

Level 2 Safety Training

MindCORE Neuroimaging Facility
University of Pennsylvania

Thank you for your interest in completing the advanced MRI safety (Level 2) training at the MindCORE Neuroimaging Facility. It is assumed that you have completed the following training modules in Workday:

1. [MRI Safety Training Level 1](#)
2. [HIPAA Protecting Patient Privacy](#)
3. [CITI Protection of Human Subjects](#)

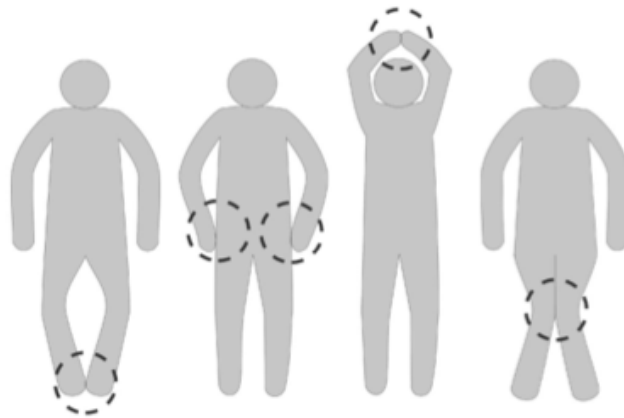
After reading the following document, you will need to make arrangements with the directorship of the Facility to complete your practical training (i.e., shadowing) on the operation of the MRI scanner and to complete an oral exam on the operation and safety protocols of the Facility. Level 2 certification will allow you to have unaccompanied access to Zone 3 (the scanner control room) and Zone 4 (the MRI scanner room). You will also be able to scan participants on your own.

The material in the following document is a summary of information from Siemens safety training materials and focuses on safety concerns for research personnel and research participants alike. Please refer to the MindCORE Neuroimaging Facility Governance Document and the American College of Radiology Guidance Document on MR Safe Practices (DOI: [10.1002/jmri.24011](https://doi.org/10.1002/jmri.24011)) for more detailed information.

Hazards of the MRI environment

- THE MAGNET IS ALWAYS ON
- There are several hazards associated with the static magnetic field:
 - Movement by implants & prostheses in the body
 - Attraction, alignment, & projectile-like acceleration of magnetizable objects
- Hazards associated with gradient fields:
 - Peripheral nerve stimulation due to shifts in charge in participant's tissue
- Hazards associated with radio frequency fields:
 - Warming of body tissue may occur due to the absorption of RF power by the tissue. This is measured as specific absorption rate (SAR) and is monitored by the scanner software. Larger subjects absorb more RF power, so it is important that body weight is accurately entered when registering participants.
- Possible undesirable side effects
 - Dizziness, heating, claustrophobia, & nerve stimulation
 - When persons (MR workers or participants) are exposed to the static magnetic field, possible effects are dizziness, light-headedness, or metallic taste, especially in 3T magnetic fields
 - To reduce participant reaction of fear: inform participant about possible occurrence of these symptoms prior to examination
 - Ask participant to lie still during measurement

- Keep sufficient distance to magnet & avoid rapid movements of the head
 - Do NOT examine participants unable to communicate potential overheating effects (small children, seriously ill, paralyzed, unconscious, sedated, or handicapped participants)
- Current loops and bore wall contact
 - Dangerous current loops may be generated when parts of the participant's body touch
 - These loops may lead to burns or increase the probability of stimulation
 - Current loops also generated when participant's skin contact the tunnel lining or RF coil cables
 - Ensure participant does not have potential current loops as shown in diagram below
 - Ensure participant is positioned with proper distance to magnet tunnel as well as proper distance between parts of the body
 - To lower the effects of gradient coils or RF fields, keep a sufficient distance to the magnet tunnel and RF coils, & reduce the time of exposure during measurements



Examples of skin contact that may lead to large-surface current loops

- Peripheral nerve stimulation
 - Ensure participant does not wear clothing that is wet or dampened by perspiration
 - Ensure that the participant is free of metallic rings, chains, or electrically conductive materials worked into items of clothing (brassiere support wires, metallic appliques or woven metallic yarns)
 - Always position the participant so that the participant's arms are aligned with the torso and ensure that hands, arms, and legs do not touch (min distance: 5 mm)
 - Ensure that the min distance of 5 mm is maintained between participant and tunnel covering
 - Ensure sufficient ventilation
- Possible heating of synthetic blankets via the RF field during the measurement. Only use covers made of paper, cotton, or linen

Contraindications:

- MR examination is contraindicated for participants with electronic or electronically conductive implants or metals, especially those containing ferromagnetic foreign matter. Please see the screening form for a complete list of contraindications for MR examinations.
- Fill out a screening form for every participant every time you scan them regardless of whether you have filled out a form for the participant in the past.

What else must be observed?

- Ambient conditions:
 - As the ambient conditions & SAR have a considerable effect on the participant's body temperature, you must regularly check the ambient conditions.
 - The participant's ability to dissipate surplus heat is increasingly affected as the room temperature & relative humidity increase. Therefore, ensure the room temperature is at max 22 degrees C (71 degrees F) & the relative humidity does not exceed 60%
- Free access to & exit from the examination room must be ensured at all times
 - Regularly check the correct functioning of the door to the scanner room.
 - Ensure that the door to the scanner room opens & closes correctly
- Noise development
 - The mechanical forces lead to noise development (humming, knocking noises) during the MR examination
 - Noise development during the MR examination may cause injury to participant, such as hearing loss
 - Due to an increase in tension, the permissible sound pressure level may be reason for concern for pregnant women & their unborn, for newborns, infants & small children, as well as older persons
 - Provide the participant with appropriate hearing protection that lowers noise to at least 99 dB(A).
 - Ensure that personnel & accompanying persons in the examination room wear hearing protection during the examination.

Participant care

- Participants must be informed about the hazards & safety measures during MR examination:
 - Explain to the participant the conduct expected & possible risks involved.
 - Inform the participant about the monitoring & communication equipment (squeeze ball, intercom).
 - Instruct the participant regarding possible heat development during the MR examination.
 - Inform the participant about the noise developing during the MR examination.
 - Prior to the MR examination, instruct participants of possible stimulations during the examination (twitching muscles, tingling sensation).
- Participant monitoring:
 - Participants are acoustically as well as visually & physiologically monitored in the MR system
 - The viewing window and video system are used for visual monitoring.
 - The intercom can be used to acoustically contact the participant.
 - All participants should receive routine monitoring

- For some participants (sedated, physically unstable), monitoring of the vital parameters is mandatory.
- Potential causes of patient discomfort
 - Peripheral nerve stimulation
 - Stimulation threshold
 - The electrical field affects the participant
 - If the strength of the electrical field exceeds a certain threshold (stimulation threshold), the participant experiences peripheral nerve stimulation
 - Nerve stimulation manifests itself as tingling sensations or slight muscle spasms in the ribs, side, abdomen, hip, buttock, or thoracic regions, along the upper arms or the back muscles in the shoulder region
 - Depending on physiological conditions, the stimulation threshold may vary greatly from participant to participant
 - Stimulation limits
 - So-called stimulation limits were determined by averaging the individual stimulation thresholds of test subjects during an extensive clinical trial
 - Based on the statistical distribution, it can be expected that up to 50% of all participants will experience at least mild stimulations after reaching this stimulation limit
 - Monitoring
 - The MR system software includes a monitoring feature (stimulation monitor) which monitors the stimulation limit
 - The info window of the stimulation monitor provides info regarding how close participants are to the stimulation limit during the examination
 - Look ahead monitoring
 - Prior to starting the MR examination, the stimulation monitor checks whether the stimulation limits may be exceeded
 - If so, the measurement cannot be started
 - To perform the examination, the parameters of the measurement sequence must be adjusted accordingly
 - Online monitoring
 - If the stimulation limit is exceeded while a measurement is in progress, the active measurement is aborted & the gradient currents are reduced
 - Exposure to RF electromagnetic fields
 - During an MR examination, the participant's body absorbs energy from the RF field of the transmitter coil. Depending on the type of transmitter coil used, the absorption is either concentrated locally (when using so-called non-volume coils) or relatively uniform across the part of the body examined (when using volume coils, e.g., extremity or body coil).
 - The Specific Absorption Rate (SAR), expressed as W/kg, serves as a stress indicator.

- Unacceptably high local SAR values may lead to RF burns. At high values, the SAR that is exposed evenly across the body adversely affects the participant's thermoregulation & the cardiovascular system
 - Warming of body tissue
 - The energy absorbed during the MR examination warms the tissue. The heat generated is dissipated by the thermoregulation mechanisms of the participant (through increased perspiration & blood flow)
 - The body temperature increases if the participant absorbs more energy per unit of time than can be dissipated through thermoregulation. The longer this condition lasts, the greater the increase in temperature.
 - The increase in core body temperature is usually well below 1° C during the course of the MR examination (if the SAR limits are maintained).
 - Noticeable effects on the participant:
 - During the MR examination, participants may experience heat sensations on the skin & may begin to perspire.
 - Their pulse rate may increase as well.
 - Individual effects vary from participant to participant.
 - Intensity of these effects depends on the scan sequence.
 - Following the examination, the body will cool off; the pulse rate will return to normal.
 - Temperature control inside the examination room
 - A temperature sensor, located near the air intake for the tunnel ventilation, monitors the room temperature.
 - If the room temperature exceeds 25°C (77°F), the SAR limits are regulated & lowered; as a result, the parameters of certain MR measurement sequences may need to be adjusted.
 - SAR limits
 - Considering all possible tolerances, the SAR values are always calculated based on the worst possible value; this ensures that the specific SAR limit is maintained
 - Depending upon the research question, different RF coils are applied (e.g., extremity or body coil).
 - The effects on the participant vary, depending on the type of coil used.
 - Taking this factor into consideration, different SAR limits have been established for different types of examinations.
 - The scanner software automatically determines the limit to be applied.
 - SAR monitoring
 - SAR limits are monitored by a software monitoring function.
 - Look ahead monitoring:
 - Prior to each measurement, the estimated SAR values are automatically calculated & compared w/ the prescribed limit values, including possible measurement errors
 - If one of the calculated SAR values exceeds the corresponding limit, the measurement cannot be started and a warning

message appears. Adjustments to the scan protocol must be made before proceeding.

- To ensure correct computation of the SAR values, the weight of the participant has to be entered during registration.
- Participant burns
 - Never run coil cables over the participant's head.
 - Avoid direct contact between the coil cables & the participant.
 - Use only operationally satisfactory RF coils/coil cables.
 - In case of damage to coils or cables, contact Siemens Service.

In case of emergency

- Before working with the system, familiarize yourself with the location & functionality of the emergency switches.
- Report all accidents resulting in personal injury immediately to the MindCORE Facility Directors.
- Observe the established emergency plans (e.g., emergency plan in case of coolant accidents, emergency plan for fire fighting).
- Emergency switches:
 - The MR system has different types of emergency switches. In case of emergency, the relevant switch should be pressed
 - Magnet Stop switch (Quench)
 - Press the quench button if there is an immediate threat of injury or death due to the static magnetic field.
 - The Magnet Stop switch triggers a controlled magnet quench (shutting down the magnetic field).
 - The MR system is not disconnected from the power.
 - After the Magnet Stop switch has been pressed, an alarm is triggered at the alarm box.
 - The MAG STOP LED will light up & an alarm signal will sound.
 - As a rule, Siemens Service must be called following a quench. The magnet must be put back into operation by Siemens Service personnel.
 - Emergency Power Off switch
 - Press the Emergency Power Off button in case of fire or flooding.
 - The Emergency Power Off switch is a separate red switch located in the scanner room and the control room.
 - The switch is used to switch off the electric power of the entire MR system.
 - Table Stop button
 - The Table Stop button is used to stop motorized table movement.
 - It is located on the control unit & on the intercom.
- Medical emergency
 - If there is a medical emergency during MR scans:
 - Terminate the scan immediately
 - Remove participants from the scanner room for treatment unless it is certain that the medical equipment required is appropriate for use inside an MR room.

- Do not store or operate oxygen tanks, defibrillators or other auxiliary tools for resuscitation in the scanner room.
 - Coolant accidents
 - First aid in case of shortness of breath:
 - If a person becomes unconscious due to severe shortness of breath
 - Remove unconscious persons immediately from the examination room
 - Start CPR & contact a physician immediately
 - First aid in case of frostbite
 - Direct contact with subzero liquids, gases, & surfaces (e.g., pipes) may lead to frostbite
 - Do not rub frostbitten skin areas
 - Remove clothing carefully from the locations involved
 - Rinse frostbitten skin with lukewarm water
 - Cover frostbitten skin with sterile bandages
 - Do not apply powder or creams
 - Contact a physician immediately
 - Fire
 - The following devices/materials may be used for fire fighting:
 - Non-magnetic CO₂ extinguisher
 - Self-contained, anti-magnetic compressed-air breathing apparatus (or hose connection)
 - Airtight chemical protective suit
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