

Nuclear Magnetic Resonance (NMR) Spectrometry LAB HAZARDS & SAFETY GUIDELINES

All NMR users should read and be familiar with the following safety information. There are multiple potential hazards in the NMR laboratory.

- Chemistry's NMR instruments use large superconducting magnets that are housed in a cryostat containing liquid helium and liquid nitrogen in room 5.19.5 and 5.19.6
Instruments: Bruker NMR Spectrometer 300MHz
Bruker NMR Spectrometer 400MHz
Bruker NMR Spectrometer 600MHz
- Every magnet has a stray magnetic field that extends beyond the physical structure of the magnet.
- NMR magnets are ALWAYS ON, so users must always exercise caution in the NMR lab.

Please let the NMR Chief Scientific Officer know of problems as soon as you encounter something that seems not quite right.

EMERGENCY CONTACT

NUMBERS:

NMR: Chief Scientific Officer:

Stephen De Doncker- 060 712 7270

NMR: Supervisor

Marwaan Rylands - 072 754 3551

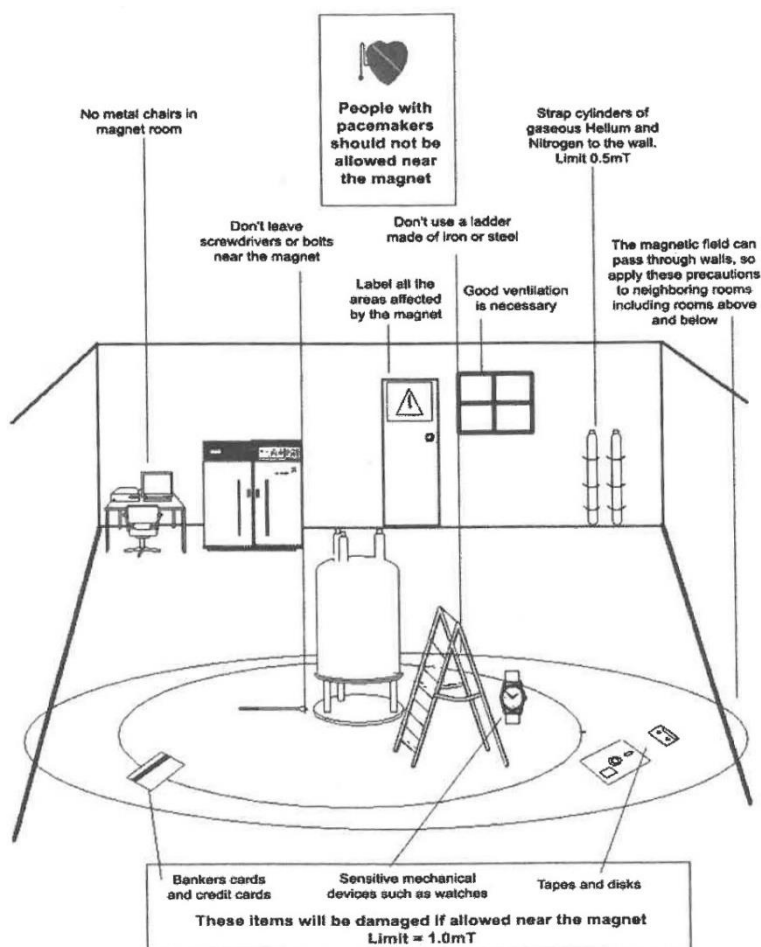
CEM OHSE UNIT

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CPS Risk Operations Centre

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HAZARDS:

A) Strong Magnetic Field

1. The superconducting magnet of NMR equipment produces strong magnetic and electromagnetic fields. It can suddenly pull nearby unrestrained magnetic objects into the magnet with considerable force. [Here](#) you can see a video of a demonstration of what happens when you get a heavy iron object too close to such a large magnet.
2. Keep the following in mind:
 - i. The closer to the magnet, the larger the force.
 - ii. The larger the mass, the larger the force.
 - iii. The superconducting magnets are ALWAYS on.
3. These magnetic fields can interfere with the function of cardiac pacemakers. Users of pacemakers and other implanted ferromagnetic medical devices are advised to consult with their physician, the pacemaker's manual and pacemaker manufacturer before entering facilities which house NMR equipment.
4. Small pieces of metallic subjects (wrenches, screwdrivers) may become projectiles.
5. Large equipment (gas cylinders) can significantly damage the instrument and likely injure anyone in the way or who attempts to stop the motion once it starts. This can trap bodies or limbs between the equipment and the magnet.
6. If such items above were to get stuck in/on the instrument, the magnet would probably need to be de-energized in order to remove them. This would be very expensive and lead to extended down time.
7. The magnet can erase magnetic media, disable credit/debit cards and damage analogue watches.

B) Cryogen Hazards

A concentric dewar of liquid nitrogen is placed around the helium cryostat in order to keep the helium boil-off rate low. Additionally, liquid nitrogen may be kept in portable dewars in the facility. The liquid nitrogen (LN₂) and liquid helium (He) that are present in the magnet cryostat and portable dewars may pose several dangers:

1) Asphyxiation – Cryogenic Liquid Spillage/Magnet Quenching

- In the event of a magnet quench, the superconducting wire inside the instrument transitions to a normal conducting state.
- This would boil off all of the liquid helium very quickly. [Here](#) is a video of a magnet quenching.
- The rapid expansion of helium as it vapourizes can displace the oxygen in the NMR lab.
- Due to their large expansion ratios (nitrogen 695:1, helium 760:1), these gases can quickly displace all the oxygen in the NMR room and cause asphyxiation.
- Effects from oxygen deficiency become noticeable at levels below ~18% and sudden death may occur at ~6% oxygen content by volume.

2) Frostbite

Direct contact with cryogenic substances in liquid or vapour form can produce “cold burns” on the skin similar to conventional burns. The temperature of liquid helium (LHe) is -269°C and of liquid nitrogen (LN₂) is -196°C.

3) Chemical Explosions

- Cryogenic fluids with a boiling point below that of liquid oxygen are able to condense oxygen from the atmosphere.
- Repeated replenishment of the system can thereby cause oxygen to accumulate.

- Violent reactions e.g. rapid combustion or explosion may occur if the materials, which make contact with the oxygen, are combustible.

C) Chemical Hazards: Hazardous and Dangerous Materials

1. All users who conduct experiments with hazardous materials, including toxic, pressurized, explosive or otherwise unusually hazardous materials must closely follow Chemistry's Health and Safety guidelines in regard to chemicals.
2. Failure to do so may jeopardize the environment and safety of all users and may lead to suspension of facility access privilege and payment of any clean-up cost.

D) Breakage of NMR sample tubes

1. Broken Glass piercing skin or goes into eye/s.
2. Absorption of sample chemical into cut wound or through skin.
3. Glass & sample residue in NMR or NMR lab.

SAFETY GUIDELINES & RULES OF NMR LAB

A) **NMR staff** are responsible (besides the normal technical duties i.e. the NMR equipment) to also abide by the following i.e. to health and safety rules:

1. Manage and control access of persons to NMR laboratory.
2. Ensure signage warning against strong magnetic fields are up and clearly visible at entrance.
3. Train and inform everyone not just of the use of the NMRs, but also on these hazards and safety guidelines.
4. Follow the safety rules in regards the refill of liquid nitrogen and helium when they fetch and replenish the magnet's cryogenes.
5. Avoid skin contact with cryogenic (liquid) helium and nitrogen.
 - i. **Protective clothing, including lab coats, closed-toed shoes, cryogenic protective gloves and splash proof eye protection MUST be worn by all individuals who handle or are in close proximity when cryogenic liquids are being transferred, during dewar filling and replenishment.**
 - ii. **During a fill of NMR, All PPE should be worn when setting up the fill and keep away from the gaseous exhaust from the magnet as frostbite burns may result.**
 - iii. **When filling up the NMR machine with the cryogenic liquid make sure the laboratory doors are open and no person and in the laboratory.**
 - iv. **Always make connections to storage dewars carefully and without force.**
6. Ensure that ventilation is sufficient to remove the helium or nitrogen gas exhausted by the instrument.
7. Avoid positioning your head over the helium and nitrogen exit tubes.
8. Care must be taken to avoid overturning of the magnets. No person should ever lean on the magnet or pull on the magnet when climbing up or down when tuning the magnet.
9. Cryogenic storage dewars can also be overturned quite easily. They should never be pulled from the top, but rather from the handles provided.

B) **All users:**

Rules of Use of NMRs:

1. Each spectrometer requires training with the NMR Chief Scientific Officer

2. An authorized user must demonstrate to the NMR Chief Scientific Officer (or another trained user, designated by the Chief Scientific Officer) that he/she can use the specific NMR instrument without assistance from another person, and without endangering either themselves or the spectrometer.
3. Unauthorized or another authorised user may NOT attempt to train a NEW user on any instruments – this may ONLY be completed by the NMR Chief Scientific Officer.
4. No person may enter the NMR laboratory without authorization from the NMR Chief Scientific Officer.
5. Each research lab is required to cover damage to the NMR Facility as a result of inappropriate use.
6. Users will be charged according to the departmental NMR price list
7. The NMR Chief Scientific Officer reserves the right to deny spectrometer access if the instrument is used inappropriately or if the user does not follow the standard laboratory conduct or rules in this and the user policy.

Additional Important Safety Rules:

8. Keep all metal or suspected metal containing tools, equipment, trolleys and personal items containing ferromagnetic material (e.g. steel, iron) at least 2 metres away from the magnet in the NMR.
9. Limit the amount of time spent close to the NMR magnet
10. **NEVER** put any object into the magnet except NMR tubes and sample holders.

11. Medical Implants & Devices:

- i. 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.
 - ii. Medical implants such as aneurysm clips, surgical clips or prostheses may contain ferromagnetic materials and therefore would be subjected to strong attractive forces near the magnet. This could result in injury or death.
 - iii. Additionally, in the vicinity of rapidly changing fields (pulsed gradient fields), eddy currents may be induced in the implant resulting in heat generation.
 - iv. **Persons with these types of implants MUST remain outside the NMR laboratory.**
12. Remove all personal articles containing metal or items that can be demagnetized such as hairpins or jewellery, wallets and cell phones before entering NMR lab.
 13. Do NOT bring compressed gas cylinders into the NMR lab without NMR staff supervision.
 14. The NMR magnets are quite large. **Steps and/or ladders** are provided to facilitate putting your sample in the magnet.
 - i. Take caution to avoid losing your balance and falling.
 - ii. Adjust the ladder or stepladder position so the NMR sample can be safely inserted and removed.
 - iii. Step stools or ladders must be of non-metallic & contain non-metallic parts.
 15. NEVER put any object into the magnet, except the NMR tube and holder.

C) NMR TUBES/SAMPLES:

NMR tubes are thin-walled and are easily broken; handle them carefully and reserve them for NMR use only.

1. Once broken, they are extremely sharp and pierce skin easily.
2. **Handling of NMR tube/sample:**
 - Cap/seal all sample tubes properly.

- All NMR samples **MUST** be labelled appropriately with an appropriate identifier to avoid safety issues of unknown compounds and all samples submitted must be logged in the NMR logbook
- Transport sample tubes from lab to NMR lab & back in appropriate secondary safety containers, **NOT** simply in a flask or another open container.
- Use material such as Styrofoam to steady and secure tubes in and place in a secondary container such as a tray or bucket.

NOTE Please **DO** the following

- **DO** use your fingers instead your palm when inserting an NMR tube into a spinner and/or depth gauge.
When inserting an NMR tube into spinner, grab the tube close to the spinner. This will avoid applying a torque that can easily break a tube and often drive it into a finger.
- **DO** dispose of NMR tubes that are chipped, cracked, scratched or damaged.
Damaged NMR tubes greatly increase the likelihood of personal injury and equipment damage.
- **DO** remember to **TURN ON** (press the eject button) *the lift air* before inserting your sample in the magnet. Neglecting to do so can break your sample and damage the instrument.

DO NOT do the following

- **DO NOT** use excessive force to fix a cap to an NMR tube.
- **DO NOT** put an empty spinner into the spectrometer. They are impossible to retrieve.

NOTE

- When using NMR tubes filled with highly toxic and dangerous materials the NMR staff must be informed of these dangerous materials. Best to talk to the NMR Chief Scientific Officer beforehand on procedures to be followed.

D) THE NMR LAB:

- Keeping a shared lab clean requires the cooperation of everyone.
- You must wear long pants (or equivalent) and closed-toed shoes.
- No food or beverages are allowed in the NMR lab.
- **DO NOT bring your lab coat or gloves into the NMR lab.**
- Gloves **MAY ONLY BE ALLOWED** when handling a hazardous sample. **BUT may NOT** be worn for any other NMR work or typing or pushing any buttons in the NMR lab.
- It is not a wet lab and there are no fume hoods in the lab, therefore all sample preparation should be done in your lab.
- No other chemicals, except your samples may be stored at or brought to and into the NMR lab.
- Should you break a sample in the NMR lab, use the items in your lab to thoroughly clean up the area of the spill.
- Please **DO NOT** leave KimWipes, paper towels, etc. laying around.
- If you believe any sample may have spilled into or onto one of the instruments, please notify the NMR staff immediately.
- Place a written note on the keyboard to inform the next user.
- Dispose of the waste or spill clean-up waste generated at your lab.
- Sample spinners are extremely expensive, precision machined items.
 - i. Never take spinners out of the NMR labs.

- ii. Do not drop them on the floor or place them on their sides so that they may roll off the bench and on to the floor.
- iii. If your tube does not fit the spinner, either your tube or the spinner O-ring needs to be replaced. If you think it might be the O-ring, please contact the NMR staff.
- If the fire alarm goes off, please leave the lab and evacuate the building.

INCIDENTS

Listed below are the procedures to follow for various types of incidents that can occur in the NMR laboratory.

- A) In the event of **exposure to cryogen liquid or gas**, the following **first aid procedures** are recommended:
1. Immediately remove the person from the cryogen hazard (or vice versa).
 2. Remove clothing that may interfere with the circulation of blood to the frozen tissues, but do so slowly, to prevent additional damage to skin.
 3. Do not rub or massage the affected region.
 4. Immerse the affected area in a warm water bath <40°C or exposure to warm air of the same temperature range.
 5. After this rub more than enough Burnshield in on burnt area/s.
 6. **Eyes** exposed to cryogen liquids or gases should be flushed with warm water, <40°C, for at least 15 minutes.
 7. The person should seek immediate medical attention.
- B) If there is a **sudden exhaust of gas** from one of the magnets (and NMR staff are not performing a cryogen fill) or if the oxygen sensor alarm sounds, **EXIT the NMR lab IMMEDIATELY**.
1. Leave doors to the laboratory open to aid in the dispersal of helium and nitrogen gases.
 2. Once outside the NMR lab, contact the NMR emergency numbers ASAP.

Please take note of the following:

- A developing quench can be detected by visible (and/or audible) emission of cryogenic gas from the magnet. (may co-inside with an explosive sound).
- The gas that is exhausted during a quench or a fill can be extremely cold.

C) Breakage of NMR Tubes & Chemical Spills

1. Clean up non-hazardous spills and broken glass immediately using items from your lab and chemical clean-up kit.
 2. Dispose of the clean-up material and broken glass appropriately at your lab.
 3. For toxic or hazardous materials, **DO NOT** attempt to clean up yourself. Instead, inform the NMR Chief Scientific officer and the **CEM OHSE unit** immediately.
- As indicated NMR tubes have thin walls and are easily broken.
 - Once broken, they are extremely sharp and can pierce the skin and cause chemical absorption in this way too.
 - Be aware of the chemical hazard of your sample prior to NMR work.

It is your responsibility to report any incidents to the NMR Chief Scientific Officer immediately.

D) In case of a Fire

NOTE Use only carbon dioxide fire extinguishers to avoid equipment damage.