Environmental Health and Safety

Central California NMR Facility at UC Berkeley – Stanley Hall – Rm B-304.

Room B-304 Stanley Hall houses five superconducting magnets, including 500 MHz, 600 MHz, 700 MHz, 800 MHz, and 900 MHz systems. This document describes the potential hazards associated with working on and performing routine maintenance on these systems and is intended to be used to train users of the facility. As detailed below, the primary hazards are the potential for injury resulting from the strong attraction of ferrous objects with the strong magnetic fields, handling of cryogenic liquids, and the displacement of oxygen as a result of a magnet quench. Additional hazards, including the potential for fire, electric shock, floods, and trip hazards are also discussed.

- **Dial 911 for life threatening emergencies.**

- **Health providers**

  University Health Services/Tang Center
  2222 Bancroft Way #4300
  Berkeley, CA 94720-4300
  (510) 643-7197

  Alta Bates Hospital
  2450 Ashby Avenue
  Berkeley, CA 94705
  (510) 204-4444

- **Fire alarm**

  Use stairs rather than elevators to exit the building.

  Proceed up to level B1 and exit through courtyard.

  Wait in the parking lot next to Tan Hall for instructions.

Emergency contacts:

Jeff Pelton
510-666-2752 – office
510-524-6332 – home
510-439-8008 – cell

David Wemmer
510-666-2683 – office
510-527-2787 – home
510-207-7931 - cell

QB3 Facilities Management
510-666-2666 – office
510-326-0496 – 24 hr cell

Physcial plant – campus services
24 – hour maintenance – 642-1032

UC Police, non-emergency – 642-6760
UC Police, emergency – 911 or 642-3333

What to do if a fire alarm is activated during a cryogen fill.

Liquid nitrogen fill:

- Stop liquid flow by closing the valve.
- Leave hoses connected.
- Leave the building.

Liquid helium fill:

- Stop the flow of helium gas into the dewar by closing the valve at the He gas cylinder.
- Vent the dewar by opening the pressure release valve.
- Leave the transfer line connected to the magnet.
- On the 500, 600, and 700, reconnect the one-way valve at the He release port.
- On the 800 and 900, a one-way valve is always connected, even during fills. There is no need to immediately reconnect the one-way valve.
- Exit the building.

- **Magnetic fields and medical implants**

Persons with pacemakers or other electronic, electrical, or mechanical medical implants and devices must not enter room B-304 Stanley Hall due to the risk of damage to the device and possible injury or death.

Hazard analysis:
The operation of electronic, electrical, or mechanical medical implants, such as cardiac pacemakers, biostimulators, and neurostimulators may be affected or even stopped in the presence of either static or changing magnetic fields.

Besides electronic, electrical, and mechanical medical implants, other medical surgical implants such as aneurysm clips, surgical clips or prostheses, may contain ferromagnetic materials and therefore would be subject to strong attractive forces near to the NMR magnet system. This could result in injury or death.

Safety zone and magnetic fields

The safety zone is outside of the 5 Gauss line, marked around each magnet in yellow and black tape. Do not bring ferromagnetic objects (examples: iron or steel wrenches, other tools, or ferromagnetic electronic equipment such as power supplies) into B-304 Stanley Hall unless absolutely necessary, and do not cross the 5 Gauss line with such objects.

Steel gas cylinders must be kept out of the 5 gauss line of all of the magnets. Use the non-magnetic aluminum cart to transport the cylinders.

Hazard analysis:
Large attractive forces may be exerted on equipment in the proximity of the NMR magnet system. The force may become large enough to move the equipment uncontrollably toward the magnet. Small pieces of equipment may become projectiles.

Large equipment (e.g. gas bottles, power supplies) could cause bodies or limbs to become trapped between the equipment and the magnet, and may damage the magnet and cause a quench.

The closer a ferromagnetic object gets to the magnet, the larger the force. Also, the larger the equipment mass, the larger the force.

Safe handling of liquid nitrogen and liquid helium

The main hazards associated with handling liquid nitrogen and liquid helium are: A) burns when skin comes into contact with cold pipes or liquid, and b) asphyxiation if nitrogen or helium has expanded from its liquid form and the gas has displaced oxygen. To reduce the potential for injury, follow these guidelines:

- ***Avoid contact with cold unprotected pipes and vessels when working with liquid nitrogen or liquid helium.***

- ***Wear proper protective equipment:***

    - ***Dry leather or cryogenic gloves must be worn to avoid cold burns. The gloves must be loose fitting so that they can be removed easily.***

    - ***Goggles or a face shield must be worn to protect the eyes and face.***

    - ***Wear close-toed shoes and long pants while handling cryogens to protect feet and legs from accidental spills.***

- ***Metallic objects (e.g. jewelry) should be removed from those parts of the body that may come into contact with the liquid.***

- ***Liquid cryogens pose a potential asphyxiation hazard. Nitrogen expands by a factor of 680 and helium expands by a factor of 740 when changing from the liquid to gas phase. The expanding gas displaces breathable oxygen. To limit the asphyxiation hazard, liquid nitrogen and liquid helium should only be handled in well ventilated areas. Immediately evacuate the room if oxygen senor audible alarm sounds.***

- ***The extreme cold of liquid nitrogen and helium can cause oxygen to condense from the air, resulting in fire danger. Keep cryogen use areas free of combustible materials (paper, cardboard, machine oil, etc) and eliminate any other sources of ignition.***

- ***Never accompany cryogens in the elevator. If the elevator were to malfunction, the expanding gas could fill the elevator and pose a serious risk of asphyxiation.***

  Load dewar on elevator, post "No Passengers" sign on the dewar, and retrieve it after using separate route (stairs or another elevator).

- ***When transferring cryogenic liquids, always direct the flow away from others.***

Delivery of liquid helium dewars to Stanley Hall

Passengers should never accompany cryogens (liquid nitrogen or liquid helium dewars) in an elevator due to the risk of asphyxiation.

Procedure: Attach a sign to the dewar that states: Asphyxiation Hazard, PLEASE DO NOT ENTER ELEVATOR. Place the dewar in the elevator with the sign clearly visible, select the floor and close the elevator, walk down the stairs, and retrieve the dewar.

Hazard analysis:
The insulation of the liquid helium provided by the dewar is not perfect. As heat enters the dewar, small amounts of liquid helium are converted to the gaseous state. Helium expands by a factor of 740 during this conversion and displaces oxygen.. This could result in an asphyxiation hazard, if the elevator were to stop for a prolonged period and passengers were not able to exit the elevator.

Magnet quenches and oxygen sensors

A magnet quenches when the electrical resistance in the coil of wire that forms the magnet suddenly increases. The electrical current is rapidly converted into heat, which then causes the liquid helium surrounding the magnet to boil and expand. The rapid boil-off of liquid helium displaces oxygen, which poses an asphyxiation hazard.

The greatest chance of a low oxygen condition occurs during the quench of a magnet. All of the liquid helium and liquid nitrogen are converted to gas in a short time. Helium expands by a factor of 740 and nitrogen expands by a factor of 680 when transforming from the liquid to gas phase. The expansion poses an asphyxiation risk due to the displacement of oxygen.

The volume of the room is approximately 100,000 cubic feet, with complete air exchange occurring four times an hour (average flow rate 6,666 cubic feet per minute). The quench of the largest magnet would release 6,500 ft^3 of nitrogen gas and 7,000 ft^3 of helium gas in approximately 1 minute. Based on the above calculations, even a quench of the largest magnet should not cause the oxygen content in the room to drop below the OSHA standard of 19.5% oxygen for more than 10 to 15 minutes.

Never-the-less, two oxygen monitors are located in B-304 Stanley Hall. The oxygen level should read approximately 20.8% and vary within a few tenths of a percent. The Cal/OSHA standard for minimum oxygen content is 19.5%. A value lower than this is hazardous and the alarm should alert you to leave the room immediately.

In the event of a quench or oxygen sensor alarm:

- ***The loud release of gas from the top of the magnet indicates that a quench is occurring. Similarly, a loud alarm indicates the potential for low oxygen.***
- ***Leave the room immediately and close the doors.***
- ***Post signs on the doors stating –MAGNET QUENCH and/or LOW OXYGEN DO NOT ENTER.***
- ***Contact Jeff Pelton, David Wemmer, and QB3 facilities management.***
- ***Reassess the oxygen level after a period of 20 minutes.***

Compressed gas safety

- ***Most cylinders are made of steel, and because of their size, can be violently attracted to the magnets. Gas cylinders and gas carts should be kept out of the 5 Gauss lines of the magnets at all times. Also, use the non-magnetic wrenches provided to attach gas regulators. No not bring magnetic wrenches into the room for this purpose.***

- ***Cylinders must be stored in upright positions and immobilized by non-combustible restraints (chains) to prevent being knocked over.***

- ***Cylinder valve caps must be in place when not in use.***

- ***Cylinders must be moved only by a suitable hand truck.***

- ***A gas regulator must be attached and in good working order before use.***

- ***During use make sure that there are no leaks at the regulator. After use, make sure that the main valve is closed tightly and that there are no leaks.***

Hazard analysis:

Compressed gas cylinders containing low grade helium gas are used to pressurize liquid helium dewars as part of the liquid helium fill procedure. Compressed gas cylinders containing high grade liquid helium (research grade – 6 nines) are used to supply the helium compressors associated with cryoprobes. The hazards associated with compressed gas use in this facility are as follows:

- Steel cylinders are magnetic and can be violently attracted to the magnets.

- The cylinders contain high pressure gas. In the event the valve is broken, the cylinder can become a lethal rocket.

- Leaks can lead to the displacement of oxygen and therefore pose an asphyxiation hazard.

Other potential hazards:

- **Fire:**

  Pull the fire alarm located in the hallway next to the main entrance to room B-304 or dial 911 to report a fire. Two non-magnetic fire extinguishers are located near each of the two exits. These are Class A extinguishers that use water. They should only be used on certain types of fires, such as paper, cloth, cardboard etc. Do not use these extinguishers on electrical chemical fires. Only attempt to extinguish a fire if it is safe to do so. Maintain a safe exit path. Proceed up Stairwell 4 to level B1 and exit through the courtyard. Do not use an elevator.

  In the event of smoke or fire in a console, turn off the unit by pressing the red emergency-shutoff switch on the front of the console.

- **Floods, ceiling water leaks:**

  Floods and ceiling water leaks can present a danger of electric shock to the operator if the floor or electronics becomes wet. Immediately press the red emergency-off switch on the front of the console.

- **Electric shock**

  Consoles contain amplifers and other electronic equipment that operate at high voltage (120 V and 208 V). Do not reach inside electronics consoles. If you receive any kind of electrical shock, seek medical attention immediately (for example, the Tang Center). Even minor shocks can cause injuries that are not immediately apparent.

- **Obstacles**

  Tripping hazards exist in B-304 due to cabling between the magnet and consoles. Be careful when moving around in the lab. Do not stray beyond the yellow-black safety marks on the floor unless you are authorized to do so.

Document update history.

09-15-08	Added reference to 700 MHz system, which will be energized soon.
10-05-10	Added reference to UC Berkeley Cyrogens Fact Sheet Added instructions on what to do if filling cryogens and a fire alarm is activated.