77 Massachusetts Avenue,
Cambridge, MA 02139

Magnet Safety Guide

(617)-452-3477 | environment@mit.edu | ehs.mit.edu

MIT EHS
ENVIRONMENT · HEALTH · SAFETY

Delegation of Authority

MIT has a standing institute **Committee on Radiation Protection** to oversee all uses of radiation at the Institute and its associated off campus locations. They give the RPP authority to stop any experiment or process involving radiation that is deemed unsafe.

Units of Magnetic Fields

Flux density, B, or magnetic induction: the total number of flux lines passing through a given area. In the *CGS system* a ***gauss (G)*** is one flux line passing through one square centimeter. In the SI system the ***tesla (T)*** is 10,000 lines per square centimeter.

MIT's Magnet Exposure Limits

Exposure Condition		ACGIH - 2009		ICNIRP [a] – 2009	
		SI Units	Traditional	SI Units	Traditional
Occupational Limit	Whole Body (no exposure allowed above this limit)	2 T	20,000 G	2 T	20,000 G
Special Training/ Specific Authorization[b] [c]	Whole Body (Special worker training and controlled workplace	8 T	80,000 G	8 T	80,000 G
Extremity Ceiling Limit	Limbs (no exposure allowed above this limit)	20 T	200,000 G	-	-
General Public Limit (no implants)	Exposure of any part of the body			400 mT	4000 G
Medical Device Wearer[d]	Highest allowed field for implanted cardiac pacemakers	0.5 mT	5 G	0.5 mT	5 G

1 T = 10,000 gauss

Notes:

a) ICNIRP recommends that these limits should be viewed operationally as spatial peak exposure limits
b) For specific work applications, exposure up to 8 T can be justified if the environment is controlled and appropriate work practices are implemented to control movement-induced effects
c) Not enough information is available on which to base exposure limits beyond 8 T.
d) Because of potential indirect adverse effects, ICNIRP recognizes that practical policies need to be implemented to prevent inadvertent harmful exposure of persons with implanted electronic medical devices and implants containing ferromagnetic material, and dangers from flying objects, which can lead to much lower restriction levels such as 0.5 mT.

Magnet Registration

Registration required for all magnets ≥ 2 tesla

- Anyone working in a room with such a magnet should complete the **web-based training** (found on RPP website).
- An RPP officer will perform hazard assessment of all magnet labs and surrounding rooms.

Types of magnets:

- superconducting electromagnets
- ambient temperature electromagnets
- permanent magnets

Required Postings:

5 gauss > 30 cm (equipment posting)

30 gauss ≥ 30 cm (door posting)

Always contact RPP when acquiring a new magnet.

Cryogenic Safety

Protective Equipment

When working with cryogens, be sure to wear PPE:

- Face Shield
- Cryogen protective gloves
- Pants or trousers
- Closed-toe shoes

Oxygen Monitors

Oxygen monitors are an institute requirement in rooms with newly installed registered superconducting magnets.
MRIs may also be equipped with a ventilation system for expelling quench gases outside a facility.

Superconductivity

High magnetic fields can be obtained using superconductive wire which has exactly zero electrical resistance.

This phenomenon requires ultra low temperatures and is maintained using LN_2 and LHe.

Quenching

In an **emergency**, some rooms are equipped with an emergency button that which causes a heat pulse which raises the temperature of the magnet coils to terminate the superconductive state.

Consequently, the LHe rapidly changes from a liquid to gaseous state.

If not controlled or externally vented, cryogen quench gas can displace oxygen in the room and lead to asphyxiation.

Oxygen alarms are required

Magnetic Fields: Physical Properties

Time varying magnetic fields are those generated by alternating currents having frequency above zero and up to about 300 Hz. May also be referred to as extremely low frequency or ELF magnetic fields.

Static magnetic fields do not vary with time (frequency of 0 Hz). They are created by a magnet or by a steady flow of electricity, for example in appliances using direct current (DC).

Strongly magnetic metals:

- Ferromagnetic element: iron, nickel, cobalt + their alloys (permalloy, mumetal)
- Ferrimagnetic: ferrites
- Permanent magnets: ALNICO, rare earths

Non-magnetic metals:

- All other metals (permeability μ = 1/1000 Fe)

Using Magnets Safely*

Force Hazards:

- Large attractive forces: force may become large enough to move equipment towards magnet system, causing small objects to become projectiles.
- Large equipment could trap a person (or their limbs) between the object and the magnet.
- The closer the ferromagnetic object gets to the magnet, the larger the force.
- The greater the equipment mass, the larger the force.

Effects on medical implants and devices:

- Electronic and mechanical medical implants and devices should never be exposed to fields above 5 gauss.
- The operation of devices such as cardiac pacemakers, biostimulators and neurostimulators may be affected or stopped in the presence of either static or changing magnetic fields.
- Medical surgical implants may contain ferrous materials, resulting in strong attractive forces near powerful magnets.

Heating Hazard:

In rapidly changing fields, eddy currents may be induced (particularly in a medical implant), resulting in heat generation, leading to a possible life-threatening situation.

Actively Shielded Magnets:

- Active shielding of the superconducting coil reduces stray magnetic fields.
- Magnetic field gradient is much stronger compared to non-shielded,
- Stray magnetic fields directly above and below the magnet can be very high

Technical Hazard in a field:

- Watches, phone, etc. may be magnetized and irreparably damaged if exposed **great than 10 gauss**.
- Info on credit cards and magnetic tape may be irreversibly corrupted.
- Electrical transformers may become magnetically saturated in fields **above 50 gauss**, affecting safety characteristics.

Ramping Magnet to Field:

Before: Remove all loose ferromagnetic objects within the 5 gauss line.

- Display magnet warning signs at all points of access to room.
- Display warning signs of possible presence of magnetic fields and potential hazards in ALL areas which may exceed 5 gauss.

After: Do NOT bring ferromagnetic objects into room.

- Use only non-magnetic cylinders and dewars (and equipment to transport these items) for storage and transfer of compressed gas or cryogenic liquids.

General Safety Precautions:

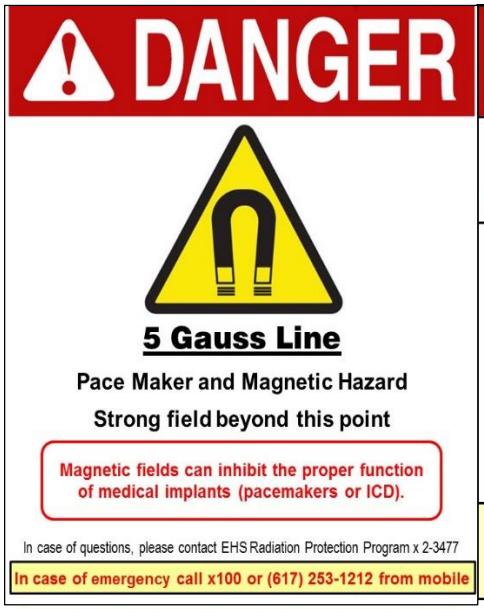
- Every magnet site location should be reviewed individually by RPP to determine the precautions that must be taken against these hazards.
- Consideration must be given to floors above and below the magnet as well as adjacent rooms at the same level, since the magnetic field produced by the NMR magnet is three dimensional.

Gradient Hazard:

- Torque + translational force
- Most commonly from fringe fields

**compiled from "General Safety Considerations for the Installation and Operation of Superconducting Magnet Systems", Rev. 1.1, 03/29/2002, Bruker*

Required Postings and Warning Signs



Small Magnets Warning

Children or pets could swallow small magnets. It is possible for the magnets to get stuck in the intestine and cause severe injury or death. This hazard is particularly prevalent for rare-earth magnets.

- Magnets are not toys; make sure that children do not play with magnets.
- Keep track of small magnets and store them in child-proof locations.
- Wear safety glasses when handling non-coated magnets as forceful impacts (snapping together) can cause chips which pose an eye hazard.

9 Traits of a Positive Safety Culture

1. Leadership Safety Values and Actions
2. Problem Identification
3. Personal Accountability
4. Work Processes
5. Continuous Learning
6. Environment for Raising Concerns
7. Effective Safety Communication
8. Respectful Work Environment
9. Questioning Attitude

Rev 2.0 06/11/2020