by an RF pulse. Also called Spin Lattice or Longitudinal Relaxation Time.

T2
The characteristic time constant for loss of phase coherence among spins, caused by their interaction, and the resulting loss in the transverse-magnetization MR signal. Also referred to as Spin-Spin or Transverse Relaxation Time.

T2*
The characteristic time constant for loss of transverse magnetization and MR signal due to T2 and local field inhomogeneties. Since such inhomogeneities are not compensated for by gradient reversal, contrast in gradient-echo images depends on T2*.

TD
Time Delay

TE
Echo Time. The time between the center of the excitation pulse and the peak of the echo, which usually occurs at the center of the readout.

TE Min
The shortest possible TE time for a given prescription, used to minimize flow dephasing and T2 effects.

TE1
The time from the middle of the first excitation pulse to the middle of the first readout in an Asysmmetrical Spin Echo pulse sequence.

TE2
The time between the middle of the first excitation pulse and the middle of the second readout in an Asysmmetrical Spin Echo pulse sequence.

TEA
TE Averaged

Threshold
A technique for setting the desired pixel signal intensity values the system uses to process an image.

Throughplane
A flow-encoding direction which is perpendicular to the imaging plane.

TI
Inversion Time. The time between the center of the 180° inversion pulse and the center of the acquired k-space segment.

TLT
Top Level Test

Tmax
Time to maximum value of Residue function, which represents the tracer delay effect at a pixel

TOF
Time of Flight

TP
Trigger Point

TPS
Transceiver Processing and Storage

TR
Time to Repeat or Repetition Time. The time between successive excitations of a slice. That is, the time from the beginning of one pulse sequence to the beginning of the next.

TRICKS
Time Resolved Imaging of Contrast Kinetics

Trigger
In cardiac/respiratory gating, signal sent by the cardiac/respiratory monitor to activate data acquisition.

Trigger Delay
The time between the occurrence of the triggering pulse and the actual onset of imaging.

Trigger Window (TW)
In cardiac gating, a period during which no further data can be acquired. During this period, the system waits for the next R-wave trigger, which initiates a new sequence of data acquisition.

TTP
Time to Peak

TW
Trigger Window

U

UDO
Ultra Density Optical disk

UL
Upper Left

USB
Universal Serial Bus

V

Velocity Encoding (VENC)
A value entered to prescribe the highest velocities to be encoded without aliasing in Phase Contrast angiography.

VIBRANT
VIBRANT

VOF
Venous Output Function

VOI
Volume Of Interest

VPN
Virtual Private Network

VPS
Views Per Segment

VSS
Very Selective Saturation

W

W/L
Window width and window level

Water Suppression
The suppression of the water signal in a MR spectrum, usually by a specialized excitation sequence.

WEEE
Waste Electrical and Electronic Equipment

Weighted-Phase Images
Images that present flow data. Directional-flow images demonstrate flow along a single axis; speed-flow images combine all flow information into a single presentation.

X

XETA
eXtended Echo Train Acquisition

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