NATIONAL HIGH MAGNETIC FIELD LABORATORY

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National High Magnetic Field Laboratory Safety Program

TITLE: Magnet Cell Safety Program (DCMB)	**SUBJECT:** Hazards and associated safety practices around resistive, superconducting and hybrid magnets located in DCMB
PROGRAM NUMBER: SP-16	**EFFECTIVE DATE:** July 19, 2006
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ISSUING AUTHORITY: Safety & Admin	**REVIEW DATE:** September 6, 2024
Additional Approval Signatures on Revision and Approval Page in Appendix	**APPROVAL:** NHMFL Deputy Lab Director DocuSigned by: Eric Palm 074CDA665DEF4E8...

Overall Mission and Overview

The National High Magnetic Field Laboratory (NHMFL) Environmental, Health, and Safety (EHS) program's mission is to:

Provide support and guidance to all NHMFL departments with the implementation, maintenance, and review of a comprehensive environmental, health, and safety program. The primary goal of the MagLab Safety Dept. program is to control, reduce or eliminate work-related injuries, illnesses, and loss of NHMFL resources.

The NHMFL is charged by the National Science Foundation (NSF) to safely:

- Promote magnet-related research to serve an interdisciplinary scientific user community.
- Provide unique high-magnetic-field facilities through a competitive and transparent proposal review process.
- Advance magnet and magnet-related technology.
- Partner with universities, other national laboratories, and industry to enhance national competitiveness in magnet and related technologies.
- Serve the NSF as a prominent example of its successful stewardship of large research facilities.
- Support science and technology education in the United States.
- Increase diversity in the science, technology, engineering, and mathematics workforce.
- Promote collaboration among our three partner institutions: Florida State University (FSU), the University of Florida (UF) and Los Alamos National Laboratory (LANL).

MAGNET CELL SAFETY PROGRAM (DCMB) INDEX

1.0 PURPOSE:

The purpose of this procedure is to outline potential hazards and associated safety practices for working in the DC Field Facility research environment. In particular, this document provides information on and a framework of guidelines and rules for any person entering or working in a resistive, superconducting and/or hybrid magnet research cell in the DC Magnet Building or the Millikelvin Facility.

- Conformance to this program ensures that sources of hazard are properly identified and personnel are adequately informed and protected.
- The use of this program will ensure consistent application of the NHMFL magnet cell work and safety requirements across all work and/or research activities.

2.0 SCOPE:

This program is to be used by all personnel at the NHMFL, including employees, students, visitors, internal and external facility users and contractors. This program identifies potential hazards associated with the operation and use of:

- Water-cooled, resistive magnets,
- Superconducting magnets,
- Hybrid (water-cooled resistive + superconducting) magnets.

The program provides rules and guidelines for anyone entering a resistive, superconducting and/or hybrid magnet cell, and defines requirements for the protection of personnel from workplace hazards associated with the operation of the research magnets in the DC Magnet Building and Millikelvin Facility.

This program also establishes responsibilities as applicable for the administration and implementation of the program. All internal and external users, contractors, NHMFL personnel, and visitors are required to comply with this program.

All NHMFL personnel and users who work around or with the magnet systems in the DC Magnet Building or in the Millikelvin Facility must complete the assigned online safety training prior to accessing the facility. It is the responsibility of NHMFL staff and users to understand and act according to the safety training and on-site training while working at the NHMFL.

Employees who fail to follow the rules and guidelines for conduct around a resistive, superconducting and/or hybrid magnet or who fail to take appropriate steps to protect the safety of all personnel who are performing work around the magnet are subject to disciplinary action in accordance with the NHMFL Safety Disciplinary Policy. External users, visitors or contractors who fail to follow the rules and guidelines for conduct around a resistive, superconducting and/or hybrid magnet or who fail to take appropriate steps to protect the safety of all personnel who are performing work around the magnet are subject to expulsion from the facility.

3.0 GENERAL RULES AND GUIDELINES

Protective/adequate footwear: It is mandatory to wear closed-toe footwear in the DC Magnet Building. Footwear must provide secure footing on stairs and ladders.

Arrange equipment neatly: Experimental equipment must be arranged neatly in the magnet cell. The experimental setup must be arranged to ensure sufficient work-space around the equipment. Do not block the platform, staircase or the way of egress out of the experimental area.

Mitigate trip hazards: Cables and hoses should be tied up neatly. Use cable covers when cables or hoses are routed across the floor. Use Velcro straps to secure cabling to hand-rails or to equipment carts. Cable covers and Velcro ties can be obtained from User Support personnel.

Housekeeping: The users of an experimental area are responsible for keeping the experimental area neat and orderly during an experiment and for returning all equipment and supplies to their proper places after finishing. Food and drinks may only be stored and consumed in "Dedicated Eating Areas".

Secure compressed gas bottles: Compressed gas bottles must be secured using dedicated wall mounts or approved table mounts.

Supervise energized magnet systems: There must be at least one person in the resistive or hybrid magnet cell whenever magnet control has been transferred to the cell. If you need to leave the magnet cell, contact the Control Room and ask the operators to take control of the magnet system during your absence. If users of a magnet cell fail to contact the Control Room operators and leave the energized magnet system unattended, Control Room personnel will immediately remove control from the cell and ramp the magnet down**.** This rule also applies at zero current when control of the magnet is with the users in the magnet cell.

Work in pairs: It is a recommended best practice to have two persons present and participating during experiments in a magnet cell. This becomes especially important after normal business hours when Operations staff are less available. If you need an extra person temporarily to help with an operation, contact the Control Room and ask for help.

Magnet Cell Access: The user is responsible for the safety of everyone, other than Operations staff, who are in the cell during a magnet run. The user must warn anyone entering the cell that the magnet is energized. The user must inform anyone entering the cell of hazards in the cell. The user has the authority to direct anyone who is not a member of the Operations staff to leave the cell if magnet operations require this.

Closing off a magnet cell: Roll-out barriers are mounted across the front of each resistive and hybrid magnet cell. A magnet cell may be closed off to keep unauthorized personnel out of the experimental area while performing a hazardous task or sensitive experiments. The reason for the

cell closure must clearly be noted to inform Operations staff of the status of the magnet cell. If closing off a cell: Indicate the reason for the cell closure, your name and phone number if you are not present in the cell.

ISM process: The NHMFL follows the Integrated Safety Management process as outlined in the online safety training. Any person working in the DC Magnet Building must apply the ISM process and perform a Task Hazard Analysis (THA) before engaging in any potentially hazardous activity. THA forms and assistance with the process may be requested from the Control Room personnel or User Support staff.

Be alert: Be observant about the condition of your experimental area. Contact the Control Room if you notice anything you feel is abnormal (noises, smells etc). Be aware of the location of emergency stop buttons, fire extinguishers, fire alarm pull stations and safety showers in relation to your work area.

4.0 HAZARDS ASSOCIATED WITH MAGNET OPERATIONS AND ASSOCIATED RULES & GUIDELINES

Electrical Hazards: The resistive and hybrid magnets are powered by one or more 700 V, 20 kA DC power supplies. These power supplies are connected to the magnets via thick, green, water-cooled cables. The terminals on either end of the green cables are a potential source of a lethal shock hazard. The cables connect to the power supply bussing at the back wall of the magnet cell. The terminals are barricaded off by plexiglass/plastic sheathing (Figure 1).

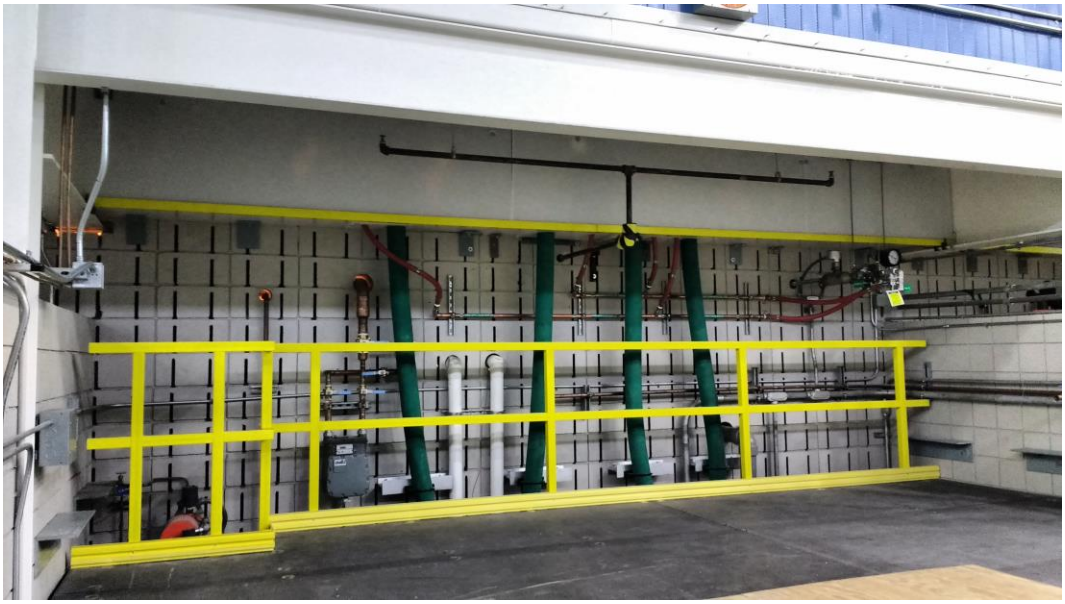

Figure 1: Green, water-cooled cables connect to the power supply bussing at the back wall of the magnet cell. The terminals are barricaded off by plexiglass/plastic sheathing to protect personnel from exposed conductors.

The cables connect to the magnet terminals under the personnel platform. The cable-to-magnet terminals are covered with insulating cable covers (Figure 2). Access under the magnet platform is closed off by protective paneling. Access under the magnet platform is prohibited unless authorized by the Control Room personnel (Figure 3).

Figure 2: The cable-to-magnet terminals are covered with insulating cable covers to shield personnel from exposed conductors.

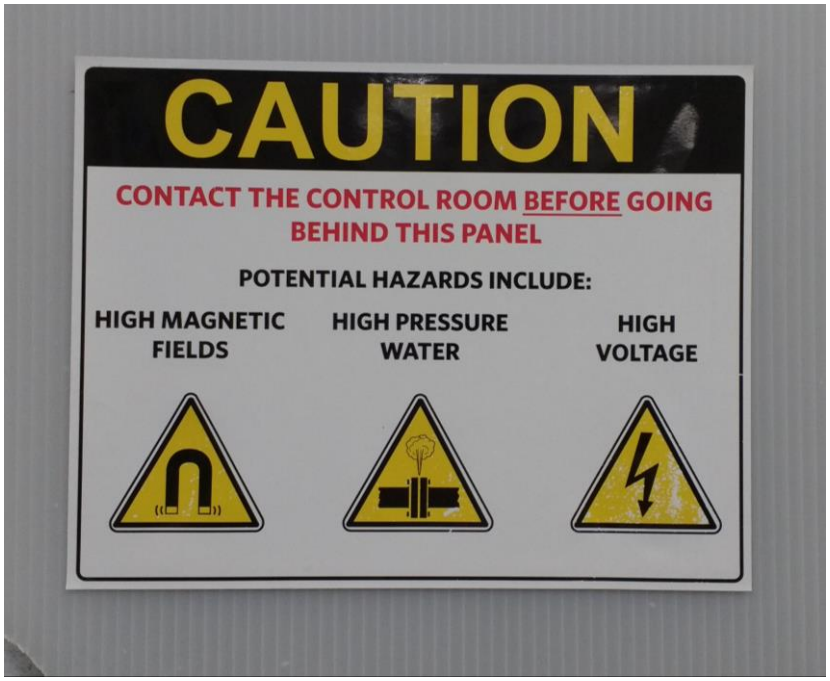

Figure 3: Access under the magnet platform is closed off by protective paneling. Comply with signage. Access under the magnet platform is prohibited unless authorized by the Control Room personnel.

The magnet housing is in contact with the magnet through the magnet cooling water and the

magnet housing is grounded to the facility's grounding grid. The magnet bore tube is grounded through a 20 Ω resistor to detect any ground faults.

High Pressure Water: The resistive magnets are cooled with high-pressure water, i.e. there is high-pressure water (up to 500 psi/34.5 bar) flowing through the magnet housing and in the connected pipes at a rate of several thousand gallons per minute. In case of a bore tube rupture or housing failure, high pressure water will be forced from the magnet system. Limit your exposure to the top or bottom of the magnet whenever magnet cooling water is circulating through the magnet system.

Handling of Cryogenic Liquids: Only trained and authorized personnel are permitted to handle cryogenic liquids. While handling cryogenic liquids appropriate personal protective equipment must be worn:

- Face shields and gloves are available for each cell and may be obtained from the Cryogenics Operators or User Support personnel.
- Eye protection must be used when handling cryogenic fluids.
- Gloves must be used when removing a transfer tube from a dewar.

Magnetic Fields: The magnets in the DC Field User Facility provide strong magnetic fields up to 45 T. The fringe magnetic fields extend well beyond the magnet itself and may even penetrate into adjacent rooms or experimental areas. When energized, strong magnetic fields exist around the magnet and will affect the entire experimental cell. Yellow lines on the floor of the magnet cell/experimental area, indicate where the magnet's field has dropped to 100 Gauss and 10 Gauss.

Guidelines:

- Individuals with pacemakers must consult with NHMFL Operations or Safety personnel before entering magnet cells.
- Steel, iron or other magnetic objects should be fastened down or kept behind the 100-G line. Be very sure that screwdrivers, wrenches and other hand tools are not left around the magnet because the force between the magnet and the ferromagnetic metal might cause them to be pulled into the magnet. If tools are needed in areas with high fringe fields non-magnetic tools must be used.
- User electronics should be set up outside the 100 Gauss line.
- Credit cards, watches, computers, etc …should be kept outside the 100-G line.
- Be especially aware of the location of compressed gas cylinders, as they must be kept behind the 100 G line.

Access to the Magnet Systems:

Access to the magnet platform for water-cooled magnets: Access to the magnet platform is

permitted up to ½ of a resistive magnet's maximum field/current (i.e. ¼ power). Beyond ½ the magnet's maximum field/current, access to the platform is prohibited (Figure 4).

Figure 4: Example sign indicating maximum power to access platform.

Access to the bottom of the magnet: Do not enter the closed-off area(s) around the magnet under the personnel platform. The area directly under the magnet may be made available for experimental access. To gain access to the bottom end of the magnet bore, talk to your User Support staff contact and the Control Room personnel. They will identify any hazards in that area and implement controls for a safe work environment.

Access behind Safety Barriers: Contact the Control Room if access behind any safety barriers is required. They will identify any hazards in that area, implement controls for safe access or will perform the task in this area for you.

Overhead crane: Only trained and authorized personnel may operate the overhead crane in the DC Magnet Building or MilliKelvin Facility. Affected personnel must step out of a magnet cell during overhead crane operation. Workers must wear hard hats & safety glasses.

5.0 MAGNET SYSTEM SPECIFIC HAZARDS AND ASSOCIATED RULES & GUIDELINES

5.1 45 T HYBRID MAGNET SYSTEM (CELL 15)

Tools: No tools can be brought any closer than the 100 gauss line : The forces on ferromagnetic tools are too great for them to be allowed any closer than 6 meters from the axis of the magnet when the outsert is energized to full field. The hybrid operators have a small supply of non-magnetic tools for use while the outsert is energized. Users whose probes require special tools for adjustment will have to bring non-magnetic versions with them.

Access to the magnet while at field: All personnel must keep themselves, their hands, and even non-ferromagnetic tools at least two meters away from the axis of the magnet when the insert is energized to more than 28 kA. Probes that require positioning or adjustments at fields higher than this value must have remote actuators for all the adjustments. Other adjustments can be made by ramping the insert current to less than 28 kA, making the adjustment, and returning to the set point.

Liquid helium transfers: Liquid helium transfers from a storage dewar on the outsert cryostat will be permitted while the outsert is fully charged and the insert current is less than 28 kA. Liquid helium transfers (particularly at field) must be supervised by a hybrid operator. Users must use one of the yellow plastic platforms when inserting the transfer tube into or withdrawing it from the storage dewar.

EPO Buttons: There is a RED **E**mergency **P**ower **O**ff button mounted at the top of the stairs and another near the Emergency Exit door (Figure 5). Do not block access to the EPO buttons. Pressing this button shuts off power and cooling water to all the magnets, therefore it is not something you should lean against while having a conversation.

Figure 5: Emergency Power Shut-Off (EPO) button. These buttons are located on the wall close to the exit of the Magnet Cells.

In case of unexpected events: Leaving the platform in haste is more likely to cause an injury than staying on it during a magnet fault. Users are advised to evaluate the situation then take the most sensible route off of the platform. If the oxygen deficiency hazard

(ODH) alarm sounds and blue strobe begins flashing all personnel should exit the platform immediately.

Hybrid Operators: The Hybrid Operators control the operation of the 45 T hybrid magnet system. Hybrid Operators instruct users on general 45 T user platform safety as well as the safest way of egress in case of emergency. Hybrid operators are responsible for enforcing the safety rules and other required procedures on the hybrid platform. Users must follow the Hybrid Operators' instructions.

Access to the 45 T Hybrid Magnet System during Operation: Warning lights are activated when the magnet is operational. Yellow lights are mounted near the swinging gates that limit visitor access. Red lights are mounted in the area that is restricted to Hybrid Operators only. All personnel with the exception of the Hybrid Operators are prohibited from entering the area that is designated as Hybrid Operators Only. The swinging gates will be closed and signage will indicate "Hybrid Operators Only".

Access to the 45 T Hybrid Magnet System While NOT in Operation: Access will be permitted up to the Plexiglas area if all gates are opened. In the event of an emergency evacuate the area and if possible contact the Hybrid Operator or the Control Room.

5.2 SERIES CONNECTED HYBRID (CELL 14)

Loud noises: In the event that, the Series Connected Hybrid quenches, trips or is shut down by the magnet protection system, the in-cell electrical breakers open with a loud "bang" noise. The breakers are located on the electrical services platform in the back of Cell 14. Since the amplitude of the noise scales with the field in the SCH, users are advised to wear hearing protection when operating the magnet system close to full field. Hearing protection (ear plugs and noise cancelling head phones) are provided in Cell 14.

Access to platform: Access to the magnet platform is permitted up to ½ of a magnet's maximum field/current (i.e. ¼ power). Beyond ½ the magnet's maximum field/current, access to the platform is prohibited. In the event of a quench, platform access is allowed only after being cleared by the control room & hybrid operators.

Detailed SCH safety training: All users and personnel who will be working in Cell 14 must complete the SCH safety training module prior to accessing the cell.

6.0 DEDICATED SAFETY INFRASTRUCTURE IN THE DC MAGNET BUILDING

Emergency Exit Routes: Maps with indicating emergency exit route (Figure 6) are located in every magnet cell and in several areas throughout the DC Magnet Building. The maps show the locations of emergency exits, fire extinguishers, eye wash stations and safety showers. Identify the closest emergency exit, eye wash station, and safety shower to your experimental area prior to starting work.

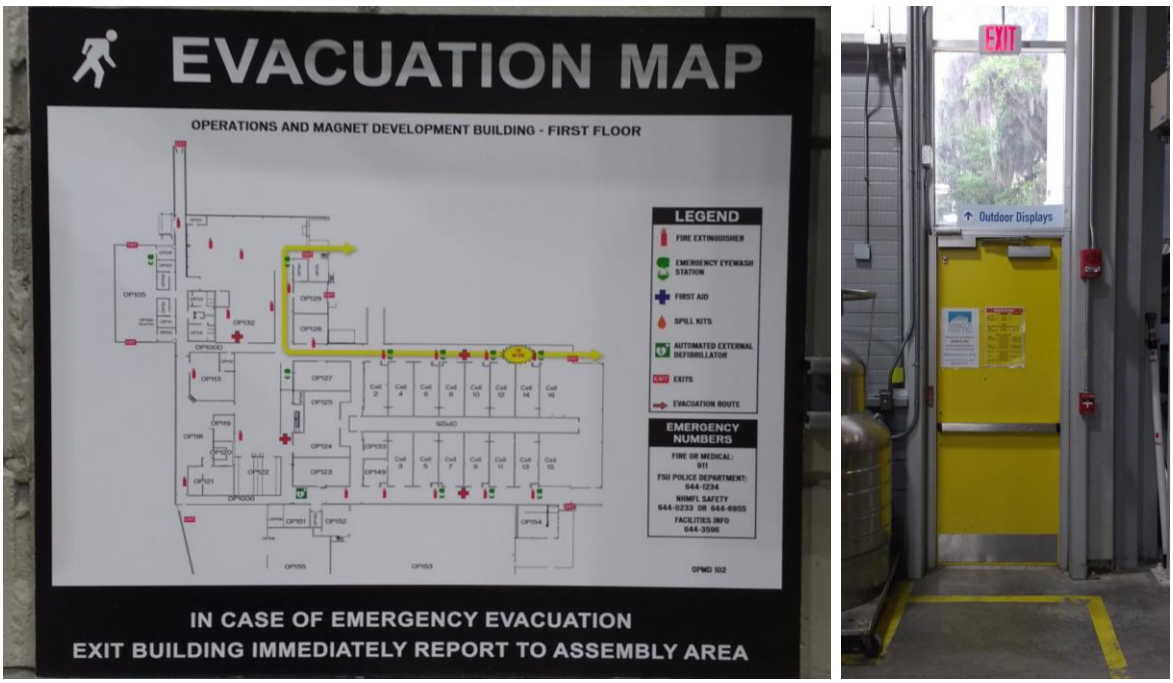

Figure 6: Example of an Evacuation Map and an emergency exit door. Identify at least two ways of egress out of the building to be prepared for emergency evacuations.

Eye Wash Stations & Safety Showers: Eye wash stations and safety showers (Figure 7) for emergency use are located throughout the DC Magnet Building.

Figure 7: Safety showers and eye wash stations are located in several locations in the DC Magnet building. The locations of this safety infrastructure are indicated on the Emergency Exit Route panels. Make sure to familiarize yourself with the locations and working mechanism of the safety showers and eye wash stations before starting your experiment.

Fire Alarms: If the fire alarm sounds you must exit the building. The control room operators will take control of the magnet and ramp it to zero magnetic field.

EPO Button: Each magnet cell is equipped with an "Emergency Power OFF" (EPO) button. The red EPO button is located on the wall, eye level, near the exit in each cell (Figure 8). Pressing the EPO button shuts off electric power to **all** energized resistive and hybrid magnets in the DC Magnet Building, and stops the magnet cooling water pumps. In case of an emergency in the magnet cell, press this button on your way out of the magnet cell.

Figure 8: Wall-mounted Emergency Power Off button. EPO buttons are located near the exit of each magnet cell in the DC Magnet Building.

Magnet Protection Systems & Control Systems: Several safety circuits continuously monitor magnet operation and detect magnet and/or cell faults. These systems shut off power to the magnets instantly in the event that anomalies or failures in the system are detected. After one of these events the control room operators and staff will analyze the data from the event and determine how to proceed. Do not attempt to use or adjust the magnet protection computer.

7.0 EMERGENCIES

In case of an emergency: Quickly and calmly evacuate the experimental area. If possible, push the in-cell "Emergency Power Off" button on your way out. In case of physical injury, call 911 or 855-SAFEMAG (723-3624) immediately depending on the severity of the injury. Then, contact the Control Room.

In case of a Building Evacuation: Leave the experimental area and calmly evacuate the building via the closest exit. The Control Room personnel will take control of the magnet and secure the system.

8.0 VISITOR REQUIREMENTS

Tour guides: Formal and informal tour groups must be lead by a tour guide who understand the hazards of the DC Magnet Building and are familiar with the safety rules and guidelines.

Walk within Yellow Lines: Visitors and tours must stay within the yellow lines indicating the visitor path way throughout the DC Magnet Building.

Close-toed shoes: All visitors must wear close-toed shoes to enter the DC Magnet Building.

No touch rule: Visitors should be instructed to not touch any equipment or devices.

Respect Safety Signage: Tour groups and guides must respect safety signage.

Restricted Areas:

- Tours cannot enter the 45 T Hybrid Magnet area when the swinging gates are closed and signage indicates “NHMFL Employees and Users Only”. Warning lights will be activated when the magnet is operational. Yellow lights are mounted near the swinging gates that limit visitor access. All visitors are prohibited at all times from entering areas designated as Hybrid Operators Only.
- Unauthorized access is prohibited on the Hybrid Magnet Platform even when the gates are opened.
- No visitor access to operational magnet cells.
- No visitor access to magnet cells unless specifically instructed to do so.

Monitor Tours Closely: Tours shall be closely monitored by the tour guide(s) to ensure the safety of all persons. The tour guide shall account for all persons before allowing the group to exit the area.

9.0 TRAINING REQUIREMENTS

The training requirements for users and staff working in the DC Magnet Building vary according to the location and the experiments/work they will be doing and since the training can change over time, a list is not presented here. The DC Field Facility Coordinator is responsible for ensuring that users have the correct safety training prior to working in the magnet cells. For staff working in the DC Field Facility it is the responsibility of their coordinator and supervisor to ensure they have taken the proper training.

The training requirements are documented and maintained by the NHMFL Safety Department.

10.0 COMMUNICATIONS WITH CONTROL ROOM STAFF

You can communicate with the Control Room personnel

- Via the in-cell intercom system: The user can start the communication by pressing and releasing the Call Button on the speaker cabinet and saying, for example, "Cell five calling the Control Room." Do not press the Call Button after the Control Room has answered, just speak in a clear and distinct voice directly into the speaker cabinet.
- By telephone: 850-644-4416 or 850-408-8102 (Operator Cell Phone),
- Or in person in the Control Room.

11.0 REVISIONS AND APPROVALS

Revisions

Date	Revision #	Section	Description
6/7/06	02	Cover	Names and positions changed to reflect current management
7/13/06	02	Throughout	Control Room Phone number added where "contact the control room" is referenced
7/13/06	02	5.2	Figure 1 added
7/13/06	02	5.3	Figure 2 added
7/13/06	02	5.2	Changes made to reflect current electrical hazards
7/13/06	02	5.7	Add use of eye protection when working with cryogens
7/3/06	02	6.1	Updated to reflect current policies including the addition of the 2 meter rule when the magnet insert in energized
7/13/06	02	6.1	Figure 3 added
7/13/06	02	6.2	Addition of section 6.2 Guidelines for NHMFL/FSU Personnel
7/10/06	02	7.0	Addition of Section 7.0 Exceptions
7/10/06	02	7.1	Addition of Section 7.1 Exceptions Request Form
8/12/08	03	4.0	Change allows access to the water cooled magnet platform at stated power.
8/22/24	04	All	Formatting updated and reviewed

Approvals

Title	Reviewer	Signature
NHMFL Director of Safety	Alfie Brown	DocuSigned by: Alfie Brown 244772F051A0421...
Director: DC Field	Tim Murphy	Signed by: Tim Murphy EEC858BD1BAA403...