



Institute of Physics and Engineering in Medicine

IPEM MR-SIG Working Party Report: Recommendations for MRI Safety Notices

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Aim

The aim of this Working Party was to review current MRI safety notices in the UK and create a standardised approved set, freely available via download from the Institute of Physics and Engineering in Medicine (IPEM) website (www.ipem.ac.uk) that can be used by MRI safety professionals. The Working Party comprised members of the IPEM Magnetic Resonance and Radiation Protection Special Interest Groups (IPEM MR-SIG/RP-SIG) in collaboration with representatives from the Health and Safety Executive (HSE), the Health and Safety Sign Association (HSSA) and the Medicines & Healthcare products Regulatory Agency (MHRA).

Introduction

Safety must be of paramount importance in MRI departments. Fatalities can occur by virtue of a patient, volunteer, accompanying person or member of staff simply entering the region of strong static magnetic field with an unapproved implanted medical device [1, 2]. Likewise, if an unapproved object is brought into the elevated magnetic field, it can be ferromagnetically attracted to the MRI scanner at high velocity which

can cause death [3, 4, 5] or serious injury [6, 7]. During imaging, radio-frequency (RF) energy pulses and time-varying gradient magnetic fields are applied. The radiofrequency pulses can interact with implants and devices causing malfunction or heating that may result in serious injury, such as burns leading to coma [8] or amputation [9, 10]. RF burns are also possible without devices present, where the radiofrequency field induces currents within the human body [11, 12]. The rapid switching of the gradient magnetic fields can adversely interact with implants and devices leading to inappropriate functioning, device heating and vibration [13]. These time-varying gradient magnetic fields can also generate high levels of acoustic noise which has the potential for temporary or permanent hearing impairment [14]. The vast majority of clinical MRI scanners worldwide have the strong static magnetic field supplied by a superconducting solenoid in which the conducting wires are immersed in cryogenic liquid. This hazard in MRI has also caused serious injury [15] and death [16]. In addition to patient or staff harm, there can be huge reputational damage to individuals and healthcare facilities, as well as severe financial penalties [17, 18].

To minimise risk, the MHRA recommends that MRI departments have control of access of personnel and equipment to the *MR environment* by having an *MR Controlled Access Area* and that suitable safety signage is in place [19]. This signage plays a key role in alerting individuals to these hazards, however no standardised signage exists. It is recognised that there is a wide variation in MRI safety notices within MRI departments. Many installations use the manufacturer-provided notices which may not be the most appropriate for the UK.

MRI Safety Notice Review

The MRI Physics community in the UK and Ireland was canvassed and requested to supply examples of MRI safety signage for the various locations around MRI departments. Over 320 relevant images of MRI safety notices were collated from more than 20 MRI Physicists, representing various field strength MRI scanners from multiple MRI manufacturers, in both clinical and research settings. As expected, the examples varied widely and in many instances did not adhere to UK standards on signage [20, 21, 22]. There were cases of very different signage displayed within the same department housing multiple MRI systems. There was significant ambiguity in emergency button labelling. Some signs and emergency button labels were primarily or exclusively in languages other than English. There were many instances of misleading or simply incorrect signage being used. This review was presented at the biennial IPEM MR Safety Update in 2015 [23].

Advice on current signage on ionising radiation controlled and supervised areas, for which there is a high degree of standardisation, was provided by the IPEM RP-SIG, along with information on relevant ionising radiation legislation and guidance [24, 25].

Recommended MRI Safety Notices

This IPEM Working Party has created a set of MRI safety notices for various locations around an MRI department. The safety notices have been created with advice from the Working Party representatives of the HSE, the HSSA and the MHRA, and following national and international guidance on signage [20, 21, 22] and MRI safety marking [26]. The safety notices are listed below and are shown at the end of this report. High resolution versions for printing and production are available to download at www.ipem.ac.uk.

- Figure 1 - IPEM recommended MRI safety notice for MRI scanner room doors. For an outwardly opening door, it may be beneficial to also have this safety notice on the inner side.
(suggested size: A1 / 594mm × 841mm / 23.4in × 33.1in)
- Figure 2 - IPEM recommended MRI safety notices for entrance points to the *MR Controlled Access Area*, as defined by the MHRA guidelines [19], in portrait and landscape orientations.
(suggested size: A2 / 420mm × 594mm / 16.5in × 23.4in)
- Figure 3 - IPEM recommended MRI safety notice to be placed at approaches to the cryogen quench pipe exhaust. The MHRA guidelines recommend a minimum 3m exclusion zone around the quench pipe exhaust [19].
(suggested size: A3 / 297mm × 420mm / 11.7in × 16.5in).
- Figure 4 - IPEM recommended MRI safety notice to be placed on the floor or embedded into the floor at entrances to the MRI scanner room. It is suggested that this notice fills the full width of the entrance with the aspect ratio retained.
- Figure 5 - IPEM recommended MRI safety notice for entrances to regions with magnetic flux density > 0.5mT, other than the MRI scanner room (e.g., an MRI equipment room).
(suggested size: A4 / 297mm × 210mm / 11.7in × 8.3in)

Emergency Button and Environmental Control/Display Labelling

The Working Party has created a sample set of labels (recommended minimum size: 90mm × 90mm / 3.5in × 3.5in) for use in MRI departments to clearly and unambiguously identify emergency buttons, the MRI scanner room oxygen alarm/monitor and the MRI scanner room environmental control/display. These are illustrated in figure 6.

Examples of these MRI safety notices and emergency button, oxygen alarm/monitor and environmental control/display labels in use are given in figures 7 and 8.

Colours

Colours used in the creation of these MRI safety notices are those given in the American National Standard ANSI Z535.1-2016 [27] and are within the gamut of safety colours defined in ISO 3864 [22]. These colours are precisely specified in the individual PDFs (available at www.ipem.ac.uk) to enable accurate colour reproduction during manufacture. The colours are given below in table 1. Note that the colours represented in electronic or paper copies of this document may not match the colours as defined in table 1.

Colour	sRGB			CMYK				HTML	PANTONE®
	R	G	B	C	M	Y	K		
Red	200	16	46	2	100	85	6	C8102E	186 C
Yellow	255	209	0	0	9	100	0	FFD100	109 C
Green	0	123	95	97	6	69	19	007B5F	335 C
Blue	0	114	206	90	48	0	0	0072CE	285 C

Table 1: Standard safety colours used in the creation of the IPEM recommended MRI safety notices, adapted from ANSI Z535.1-2016 [27].

Additional Safety Measures

Other safety measures similar to the above MRI safety notices that would enhance safety in MRI departments were also considered. The Working Party recommends an easily removable physical barrier across the MRI scanner room entrance, e.g. a retractable belt stating “AUTHORISED ACCESS ONLY”. Examples are shown in figure 7.

MR Conditional ancillary equipment that is used in the MRI scanner room (e.g. an anaesthetics machine) usually has as one of its MR Conditions a magnetic flux density limit. The Working Party recommends floor marking or shading, following a suitable magnetic flux density isocontour at isocentre height, to clearly demarcate the region within the MRI scanner room into which the equipment should not be taken. Examples are provided in figure 9. A 10mT exclusion zone is appropriate for most MR Conditional ancillary equipment and should be considered at the design stage of an MRI scanner room. Sites may prefer to tailor the floor marking to meet specific MR Conditions for their equipment.

Conclusions

To address the wide disparity and deficiencies of MRI safety notices in the UK, IPEM in collaboration with the HSE, HSSA and the MHRA have produced a set of MRI safety notices for free download via the IPEM website (www.ipem.ac.uk). This set includes recommended safety notices for *MR Controlled Access Area* entrances, MRI scanner room doors, MRI scanner room entrance floors, approaches to cryogen quench pipe exhausts and entrances to regions of elevated magnetic flux density (>0.5mT) other than the MRI scanner room. Clear and unambiguous labels for emergency buttons, the oxygen alarm/monitor and the

environmental control/display have been provided. Recommendations for floor demarcation within the MRI scanner room to assist with the safe use of ancillary equipment have been given. It is also recommended that a physical barrier is placed across MRI scanner room entrances. It is recognised that these safety notices will not be suitable for all MRI systems (e.g., permanent magnet MRI scanners) and MRI departments but can serve as templates.

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MRI



No access for unauthorised persons



Strong Magnetic Field ALWAYS ON!



No access for persons with unapproved implants



No unapproved objects PROJECTILE RISK



MR Conditional

MR Conditional and MR Safe devices and equipment only



MR Safe



Cryogenic Helium
Low temperature and asphyxiation hazard



Wear ear protection while scanning



Radiofrequency field while scanning

Figure 1: Recommended MRI safety notice for MRI scanner room doors.



Figure 2: Recommended MRI safety notices for entrance points to the MR Controlled Access Area.

MRI Cryogen Exhaust



WARNING

Cryogenic Helium Gas Exhaust
Sudden large volume emission possible
Low temperature and asphyxiation hazard



**No access for
unauthorised
persons**



**For access to this
area, contact
Estates Department**

Produced by the Institute of Physics and Engineering in Medicine (available at www.ipem.ac.uk)

Figure 3: Recommended MRI safety notice to be placed at approaches to the cryogen quench pipe exhaust.



Figure 4: Recommended IPEM MRI safety notice to be placed on the floor or embedded into the floor at entrances to the MRI scanner room.

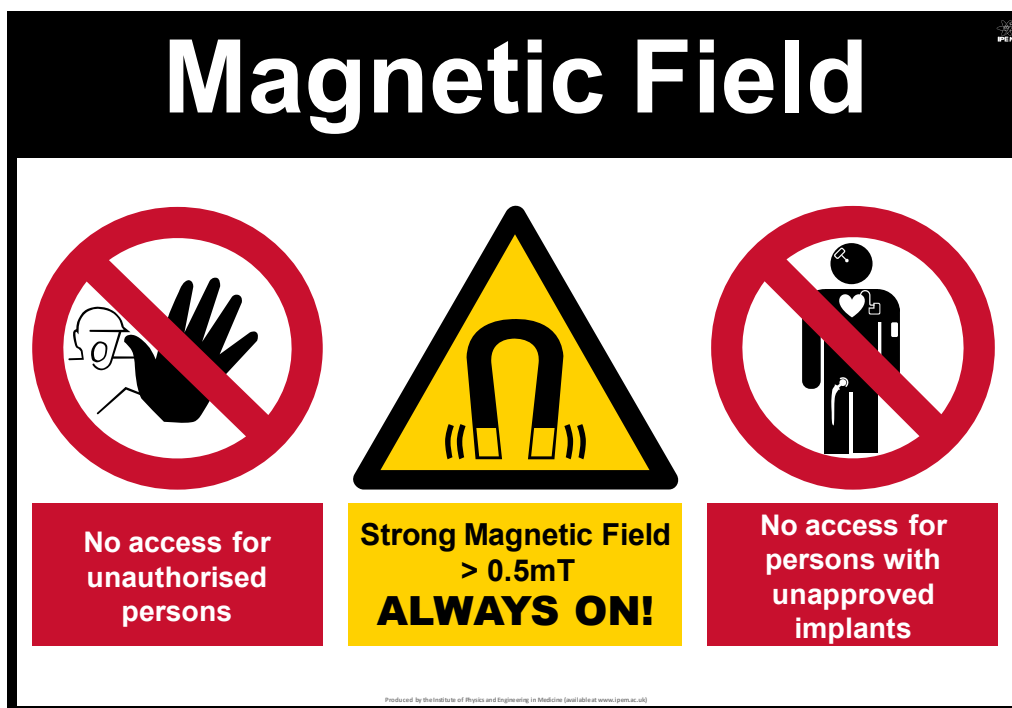


Figure 5: IPeM recommended MRI safety notice for entrances to regions with magnetic flux density >0.5mT, other than the MRI scanner room (e.g., an MRI equipment room).

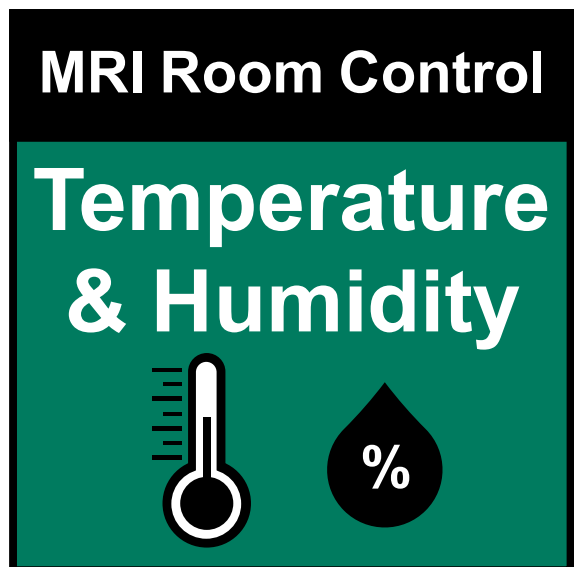
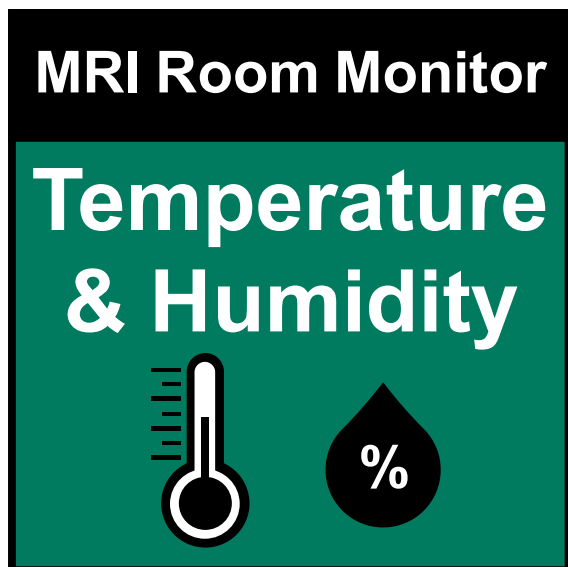
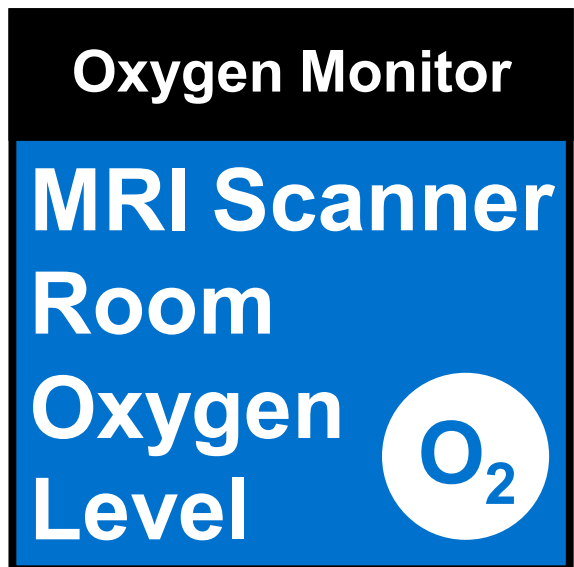
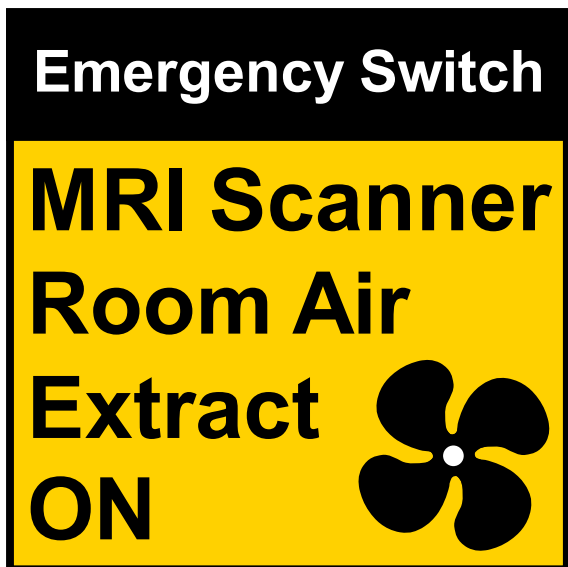
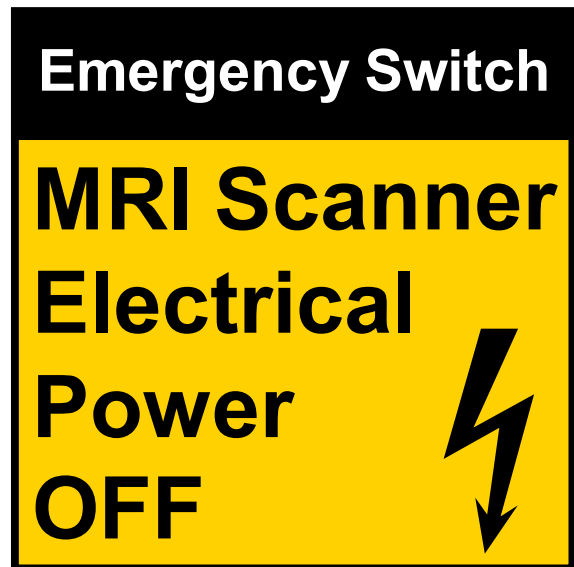
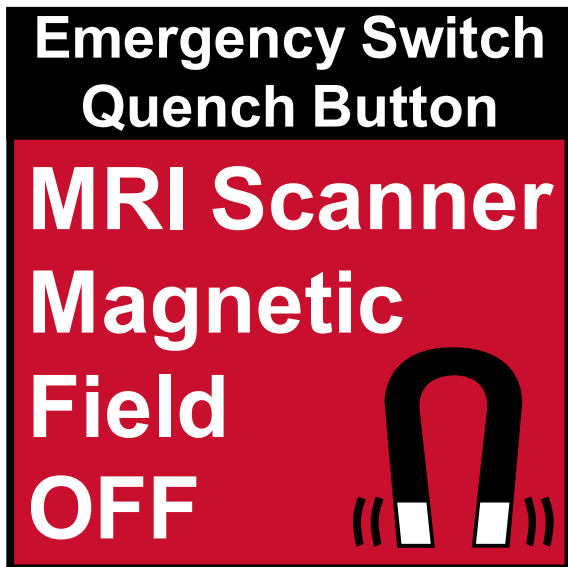


Figure 6: A sample set of labels for use in MRI departments to clearly and unambiguously label emergency buttons, the oxygen alarm/monitor and the environmental control/display.



Figure 7: Examples of MRI safety notices in use and suitable physical barriers across the entrance to the MRI scanner room.

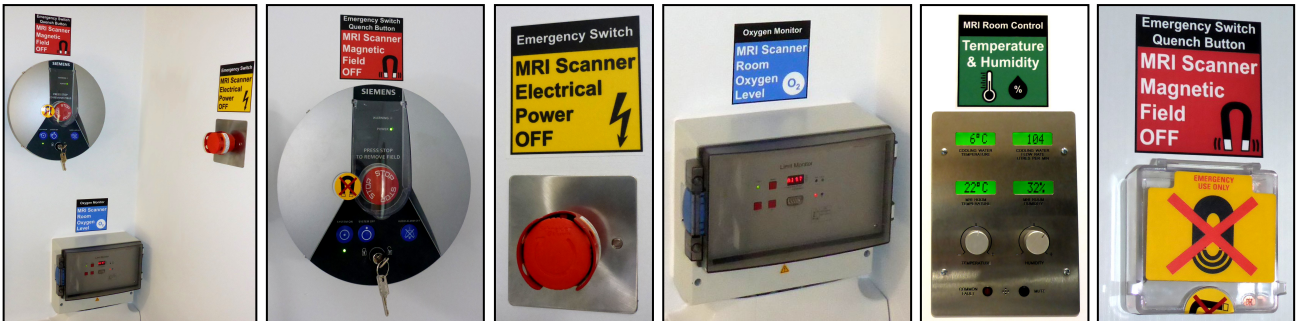


Figure 8: Examples of labels for emergency buttons, the oxygen monitor and the environmental control in use in both the MRI control room and the MRI scanner room.



Figure 9: Examples of suitable floor marking within the MRI scanner room to aid safe working practices with regard to MR Conditional ancillary equipment.