Subject: Magnet Safety

Overview:

The purpose of this document is to define and clarify policies associated with the use of magnets and magnetic fields at University of Houston. Superconducting magnets pose unique safety concerns that include handling of cryogens, strong magnetic fields, high voltages/RF sources and the potential to create oxygen deficient atmospheres. The most severe of these hazards exists during magnet start-up procedures, cryogen filling and equipment maintenance activities. These hazards can be minimized if operators, maintenance personnel, students and/or visitors understand proximity limits and procedures to follow while working with magnets. In addition to the general hazards with superconducting magnets, persons with cardiac pacemakers, prosthetic limbs, insulin pumps, aneurysm clips should not be allowed to enter magnet rooms with field strength above 5.0 Gauss*. Only authorized personnel should have access to magnet room and equipment.

**This document references the American Conference of Governmental Industrial Hygienists Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices (ACGIH, 2009).*

Please contact the Environmental Health and Safety Bureau (EHS) of the UH Department of Public Safety (DPS) for additional questions regarding this policy at 713-743-5858.

1. Hazards Associated with Magnets

    1.1. Magnetic Field Hazards

- Ferromagnetic objects are strongly attracted to the magnet, and can become potentially lethal projectiles. Personnel can be severely injured and/or equipment can be damaged if hit by objects that are attracted to the magnet at a high rate of speed. Therefore, absolutely no ferromagnetic objects are allowed inside a magnet room or within the pre-determined radius of the magnetic field.

- Examples of items that must not enter the magnetic field or room include regular fire extinguishers, compressed gas cylinders, axes (fire fighters), guns, radios, flashlights, wheelchairs, stretchers, and defibrillators. Smaller metallic objects like badges, jewelry, watches, keys, dentures, glasses, hearing aids, hair accessories must be removed before entering the magnet room or magnetic field. Credit cards and magnetic storage media can be damaged and/or destroyed by the magnetic field and therefore should be housed outside the predetermined magnetic field lines.

- Metallic implants, prostheses and foreign metallic bodies (even those that are not ferromagnetic) can move or dislodge, causing severe injury. Examples include aneurysm clips, implanted pins, shrapnel, insulin pumps, prosthetic limbs, cochlear

implants, pacemakers, and cardiac or neural defibrillators. Persons with such devices are not authorized to access the magnet room and must be adequately warned. Magnets generate strong electromagnetic and magnetic fields that can inhibit the operation of magnetically-sensitive equipment (certain implants or external devices), resulting in death or serious injury to the user. The most common item in this category is the cardiac pacemaker. Persons with pacemakers should be restricted to areas where the magnetic field is less than 5.0 Gauss.

1.2. Cryogen Hazards (cryogens are extremely cold substances)

- Liquid helium is mainly utilized to maintain the magnetic field of strong magnet systems and sometimes liquid nitrogen is also utilized. Both liquids are extremely cold (liquid helium -452°F, liquid nitrogen -320°F), colorless, and odorless. A sudden boil-off of cryogens and accompanying loss of magnetic field (called a "quench") poses a significant safety risk. During a system quench (deliberate or accidental), gases generated by the rapid boil-off of liquid helium and nitrogen should be vented outside, but there exists potential for gaseous helium and nitrogen to be released into the magnet room. These gases will appear as a dense white fog, and visibility may be obscured in the vapor cloud. The released gases displace oxygen in the air, which can cause rapid asphyxiation and unconsciousness without warning. During the next few minutes the remaining helium will boil off. Nothing can be done to stop a magnet quench once it begins. Do not attempt to prevent the release, refer to emergency procedures.

- Contact with liquid or cold vapor can cause severe frostbite and therefore appropriate personal protective equipment (PPE) must be utilized. PPE includes the use of lab coats, thermal-rated gloves, face shields, safety goggles, etc.

1.3. Fire Hazards

- The cryogenic gases are not flammable; however, the extreme cold that exists during and immediately after a quench may cause air to condense and create liquefied oxygen on surfaces. Any liquid dripping from cold surfaces should be presumed to be enriched oxygen and treated as a potential fire hazard.

- Exposure of the magnet to intense heat (such as the conditions that exist during a serious structure fire) could cause the magnet to rupture violently if pressure relief devices fail. Cooling the magnet with water helps prevent the rapid venting of cryogens.

1.4. Other Hazards

- Superconducting magnets require a large amount of electrical power for operation. This power is proportional to the voltage utilized by the equipment. Therefore, when working around magnet equipment, electrical hazards must be considered.

2. General Guidelines for Magnet Safety

2.1. Magnet Locations

- All magnets capable of generating strong magnetic fields must be located in areas with restricted access to the public.
- Only authorized personnel should have access to magnet rooms.
- EHS will audit and assess magnet rooms to ensure safety and compliance with this policy.
- All magnet equipments must have standard operating procedures (SOPs). These SOPs must contain information on hazard identification and mitigation along with emergency procedures and contact information.
- Primary investigators (PI) and/or lab managers are responsible to implement safety protocols through development of standard operating procedures (SOPs) and providing adequate training for their personnel.
- No work stations should be designed or placed within the 5 Gauss field of a magnet. The 5 Gauss line should not extend into public thoroughfares or building egress routes. Individuals should be able to enter and exit the room without passing through strong magnetic fields. Magnetic fields must remain within the limits of the room or occupied area realizing that normal wall, ceilings and floor materials do not block static magnetic fields. Some magnets have the strongest magnetic fields which may occur at the bottom and top of the equipment where adequate shielding is not provided, and therefore consideration must be given to occupied areas above and below the magnet.
- At least one magnetically compatible fire extinguisher must be mounted immediately external to magnet rooms.

2.2. Room Size

- For superconducting magnets which utilize liquid cooling, the magnet room must be large and high enough to accommodate the helium cloud resulting from a quench (loss of superconducting field). During a quench, one half of the helium volume will boil off and be violently ejected from the helium vent on top of the magnet within one minute. This vapor cloud will seek the highest point in the room as it warms and expands up to 700 times in volume.
- A superconducting magnet room with required liquid cooling should always be sized so the space between the ceiling and the level of seven feet in the room is large enough to contain the initial volume of helium gas released from a quench. There must be adequate exhaust ventilation in the room of at least 10 air changes per hour.
- Oxygen sensors with associated local alarms must be installed in magnet rooms where there exists the potential for asphyxiation. Alarms for oxygen monitors

installed in the magnet rooms must activate when levels of oxygen are below 19.5%. For superconducting magnet units that utilize larger volumes of cryogens or for magnets in smaller rooms or in rooms with inadequate ventilation, helium vent pipes hard-ducted to the helium quench valve or automated exhaust fans tied to oxygen monitors must be installed.

- Supplemental ventilation, oxygen alarms and emergency procedures must be established when magnets are installed in below grade pits. These systems are required to warn personnel during cryogenic liquid vapor release that can collect in low areas and expand to create an oxygen deficient environment during a quench event. Because of this significant hazard only duly trained and experienced personnel should be allowed in the room during start-up.

2.3. Signage and Postings

- The PI and/or lab manager are required to post approved signage at all entrances to superconducting magnet rooms, conspicuously warning of magnetic fields and associated hazards to prevent entry by unauthorized personnel.

- A visible indicator demarcating the 5 gauss line should be installed after magnet start up. The indicator can be a temporary barrier or permanent floor marking.

2.4. Cryogen Safety

- When performing maintenance of superconducting magnets such as cryogen filling, the minimum personal protective equipment requirements are thermal gloves, face shield, lab coats, closed-toed (covered) shoes, and long pants.

- SOPs are required for Dewar filling and transport, cryogen spills and clean-up, response to emergency alarms including oxygen sensor alarms and magnet quench.

- Training is required regarding emergency procedures for magnet quench, catastrophic loss and discharge of coolant, causes and consequences of a quench event. In addition, training on how to prevent quenching, actions and notifications in the event of a quench, and evacuation procedures must be provided to authorized users and emergency personnel.

3. Emergency Procedures

3.1. Procedures for Staff

- <u>Emergencies:</u>

  For all emergencies, contact University of Houston's Department of Public Safety (DPS) by calling 9-1-1 from a campus phone line.

- <u>Non-Emergencies:</u>

During working Hours: All non-emergency incidents during normal business hours (8 AM – 5 PM) should be directed to EHS at 713-743-5858.

After Hours: For assistance with non-emergencies after business hours, contact DPS at 713-743-333

Personnel with access to the magnet rooms must be knowledgeable regarding magnetic fields, cryogen hazards, oxygen sensors, alarms, and other associated hazards.

On-site personnel, visitors and emergency responders without training must follow the direction of authorized personnel for existing hazards.

3.2. Medical Emergency

- In case of an emergency where an individual is conscious and oxygen levels are safe for entry, assist the person to safety. After providing available aid to the injured person, notify the safety contact designee and EHS at 713-743-5858 to report the incident.
- If an incident occurs, where an individual is unconscious or assistance from an outside emergency medical team is required, contact University of Houston's DPS by dialing 9-1-1 from a campus phone line. For non-emergencies follow the emergency procedures outlined above. In addition, notify the designated contact person of the area and EHS at 713-743-5858 of the incident.
- Authorized personnel must be posted at all direct entries to the magnet room(s) to greet emergency response personnel so that they may provide this document to emergency responders to remind them of the existing hazards. Available personnel must be ready to direct and assist responders, and to ensure that only magnet compatible equipment is taken into magnet rooms.

3.3. Fire Emergency

- All staff should review and familiarize themselves with the guidelines and procedures listed in the University of Houston's Fire and Life Safety Code policies from the Department of Public Safety MAPP 07.02.01.
- Be aware of the compatible fire extinguisher locations adjacent to magnet rooms. Follow the applicable emergency procedures outlined above.
- From a safe location, contact the designated personnel in charge of the magnet area and inform them of a fire emergency.
- Personnel must be posted outside the building or at all direct entries to magnet room floors to provide the applicable SOP document to emergency responders and remind them of the existing hazards.

For additional questions regarding this policy, please contact EHS at 713-743-5858.

A. Review and Responsibility

Responsible Party: Applicable UH Laboratory Managers/Research Center Directors, Supervisors as well as researchers are required to ensure these guidelines are followed.

University of Houston Environmental Health & Safety Bureau of DPS

Review will be conducted every even numbered year and as needed.

B. Approval Director, Environmental Health & Safety

Date of Approval: July 29, 2011