CAMRI
MRI SAFETY MANUAL

Manual Last Updated November 2015

GENERAL INFORMATION

Risks associated with the MRI lab:

Used properly, the magnetic resonance imaging equipment contained within the MRI lab is quite safe, however, it poses serious risks to the unwary. Users of the lab should be completely familiar with this manual and with the procedures for protecting others from hazards. To minimize risks to subjects and other members of the research team, **only personnel who have successfully completed the full CAMRI safety certification process are allowed access to the MR scan rooms, control rooms or equipment rooms.** Observers who have not been safety trained are **not permitted** to enter the MRI suites without special prior arrangements.

The main hazards in the lab are:

- The "projectile effect" when heavy, sharp, or dangerous objects are hurled into the instrument. Even seemingly innocuous objects, such as hand tools, can be *lethal*.
- Pacemaker damage. Certain cardiac pacemakers can be damaged by exposure to magnetic fields, causing direct hazards to subjects. Under no circumstances should persons with pacemakers enter the MRI suites at CAMRI.
- As in many laboratories, the MRI lab contains wiring and circuitry that operate at dangerous voltages. Under no circumstances should users touch any exposed wiring, or any exposed terminals in the equipment cabinets.
- Grossly improper scanner operation could result in excessive heating of the subject due to RF energy being deposited. This is easily avoided by operating the equipment according to the guidelines contained in the user manuals and set by the individual instructors.
- Suffocation: in extreme cases, the imaging magnet may release large volumes of helium gas that can rapidly force all air out of the scan room. Normally, the helium gas would be vented through the roof. However, there is a small but significant risk that the venting system could fail.

Safe Areas

There are no areas in the MR suites that can be considered completely safe. The control rooms, scanner rooms, and equipment rooms all have risks associated with magnetic fields and/or electrical equipment. CAMRI safety certification is required for personnel to enter any of these areas.

Reduction of Risks

The chief risk exposure in the lab is to entering personnel who are unfamiliar with the equipment and its hazards. Personnel working in the facility must be constantly vigilant of who is entering the console or scan room areas. Especially in emergency situations, you must ensure that no one without proper training enters any of the scanner rooms, and even then, that they have adequately checked themselves for possible hazards such as projectiles.

Many objects in the scanner control rooms and equipment rooms are **NOT MR compatible** and may become projectiles in the MR scanner rooms. You must never move any object from these rooms into the MR scanner rooms unless you are absolutely certain that the object is MR safe.

Similarly, some objects in the MR scanner rooms may only be safe when kept at a distance from the MR scanner. **Only personnel explicitly authorized to do so should move objects in the scanner room that are labeled "Not MR safe"**. Only objects that are not ferromagnetic should be labeled with a "MR safe" label and this safe label should not be in red or orange. Unlabeled objects should be assumed **NOT** safe to move unless they are clearly non-metallic.

Tours and Training Exercises

As interesting as the equipment is, please resist the temptation to show visitors the scanner "up close," as this introduces the unnecessary risk of unwittingly exposing people to potential hazards. Tours or training exercises that would involve having non-safety trained personnel present in the scanners, control rooms or equipment rooms must be authorized in advance by a CAMRI staff member and must be performed in compliance with any special requirements included as part of that authorization.

Reporting of safety incidents or near-incidents

All incidents or near-incidents must be reported to Krista Runge or Lacey Berry as soon as possible and no more than 24 hours after the incident. Contact information is available at the end of this manual.

Information in this manual that you believe to be incorrect or out-of-date should be reported to Lacey Berry.

In any emergency, try to step through the following guidelines methodically and carefully. Review the safety features, policies and procedures in this manual regularly to assure that you do not need to take unfamiliar actions in a panic situation.

A printed copy of this safety manual is available in all 3 of our scan rooms. You should familiarize yourself with its location.

METAL SCREENING

Anyone preparing to enter an MR scanner room must complete a metal screening form, and this form must be reviewed before access to the scanner room is granted. Individuals who are safety certified at CAMRI are not required to personally complete a formal written metal screening form about themselves but are responsible for verifying that they are personally safe to enter the scanner room.

If there are any doubts regarding the metal screening responses, **do not allow the individual to enter the scanner room**. The fact that the individual has been scanned in an MR scanner previously (even at CAMRI) is **never** a sufficient basis upon which to conclude that the subject can enter the scanner room safely, since risks vary according to magnetic field strength. Dental fillings and orthodontic braces do not constitute significant risks (though the latter may produce unacceptable artifacts) and do not preclude scanning. Subjects with tattoos or permanent eyeliner should be advised of the small risk of local redness or irritation and asked to report any discomfort immediately. Scanning should be stopped immediately if such discomfort develops. These small risks may be further reduced by applying a damp cloth to the area during scanning.

Some implanted metal devices have been established as safe for MR scanning. A recent copy of Shellock's book cataloguing implanted medical devices is available in the MR suite and up-to-date information is always available on the website http://www.mrisafety.com. If, in reviewing these resources, you believe that it is possible to safely scan your subject, you should contact Krista Runge or Lacey Berry to request authorization to scan the subject. Even if you are certain that the implanted metal does not constitute a risk**, do not allow the individual into the scanner room unless you have obtained explicit authorization to do so**. It is better to ask these questions before your research subject arrives to prevent cancellation at the last minute and inability to scan.

Before entering the scanner room, subjects and staff must remove all objects from their person that might constitute a risk in the MR environment. It is the investigator's responsibility to assure that this has been done. Subjects should be asked to turn pockets inside out to demonstrate that no potentially hazardous objects have been overlooked. Silver, gold and platinum jewelry is not ferromagnetic. Nonetheless, subjects should remove jewelry before going in the scanner since these metals can still conduct electricity and therefore pose a risk for burns in the presence of time-varying magnetic fields. Jewelry that forms large loops is particularly hazardous.

EAR PLUGS AND HEADPHONES

Anyone in the scanner room while the scanner is in operation must be provided with and must use hearing protection in the form of earplugs and/or headphones to avoid hearing injury from the acoustic noise generated by the scanner. According to the Trio documentation, hearing protection for subjects should provide a single number rating (SNR) of 10 dB or greater. We provide both ear plugs and headphones in each of our rooms here at CAMRI.

Sources of acoustic noise:

When the scanner is not acquiring images, the only source of acoustic noise is the chirping of the pump used to circulate cold water. Different studies have report this noise to be in the 65-80 dB range, below the OSHA standard necessitating the use of a hearing protection device (HPD).

The time-varying gradient magnetic fields are the primary source of acoustic noise during MR imaging. The rapid rise and fall of currents within the gradient coils in the presence of the static magnetic field create strong Lorentz forces that cause the gradient coils to move against their mountings. The vibration of the coils and the vibration and flexing of their mountings cause the loud tapping and knocking noises during imaging

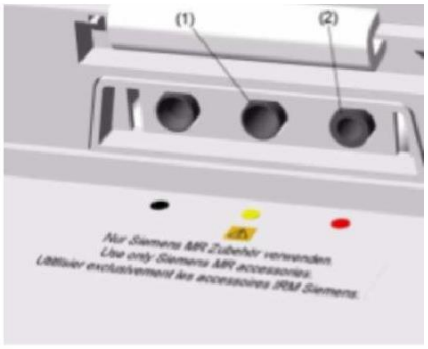
MEDICAL CRASH CART

We do not have a MD here at CAMRI and we do not have a medical crash cart. For these reasons individuals that pose a risk for coding or any other safety concern should not be scanned here at CAMRI. Because we have no crash cart we do not do studies that involve contrast. In case of an emergency you should dial 911 and remove the individual from the scanner before they arrive.

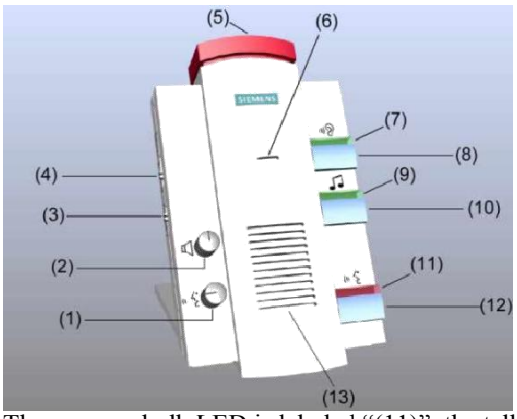
SUBJECT SQUEEZE BULB

Siemens Squeeze Ball

The scanners are equipped with a squeeze bulb that allows the subject to set off an audible alarm to attract the operator's attention. The squeeze bulb should be made available to subjects unless some alternative method of constant monitoring (e.g., another person in the scanner room) is in effect. Use of the squeeze bulb or some comparable form of continuous subject monitoring is mandatory if you are operating the scanner in "Level 1" mode, which has an increased risk of magnetostimulation or subject heating due to RF energy deposition or if you are scanning a subject who has a tattoo or permanent eyeliner. The squeeze bulb plugs into the red connector at the foot of the bed. You can verify that the squeeze bulb is connected by noting that the squeeze bulb LED lights up when you press the talk button on the intercom. If the subject squeezes the squeeze bulb, a continuous audible alarm is emitted via the intercom and the intercom squeeze bulb LED lights up.



Trio squeeze bulb connector at the foot of the bed is labeled "(2)" and the hose connector is red.



The squeeze bulb LED is labeled "(11)", the talk button is labeled "(12)". The "STOP" button is labeled "(5)".

Responding to a squeeze bulb alarm

1) If a scan is ongoing, press the "Stop" button on the console using the mouse. Alternatively, you may press the "STOP" button on the Siemens intercom twice (5) to stop the scan immediately.

This is especially important if you are scanning in "Level 1" mode rather than standard mode since the subject may have triggered the squeeze ball in response to magnetostimulation or excessive heating.

2) Press the appropriate intercom talk button (11) to stop the audible alarm.

3) While holding down on the intercom talk button, speak to the subject to determine why the squeeze bulb was pressed. *Make sure that the volume is turned up so that you can hear the subject's response.*

4) If necessary, enter the room to further investigate and/or correct the problem.

POLICY REGARDING DOOR SECURITY

Scan doors should NEVER be left open unattended. Make it a habit to close the door after you.

POLICY REGARDING ACCURATE ENTRY OF SUBJECT HEIGHT, WEIGHT, AGE AND SEX

The scanners require that the subject's height, weight, age and sex be entered before scanning.

Accurate information must be provided to ensure that FDA limits for energy deposition are not exceeded. Weights should be correct to within five pounds. Incorrect information should **never** be entered in an effort to get the scanner to conduct a study that it otherwise would not perform because FDA limits would be exceeded.

POLICY REGARDING TEMPERATURE CONTROL

In regulating energy deposition in the subject's body in accordance with FDA guidelines, the scanners assume that the ambient temperature in the room does not exceed 72° and that the relative humidity does not exceed 60%. Consequently, the thermostat should never be set for a room temperature higher than 72°. Please note that only cotton, linen or paper should be used for bed covering or blankets since radiofrequency energy may cause heating of synthetic sheets or blankets.

POLICY REGARDING OBESE OR LARGE SUBJECTS

Subjects weighing more than 300 pounds should not be scanned. The Trio 3.0 Tesla scanner bed is designed to support weights up to 440 pounds. Even subjects weighing substantially less than 300 pounds should never be allowed to sit at the distal end of either of the scanner beds, since they are not designed to support the full weight of a large subject applied at full mechanical advantage.

To avoid burns or peripheral nerve stimulation, a minimum distance of 5 mm should be maintained between the subject's body and the wall of the scanner tunnel. MR pads or cotton sheets available in the MR scan rooms can be used to assure this distance is maintained.

POLICY REGARDING CHILDREN

Children may only enter the scan rooms as participants in an IRB approved research study of children. Children not involved in the research study (e.g, the child or sibling or a research subject) may not enter the scan room.

All safety precautions applicable to adult subjects are applicable and if anything, more important in children. Careful metal screening, accurate entry of age, sex and weight, and use of "Standard Mode" scanning options whenever possible are important steps in minimizing risks to this population .

3 Principles of MR Imaging:

THE SCANNER IS ALWAYS ON. A serious hazard for MRI safety is allowing object to become attracted to the static magnetic field. This can result in an individual being struck, injured or trapped against the magnet by the object. Equipment can also become damaged by slamming into the magnet or being struck by another object that is accelerating rapidly due to the strong attraction of the magnetic field. There are three main component of the MRI scanner: the static magnetic field, the radiofrequency field, and the gradient or time varying magnetic field.

3.1 Static Magnetic Field

The static magnetic field is the main magnetic field that is always present once the scanner is ramped up to the designated field strength. This field is described in units of Tesla (T) or Gauss (1T = 10,000 gauss). Our system uses a 3T static magnetic field, approximately 60,000 times stronger than the earth's magnetic field that induces a compass to point North. The distance for the magnet that is safe for the general public and to use all objects and devices is denoted as the 5 gauss line. The researcher(s) must be aware of the fringe field, before deciding to take objects into the scanner room.

3.2 Radiofrequency Field

The radiofrequency (RF) coil is the heating source within the scanner. This system uses coils as transmitters to excite the MRI signal and as a receiver to detect the MRI signal. It is important to properly use the equipment and accessories of the MRI scanner.

3.3 Gradient/Time varying Magnetic Field

The gradient or time varying magnetic field selects the slices and imaging planes. This particular field is superimposed over the static magnetic field, and is the sources of all the acoustic noise. The coils within this system are pulsed on and off to produce linear gradients of the magnetic field for imaging. This allows producing an array of images with different spatial and temporal resolutions, and with different contrast between tissues in the image.

Performing a Routine Scanner Shutdown or Reboot

A shutdown or reboot of the MRI scanner initiates a routine electrical shutdown should a situation or problem arise. This takes a few minutes to complete and can be down if any of the following occurs:

1. A notice has been received that there is an electrical outage to the building.
2. There are visible alarms that revealed that the magnet has quenched or that helium levels are low.
3. The scanner table is not responding to controls.
4. An error message has occurred that requires the system to be rebooted.

Shut down or Reboot Procedure:

1. Along the top of the system is a bar of various commands. Select "System".
2. From "System" <End Session>:
3. Then select either, <Shutdown System>, <Restart System>, or <Restart Application>

    a. Shutdown System will shut down the entire MR system.

    b. Restart System is only used to reboot the system.

    c. Restart Application is only used to reboot the software. {i.e. 3D, Spectroscopy Tabs not functioning}

To turn on the scanner:

1. Turn the key on control panel to unlock position and press blue scanner on button.

   Scanner will take about 20 minutes to boot up before you can use it.

   (you will see a red line at bottom of screen while booting)
2. Once you hear 3 beeps then the scanner is ready to use. (The red line will disappear as well)

Users of the CAMRI facility should only quench the magnet in the event that the magnetic field itself poses an **immediate risk to life or major property**. Two such circumstances are:

1) A metal object is lodged in the scanner in a way that poses an immediate serious threat to a person (e.g., the person is pinned to the magnet by a metal object that is causing internal injuries).

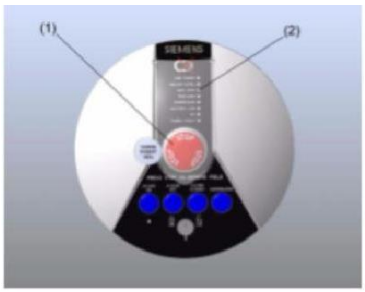
2) Fire personnel determine that there is ***no other alternative*** to entering the room with axes or other heavy gear when fighting a fire.

If the absence of a major emergency, facility users should never quench the magnet by themselves, even if they are convinced that a magnet quench will ultimately be necessary (e.g., if a large object has been drawn into the magnet, but poses no immediate risk to a person).

Quench Procedure

1. Locate and press the **QUENCH BUTTON** in the control room or scanner room. The magnetic field will fall to a safe level within 20 seconds.

   In the control rooms, quench buttons are located on the top portion of the Siemens wall mounted control boxes located just to the right of the window. The Sonata control room quench button is covered by a plexiglass cover with a label that says "Quench Button For Emergency Use Only". The Trio control room quench button is covered by a tamper evident plastic cover. In each control room, the quench button itself has the word "STOP" printed three times around its perimeter. Lift the plexiglass cover and press the button.



Trio control room quench button is the button labeled "(1)"

scan room quench button plexiglass covers

2. When the magnet is quenched, the helium in the scanner boils off. Although the helium should vent out of the room to the rooftop, **you should make sure the door to the scanner room is wide open before quenching the magnet**. If possible, you should remove yourself and the subject from the scanner room before quenching the magnet to minimize the chance of asphyxiation in the event that the helium is improperly vented.

3. If emergency medical assistance is needed, dial 911 (not 8-911) and request medical assistance as detailed elsewhere in this manual.

4. The helium vent ducts become dangerously cold during a quench. Do not touch them.

5. Immediately notify an CAMRI staff member that you have quenched the magnet.

6. At best, it will be many days before the scanner can be returned to service. If uninjured, your research subject should be sent home.

PERFORMING AN EMERGENCY ELECTRICAL SHUTDOWN

The following events should prompt an emergency electrical shutdown:

1. You see smoke or fire coming from the scanner, equipment room or console.

2. Flooding has carried or is threatening to carry water into electrical equipment

Electrical shutdowns do not turn off the magnetic field—the magnet is always on unless the magnet has been quenched.

Emergency Electrical Shutdown Procedure

1. Locate and press one of the large red electrical shutdown buttons in the scanner room or control room. **Make sure that it is the electrical shutdown button, not the quench button.**

The emergency electrical shutdown button is red and it is labeled Emergency electrical shutdown button.

2. Electrical shutdown immediately stops all power to the scanner, the scanner equipment and the console computers. It does not turn off the lights. Also, power to the stimulation equipment will not be interrupted, so be aware that electrical or fire hazards may still be present.

3. In the case of fire or medical emergency, call 911 (not 8-911)

4. Remove your subject from the scanner room. The electric brakes on the scanner bed will have been released automatically, so simply pull the bed out of the gantry manually using the handle at the foot of the bed.

5. Notify CAMRI staff that you have performed an Emergency Electrical shutdown.

6. Circumstances that justify an emergency electrical shutdown do not typically justify quenching the magnet. **Do not quench the magnet unless there is a specific reason to do so** (possible reasons for quenching the magnet are discussed elsewhere in this manual).

7. If uninjured, send your subject home. It will take at least a couple of hours to restore the scanner to operational status.

PERFORMING A ROUTINE SHUTDOWN

You should initiate a routine electrical shutdown if you believe that a situation is developing that might predispose the equipment to electrical damage or that might soon warrant an emergency electrical shutdown. **Electrical shutdowns do not turn off the magnetic field—the magnet is always on unless the magnet is quenched.** A routine electrical shutdown requires 3-5 minutes to complete. **If an emergency electrical shutdown becomes warranted at any time, you should follow the emergency electrical shutdown procedure described elsewhere in this manual**, even if you have already initiated a routine electrical shutdown. Situations that would warrant a routine electrical shutdown include:

1. Receiving notice that an electrical outage in the building is likely

2. Development of a minor water leak that is not expected to flood electrical equipment before a routine shutdown can be completed

3. Alarms sounding indicating that the magnet has quenched or that helium is unacceptably low (a routine warning message on the console that the helium needs to be refilled and instructing you to call service is not an alarm and does not warrant an electrical shutdown).

4. Error messages from the scanner console indicating that correction of a problem requires rebooting the equipment.

5. Failure of the scanner bed to respond to its controls

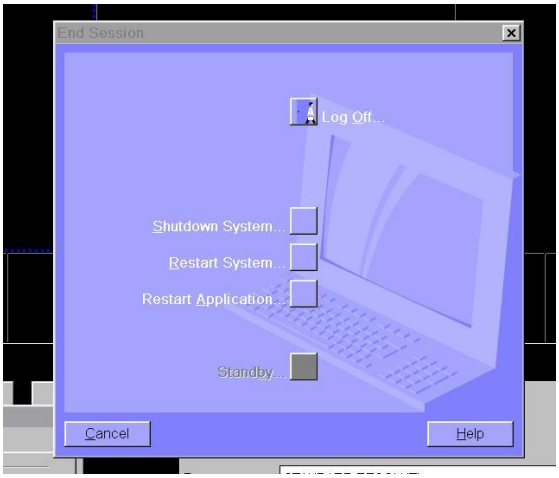
Per the manufacturer's updated recommendations, a routine electrical shutdown should NOT be routinely performed at the end of the day. The scanner should be left in operational status.

Routine Shutdown Procedure

1. Click the System tab at the top of the screen:

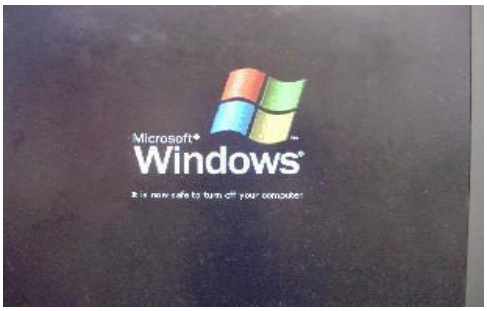
2. Click on "End Session":

3. Click “Shutdown System”.



4. In the confirmation dialog box that appears, click “Yes”

5. It will take approximately 5-10 minutes before you see “It is now safe to turn off your computer” (picture a.) on the MR computer screen. You must then press the blue “system off” button on the Siemens scanner control box (picture b.) located on the wall next to the MR Scanner window.

a. 

b. 

When it is appropriate to restore power, press the blue “power on” button located on the Siemens control box next to the control room window. The system will need approximately 20 minutes to reinitialize. To avoid subsequent problems, make sure that the bed is completely out of the gantry at its home position and that the top head coil is attached and plugged in before restoring power.

HANDLING MEDICAL EMERGENCIES

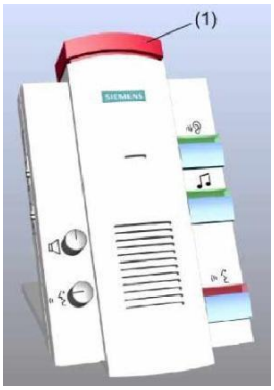
The following procedures are designed on the assumption that a physician or nurse is not immediately available in the MR laboratory at the time of the emergency. If a physician or nurse is present, the medical recommendations may be adjusted as deemed medically appropriate for the subject's condition. However, all non-medical aspects of these guidelines, **particularly those related to removing the person from the magnet or scanner room, must be followed** to avoid unnecessary injury to the subject or personnel.

1. If (**and only if**) the medical emergency involves the subject being pinned to the magnet by a metal object held in place by the magnetic field, quench the magnet following the procedure described elsewhere in this manual.

2. Call 911 (Not 8-911). Describe the event. Advise the person taking the report that the building is a secure building and that you will provide access via the back door, which is the entry closest to you.

3. If the emergency involves a subject in the magnet:

   A. Press the "STOP" button on the top of the intercom twice to abort the scan and



The "STOP" button is labeled "(1)"

Table Stop button

to allow the scanner bed to be moved manually, alternatively, in the scanner room, press the "STOP" button on the scanner control panel.

B. Pull the bed completely out of the scanner bore. ***The scanner bed cannot be detached from the scanner.***

C. Remove the subject from the scanner room.

Under no circumstances should a code team or emergency personnel untrained in MR safety enter the scan room. **Always remove the subject from the instrument first!**

5. Provide medical assistance in accordance with your training and experience while awaiting arrival of the paramedics. Consider the following options:

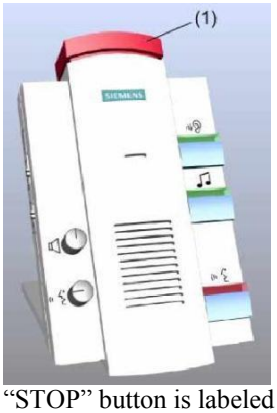
   A. Initiate CPR if the person is pulseless or not breathing

HANDLING FIRE EMERGENCIES

1. In case of fire, call 911 (not 8-911).

2. If smoke or fire is coming from the scanner, equipment room or console, perform an emergency electrical shutdown as described elsewhere in this manual.

3. If you are scanning and smoke or fire is NOT coming from the scanner, equipment room or console, stop the scan and release the bed by tapping the red "STOP" button on top of the intercom twice. If time permits, initiate a routine electrical shutdown by selecting "End" from the "System" menu at the far right at the console.



The "STOP" button is labeled "(1)"

NEVER BRING A STANDARD RED FIRE EXTINGUISHER FROM ELSEWHERE IN THE BUILDING INTO THE SCANNER ROOM.

4. Remove the subject from the scanner and escort the subject out of the building.

5. Do not return to the building until advised by fire personnel that it is safe to do so.

6. Contact CAMRI personnel to advise them that there was a fire in the building.

HANDLING NON-FIRE FACILITIES EMERGENCIES

- Unscheduled Power Shutdowns
- Earthquakes
- Magnet Quench (catastrophic boil-off of helium)
- Water Leaks
- Foreign Metal Objects in the Magnet

1. Perform a routine shutdown, or if circumstances such as a rapid flooding threaten to reach the equipment before a routine shutdown could be completed, perform an emergency electrical shutdown. Both shutdown procedures are described elsewhere in this manual.

2. Remove the subject from the scanner

3. If appropriate, evacuate the building and do not return until advised that it is safe to do so.

4. Notify an CAMRI staff member of the emergency.

HANDLING AUDIBLE ALARMS

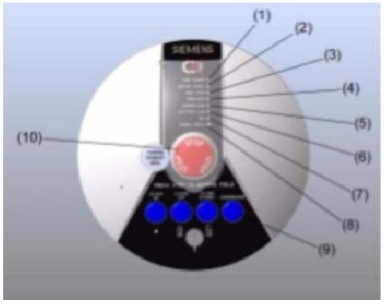
You should never scan while an audible scanner-related alarm is sounding. If you cannot identify and correct the underlying problem, your study should be discontinued. If an audible alarm is sounding, investigate the following possibilities:

1) The alarm might be the building fire alarm. This extremely loud alarm is audible throughout the building, is associated with flashing lights in the hallways, and would be difficult to mistake for a scanner related alarm. Even if you suspect that the fire alarm has been triggered accidentally, you **MUST** do the following:

A. If you are scanning, press the "STOP" button on top of the intercom twice.
B. Go into the scanner room and pull the bed out of the gantry using the handle at the foot of the bed.
C. Assist the subject off the bed
D. Accompany the subject out of the building via the nearest accessible exit.
E. Do not reenter the building until told that it is safe to do so by fire personnel.

2) The alarm might have been triggered by someone squeezing the squeeze bulb. Look to see if the squeeze bulb LED on the intercom is lit. If it is, see the separate section regarding the squeeze bulb. You will be able to continue your study if this is the source of the alarm.

3) The helium level might be low or the magnet might have quenched spontaneously due to an earthquake or as a result of someone pressing the quench button. Check the Siemens control box located in the control room immediately to the right of the window. If the magnet stop LED is lit, the magnet has quenched. If the helium level LED is lit, the helium level is low. On the Trio, other LEDs indicate power problems, compressor problems, battery problems and communications errors. You can press the alarm silencer to stop the audible alarm, but **do not scan**. Notify CAMRI staff of the problem and send your subject home.



Trio
The magnet stop LED is labeled "(3)"
The helium level LED is labeled "(2)"
The alarm silenced (acknowledge) buton is labeled "(9)"

4) The alarm might be a building related alarm. Check the annunciator panel in the hallway near the building exit for an LED indicating the source of the problem. If the LED's indicate a

problem that is outside the MR suite, you will generally be able to continue your study. Facilities should automatically be notified of alarms appearing on this board.

5) The alarm be might related to the Oxygen Sensors.

PureAire Aircheck O2 Systems oxygen sensors are located in the Trio control rooms. In the unlikely event of helium venting into the scanner room, these sensors will generate a low oxygen alarm. A normal oxygen level is 20.8-20.9%.

Low Oxygen Level Alarm - STOP SCANNING IMMEDIATELY

The oxygen monitors will emit an audible alarm if the oxygen level drops to 19.5%. An LED will light up on the front panel, and the display will alert you to the oxygen level AND/OR the error message. If the alarm sounds and the display indicates a low oxygen level, immediately check on your subject, open the door to the scanner room and remove the subject from the scanner room in the safest manner possible (. If your subject needs medical attention, call 911. Please alert CAMRI staff immediately if there is a decrease in oxygen in the scanner room.

Other Errors - IT IS SAFE TO SCAN IF THE OXYGEN LEVELS ARE NORMAL

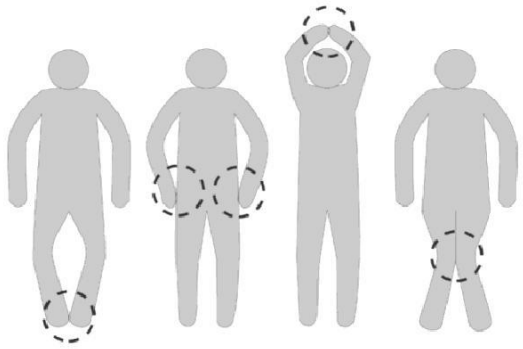
If a voltage or surge problem occurs, it is possible that the device will alarm, that the LED light will come on AND/OR that an error message will be displayed, despite normal oxygen levels in the room. In this case, verify that your subject is fine and ALWAYS verify that the oxygen level is normal (20.8-20.9%) before resuming scanning. If the error is non-oxygen related, please contact BMC MRI staff by email to let them know the details of the problem.

Audible Noise Check:
The scanner makes a chirping sound, this sound is perfectly normal and should be heard on all properly functioning scanners while not in use. This chirping sound is produced by the compressor and if you do not hear this sound please let CAMRI staff know. If the sound is not present it could be the chiller not functioning properly and the scanner may heat up. The scanner will be out of commission for repairs if the compressor is down.

HANDLING SUBJECT TINGLING OR MUSCLE TWITCHES

Tingling or muscle twitches are potential physiologic effects of time varying magnetic fields. Such effects are particularly likely to occur with echo-planar imaging in fMRI studies. To minimize the likelihood of such magnetostimulation, operate the scanner in "Standard Mode". In this mode, only 1% of subjects should experience such effects. However, the scanner may refuse to scan certain subjects with certain pulse sequences in "Standard Mode". If you operate in "Level 1" operating mode, up to 50% of subjects may experience magnetostimulation with certain pulse sequences.

Complaints of tingling or muscle twitches should prompt rescreening for any metal objects that might have been previously overlooked and verification that subject positioning does not form potential loops. For echo planar imaging, selecting a phase encoding direction that is anterior-posterior (when this is an option) should reduce the likelihood of magnetostimulation. Note that the sensory input associated with magnetostimulation will pose an unwanted confound in fMRI studies.



Subject positioning loops that predispose to magnetostimulation or burns

HANDLING PERSPIRATION AND INCREASED PULSE AND SUBJECTS WITH CONDITIONS ASSOCIATED WITH IMPAIRED THERMAL REGULATION

Perspiration and an increased pulse rate may result from energy deposition in the body during scanning. Energy deposition in the body is carefully regulated by the scanner in accordance with FDA guidelines. If your subject develops these symptoms, you should verify that the subject's age, height and weight were entered correctly when registering the patient, since these parameters may influence the calculated energy deposition. You should also verify that the room temperature does not exceed 72° and the humidity does not exceed 60% since the calculated energy deposition limits assume that they do not. The Trio will measure the temperature and may refuse to scan certain sequences if the temperature exceeds 71.6°. For subjects who have medical conditions such as fever, diabetes, pregnancy, or cardiovascular disease that can impair thermal regulation, you should operate the scanner in "Standard Mode" if possible, since energy deposition is not a concern in this mode. Childen or elderly subjects are also at increased risk of overheating. If you do scan subjects with conditions associated with impaired thermal regulation in "Level 1" mode, you should be attentive to signs or symptoms of overheating and stop the scan if overheating is suspected. "Level 1" mode should be avoided if possible in subjects who are unable to communicate reliably (e.g., children, sedated subjects, stroke patients). Adjusting the fan in the scanner may be helpful in reducing the likelihood of overheating in subjects.

LASER LIGHT LOCALIZER HAZARDS

On the 3.0 Tesla Trio scanners, a laser is available for landmarking the patient's position in the scanner. Subjects should be instructed to keep their eyes closed while the laser light is turned on to avoid eye injury. If the laser light appears as a spot rather than as crosshairs, it should be turned off immediately, and you should notify one of the designated CAMRI staff that it is in need of repair.

MRI PHANTOM LEAK HAZARDS

The MR phantoms used to calibrate the scanners are sealed and should not show any evidence of leakage. The contents of some of the phantoms is potentially hazardous. If a phantom develops a leak, protective clothing (gloves, labcoat, goggles and, if the contents have become aerosolized, a face mask) should be worn while cleaning the leak. The contents should be disposed of as hazardous materials (i.e., not simply poured down the drain).

ECHOPLANAR (fMRI) IMAGING HAZARDS

Echoplanar imaging, used in fMRI, utilizes rapidly changing gradients and is associated with higher voltages than many other MR imaging modalities. The risk of magnetostimulation is increased with echoplanar imaging. The risk of magnetostimulation can be reduced by choosing a phase-encoding direction that is oriented anterior-posterior when this is an option.

The List of Common Unsafe Devices	
• Cardiac Pacemaker	• Vascular access port and/or catheter*
• Implanted cardioverter defibrillator (ICD)	• Radiation seeds/implants
• Electronic Implant or Device	• Swan-Ganz (thermodilution catheter)
• Magnetically-activated implant/device	• Mediation patch (Niction, Nitroglycerin)
• Neurostimluation system (Deep Brain)	• Any metallic fragment/foreign body
• Neurostimulation system (Urinary Control)	• Wire mesh implant
• Spinal cord stimulator	• Tissue expander (e.g. breast)
• Internal electrodes/wire	• Surgical staples, clips, or metallic sutures*
• Bone growth	• Joint replacement (hip, knee, etc.)*
• Cochlear, otologic, or ear implant	• IUD, diaphragm, or pessary
• Insulin or infusion Pump	• Dentures or partial plates*
• Implanted drug infusion pump	• Tattoo or permanent makeup
• Prosthesis (eye and/or penile)	• Body piercing jewelry
• Heart valve prosthesis	• Hearing aid*
• Eyelid spring/wire	• Other implant
• Artificial or prosthetic limb	• Breathing problems or motion disorder
• Metallic stent, filter, coil*	• Claustrophobia
• Shunt	• Aneurysm Clips

*** This is not a complete list of unsafe objects, just the most common***

Contra-indicators of MR

There are equipment, devices, medical implants, etc that are at risk to injury and/or damage if they are entered into the scanner room. This pertains to be within the body or in personal possession. The items that are listed are considered to be potential risk to an individual's safety. Some items on the list are conditional (*), and further information can be founded at www.mrisafety.com.