SUPERCONDUCTING MAGNET: BASIC SAFETY

When using nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI) and other superconducting magnetic equipment, there are a number of unique safety concerns to consider.

RESPONSIBILITIES

EH&S's Radiation Safety team is responsible for determining specific hazards for each facility housing such magnetic sources, identifying hazardous areas, reviewing safety precautions, and providing training when needed.

Supervisors and principal investigators are responsible for ensuring that all personnel are trained to safely perform the tasks assigned to them and that all protective control measures are maintained.

Non-user staff such as administrators and custodians should also be trained not to enter the magnet room.

Supervisors are responsible for ensuring that work done, in the vicinity of high magnetic fields, by facilities personnel or contractors will be carried out appropriately and safely. All contract work should be reviewed for safety concerns prior to scheduling.

MAGNETIC FIELD HAZARDS

- Ferromagnetic objects shall be kept outside a pre-determined radius in order to prevent those objects from becoming projectiles, which can cause severe injury to personnel as well as equipment damage.

  Examples of such ferromagnetic objects are: fire extinguishers, tools, radios, wheelchairs, keys, defibrillators, jewelry, hearing aids, magnetic stirring bars, watches, scissors, badges, and flashlights, among others.

- If the magnetic field is 100 gauss or greater, gauss lines of 100, 10, and 5 gauss should be clearly indicated. No work stations should be within the 5 gauss line, nor should the line intrude into public thoroughfares, nor entrances or exit spaces. This also includes locations above and below the magnet room.
- All gas cylinders shall be secured. If used within the 100 gauss line, all tools should be non-magnetic. Magnetic objects in general should be secured or kept outside the 100 gauss line.
- Magnetically-sensitive equipment, such as implants and cardiac pacemakers, can be adversely affected, resulting in injury or death. All individuals with cardiac pacemakers are restricted to areas that have a magnetic field of less than 5 gauss.
- Metallic implants (even if not ferromagnetic) can move in a magnetic field and in some cases become dislodged. In cases of a rapidly changing field, eddy currents

could possibly be induced in an implant, resulting in a serious heating of the implant.

> Examples of such implants include pins, shrapnel, insulin pumps, aneurysm clips, cochlear implants, and prosthetic limbs.

- All magnetic storage media, especially credit cards, can be destroyed by magnetic fields. Credit and ATM cards should be kept beyond the 10 gauss line.
- Room size should be considered when installing an NMR device: During a quench event nearly half of the helium volume will boil off very rapidly and form a white vapor above the magnet. Once a quench begins (boil off cryogens when the magnetic field is lost) it will not stop until all the helium boils off. The result is a very large and expanding vapor cloud. The room must be large enough to accommodate the initial cloud. Exhaust ventilation must be adequate for the room under quench event conditions.
- If room size or ventilation is inadequate, then helium vent pipes should be installed to the quench valve, or oxygen monitor-connected exhaust fans should be used.

CRYOGEN HAZARDS

- Both liquid helium and liquid nitrogen are colorless and odorless. If a sudden magnetic quench occurs, these gases can displace oxygen in the magnet room, causing asphyxiation. Oxygen sensor alarms should be installed.
- Liquid helium is at – 452°F and liquid nitrogen is at – 320°F. The liquid itself or its vapors can cause severe frostbite.
- During cryogen filling operations, personnel shall use at least thermal gloves, face shields, lab coats, long pants, and covered shoes. Proper procedures for filling and transport should always be followed. At least two staff members should be present during filling.
- Quench prevention is paramount. Training of personnel should include quench prevention and emergency procedures, including evacuation.

FIRE HAZARDS

- Magnetic systems fire can cause the magnet to dangerously rupture.
- If a magnetic quench occurs the extreme cold of the gases may cause the air to condense on surfaces. The moisture on these surfaces is most likely liquid oxygen and would be a potential fire hazard.
- At minimum, one fire extinguisher that is magnetically compatible should be available just outside the magnet room.

OTHER HAZARDS

- Caution should be taken around high energy power supplies to prevent accidental contact. Every attempt should be made to keep power cords and cables off the floor and reduce tripping hazards. Evacuation routes should be clearly visible. Unescorted visitors should never be allowed in the area of high magnetic fields.

- Electrical transformers could be magnetically saturated above 50 gauss.
- If flooding occurs there could be the risk of electrocution.

SIGNAGE

The appropriate signage shall be posted at all entrances to the magnet room indicating the hazards and prohibiting unauthorized personnel in the area.

EMERGENCY PROCEDURES

Emergency procedures are specific for each facility and should be organized (with assistance from the Radiation Safety team) and posted.

MAGNETIC FIELD UNITS AND CONVERSION FACTORS

Magnetic Fields are generally measured in tesla (T) or millitesla (mT). In the US, fields are often measured in gauss (G) or milligauss (mG).

1T = 1,000 mT

1G = 1,000 mG

1T = 10,000G

1mT = 10,000mG

MORE INFORMATION

Contact EH&S's Radiation Safety team at radsaf@uw.edu or 206.543.0463 for assistance with shielding, PPE, hazard evaluation and training.