# EMRRC Health & Safety Profile & Risk Assessment

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# 1 BACKGROUND INFORMATION

| | | |
|---|---|---|
| **REF. No:** | **DATE:** 07/10/2015 | |
| **SCHOOL:** CEMPS | **SITE:** EMRRC (MR Centre) | **BUILDING:** PMS St Luke's |
| **REMEDIAL ACTION REQUIRED? YES ☐ NO ☒** | | **REMEDIAL ACTION PRIORITY?**<br>**HIGH ☐ MEDIUM ☐ LOW ☐x** |
| **Risk Assessment completed by:** | | Abdelmalek Benattayallah |

| **FIELDWORK ACTIVITY:** | |
|---|---|
| Operation of the Magnetic Resonance Imaging (MRI) facility in the Exeter Magnetic Resonance Research Centre (EMRRC). | |
| **BRIEF DESCRIPTION :** | |
| The centre includes waiting and changing room (Reception), MRI control room, magnet room and machine room. | |
| **ESTIMATED No OF EMPLOYEES AT RISK:**<br><br>25 | **ESTIMATED No OF NON EMPLOYEES AT RISK:**<br><br>3500/year |

## *1.1 Equipment*

The EMRRC MRI facility is equipped with a **Philips** MR scanner which incorporates a **1.5 Tesla** (1.5T) superconducting magnet with a cylindrical bore. The scanner equipped with RF coils for different body part such as: the head, neck, spine and Knee.

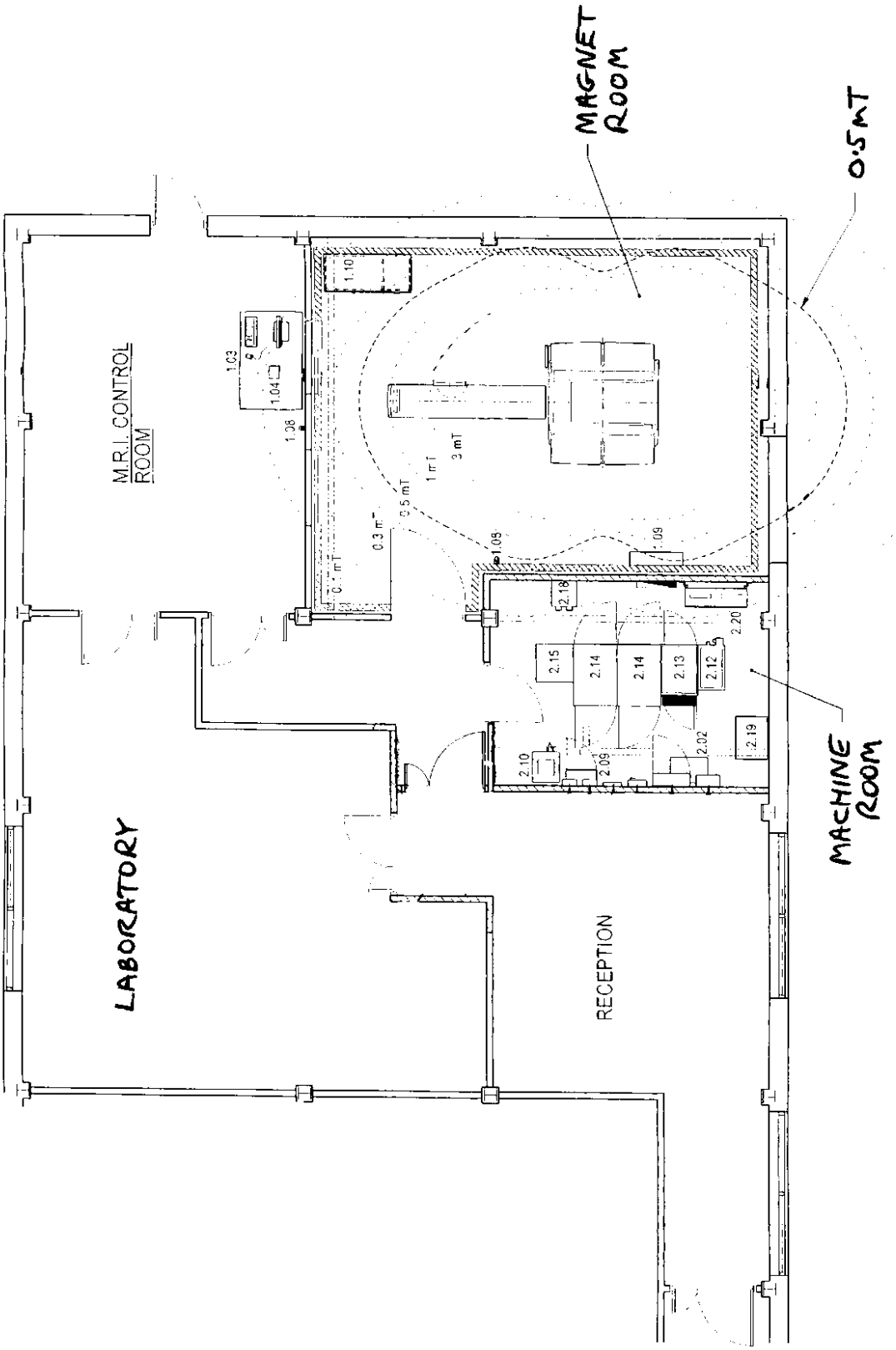

## *1.2 Definitions*

| | | |
|---|---|---|
| Authorised user | who can operate the scanner unsupervised and work in the magnet room without supervision | |
| MR | Magnetic Resonance | |
| MRI | Magnetic Resonance Imaging | |
| RF | Radiofrequency | |
| Participant | Any person who is scanned in the EMRRC MR scanner and who has signed an appropriately approved safety form. | |
| EMRRC | Exeter Magnetic Resonance Research Centre | |

## *1.3 Relevant legislation, safety standards and guidelines*

| Legislations, Standards or guidelines | Comments |
|---|---|
| ACR. (2007). *ACR Guidance Document for Safe MR Practices: 2007*. Reston VA. American College of Radiology. | This white paper provides guidelines which have become the de facto industry standards in the US for safe and responsible practices in clinical and research MR environments. |
| ICNIRP. (1998). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). *Health Physics, 74*(4), 494-522. | The RF exposure limits recommended by the ICNIRP guidelines are widely adopted around the world, and are incorporated in the ARPANSA (2002) standard. The guidelines exempt compliance for research and medical use in participants, but still apply for incidental exposure of operational staff. |
| UK HPA RPD. (2010). *Protection of patients and volunteers undergoing MRI procedures – A document for consultation*, UK Health Protection Agency: Radiation Protection Division. | This consultation document contains a very recent review of health risks arising from the static magnetic, electromagnetic and acoustic exposures in an MR scanner. |
| ICNIRP (2009) Guidelines on limits of exposure to static magnetic fields. Health Physics, 96(4), 504-514. | This paper provides the most recent ICNIRP guidelines for safe human exposure to static magnetic fields (e.g. from MR 1.5T magnet). |
| RANZCR. (2007). *RANZCR MRI safety guidelines.* Sydney. Royal Australian and New Zealand College of Radiologists. | The RANZCR endorse the latest edition of the IEC 60601-2-33 standard. |
| WorkSafe Victoria. (2005). *Guide for assessing and fixing noise problems at work*, 1st ed., Victorian WorkCover Authority. | This reference provides guidance on safe exposure levels to acoustic noise. |
| Philips Gyroscan Intera (2002). Instruction for use, Release 9.1. | This is the MR system manufacturer manual that provide a general safety summery specific to our MR system. |
| Exeter University Health and Safety Standards. http://www.exeter.ac.uk/staff/wellbeing/safety/guidance/ | The web link contains the University's Health and Safety Standards including links to relevant documents, forms and training. |

## *1.4 Floor plans of MRI facility*



## *1.5 Exeter Risk classification scheme*

**RISK = a combination of the likelihood a hazard will cause injury and the severity of the injury**

Quantify risk for each hazard identified using the following table:

| **Likelihood of injury** | ***Score A*** |
|---|---|
| improbable | *1* |
| remote | *2* |
| possible | *3* |
| probable | *4* |
| likely | *5* |

| **Severity of injury** | ***Score B*** |
|---|---|
| very minor injury; abrasions / contusions | *1* |
| minor injuries; cuts / burns | *2* |
| major injuries; fractures / cuts / burns / damage to internal organs | *3* |
| severe injury; amputation / eye loss / permanent disability | *4* |
| death | *5* |

Quantify risk factor by multiplying **Score A** and **Score B**.

**If the risk factor is over 5 take remedial action to improve existing control measure or abandon the task.**

# 2 IDENTIFIED HAZARDS

## *2.1 Acoustic Exposure*

| **Operation/Activity** |
|---|
| MR scanning |

| **Hazards** |
|---|
| Acoustic noise is potentially significant within MR scanning, both in terms of the actual physical damage that may occur to hearing with excessive exposure and the psychological distress that may occur. The actual scanning protocol employed will dictate both the level of noise and its frequency and thus, special attention should particularly be taken with very rapid data acquisition that demands rapid changes in gradient field and a correspondingly high level of noise. In contrast, spectroscopy studies will have very low associated noise levels. |

| **Individuals or groups at risk** |
|---|
| Any person in the Magnet, Control or Machine room during scanning including:<br>❖ Participant<br>❖ MR Users and Helpers<br>❖ Foetus |

| **Risks associated with each hazard** |
|---|
| Exposure to sound pressure levels above 80 dB(A) are considered dangerous. Hearing damage due to acoustic noise cannot be cured, and even a onetime exposure to high sound pressure levels (i.e. disco, drill) can permanently damage the auditory system. The seriousness of damage due to acoustic noise depends on levels and exposure time. Standards, like the OHS Noise Regulations set exposure levels commonly referred to as 85 dB(A) Leq averaged over an *eight hour period* and a maximum or peak noise level of 140 dB(C). For shorter durations of noise exposure, WorkSafe (2005) recommend the following dB(A) limits: |

| Exposure Level dB | Exposure Time |
|---|---|
| **85** | 8 hrs |
| **88** | 4 hrs |
| **91** | 2 hrs |
| 94 | **1 hr** |
| 97 | **30 min** |
| 100 | **15 min** |
| 103 | **7.5 min** |
| 106 | **3.8 min** |
| 109 | **1.9 min** |

| | |
|---|---|
| 112 | **57 sec** |
| 115 | **28.5 sec** |
| 118 | **14.3 sec** |
| 121 | **7.1 sec** |
| 124 | **3.6 sec** |
| 127 | **1.8 sec** |
| 130 | **0.9 sec** |

The RANZCR guidelines (2007) allow acoustic exposure up to **99 dB(A)** without hearing protection for scanning times of less than 1 hour, which is less protective than the Worksafe (2005) recommendations.

The foetus may be more vulnerable to noise injury as no additional hearing protection can be provided, and due to the developmental state of its hearing system. The UK HPA provide the following advice on this topic:
*There have been a limited number of studies that have examined the hearing of children whose mothers were exposed to high noise levels occupationally during pregnancy. (Daniel and Laciak, 1982, Lalande et al, 1986). Both studies identified a small degree of hearing loss in some subjects. Lalande et al concluded that pre-natal noise exposure to sound pressure levels between 85 dB and 95 dB increased the risk of hearing damage in children by a factor of 3 compared to prenatal exposure levels of up to 85 dB. There was some evidence of damage to low frequency hearing in children whose mothers were exposed to noise with a significant low frequency component (although what was meant by low frequency was not defined by the authors). The studies in question have been criticised for various methodological errors including lack of adequate controls and retrospective noise evaluations (Hepper and Shahidullah 1994a, Etzel et al 1997, Pierson 1997).*

**Existing control measures**

**For the participant:**

In order to reduce potential damage and stress, ear protection should always be provided for **everyone** within the magnet room. This may take the form of either noise cancelling headphones provided by Philips, earplugs or under some circumstances both. Both devices result in similar levels of noise attenuation and significantly reduce participant noise exposure. However, earplugs are only effective if properly fitted, so care should be taken to ensure that subjects do so, particularly in the case of children.

In addition to the above, the potentially vulnerable groups of infant and pregnant participants will generally be excluded from MR scanning unless specific ethics approval has been granted. Small children and the elderly require more attention before scanning is allowed. Due consideration will be given to minimising the scan time as far as practicable and using noise reduction techniques such as the Philips “SofTone” setting.

**For non-participants:**

Since acoustic levels outside the scanner bore are not expected to exceed **80 dB(A)**, and 8 hour continuous exposure at the higher level of **85 dB(A)** is permitted by the WorkSafe

| | | | | | | |
|---|---|---|---|---|---|---|
| Victoria guidelines, no special acoustic precautions are required for non-participants outside the magnet room.<br>As a general matter of policy, non-participants *pregnant* will be excluded from the magnet room during scanning as a precautionary measure to protect the foetus. | | | | | | |
| **Existing risk rating:** | **Score A** | 1 | **Score B** | 1 | **Risk (A x B)** | 1 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

## *2.2 Gradient field neural effects*

| **Operation/Activity** |
|---|
| MR scanning of participant |

| **Hazards** |
|---|
| Exposure to low frequency magnetic fields produced by the MR switched gradient field coils.<br>Gradient field exposures are only generated during MR scanning. |

| **Individuals or groups at risk** |
|---|
| ❖ Participant<br>❖ MR Users and Helpers<br>❖ Friend or relative accompanying the participant during scanning |

| **Risks associated with each hazard** |
|---|
| A time varying magnetic field either due to the switched gradient fields during scanning, particularly in EPI, or else rapid movement near the entrance to the bore (where the static magnetic field has a strength that although constant with time varies with position-thus a person changing position with time, will effectively experience a time varying magnetic field) may potentially produce a number of minor effects. Such effects include nausea, vertigo and a metallic taste in the mouth, potentially arising from the movement of charged particles in the mouth and inner ear causing nerve stimulation. Such effects are physiologically harmless but may be potentially distressing to a subject.<br><br>Exposure to switched gradient fields occurs when the MR scanner is collecting images. It induces time-varying electric fields and currents in the body which can stimulate excitable tissues if of sufficient intensity and in the appropriate frequency range. The rapidly changing fields induced by the high rates of gradient field switching used in MR systems will preferentially stimulate peripheral nerves. The PNS thresholds are well below those for ventricular fibrillation for induced current pulse widths of less than 3 ms. Hence, limiting exposure of participants to switched gradient fields can be based on minimising any uncomfortable or painful sensations caused by the field (UK HPA, 2010).<br><br>More importantly gradient fields can induce a time-varying electric fields and currents in the body which can stimulate excitable tissues if of sufficient intensity and in the appropriate frequency range. And potentially leading to cardiac fibrillation, peripheral muscle stimulation and peripheral nerve stimulation (PNS). At 1.5 T the only one of these 3 that needs to be considered is PNS. Although PNS is not harmful it can cause subject distress and is therefore not acceptable within the scanning regime. If the subject reports any such distress scanning should cease immediately. |

| Existing control measures |
|---|
| The Philips 1.5T Intera MR scanner has been certified to operate in accordance with the IEC 60601-2-33 MR safety standard.<br><br>Before the start of each MR sequence, the slew rate (sum of all gradients) and RF exposures are calculated by the MR system. By default, the limits are set for the normal mode when registering a new participant. If the slew rate exceeds the lower level threshold value (dB/dt = 20 T/s) of First Level Control Mode, the operator will be automatically alerted.<br><br>Since the permissible Gradient field exposures for the MR Users, Helpers and others are the same as for the participant, and the MR User exposures are always substantially less than for the participant, then MR system control of EMF exposures of the participant will also automatically provide adequate protection for the MR User and others.<br><br>The system is not capable to exceed the upper level of IEC-60601-2-33 First Level Control Mode. The second level controlled operating mode cannot be entered on the Intera system (Philips Gyroscan Intera (2002)). |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Existing risk rating:** | **Score A** | 2 | **Score B** | 1 | **Risk (A x B)** | 2 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

## *2.3 RF body heating*

| **Operation/Activity** |
|---|
| Activation of RF coils during MR scanning |

| **Hazards** |
|---|
| Exposure to radiofrequency (RF) electromagnetic fields (EMF) can induce heating in biological tissue. This heating dose is quantified as the specific energy absorption rate (SAR) in units of W/kg. High SAR heating can cause both systemic (whole body) and localised tissue effects.<br>RF exposures are only generated during MR scanning. Since most of the RF coils such as the head and spine coils provided with the Philip MR scanner are *receive only*, then the only RF exposure that can be generated is by the main RF (whole body) coil built into the scanner. |

| **Individuals or groups at risk** |
|---|
| ❖ Participant<br>❖ Non-participants close to the RF coils |

| **Risks associated with each hazard** |
|---|
| Restrictions on EMF exposure to RF fields used in MR procedures are based on limiting both body core temperature and temperature rises in localised parts of the body (UK HPA 2010). While there have been some reports of RF EMF effects in the absence of heating, the validity of these data remains unconvincing &/or is of no clinical relevance, a view which is reflected in the RF EMF exposure limits of national (ARPANSA 2002) and international (ICNIRP 1998) standards on RF safety.<br><br>The UK HPA (2010) advise that infants and pregnant women, and people with impaired thermoregulatory ability as a result of age, disease or the use of medications should be imaged with caution since there are uncertainties concerning the effects of increased heat loads on their ability to thermo-regulate.<br><br>When positioning participants in an MR scanner, the UK HPA (2010) warn of the risk of RF burns when a conductive loop pathway is created in the body, e.g. by hands/thighs/calves touching together. Burns can also occur if metallic objects are in close proximity to the individual.<br><br>RF exposure of staff or visitors outside of the MR scanner is far lower than for participants due to the substantial reduction in RF field strength with distance from the coils. Nonetheless, exposure of non-participants to RF fields is a potential OHS issue which must be managed in accordance with an appropriate safety standard or guideline. As discussed in the previous section, the MR community have developed their own EMF safety standard which is codified in IEC 60601-2-33 (2010). This standard specifies RF exposure limits in the metric of specific energy absorption rate (SAR) averaged over the whole body, over the head and for partial body parts. The standard notes that “MR user exposure limits are the |

| |
|---|
| same as the maximally allowed limits for the Patients.” |

| **Existing control measures** |
|---|
| **Participants:**<br>Infants and pregnant women will not be scanned unless specific ethics approval has been granted.<br><br>Participants with impaired thermoregulatory ability as a result of age, disease or the use of medications will be handled with caution, and scanning times will be kept as short as practicable.<br><br>To minimise the risk of RF burns, MR User will advise and monitor the participant to ensure that they do not position their limbs in a way that will create conductive body loops (though this risk is already low if only RF head coils are used). Furthermore, coil leads, ECG leads and other probes must be MR SAFE and insulation shall be placed between the individual’s skin and these types of items.<br><br>RF exposure of participants will be pre-assessed and monitored by the MR console.<br><br>**Non-Participants:**<br>Since RF exposures of MR Helper will be in compliance with ARPANSA/ICNIRP SAR limits, no access restrictions are required other than to instruct MR Helper to stay out of the MR bore during scanning. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Existing risk rating:** | **Score A** | 2 | **Score B** | 2 | **Risk (A x B)** | 4 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

## *2.4 Magnet missile hazards*

| **Operation/Activity** |
|---|
| Introduction of ferromagnetic items into the magnet room. |

| **Hazards** |
|---|
| The 1.5T magnet of the MR scanner generates a very powerful static magnetic field which strongly attracts ferromagnetic items into the bore of the magnet.<br><br>A large number of metallic objects will be attracted to the magnet e.g. those containing iron or zinc will be the most common to be affected. Two kinds of effect may be produced;<br>1) The object will be pulled towards the magnet,<br>2) The object will be twisted / rotated by the magnet.<br><br>The action of 1) will lead to the generation of projectiles which will be attracted towards the centre of the magnet and which may either hit someone in its path potentially leading to a significant injury or else strike objects already within the magnet e.g. coils, leading to potentially very expensive damage. The strength of the field attracting objects towards the magnet increases rapidly as the magnet is approached. Thus, it is possible to enter the room and not notice the effect of the field until almost adjacent to the magnet. Unfortunately, you are typically nearest to the scanner when helping the subject into it, thus increasing the possibility of the subject being struck by any projectiles that arise. |

| **Individuals or groups at risk** |
|---|
| ❖ Participants<br>❖ Helper and relatives of the participant in the magnet room<br>❖ MR users |

| **Risks associated with each hazard** |
|---|
| Serious injuries including death have been reported from MR missile incidents. Smaller items such as coins generally pose a lesser hazard as they experience a smaller attractive force, though can still cause serious injury if they collide with the head or eyes. Sharp ended items are more risky as they are more likely to cause a puncture injury. Heavy items such as wheelchairs and gas cylinders are most likely to cause serious injury and may be lethal if they strike the chest or the head. The risk of dislodging an internal ferromagnetic *implant* is discussed in a separate section. |

| **Existing control measures** |
|---|
| All persons who intend to work in the magnet room (staff or students, whatever their affiliations) are first required to:<br>❖ Study safety section in the *Safety Manual and Rules of Operation* and sign a declaration to confirm that this has been done. |

- ❖ Fill in a user safety checklist to identify any contra-indications to working in the Centre; this must be signed by an authorised user.

Other persons (All non-MR users) who are intended to enter the magnet room (e.g., participants, patients, helpers, observers) are first required to complete a safety checklist (for scanned or non-scanned persons, as appropriate), under the supervision of an authorised user.

All devices, equipment, implements, etc. must be tested for MRI safety and compatibility, before being allowed into the magnet room, and (where practicable) confirmed and labelled as MRI SAFE.

It shall never be assumed that an object is MRI SAFE if it is not clearly labelled and documented in writing. All unknown external objects or devices being considered to be in the magnet room should be tested with a strong handheld magnet for ferromagnetic properties before permitting them entry to the magnet room. The results of such testing, as well as the date, time, and name of the tester should be documented in writing. If a device has not been tested, or if its MR compatibility or safety status is unknown, it should not be permitted unrestricted access to the magnet room (ARC 2007).

The magnet room must be kept locked when not in use. Only authorised users may use the key.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Existing risk rating:** | **Score A** | 1 | **Score B** | 4 | **Risk (A x B)** | 4 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

## *2.5 Static magnetic field*

| **Operation/Activity** |
|---|
| Introduction of ferromagnetic items into the magnet room. Or the presence of pacemaker, implants or any other implanted electronic in the participant body. |

| **Hazards** |
|---|
| The 1.5T magnet of the MR scanner generates a very powerful static magnetic field which strongly attracts ferromagnetic items into the bore of the magnet.<br><br>A large number of metallic objects will be attracted to the magnet e.g. those containing iron or nickel will be the most common to be affected. Two kinds of effect may be produced;<br>1) The object will be pulled towards the magnet,<br>2) The object will be twisted / rotated by the magnet.<br><br>The action of 1) will lead to the generation of projectiles which will be attracted towards the centre of the magnet and which may either hit someone in its path potentially leading to a significant injury or else strike objects already within the magnet e.g. coils, leading to potentially very expensive damage. The strength of the field attracting objects towards the magnet increases rapidly as the magnet is approached. Thus, it is possible to enter the room and not notice the effect of the field until almost adjacent to the magnet. Unfortunately, you are typically nearest to the scanner when helping the subject into it, thus increasing the possibility of the subject being struck by any projectiles that arise.<br><br>The action of 2) may lead to the displacement of any internal ferromagnetic implant within the participant body. |

| **Individuals or groups at risk** |
|---|
| ❖ Participants<br>❖ MR users |

| **Risks associated with each hazard** |
|---|
| Serious injuries including death have been reported from MR missile incidents. Smaller items such as coins generally pose a lesser hazard as they experience a smaller attractive force, though can still cause serious injury if they collide with the head or eyes. Sharp ended items are more risky as they are more likely to cause a puncture injury. Heavy items such as wheelchairs and gas cylinders are most likely to cause serious injury and may be lethal if they strike the chest or the head.<br><br>The risk of dislodging an internal ferromagnetic *implant* is also possible. |

| Existing control measures |
|---|
| All persons who are intended to enter the magnet room (e.g., participants, patients, helpers, observers) are first required to complete a safety checklist (for scanned or non-scanned persons, as appropriate), under the supervision of an authorised user.<br><br>The magnet room must be kept locked when not in use. Only authorised users may use the key. |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Existing risk rating:** | **Score A** | 1 | **Score B** | 5 | **Risk (A x B)** | 5 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

## *Pregnant women*

| **Operation/Activity** |
|---|
| Pregnant women in the magnet room. |

| **Hazards** |
|---|
| Exposure of the foetus to acoustic noise, low frequency gradient coil magnetic fields and RF heating from the MR scanner. |

| **Individuals or groups at risk** |
|---|
| ❖ Pregnant participants<br>❖ Pregnant MR User<br>❖ Pregnant friends or relative of the participant |

| **Risks associated with each hazard** |
|---|
| There is no clear evidence that exposure to static or low frequency magnetic fields can adversely affect pregnancy outcome (ICNIRP Procedures published in Health Physics 2004;87(2):197-216).<br><br>The ACR (2007) advise that present data have not conclusively documented any deleterious effects of MR imaging exposure on the developing foetus. Therefore, no special consideration is recommended for the first, versus any other, trimester in pregnancy. Nevertheless, as with all interventions during pregnancy, it is prudent to screen women of reproductive age for pregnancy prior to permitting them access to MR imaging environments. If pregnancy is established, consideration should be given to reassessing the potential risks versus benefits of the pending study in determining whether performance of the requested MR examination could safely wait until the end of the pregnancy.<br><br>It is also possible that the foetus may be susceptible to noise during MR scanning, and heating from RF coils (though not from head coils). |

| **Existing control measures** |
|---|
| <u>Participants:</u><br><br>Pregnant women shall be precluded from MR scans unless specific ethics approval is granted. Questions on discovering actual or possible pregnancy will be included in the safety checklist.<br><br><u>MR User:</u><br><br>MR users are permitted to work in and around the MR environment throughout all stages of their pregnancy. Acceptable activities include, but are not limited to, positioning participants, scanning, and entering the magnet room. Although permitted to work in and |

around the MR environment, pregnant MR user shall be instructed not to remain within the magnet room during actual data acquisition or scanning (ARC 2007).

<u>Pregnant friends or relative of the participant:</u>

Pregnant friends or relative of the participant shall be permitted in Zones III and IV though shall be kept away from the bore of the magnet shall not be allowed to remain in magnet room when a scan is in process.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Existing risk rating:** | **Score A** | 2 | **Score B** | 1 | **Risk (A x B)** | 2 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

# 3 RISK ASSESSMENTS FOR ACCIDENTS AND EQUIPMENT MALFUNCTION

## *3.1 Emergency quench & liquid helium leaks*

| **Operation/Activity** |
|---|
| An emergency quench or a liquid helium leak |

| **Hazards** |
|---|
| The release of helium into magnet room due to an emergency quench or the leaking of helium from the MR scanner. |

| **Individuals or groups at risk** |
|---|
| ❖ Participant<br>❖ MR users |

| **Risks associated with each hazard** |
|---|
| During a quench or explosive leak there is a danger of asphyxiation or frost-bite from the very cold helium gas exhaust for MR users and participants within or entering magnet room during the release of the helium. For a slow leak there is a risk of unwitting asphyxiation. |

| **Existing control measures** |
|---|
| A quench pipe has been installed to vent cryogenic helium gases to atmosphere rather than into the magnet room. The external outlet for the quench pipe is located on the outside wall behind the magnet room, about 3m off the ground, and has been designed in consultation with Philips to meet appropriate guidelines. As it is vented to atmosphere and helium rises up, there is no danger of asphyxiation near the vent. The sudden explosive sound of a quench may also be startling.<br><br>In the event of a system quench, all staff and participants shall be evacuated from the MR examination room as quickly as safely feasible and that the site access be immediately restricted to all individuals until the arrival of MR equipment service personnel. This is especially so if cryogenic gases are observed to have vented partially or completely into the magnet room, as evidenced in part by the sudden appearance of white “clouds” or “fog” around or above the MR scanner (ACR 2007).<br><br>Restrictions on ferromagnetic object in the magnet room shall be maintained until it can be confirmed that the magnetic field has been successfully dissipated, because there may still be a considerable static magnetic field present despite a quench or partial quench of the magnet. |

An oxygen monitor is installed in magnet room to detect oxygen depletion, with an alarm panel in the console of the MRI control room.

The MR equipment is properly maintained on a maintenance contract.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Existing risk rating:** | **Score A** | 1 | **Score B** | 5 | **Risk (A x B)** | 5 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |

## *3.2 Fire in the magnet room*

| **Identify the operation/activity** |
|---|
| Interruption of normal operation of MR facility due to fire in the magnet room. |

| **Identify the hazards** |
|---|
| Heat and smoke from the fire.<br>Ferromagnetic missile hazard due to the powerful static magnetic field of the 1.5T magnet. |

| **Individuals or groups at risk** |
|---|
| Participant, MR users, participant associates and emergency responders. |

| **Identify the risks associated with each hazard** |
|---|
| Burns due to heat of fire.<br>Suffocation due to lack of oxygen due to fire and smoke. This could also be a risk if the magnet needs to be quenched and helium is released into the examination room.<br>Equipment brought into scanning room containing ferromagnetic properties becoming missiles and striking either participant, staff or emergency workers. |
| **Existing risk controls** |
| The attending authorised user, will promptly ring fire brigade 999 (9-999 from an internal telephone), emphasizing that it is the MRI facility and requires specialised non-ferromagnetic equipment. If safe to do so, MRI safe fire extinguishers will be used to quench the fire and assist in the control of flames spreading further.<br>Also the authorised user should contact Estate Patrol who will make arrangements for personnel and vehicle entry (number from an internal phone 3999 or hotline 2222, number from a mobile/external phone 01392 26 3999).<br><br>If a fire occurs during an MR scan then the participant will be immediately released from the MR scanner and escorted to an evacuation area. MR staff will also be evacuated from the building.<br><br>When the fire brigade arrives, MR authorised user will reiterate that any fire fighting equipment used in magnet room needs to be MRI safe due to the powerful 1.5T magnetic field of the MR scanner.<br><br>However, if the fire is in such a location where magnet room needs to be entered for whatever reason by fire-fighting or emergency response personnel and their fire-fighting and emergency equipment, a decision to quench a superconducting magnet shall be seriously considered to protect the health and lives of the emergency responders. Should a quench be performed, appropriately designated MR authorised user still need to ensure that all personnel (including and especially emergent response personnel) continue to be restricted from magnet room until the designated MR authorised user has personally verified that the static field is either no longer detectable or at least sufficiently attenuated as to no longer present a potential hazard to one moving by it with, for example, large ferromagnetic objects such as air tanks or axes (ARC 2007). |

After hours contact numbers of few MR authorised users will be provided to St Luke's security in case of a fire emergency occurring outside of the EMRRC operating times.

Because the fire most likely to start in the Machine room the room is kept tidy and free from junk.

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| **Existing risk rating:** | **Score A** | 1 | **Score B** | 5 | **Risk (A x B)** | 5 |
| **Remedial Action (Additionally recommended risk controls)** | | | | | | |
| None required | | | | | | |
| **Residual risk rating:** | **Score A** | | **Score B** | | **Risk (A x B)** | |