For any patient with any implanted non-plastic foreign body or medical device, the MR technologist should obtain a copy of the *TRA MR Technologist Worksheet for Magnetic, Conducting, and/or Metallic Implant* and:

- Complete Section 1
  - This must be completed for ANY non-plastic foreign object, including MR Safe implanted medical devices.
- Complete Section 2 for all MR Conditional implanted medical devices
  - Include both the MR system parameters and the device manufacturer specifications.
- Sign the form (and include the date and time) to attest that the exam may be performed safely on that particular patient in that particular scanner.
- Complete Sections 3, 4, and 5 based upon research results, including the MR safety information from the implant manufacturer.
- Provide the Worksheet and copies of the supporting documentation to an MR Radiologist who must authorize the MR procedure.
  - The MR Radiologist must also obtain patient consent.
- Scan into PACS the completed Worksheet, along with copies of all supporting documentation related to the MR safety of the device and the signed patient consent.

CRYOGEN SAFETY

The MR system magnet must be cooled with cryogens to maintain the state of superconductivity needed to create the intense magnetic field needed for medical imaging. The most common cryogen is liquid helium. Because its temperature is -269°C (-452°F), the cryogen poses physical hazards if it is ever released from the MR system.

Quench Considerations

Quenching is the process by which there is a sudden loss of the absolute zero temperature in the MR magnet coils. With the increase in temperature, the magnet coils cease to be superconducting and become resistive, thus creating heat and eliminating the magnetic field. This heat causes a sudden, explosive boil-off of the liquid helium. A quench may happen accidentally or may be intentionally, manually instigated by qualified engineers performing scheduled testing or maintenance or by an MR technologist in the case of an emergency.

If the MR facility is properly designed, nearly all of the released cryogens should escape through a quench tube that is connected to the scanner and vented to the outside of the building. A large cloud of vapors that lasts a few minutes will be seen and heard at the exit point of the quench vent. Although most of the gas will be vented to the outside, some cryogens may escape into Zone IV, filling it with a hazardous smoke-like mist.

If the MR facility is not properly designed or if the quench vent system fails, the cryogens will immediately fill Zone IV, creating a potentially deadly environment. Under either of these circumstances, immediate evacuation of the patient and all personnel is necessary

If the scanner room door is closed when a quench occurs and helium escapes into Zone IV, the depletion of oxygen will cause a critical increase in pressure inside the room compared to Zone III. If this high pressure in the Zone IV prevents opening of the door, the glass partition between Zones IV and III should be broken to release the pressure. The scanner room door can then be opened as usual and the patient evacuated. In such a case, after the immediate evaluation, the patient should be evaluated for asphyxia, hypothermia and ruptured eardrums.

Asphyxiation

Because gaseous helium is lighter than air and will float to the top of the room, large quantities can completely displace oxygen in the scanner room and, if inhaled, may cause asphyxia.

Cold Burns, Frostbite, and Hypothermia

Liquid helium and its cold gases can damage the skin producing an effect similar to a heat burn. Unprotected parts of the skin that come into contact with non-insulated items of cold equipment may also stick fast to skin, the flesh being torn on removal. The cold vapors from the liquefied gas may cause frostbite given prolonged or severe exposure to unprotected skin. Transient exposure to very cold gas produces discomfort in breathing and can provoke an attack of asthma in susceptible people.

Oxygen Enrichment

The cryogen may cause oxygen in the air to liquefy or to become oxygen enriched due to the low temperature. This oxygen-enriched air is highly flammable.

Quench Vent Issues

All MR systems should have helium-venting equipment that removes the helium to the outside environment in the event of a quench. According to the ACR (Kanal 2013), MR facilities should:

- Inspect cryogen vent systems at least annually, identifying stress/wear of pipe sections and couplings, loose fittings and supports or signs of condensation/water within the cryogen vent pathway that may indicate a blockage; and
- Following any quench, conduct a thorough inspection of the cryogen vent system, including pipe sections, fittings, couplings, hangers and clamps, before returning the magnet to service.

Because obstructions/occlusions of the cryogen vent can increase the likelihood of rupture in a quench event, facilities should ensure that the discharge point:

- Has an appropriate weather-head that prevents horizontal, wind-driven precipitation from entering, collecting, or freezing in the quench exhaust pipe;
- Is high enough off of the roof or ground surface that snow or debris cannot enter or occlude the pipe; and
- Is covered by a material of sufficiently small openings to prevent birds or other animals from entering the quench pipe, while not occluding cryogenic gaseous egress in a quench situation.

Facilities that discover failings in any of these basic protections of the cryogen discharge point should immediately take additional steps to verify the patency of the cryogen vent and provide the minimum current discharge protections recommended by the original equipment manufacturer.

To protect persons from cryogen exposure at the point of discharge:

- A quench safety exclusion zone with a minimum clear radius of 25 feet (8 meters) should be established and clearly marked with surface warnings and signage.
- The quench safety exclusion zone should be devoid of serviceable equipment, air intakes, operable windows or unsecured doors that either require servicing or offer a pathway for cryogenic gasses to re-enter the building.
- Individuals who must enter this quench safety exclusion zone, including incidental maintenance personnel and contractors, should be permitted to do so only after receiving specific instruction on quench risks and response.

EMERGENCY PROCEDURES

Emergency Shut Down

There are two types of emergency shut downs that may be initiated by the MR technologist (UCLA 2017): electrical shut down and magnet quench. Each must be reported to the Medical Director and Radiology Administration within 24 hours or one business day of the event.

Electrical Shut Down

During an emergency electrical or power shut down, the magnet is not quenched. All power to the MR scanner, scanner equipment (such as the patient table), and console computers is immediately stopped. Emergency lighting is not affected. However, depending upon the system design, there may be residual power to gradients and other devices in the scanner room – so electrical or fire hazards may still be present after the power shut down.