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managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: *September 17, 2003*

To: *T. Sheridan, Deputy Director for Operations*

From: *E. Lessard, Chair, BNL Environment, Safety and Health Committee*

Subject: *LESHC 03-07, Acceptance Testing for the Animal MRI Magnet*

The Cryogenic Safety Subcommittee of the BNL ES&H Committee has reviewed the proposed acceptance testing activities in our meeting of September 16, 2003. The Meeting Minutes are attached for your information. The Committee recommends you approve acceptance testing of the magnet. Based on the practice of the Medical Department, your signature will be required on the procedures used for acceptance testing before each module of testing begins. Other than your signature, no further approval actions will be required on your part at this time.

Copy to:

H. Benveniste
C. Du
W. Gunther
R. Karol
J. Tarpinian
R. Travis

Laboratory Environment Safety and Health Committee

MINUTES OF MEETING 03-07
September 16, 2003

FINAL

Committee Members Present	Committee Members Absent
E. Lessard (Chairperson, Acting Secretary)	R. Travis
J.W. Glenn	M. Iarocci
W. Gunther	O. White
P. Kroon	P. Mortazavi
K.C. Wu	P. Williams
	R. Beuhler
	R. Gill
	R. Lee
	S. Kane
	T. Ginsberg
	M. Rehak
	H. Kahnhauser

Visitors
W. Rooney
C. Du
J. Peters
J. Briske
H. Benveniste
T. Monahan
C. Harris

Agenda:

Medical Department Animal MRI Facility in B490

ESH COMMITTEE MINUTES APPROVED:

__Signature on File______________
E. Lessard
LESHC Chairperson

Chairperson E. Lessard called meeting 03-07 to order at 1530 on September 16, 2003.

1. W. Gunther gave a summary of the project's status to the committee. Supporting personnel were present (Facility Manager: C. Du, MRI Technical Advisor from Chemistry Department: W. Rooney, Building 490 Manager: C. Harris).
2. The MRI magnet room in B490 was visited by the LESHC. The magnet vendor's representative, J. Briske, discussed the LN filling operation and demonstrated magnet filling techniques. J. Briske indicated he wished to fill the magnet with LN and LHe, energize the magnet, and insert shims. He wanted to do this during a period of 4 to 5 days. J. Briske also wished to train BNL staff to top off the LN and LHe so that the staff could maintain the magnet in a cold state after he leaves. The magnet power supplies will be locked out upon J. Briske's departure.

Comments and questions from the Committee during the meeting resulted in the following actions that need to be completed prior to J. Briske's activities:

1. A cool-down, energize, shim and LOTO plan and schedule shall be written to cover the activities of J. Briske and any staff member he trains during his work time at BNL.
2. ODH calculations shall be documented and submitted to the LESHC. The calculations shall be applicable to LN and LHe in the magnet room, and shall be relevant to filling and topping operations. The calculations need to address the magnet room and the hallway location where dewars are temporarily stored.
2. Procedures shall be written to assure that required ODH controls for normal and emergency conditions are in place. Procedures shall address access to the magnet room and adjacent rooms during the filling, energizing and topping tasks. Procedures shall address the keypad access for entrants into the magnet room, and key access into the magnet room. Procedures shall address ventilation requirements during filling, and when the magnet is cold. Procedures shall address response by the Animal MRI staff if the ventilation or ODH alarm system fails while the magnet is cold. Procedures shall address J. Briske's actions and staff actions should the magnet quench when the magnet is energized during acceptance testing. Procedures shall address required ODH controls and posting during filling operations, topping operations and whenever the magnet is cold. If the ODH calculations warrant, then a safety watch, escape packs and other pertinent ODH controls shall be addressed in the procedures.
3. The fire run card for the Animal MRI suite shall be updated.
4. The fire alarm systems in the magnet room and power supply room shall be operable when the magnet is energized.
5. ODH monitoring equipment in the magnet room must be tested and maintained operable while the magnet is cold.
6. The electrical system used to energize the magnet must be reviewed and approved by T. Monahan.
7. A procedure shall be written to perform a sweep of the magnet room for loose ferrous objects prior to energizing the magnet. The procedure shall address how

the Animal MRI staff prevents entrants from bringing ferrous objects into the room when a magnetic field is present. The procedure shall include a requirement to perform magnetic field measurements during the time the magnet is energized. The procedure shall address control of whole-body and extremity magnetic field exposures of J. Briske and any trainees when the magnet is powered.

8. All procedures shall be reviewed and approved by the Medical Department. All personnel affected by the procedures shall be trained and their training records shall be maintained ready for audit.
9. Personnel who top off the magnet with LN and LHe after J. Briske leaves must be trained by J. Briske. Training documentation must define clearly what the trainee is allowed to do during the training. A procedure shall be written and it shall delineate precautions, PPE and the many steps necessary to perform the topping tasks. This procedure shall be reviewed and signed by T. Monahan in addition to being reviewed and approved by the Medical Department Chair.
10. J. Briske shall have all required BNL training, or acceptable equivalent, for the work he will perform at BNL.
11. W. Gunther shall explore and report on venting LN and LHe boil off into the helium quench pipe rather than the magnet room.

E. Lessard noted that the LESHC must have evidence the above items have been closed before the LESHC can recommend approval for the magnet vendor’s representative to perform acceptance-testing and training activities. Approvals for these activities may be obtained at one time or when specific tasks are ready to approve, e.g., nitrogen cool down. W. Gunther agreed to this condition.

The meeting adjourned at 1745.

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BROOKHAVEN
NATIONAL LABORATORY

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memorandum

date: September 17, 2003

to: E. Lessard; Chair, LESHC

from: Bill Gunther

subject: Request for Approval for Animal MRI Magnet Cooldown

The Medical Department, with support from others, has prepared the necessary procedure and completed the actions needed to address the Committee's concerns associated with the process of cooling the animal MRI magnet with liquid nitrogen. The attached procedure stipulates the training, postings, access control and ventilation requirements for this process. We request the Committee's approval so that the nitrogen cool down can commence today (9/17/03).

As you are aware, an additional procedure will be forthcoming associated with the use of liquid helium to further cool down the magnet to the proper temperature where it can be energized and shimmed. At that point it will be de-energized and "locked out" pending installation of the control panel and the permanent power connection by the manufacturer (Bruker).

While the contractor, Mr. Jim Briske of Magnex Scientific, has extensive experience with the processes, he is not qualified under BNL's policies to enter an ODH 1 area unescorted. Therefore, during the short time intervals when Mr. Briske has to be in the magnet room to connect the liquid nitrogen dewars to the magnet, a qualified ODH 1 BNL staff member will be present at all times. Once the connections are made, and nitrogen is being supplied to the magnet, the entire animal MRI facility will be posted as a restricted entry area. Helene Benveniste discussed this with Jim Tarpinian this morning, who agreed that the approach was sound. This is a change from what was recommended by the Committee in item 10 of the minutes of meeting of 9/16/03.

Again, your prompt review of this procedure is requested so that can commence the controlled cool down of the magnet today using liquid nitrogen. We expect to have the subsequent procedures for the liquid helium and electrical energization to the Committee shortly.

Environment, Safety, Health, and Security
Briefing Checklist

Initial or indicate NA (Not Applicable) for each item or section

I. Emergency Information

1. **<u>Emergency number</u> is ext. 2222** (fire, medical emergency, serious injury, ambulance, leaks, and spills). You must dial 344-2222 from a cellular phone.

2. BNL Laboratory <u>Site-wide and Building alarms</u>:
   a. Alert siren: continuous sounding of site siren for five (5) minutes. Proceed to assembly area and wait for further instructions.
   b. Evacuation siren: Intermittent sounding of the site siren for five (5) minutes. Evacuate the site immediately.
   c. Sirens are tested at noon every Monday.
   d. Building Alarms: Evacuate the building immediately.

3. Report injuries immediately to your BNL Contact. (Or if an emergency, dial 2222.)

4. Note the locations of Fire Alarm Pull Boxes, phones, fire extinguishers and Material Safety Data Sheets (MSDS) in your work locations.

II. Compliance with Procedures and Regulations

1. Obey all environmental, safety and health requirements that apply to your work. If you have questions about requirements that may affect your specific work, ask your BNL Contact.

2. Comply with all warning signs posted at the Laboratory. Access to certain areas at the Laboratory is limited to individuals who are trained and qualified to be there. Do not enter any areas that are posted with warning signs. For example Radiological Areas are posted with yellow and magenta or yellow and black signs and there are special requirements that need to be fulfilled to access these areas. If you have any doubt about whether or not you may enter an area, ask your BNL Contact.

3. All unauthorized disposal or release of oil or hazardous materials is strictly forbidden. Report spills to your BNL Contact. If you witness a spill of material onto soil or into a water stream (gasoline, oil, chemicals), you must call 2222 to report the spill immediately.

4. Potentially hazardous operations require special training and permits before individuals are authorized to perform such work. Forklift operation, overhead crane operation, electrical work, handling of compressed gas cylinders, cutting and welding activities, confined space entry, disposal of hazardous materials, operations that may impair fire protection systems and any task performed in a radiological area are examples of activities that require proper authorization prior to task performance.

Initial or indicate NA (Not Applicable) for each item or section.

5. Do not use a computer, or any BNL equipment unless you are authorized for its use and handling. Inappropriate use of equipment may constitute fraud, waste, or abuse of government property. RLC

6. Report any unsafe conditions or activities to your BNL Contact. RLC

III. Traffic Rules RLC

1. Speed Limit on site is 30 m.p.h. and is radar enforced.
2. Pedestrians have right-of-way in marked areas. Cross in marked zones.
3. Vehicles are subject to police inspection.
4. Bicycles must observe all Laboratory traffic rules.
5. Park in designated parking areas. Yellow-painted curbs indicate no parking areas.
6. On-site deer population presents driving hazard.

IV. Individual Responsibility RLC

1. Carry BNL ID at all times. When your BNL work assignment is over, you must return your badge to your BNL Contact or the Badging Office.
2. You may access the BNL site for the performance of your BNL work assignment only. Accessing the site for any other purpose is prohibited.
3. Professional conduct and ethical behavior are expected and required at all times.
4. Prohibited activities include: alcohol consumption, illegal drug use, sexual harassment or any other discrimination. No smoking in any building on-site.

V. Reviewed or issued the following documents:

1. 9.4T MRI Fill/Cooldown Procedure
2. ______

The above information was reviewed with me by: Robert L. Colichio
BNL Contact Name

Robert L. Colichio
BNL Contact Signature

9/17/03
Date

26375
Contractor ID Number

James Briske
Contractor/Vendor Name

James Briske
Contractor/Vendor Signature

BROOKHAVEN
NATIONAL LABORATORY

Brookhaven National Laboratory
Medical Department
9.4 Tesla MRI, Fill/cool-down Procedure

Prepared by: ______________________ 9/17/03
Christopher M. Harris

Reviewed by: ______________________
Congwu Du

____
Jim Briske

Approved by:

MO-ESH Coordinator, ______________________
Robert Colichio

LS-ALD, ______________________
Helene Benveniste

The Laboratory ESH Committee,
Cryogenic Safety Sub-committee

____
Edward Lessard

Deputy Director for Operations,

____
Thomas Sheridan

BROOKHAVEN
NATIONAL LABORATORY

Brookhaven National Laboratory
Medical Department
9.4 Tesla MRI, Fill/cool-down Procedure

1. Purpose: The purpose of this procedure is to provide written guidance on the initial fill/cool-down of the Medical Department's 9.4 Tesla Small Animal MRI

2. Prerequisites for nitrogen fill

- Training

   i. The training requirements for any person entering into room 9-430C during the nitrogen fill/cool-down process are ODH1, and ESH Coordinator's Briefing.

- Postings

   i. 9-430C shall be posted ODH1.

   ii. 9-430C shall be posted "Authorized personnel only".

- Access control

   i. All keys providing access to 9-430C shall be returned to the 490 Building Manager and stored in a lock box in room 8-112A.

   ii. The 490 Building Manager is the only individual who shall have lock combination knowledge during the fill/cool-down process.

   iii. The only personnel authorized access during the fill/cool-down process is the Installation Engineer, and FS Support personnel utilizing Bacarach Sentinal 44 O2,LEL,Toxic (calibrated 07/23/03) monitoring equipment.

   iv. Re-entry into room 9-430C shall require O2 monitoring/re-check if the space has ~~been vacated for any period of time.~~

   v. Once the fill process has begun, the work site shall be attended at all times during top-off only. In the event of any ~~abnormal/questionable situation, the attendant shall~~ contact the Installation Engineer on (936) 465-3651.

what does this mean

24 hr watch during fill

- Safety related equipment

    i. The installed O2 Monitor shall be operational during the fill/cool/down process.

    ii. The Bacarach Sentinal 44 Monitor shall be used in the event of installed O2 system failure and only from remote location indication (outside room 9-430C).

- Personal protective equipment (PPE)

    i. All personnel handling cryogenic transfer equipment shall utilize appropriate PPE (face shield, gloves).

    ii. As an additional precaution, the Installation Engineer will wear a personal (lapel), O2 monitor.

- Ventilation requirements

    i. The installed ventilation System is a single pass (100% outside air), system that contains an HVAC supply through 4 duct registers and a separate return (roof top exhaust), system.

    ii. The installed ventilation system is on emergency back-up power and has been verified operational (during the black-out, August 14, 03).

    iii. HVAC and exhaust system shall be verified operational prior to start of work activity.

- Approvals

    i. The Medical Department ESH Coordinator and the Principal Investigator/ Life Sciences ALD shall approve this procedure.

    ii. The Laboratory ESH Committee, Cryogenic Safety Sub-committee shall review and recommend approval to the Deputy Director for Operations.

3. Fill procedure

- Emergency Response

    i. In the event of a quench or O2 alarm, all personnel shall vacate the space immediately. Re-entry shall only be authorized by Facility Support and the Installation Engineer.

    ii. All emergencies shall be reported by calling extension 2222 or 911.

    iii. Fire/rescue shall be informed of work activity with the potential for ODH1 atmosphere prior to start of work.

- Equipment set-up

    i. Cryogenic fill ladder shall be placed on the Southwest corner of the magnet and utilized in a safe manner.

    ii. Five nitrogen dewars, while in use, shall be set-up on the Northwest corner of the magnet and connected together via flexible hose enabling transfer from each dewar into the magnet nitrogen can simultaneously

    iii. The vacuum pump shall be placed on the Southeast corner of the magnet to enable sufficient working space during the fill/cool-down process.

    iv. All dewars not in use shall be stored on the 490 loading dock.

- Nitrogen fill/cool-down

    i. Reference attached procedure titled "Magnex Manual, Chapter 7, Section 3" and "Bruker – Nitrogen Fills on NMR Magnets", only as it applies to the initial filling procedure, not to supersede any requirements set forth herein.

7. LIQUID NITROGEN PRE-COOL

The liquid nitrogen pre-cool is a procedure that is used in order to cool the magnet, liquid helium vessel and liquid nitrogen vessel down to a temperature of 77K. During the pre-cool process liquid nitrogen is transferred in the liquid helium vessel and the liquid nitrogen vessel.

The Liquid Nitrogen Pre-cool of the system is a very important process and a small error could cause substantial damage to the system due for example to a large build up of pressure. For this reason it should only be undertaken by a Magnex Engineer or a competent engineer working under the strict guidance of Magnex Scientific

Nitrogen Fills on NMR Magnets

Read This Before Proceeding Further!

1. These instructions apply to Bruker BioSpin magnets only. For any other magnet, you should consult that manufacturer's documentation.
2. Bruker BioSpin does not accept any responsibility for damages or injuries associated with nitrogen filling of Bruker BioSpin magnets - using these instructions.
3. If any of the descriptions or precautions are not clearly understood or situations arise that are not covered in the procedures, contact the Bruker BioSpin magnet department before proceeding further.
4. Filling a magnet with liquid nitrogen can be a dangerous procedure.
5. The following are general instructions and guidelines that are offered to supplement (not replace) any existing documentation Bruker BioSpin magnet owners already have.
6. Specific magnet configurations may require additional procedures/precautions be taken.
7. If any liquid nitrogen filling procedure (Bruker BioSpin documentation) for your specific magnet configuration does not agree with these instructions, follow the directions written for your specific magnet configuration.

The pages that follow describe safety precautions and procedures involved in the liquid nitrogen filling of Bruker BioSpin NMR magnets.

Bruker BioSpin Magnet Dept.
Phone (978)667-9580 ext. 282
9 AM to 5 PM EST

Caution - Liquid Nitrogen "Handling"

Nitrogen is an asphyxiant.

Release of nitrogen or liquid nitrogen in an enclosed area with poor ventilation can lead to possible suffocation.

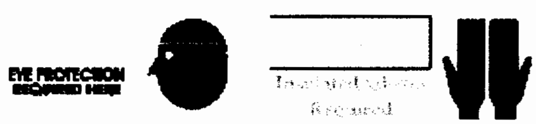
Liquid nitrogen is very cold!!

The temperature of liquid nitrogen is **320 degrees below zero Farenheit (-196 degrees C, 77 degrees K)** and will cause severe burns to the skin. If burns occur, treat the injury just like a heat burn, and consult a physician immediately.

*Handling Precautions**

All personnel working with liquid nitrogen should wear all the following safety equipment:

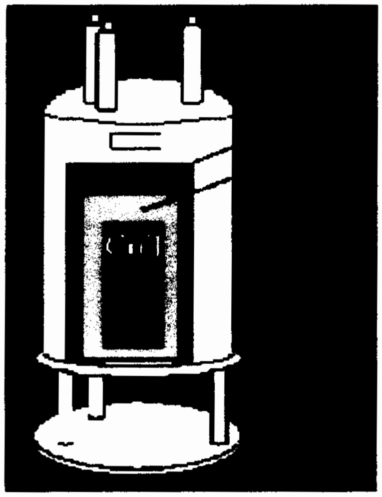
1. Safety glasses or face shield
2. Insulated gloves and
3. Protective clothing (long sleaves, pants).



***Consult your Material Safety Data Sheets (MSDs) and plant safety officer for more information on working with nitrogen.**

A Tour of the Cryo Components in a Bruker BioSpin Magnet

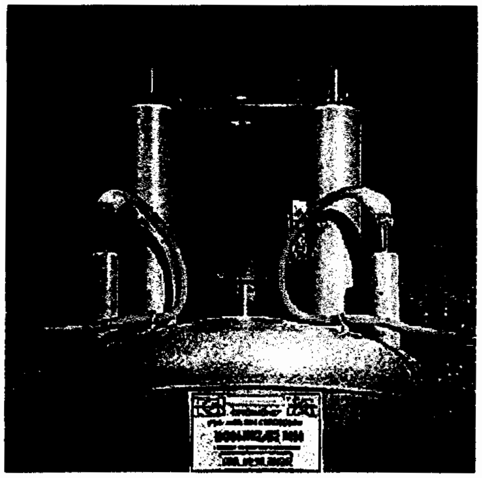
- **Magnet coil** - Located in the center of your magnet cryostat. It is enclosed in a container filled with liquid helium (red). To prevent the helium from rapidly boiling away, a can filled with liquid nitrogen (blue) surrounds the helium container.



- **Stacks** - Many Bruker BioSpin magnets are equipped with three identical stacks that lead directly into the nitrogen can. Two are supplied with latex vent hoses of equal length; the third is fitted with a safety vent cap. If your magnet is equipped with N2 heat exchangers, replace them with rubber latex tubing before starting the fill procedure. **Note the hoses are pointing away from the magnet.**

How Often Should the Nitrogen Can be Filled?

Consult your magnet manual to find the nitrogen hold time for your magnet. This is the maximum safe hold time for your individual magnet.



Rough guidelines for frequency of filling

- The Magnet Dept. at Bruker BioSpin recommends that you fill your magnet with liquid nitrogen once a week.,
  This precaution will insure that your nitrogen is always kept at a safe level.
- We also recommend that you do your nitrogen fill at the end of the week to insure that the magnet is full over the weekend.

Bruker BioSpin strongly recommends that you *NOT* use high pressure liquid nitrogen transport dewars to fill the magnet's nitrogen can!

- Low pressure dewars have only two valves. One is labeled "vent" the other is labeled "liquid" . They also have a safety valve set for 22 psi or less.

Transferring liquid nitrogen at high pressures (>22 psi) could cause your magnet's nitrogen can to rupture.

How to Recognize a High Pressure Liquid Nitrogen Transport Dewar

- High pressure transport dewars have an additional valve labeled "gas" and a pressure building valve that is equipped with a safety valve set for over 22 psi.
- High pressure transport dewars can only be used if precautions have been taken to insure that pressure in the dewar cannot exceed 22 psi.

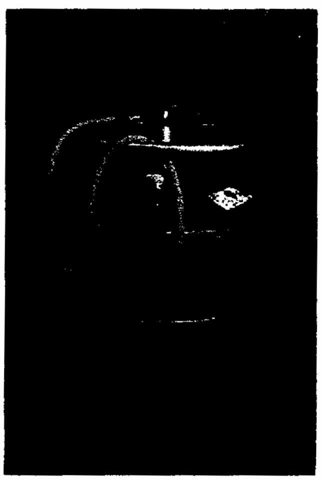
Nitrogen Filling Procedure

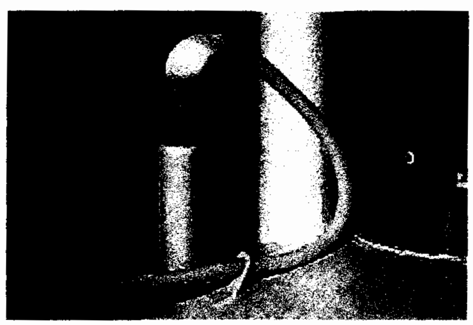
The following is a step by step description on the proper method for filling your NMR magnet with liquid nitrogen. **The procedures must be performed completely, in the order described, or damage to the nitrogen can/vacuum vessel or individuals filling the magnet could result.**

1. Attach rubber latex hose to liquid valve on non magnetic LOW PRESSURE (less than 22 psi)*transport dewar.

⚠ **DO NOT USE TYGON TUBING!!** tygon tubing will shatter when exposed to liquid nitrogen.

⚠ ***If you are in doubt as to whether you have a low pressure or high pressure transport dewar, review the previous page before connecting the hose to the transport dewar.**





- Use 3/8 inch diameter (ID) rubber latex tubing.
- Vent hoses need to be directed away from the dewar to prevent freezing of o-rings in the base plate and top flange. If the o-rings freeze or partially freeze, your magnet cryostat will lose vacuum. This will result in a high rate of cryogen boil off or even a possible quench.

Nitrogen Filling Procedure - Continued

2. Vent air from hose by opening the valve slightly.

- This step prevents air in the hose from entering the magnet and causing an ice blockage.

3. While the hose is venting, remove the vent cap from the magnet and attach the hose.

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A rubber band can be used on the end of the hose to insure a tight fit.

Nitrogen Filling Procedure (Continued)

4. Slowly open the transport dewar's liquid valve from the closed position. The liquid nitrogen should just start to flow.

- During nitrogen fill, pressure created by normal boil off in a transport dewar forces liquid nitrogen through the hose and into the magnet.

⚠ **NEVER LEAVE A MAGNET UNATTENDED WHILE FILL IS IN PROGRESS!!**

5. Monitor the Filling of the Magnet

- The hose will quickly freeze as flow is started. **Do not move the transport dewar or tubing will break.**
- A flashlight can be shown through the rubber latex tubing, to monitor flow.
- Visually check to insure that vapor is freely flowing out of both vent stack hoses.
- Look for equal sized vapor trails on both vent hoses. A small or non existent vapor trail indicates that an ice block has formed. Vent stacks can become clogged with ice if air enters the nitrogen can. Moisture in the air freezes as it comes in contact with the cold nitrogen gas.

The nitrogen can is filled when excess liquid nitrogen flows from the ends of the latex hoses. A crackling sound can be heard just before overflow.

6. When the Magnet is full.

1. Allow the hose to thaw.
2. Once the hose is thawed, remove it and quickly replace the vent cap.
   The magnet should never be left open for more than a few seconds. Quick closure prevents air from entering the magnet and causing an ice blockage.
3. Record nitrogen fill into log book or chart.

7. Filling Procedure has been completed.

The nitrogen can is filled when excess liquid nitrogen flows from the ends of the latex hoses. A crackling sound can be heard just before overflow.

To Remove an Ice Blockage

1. Reduce the flow of nitrogen via the dewar valve to a slight trickle. This will keep positive pressure in the nitrogen can.
2. Remove the rubber latex tubing from the clogged stack.

⚠ DO NOT LOOK DOWN THE STACK WHILE DOING THIS PROCEDURE, because the dislodged ice will blow out of the stack.

3. Use your thumper tube to dislodge the ice block by quickly poking it down inside the stack.
4. Immediately replace rubber latex tubing and resume fill.
5. When liquid begins to flow out of the vent hoses, the magnet's nitrogen can is full. Immediately shut off the transport dewar valve to stop the nitrogen flow.

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BROOKHAVEN
NATIONAL LABORATORY

Managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

Date: *September 17, 2003*
To: *Terry Monahan*
From: *John W. Peters, CIH*
Subject: *response to E. Lessards Questions*
IH Proj. No. *3109*

As I stated in the cover text of my memo to Terry Monahan and the memo itself (dated September 12, 2003), the original information provided indicated one dewar at a time would be used. Adding the five dewars in series does increase the total amount of nitrogen available for release along with the potential for hose failure. I agree the fatality rate per hour summation for these independent events would be on the order of $8.5 * 10^{-6}$. We are already considering total displacement of room air (F=1) and the probability would still be 10^{-6}, I consider this within the ODH (1) range of 10^{-7} to 10^{-5}.

The bayoneting activity would, as pointed out, have a probability of occurrence of 10^{-3} per demand. It is my understanding that the toppng off activity would use a single dewar at a time, the procedure will be written such that no one does it alone but adjacent rooms would be empty of non-essential personnel, and the doors to the other rooms would be left open. The fatality factor would no longer be (1) for this operation as there would be a controlled release with time allowed for the operator to escape.

With the following assumptions:

- instantaneous conversion from liquid to gas
- approximately 10 minutes for the dewar to release its entire contents at the low dewar pressures would result in a release rate of approximately 600 CFM,
- room volume is 6000 CF
- room ventilation rate is 800 CFM,
- complete mixing

and using the equation for ventilation fans blowing into the confined volume, it would take approximately two minutes for the room O_2 concentration to be lowered to 18%. There would also, most likely, be a loud hissing sound of escaping nitrogen warning occupants of a problem.

The lowest O_2 concentration would be reached at the end of the leak (10 minutes). This is calculated to be ~13%. It would then take ~ 7.5 minutes to return to 18%. Using the fatality factor formula (F) for this event, a final O_2 concentration of 13% and a PO_2 = 98.8, $F=10^{(6.5-(98.8/10))}$ or $4.1 * 10^{-4}$.

Thus, the fatality rate would be $(4.1 * 10^{-4}) * (10^{-3}) *(1/6)$ hour or $6.5 * 10^{-4}$. With an alarming personal dosimeter set at 19.5, the short distance to an open area, leaving the doors open to increase the volume of air available and either an easily reached escape bottle or trained response person prepared for immediate entry, it appears there would be adequate time for escape/rescue. Allowing for adjustment to F based on duration of exposure and ease of escape the overall fatality rate would be even lower.

The airflow dynamics with the MRI room doors open is a complex issue, which allows additional fresh air to enter the room and cold air to be displaced to the adjacent room. It would not be prudent to use the entire ventilation rate for this adjacent space in the calculations. The flow dynamics depend upon the pressure differential between the two rooms. The leak rate to this area is unknown as cold air would accumulate along the floor and be displaced laterally. However, it is assumed that these factors would ameliorate the rate at which the O_2 concentration would be lowered putting the ODH class somewhere between a high 1 and low 2 depending on the amount of credence given to these extenuating circumstances.

The difference in operational requirements for ODH 1 vs 2 would be additional requirements including multiple personnel and ventilation. As stated earlier, the procedure is to call for a minimum of two people for this operation, which will be covered in the procedure. Additional ventilation is always a good idea when dealing with ODH issues. A floor mounted fan will draw air from the room for dispersal, however, may short circuit the room ventilation system (draw fresh air out without mixing especially from the supply vents located near the doors). It would be reasonable to assume due to the decreased temperature of the escaping nitrogen that a floor level ventilation unit may be more appropriate.

To be conservative without being ultraconservative, it would be prudent to assume ODH class 2 for the topping off operation.

Installation guide for Invivo systems

Levelling the Magnet:

Even though there is no specification to level these magnets normally, it is still recommended.
It must be levelled end-to-end, and side-to-side.
Levelling should be completed during initial rigging while the forklift or pallet jacks are available.
It must be completed prior to energization.

Vacuum:

- Break the vacuum slowly to N2 gas. Use an N2 gas bottle or alternatively a transfer Dewar that has a pressurized gas outlet for connection of a regulator. Take steps to insure that the OVC will not be pressurized as it comes to atmospheric pressure by the use of a drop off plate or similar method.
- Rotate both sets of cat flaps into position and tape them down using aluminised Mylar tape for each transit hole. Continue bleeding warm N2 gas through the vacuum space.
- Tape the SI pads over each N2 cat flap before sealing the vac space and securing the N2 gas.

Pumping and Leak Testing:

The OVC should be pumped until it reaches the range of 8x10-5 to 5x10-5 before commencing precool. A quick OVC vacuum/leak test should be performed to ensure that no leaks are present by closing the valve between the roughing pump and turbo allowing the pressure gauges to read the internal OVC pressure. The vacuum pressure should stabilize within 5 minutes. If it does not stabilize a leak should be suspected.

Setup and testing of the Emergency Discharge Unit (EDU):

1. Remove the EDU from its rack, and remove its cover.
2. EDU's are shipped from the factory with the internal battery disconnected. Remove the Dummy Connector from Battery terminal #1, and connect the loose wire to the Battery.
3. Charge the battery for 24 hours by applying AC power to the unit.
4. Test the battery by pushing the test button for 10 seconds. The Heater OK and Battery test indicators should be able to remain lit for the full 10 seconds.
5. Set the B0 dump clock circuit Off/On/Timed switch to off. The timer will be removed from future units.
6. It is often the case that the Off/On/Timed switch is stuck in the Timed position. In this instance you must manually program the time, and dump cycles to be off. Make sure that no dump cycle times are set for Timing position's 1 – 4. They should all display --:-- Failure to perform this step properly can result in a continuous B0 dump and reports of high boiloff. In extreme case this could cause the magnet to quench due to lack of helium.
7. See the magnet manual EDU Section 9 for instructions on setting the timer if needed.
8. Instruct the customer to dump the B0 coil as per the manual or during LN2 fills for 2 minutes.
9. **Company Confidential: <u>Do Not</u>** inform the customer of this circuit. Check that the internal "Tell Tale" manual quench LED is not lit. The LED is located half way down the right hand side of the printed circuit board. Extinguish by pushing the red re-set button (S4) just above the LED.
10. The Manual Quench circuit should always be connected once the magnet is energized and the customer informed of its connection. If the customer wishes it to be disconnected they can do it after we leave site at their liability.

11. The manual B0 dump heater must be verified as off before departing from an installation and the customer warned of the implications of it being left on.

Nitrogen Level Meter Calibration Verification and Alarm Level settings

1. The LN2 meter and probe are calibrated in the factory.
2. Calibration needs to be verified during the initial fill and top offs. Take LN2 level readings while filling LN2 and enter them into the System Log. If the meter reading exceeds 100% during the fill and wraps back through 0 a calibration problem exists The 100% point needs to be reset. This is accomplished by adjusting the gain pot on the meter, not the oscillator on the magnet. The level should be decreased back through 0 to be set to 97%.
3. **Set the LN2 alarm to 20%** by De-pressing the "Display" button on the front of the unit. While pressing the "Display" button, adjust the Alarm trim-pot for the meter to read 20%.
4. The customer should be trained in how to set this alarm level.

Helium Level Meter Calibration Verification and Alarm Level settings

1. The helium level meter is calibrated in the factory.
2. Calibration does need to be verified. This is best done during the initial cooldown and fill, and during energization. Take helium readings on both probes after collection begins to find the point that Probe2 begins reading so that the overlap of the probes can be documented in the system log. If levels do not agree with the system manual a note needs to be made on the Site SQR report and noted on the daily report and Final system report.
3. **Set the HE alarm to a useful Value** by De-pressing the "Display" button on the front of the unit. While pressing the "Display" button, adjust the Alarm trim-pot for the meter to read the calculated refill volume minus a safety and ordering factor. This alarm can only be set for either probe #1, or #2, and will not work for both probes. Regardless of the specified maximum refill volume. If the normal refill volume is 100 liters, set the alarm to go off at 90 liters from full. If the normal refill volume is 60 liters set the alarm for 50 liters from full. In either of these cases the specified refill volume could be much greater than that requested by the customer. I.e. The system may be spec'd at 150 liter refill volume but they may only feel comfortable letting it go down by 60 or 100liters depending on other circumstances at their facility.
4. The customer should be trained in how to set this alarm level.

Temperature Sensors

- Shield Sensors
- Link Sensors
- Magnet Sensors
- Old Design's

Helium Levels

9.4T-160AS magnets.

- Until further notice, we want to insure the level of liquid helium is above 920mm during installation and 900mm during normal operation.

Insert the Sticks and check your connections.

- Insert the main current lead and check for a small resistance across the +/- connectors. On a Room Temperature magnet this will be up to 8 ohms. A magnet at helium temperature this will generally less than 1 ohm. (hint: this can also be used as an un-calibrated temperature gauge during precool, and the initial helium fill) the resistance of the coil/switch will drop with temperature.

- Insert the shim stick and check for 100 ohms across all shim switch heaters using the 19 way breakout box.

Test the SC Switch prior to Ramping

Ramp the voltage/current of the supplies linearly over these time intervals. Reverse in relation to ramping down the leads from full field. This is because the switch is stressed as you increase the current across it.
Ramp the current from 0 to 100%, in 4 minutes.
0 to 50% of full current in the 1st minute.
50 to 80% of full current in the 2nd minute.
80 to 100% of full current in the 3rd and 4th minute.
Note-The current must be increased linearly so as to prevent the switch from opening. Also, the last 1-2 minutes of adding the current, are the most stressful to the SC switch as the current through the switch reaches its peak. If the switch opens repeat this procedure to train the switch.

If the switch opens during this test, Run the leads quickly to 0 amps and allow the voltage across the switch to subside and then allow the switch to close. Repeat the test. This test must pass prior to energizing.

Energizing and Persisting FTMS Magnets:

Make sure the system you are installing is an Animal Research magnet system and not an FTMS. Identical magnets are often sold to both types of customers. Example: 7T-160 AS or 9.4T-160AS systems. NMR research magnets normally have a very narrow bandwidth required for operation. Invivo systems are typically highly sensitive to the actual operational frequency.
If in doubt inquire with the office, the end user, or both about the intended use of the system and what type of console it will be connected to.

Test and record the main coil inductance on the status report within the first 20 amps of ramping. Compare the measured inductance against the design inductance. A small variation is normal.
A large variation will indicate that a switch heater is not energized or its associated switch is not opening. The coupled coil is not being quenched and gaining energy by inductive coupling.
This test can prevent an unnecessary quench. $L = V/(di/dt)$, di = change in amps, dt = period of time in seconds.

All <u>except</u> 9.4T-AS magnets will follow the procedure in the system manuals.
Energize the magnet and record all sensor and field data in the system log at regular intervals.

<u>Procedure for persisting 9.4T-AS magnets</u>
When possible print and paste this note into the system manual.

Note: The Z2 and B0 coils must be open during energization.
The minimum level for energizing and normal operation is 900 mm.

0 - 220 Amps 2.4 amps/min (2.62 volts) 92 minutes
220 - 260 Amps 1.2 amps/min (1.31 volts) 34 minutes
260 - 282 Amps 0.6 amps/min (0.66 volts) 36 minutes

Over field the magnet by 2%
i.e. 9.58Tesla persist for 60minutes, use a ramp rate of 0.3 amps/min (0.33) volts.
It is important that this is accurate.

Under field by 0.2% i.e. bring the field down to 9.381T for 10mins.
It is important that this is also accurate

Leave the leads in for at least 1hr after the main switch is closed to make sure it stays closed, and so you are ready to catch it if it opens.

Leave the B0 dump on overnight for the first night and during all shimming. This will only consume a small amount of helium.

End of 9.4T persistence procedure…

Persistence and Lead rundown.

Reduce the voltage/current of the supplies linearly over these time intervals.
Remove the current in 4 minutes.
50% of the full current target in the 1st minute.
30% of the maximum current in the 2nd minute.
20% of the maximum magnet current in the 3rd and 4th minute.
Note-The current must be reduced linearly so as to prevent the switch from opening. Also, the last 1-2 minutes of removing the current, are the most stressful to the SC switch as the current through the switch reaches its peak. If the switch opens repeat this procedure to train the switch.

If the switch opens during lead rundown another Overfield is not necessary if it is caught quickly. If the field drops more than 5% the over cycle procedure should be repeated if the available helium allows it. If the helium level is near the minimum point for energizing then persist, refill and go the rest of the way.

Orientation of passive shim tube:

The shim tube is to be inserted from the Nitrogen level sensor end with zero degrees at top dead center. Zero degrees should also be coincident with the welded seam at the top of the passive shim tube, and 0 degrees on the plotting rigs X axis. Add this to the FTMS guide also.

90% of the new style magnets can only have the passive shim tubes fitted from one end, at one orientation.

Operating 2 Channel Super Conducting Shims:

Large Horizontal Bore magnet’s sometimes have a second shim channel for the 2nd order shims. This has been historically labelled Channel “1” by Magnex.
This high order shim channel sometimes contains X3, and Y3 but not always. These switch heaters are normally shared on the ZX and ZY shim channels, and can be verified by measuring the heater resistance for the presence of 1 or 2 shim heaters.
The shim current circuits are independently operated with regards to current but have a common series heater circuit. Because of the series heater circuit care must be given when operating the shim heaters using Constant Voltage supplies. To much or to little heater current may be delivered and unexpected results will follow.

Plotting Convention:

The plotting rig is to be inserted from the Patient or Nitrogen heat sink end. Facing the magnet at this end the rig should be rotated clockwise and plane 1 (positive) is furthest into the magnet.

Check the specifications for your particular Invivo system:

Verify the specifications that the magnet must be shimmed to prior to shimming.
Generally the specifications can be found in the system manual. Verify the numbers found with the customer to insure that the system was not a "special".
If the magnet sale is to a private party or individual, different specifications normally apply over different volumes than those listed below. Check with the customer for sales contract documentation.

Shimming into specification:

Warning
If the magnet has passive shim trays the plotting rig/mapper must be centered on the the passive shim center regardless of any other circumstances.

If the magnet does not have passive shims then center the plotting rig on the SuperCon shim's center which is normally found at the null deflection point of Z1.

Shimming over the large DSV is the best place to start. Use the Multi or IS programs.

Example of an 8.5 cm DSV
Dimensions in cm

Plane	1	2	3	4	5	6	7
Z cm	4.03	3.15	1.73	0	-1.73	-3.15	-4.03
Radius cm	1.34	2.85	3.88	4.25	3.88	2.85	1.34

The "shim by eye" worksheet contained in the "Shimming.xls file" works nicely for Z1 to Z4, and X,Y thru Z2X, Z2Y when the plotting rig is properly aligned to the magnet.
It can set each shim very accurately and also supply error ppm and Calibration/Polarity values in ppm. These can be used in the classical way of shimming on a sphere 1 map at a time with Multi or IS programs. They can also be continuously updated throughout the shimming process.

The approach is to Shim all SC shims by from low order to high order.
This will set each of these to well under 1 ppm, and also collect calibration information for use later.

Once the large sphere is set by eye, perform a 12 plane plot.
Use the 12 plane plot to load passive shims.

Reset all SC shims by eye, and repeat the process.

When you reach the final pass squeeze the SC shims to a tighter level by using the calibration values generated during shim by eye to calculate new SC shim currents based on their mapped errors.

Collect all final maps and check that all specification's have been met.

It can not be emphasised enough that the setting up of the plotting rig is crucial to accurate plots.
Both the center chosen for the Z axis and phase coherence of your data collection to the magnet. This particularly comes into play on the 4.7T where 1-2mm axial error can cause the magnet to be out of specification due the field falling off the edges of the field map.

Iron Pieces:

The addition of iron should be done with care and only as a last resort.
The standard iron piece is 10 x 8 x 0.27mm, or .39 x .315 x .0106 inches square for the acetate sheets.
Other forms of passive shims material and loading methods exist also. We commonly use washers or multiple sizes of shim stock. These will be added to this form soon also.

Warning
Multi, and IS are highly accurate.
Errors in the plotting rig or the incorrect placement of iron or marking will become apparent by unexpected results. If your results do not agree with the software program the possibilities include, improper centering, improper readings, a quenched shim, or improper placement of iron.

Finally:

The specification test's are normally to be plotted over various size Spheres or spheroids.
These will be listed in the magnet manual and should be verified with the customer for contractual obligations.

Copies of all Final spheres or spheroids should be included with the sign off sheet.

Standard Iron configuration File's:

This file needs to be verified. If not for all FTMS systems then a section needs to be added for each type of file.

These can be copied and pasted into notepad for use.
Copy the lines between the ***,s. Do not copy the *** lines.

ftms-160-isa.fig

```
************************************************************

 7.8 iron radius (cm)
 0.022 iron volume (cm3)
 24   number of trays
 25   number of pockets per tray
  4   number of pieces per tray
 axial positions
 1   -12.0
 2   -11.0
 3   -10.0
 4   -9.0
 5   -8.0
 6   -7.0
 7   -6.0
 8   -5.0
 9   -4.0
10   -3.0
11   -2.0
12   -1.0
```

```
13    0.0
14    1.0
15    2.0
16    3.0
17    4.0
18    5.0
19    6.0
20    7.0
21    8.0
22    9.0
23    10.0
24    11.0
25    12.0
*****************************************************************
```

Plotting convention

Plotting consists of measuring the strength of the magnetic field at various points over the central region of the magnet. Plotting is usually based on the cylindrical co-ordinate systems with the z (axial) ordinate coinciding with the magnet axis and the r radial ordinate representing the distance of a point from the magnet axis. Magnex convention has the angular position of a point measured clockwise from the vertical. Figure A.1 shows this co-ordinate system.

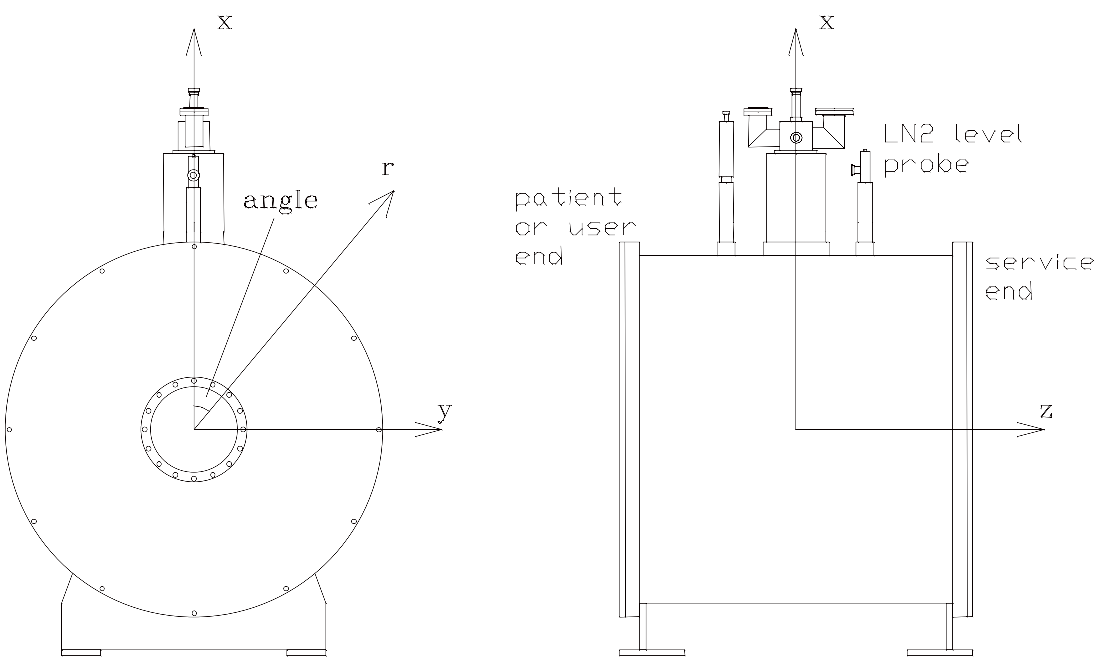

Figure A.1 Plotting Co-ordinate System

Need to update this drawing with additional coverage of shim trays and plotter orientation. Mike can complete this.

Plotting is normally performed over a series of 'planes' or circles (usually seven or twelve), each plane has a distinct axial and radial co-ordinate. On each plane the field is measured at a series of equally spaced angular positions (normally every 30 degrees).

The Magnex plotting convention is as follows:
Plot clockwise from the patient end with 0 degrees at top dead centre.
The positive z coordinates are towards the service end.
Plane 1 is always is at positive end of the magnet (i.e. closest to the service end)

Design shim strengths

Design Shim Strengths (Hz / cm without polarity)						
SC / RT	7T-160AS	9.4T-160AS				
SHIM	Shim	Shim				
NAMES	Strength ppm/amp	Strength ppm/amp				
Z0						
Z1	14.1	6.6				
Z2	6.	0.74				
X	3.7	3.88				
Y	3.7	3.63				
ZX	.26	4.9				
ZY	.26	3.7				
XY	.2	2.0				
X2-Y2	.2	2.0				

Shimming Problems

The iron shimming programs may not always come up with a suitable solution but what ever the program predicts should be achieved in practice. If the actual shim is not as predicted it is because the parameters chosen in the program do not reflect reality. The following issues are common causes of shimming problems.

- The plotting centre does not coincide with either the passive shim centre or magnet centre. Try measuring from both ends to get confirmation that the plotting rig is marked up correctly. Check to see if the plotting rig is coincident with passive shim centre. A long axial plot can sometimes show up problems, see how the field drops off either side of magnet centre. Using the position of null deflection of a Z1 shim can sometimes deceive, particularly if the shim couples to the magnet. Measure each 2 cm from lock to lock on the Metrolab. Label the X axis in relation to the plotting rig centre or 0.
- Sometimes to gain confidence in your plotting rig configuration it is helpful to perform the plot as above. Then Place 2 amps of current into the Z1, Z2, ZX, and ZY SC shims. Normalize all of the data, so that all plots have the same origin. Then graph it. This will show you the working area of the magnet and SC shims. Sometimes it is necessary to shim the magnet off center from the SC's, and the magnet center to have a homogeneous region of the required size.
- The plotting rig Z axis is not coincident with the magnet Z axis. This could be caused by the plotting rig sagging.
- The shim configuration file has the wrong settings. Check radial positions of the shim trays and the volume of an individual shim piece.
- The centre of the shim tray does not coincide with the centre of the magnet. Careful measuring should be able to confirm this.
- The co-ordinate system is wrong. The positive end of a seven or twelve plane field plot is at plane 1. Are the positive and negative ends of the shim tray consistent with this?
- The angular position of the trays is wrong. The 90 degree tray should be adjacent to the 90 degree plotting position.
- A mistake was made during the plotting process. Is there a reading that seems to stand out? The measurement could be wrong. It is recommended that all plots are analysed with MULTI, the error analysis will help identify rogue points. It is best to check for rogue points before doing a shim iteration.
- A mistake was made loading the shim trays. This is inevitable with large complex distributions. Try rechecking the trays in the angular positions close to field lumps.

- Magnetic components around the probe will give significant errors in the plot. With the accuracy required stainless steel is classed as magnetic. Brass or Nylon hardware should be used inside of the bore.
- Further inputs are appreciated. If you have your favorite plotting error mode I will gladly add it to this list.

Brookhaven National Laboratory
Medical Department
9.4 Tesla MRI, Energizing Procedure

1. Purpose: The procedure of magnet installation includes the processes of initial energizing of the super-conducting Animal MRI magnet.

2. Prerequisites for energizing the magnet and subsequent shimming:

   - Postings

     i. 9-430C shall be posted with the appropriate signage for Static Magnetic Fields and additional postings advising that the "Magnet is Always On"

     ii. 9-430C shall be posted "Authorized personnel only".

   - Access control

     i. The door to the Animal MRI Suite will be locked when unattended.

     ii. The door to the Animal MRI Magnet Room will be locked via the installed numbered keypad when unattended.

     iii. During energizing work, the assigned Safety Watch will prevent access to the Animal MRI Suite by unauthorized personnel.

     iv. Re-entry into room 9-430C after energizing is complete, shall require O2 monitoring/re-check..

   - Safety related equipment

     i. The installed O2 Monitor shall be operational during the energizing/shimming procedures.

     ii. The Bacarach Sentinal 44 Monitor shall be used in the event of installed O2 system failure and only from remote location indication (outside room 9-430C).

     iii. Once the magnet is energized, any authorized personnel entering the Animal MRI Magnet Room (9-430-C), will utilize the EIA PD-140 Hand-Held Metal Detector to ensure that no metals are on their person.

     iv. If metals are detected, the individual will utilize the 15lb. pull, 1000 Gauss Test Magnet to ensure the items they are carrying are non-magnetic.

   - Personal protective equipment (PPE)

     i. As an additional precaution, the Installation Engineer will wear a personal (lapel), O2 monitor during the power supply set up and removal.

- Electrical Safety Requirements

  i. The magnet power supply will be connected to the magnet via cables and remain exterior to the room.

- Approvals

  i. The Medical Department ESH Coordinator and the Principal Investigator/ Life Sciences ALD shall approve this procedure.

  ii. The Laboratory ESH Committee, and Laboratory Electrical Safety Officer shall review and recommend approval to the Deputy Director for Operations.

3. Initial Energizing Procedure:

   i. Connect the power supply to the magnet running the cables through the anesthesia/EKG lead access holes.

   ii. Plug in the power supply to house current.

   iii. Test and record the main coil inductance on the status report within the first 20 amps of ramping.

   iv. Compare the measured inductance against the design inductance. ***Note: A small variation is normal. A large variation will indicate that a switch heater is not energized or its associated switch is not opening. The coupled coil is not being quenched and gaining energy by inductive coupling. This test can prevent an unnecessary quench. L = V/(di/dt), di = change in amps, dt = period of time in seconds***

   v. Ensure that the Z2 and B0 coils are open during energization. ***Note: The minimum level for energizing and normal operation is 900 mm***.

0 - 220 Amps 2.4 amps/min (2.62 volts) 92 minutes
220 - 260 Amps 1.2 amps/min (1.31 volts) 34 minutes
260 - 282 Amps 0.6 amps/min (0.66 volts) 36 minutes

   vi. Over field the magnet by 2% (i.e. 9.58Tesla persist for 60minutes, use a ramp rate of 0.3 amps/min (0.33) volts. ***Note: It is important that this is accurate.***

   vii. Under field by 0.2% i.e. bring the field down to 9.381T for 10mins. ***Note: It is important that this is also accurate***

viii. Leave the leads in for at least 1hr after the main switch is closed to make sure it stays closed, and so you are ready to catch it if it opens.

ix. Leave the B0 dump on overnight for the first night and during all shimming. This will only consume a small amount of helium.

4. Persistence and Lead rundown.

i. Reduce the voltage/current of the supplies linearly over these time intervals.

ii. Remove the current in 4 minutes.

iii. 50% of the full current target in the 1st minute.

iv. 30% of the maximum current in the 2nd minute.

v. 20% of the maximum magnet current in the 3rd and 4th minute.
Note-The current must be reduced linearly so as to prevent the switch from opening. Also, the last 1-2 minutes of removing the current, are the most stressful to the SC switch as the current through the switch reaches its peak. If the switch opens repeat this procedure to train the switch.

vi. If the switch opens during lead rundown another Over field is not necessary if it is caught quickly. If the field drops more than 5% the over cycle procedure should be repeated if the available helium allows it. If the helium level is near the minimum point for energizing then persist, refill and go the rest of the way.

5. Emergency Response

i. In the event of an accidental quench or O2 alarm, all personnel shall remain outside the magnet room. Re-entry shall only be authorized by Facility Support and the Installation Engineer.
ii. Fire/Rescue will be on hand (with Self Contained Breathing Apparatus) during the initial hookup of the power supply to the magnet and subsequent removal of the power supply after energization.

iii. All emergencies shall be reported by calling extension 2222 or 911.

6. Equipment required for energizing the magnet:

Magnex provided power supply

Brookhaven National Laboratory
Medical Department
9.4 Tesla MRI, Energizing Procedure

Prepared by: ____
Robert L. Colichio(ESH Coordinator)

Reviewed by: ____
Congwu Du

____
Jim Briske

Approved by:

LS-ALD, ____
Helene Benveniste

The Laboratory ESH Committee,
Electrical Safety SME

____
Terance Monahan

Deputy Director for Operations,

____
Thomas Sheridan

KC Wu

KC's comments

BROOKHAVEN
NATIONAL LABORATORY

Medical Department
9.4 Tesla MRI, Liquid Helium Fill/cool-down Procedure

Prepared by: Christopher M. Harris 9/18/03

Reviewed by: Congwu Du

Jim Briske

Approved by:

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LS-ALD, Helene Benveniste

The Laboratory ESH Committee,
Cryogenic Safety Sub-committee

Edward Lessard

Deputy Director for Operations,

Thomas Sheridan

Medical Department
9.4 Tesla MRI, Liquid Helium Fill/cool-down Procedure

1. Purpose: The procedure for magnet installation includes pre-cooling the magnet using liquid nitrogen (LN), flushing the helium reservoir with gaseous helium and then filling the magnet's helium reservoir with liquid helium (LHe). The purpose of this procedure is to provide written guidance on the initial fill/cool-down of the Medical Department's 9.4 Tesla Small Animal MRI using liquid helium (LHe).

2. Prerequisites for helium fill

   - Training

     i. The training requirements for unescorted personnel entering into room 9-430C during the LHe fill/cool-down process are ODH1, and the ESH Coordinator's Briefing.

   - Postings

     i. 9-430C shall be posted ODH1.

     ii. 9-430C shall be posted "Authorized personnel only".

   - Access control

     i. All keys providing access to 9-430C shall be returned to the 490 Building Manager and stored in a lock box in room 8-112A.

     ii. The 490 Building Manager is the only individual who shall have lock combination knowledge during the fill/cool-down process.

     iii. The only personnel authorized access during the fill/cool-down process is the Installation Engineer, and FS Support personnel utilizing Bacarach Sentinal 44 O2,LEL,Toxic (calibrated 07/23/03) monitoring equipment.

     iv. Re-entry into room 9-430C shall require O2 monitoring/re-check if the space has been vacated.

     v. Once the helium fill process has begun, no work will be conducted in the animal mri facility (magnet room or adjacent spaces). In the event of any abnormal/questionable situation, the Installation Engineer shall be contacted at (936) 465-3651.

Medical Department
9.4 Tesla MRI, Liquid Helium Fill/cool-down Procedure

- Safety related equipment

  i. The installed O2 Monitor shall be operational during the fill/cool-down process.

  ii. The Bacarach Sentinal 44 Monitor shall be used in the event of installed O2 system failure and only from remote location indication (outside room 9-430C).

- Personal protective equipment (PPE)

  i. All personnel handling cryogenic transfer equipment shall utilize appropriate PPE (face shield, gloves).

  ii. As an additional precaution, the Installation Engineer will wear a personal (lapel), O2 monitor.

- Ventilation requirements

  i. The installed ventilation System is a single pass (100% outside air), system that contains an HVAC supply through 4 duct registers and a separate return (roof top exhaust), system.

  ii. The installed ventilation system is on emergency back-up power and has been verified to be operational.

  iii. The HVAC system, including the exhaust fans, shall be verified to be operational prior to start of work.

- Approvals

  i. The Medical Department ESH Coordinator and the Principal Investigator/ Life Sciences ALD shall approve this procedure.

  ii. The Laboratory ESH Committee, Cryogenic Safety Sub-committee shall review and recommend approval to the Deputy Director for Operations. The liquid helium cool down phase will commence only after authorization is received from the Deputy Director for Operations.

BROOKHAVEN
NATIONAL LABORATORY

Medical Department
9.4 Tesla MRI, Liquid Helium Fill/cool-down Procedure

3. Fill procedure

- Emergency Response

    i. In the event of a quench or O2 alarm, all personnel shall vacate the space immediately. Re-entry shall only be authorized by Facility Support and the Installation Engineer.

    ii. All emergencies shall be reported by calling extension 2222 or 911. ETL

    iii. Fire/rescue shall ~~be informed of~~ ON HAND DURING work activity THAT INVOLVES BAYONETING with the potential for ODH1 atmosphere ~~prior to start of work.~~

- Equipment required for flushing helium reservoir

    Helium gas bottle with pressure reducer;
    Dial gauge -1 bar to +1 bar; (location ?)
    1/2" diameter blow-out tube;
    Rotary pump of minimum capacity 16 M3/hour; (for what purpose)
    Mass-spectrometer leak detector;
    'T' piece connector with valve (purpose)

- Equipment required for helium transfer

    Liquid helium (250 Liter per dewar);
    1/2" diameter. transfer siphon;
    Helium gas bottle with pressure reducer;
    Resistance measuring equipment for monitoring magnet;
    Temperature (4 wire, approximately 300 ohm to 4.5K ohm, 100); (location)
    Micro A excitation

- Equipment set-up

    i. Cryogenic fill ladder shall be placed on the Southwest corner of the magnet and utilized in a safe manner.

    ii. Helium gas bottle or helium dewar, while in use, shall be set-up on the northwest corner of the magnet.

    iii. The vacuum pump shall be placed on the Southeast corner of the magnet to enable sufficient working space during the fill/cool-down process.

    iv. Helium gas not in use shall be stored on the 490 loading dock.

- LHe fill/cool-down

  The operating procedure for flushing and filling the helium reservoir is described in the attached Installation and Service Manual for Horizontal Bore Magnet System, Sections 8 and 9. This reference applies only to the initial liquid helium filling procedure, and does not supersede any safety requirements set forth herein.

INSTALLATION AND SERVICE MANUAL

for

Horizontal Bore Magnet Systems

Prepared : Jan 2003

Issue : 2

Document : Install_Horizontal.DOC

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8. FLUSHING HELIUM RESERVOIR

Equipment required:

Helium gas bottle with pressure reducer
Dial gauge -1 bar to +1 bar
1/2" diameter blow-out tube
Rotary pump of minimum capacity 16 M^3/hour
Mass-spectrometer leak detector
'T' piece connector with valve

Once the helium reservoir is cooled to 77K the liquid must be removed to allow the helium transfer. It is recommended but not essential that the pressure in the helium vessel, above the liquid nitrogen be reduced to approximately 200 mbar. This has the effect of supercooling the liquid and magnet. When the liquid nitrogen is supercooled it is more easily removed from the vessel, also because the magnet will now be at a lower temperature (typically 70K) the helium transfer will be more efficient.

— need to describe how to use pump etc

Ensure that the quench valve is in place and its 'O' ring is in good condition. Ensure also that the Graphite bursting disc is in place and that a backing plate is incorporated. The backing plate is essential to prevent the disc from bursting inwards. If there is no backing plate then close off the burst port with a metal disc seated on the 'O' ring to give a vacuum tight seal.

} which condition does BNL has?

Insert the bungs into the two lead entry ports and siphon entry port connect the dial gauge to the valve on the 'T' piece. Check that all these items are secure and a gas tight seal is made.

Connect the rotary pump to the normal vent port via a 'T' piece to the NW 25 fitting provided. Begin pumping and monitor the pressure on the dial gauge. The pumping time will depend on the size of the pump used and the amount of liquid nitrogen. Do not let the pressure fall below 200 mbar as the liquid nitrogen will begin to solidify below this pressure.

} Expect time at BNL?

After pumping, allow the pressure to rise by admitting helium gas to the vessel through the 'T' piece.

The liquid can now be removed from the helium vessel by inserting the blow out tube into the siphon cone and pressurising the helium vessel with helium gas. The siphon cone has a 10 mm thread and the blow out tube is threaded to match. Ensure that the tube is properly engaged in the thread so that a good seal is made. The tube should be rotated at least several turns into the thread.

Connect a flexible plastic tube to the top end of the blow out tube to direct the liquid into a suitable container. Pressurise the helium vessel with helium gas to a few psi (5 psi maximum) until liquid is seen to issue from the tube. Maintain the pressure

9. HELIUM TRANSFER

Equipment required:

Liquid helium (amount required specified in magnet manual)
1/2" diameter. transfer siphon
Helium gas bottle with pressure reducer
Resistance measuring equipment for monitoring magnet temperature (4 wire, approximately 300 ohm to 4.5K ohm, 100 micro A excitation

With the helium can purged of nitrogen and filled with one atmosphere of helium gas insert the leg of siphon into the siphon entry port. At the same time insert the other leg of the siphon into the storage dewar. Both vessels should be vented. — How ?

Lower both the legs slowly into their respective vessels, until the leg in the cryostat enters the siphon cone, and the leg in the storage dewar reaches the bottom.

Ensure that the leg in the cryostat is firmly seated in the siphon cone, lift the leg in the storage dewar about one inch above the bottom. Tighten the retaining nuts to give a gas tight seal.

Close off the vent in the storage dewar so that the pressure begins to rise. Admit helium gas to increase the pressure to 2 or 3 psi. Cold helium gas should be seen to emerge from the vent in the cryostat. A flow rate of 3 to 5 1/min. will give optimum cooling, the plume of cold gas should extend several feet from the vent. — where is the flowmeter?

Continue to transfer and monitor the carbon resistance thermometer attached to the magnet (see the wiring diagrams for the connections). When the magnet has reached 4.2K indicated by the carbon resistors (Allen Bradley) approaching 4.0K ohm resistance and a decrease in the plume length from the vent, liquid is being transferred and the pressure in the storage dewar can be increased to 5 psi maximum.

How does one know liquid fill is complete?

How to change liquid helium dewar?

in the vessel until all the liquid has gone as indicated by cold gas issuing from the tube with no trace of liquid. Continue to allow gas to purge through the tube for several minutes to ensure all traces of liquid have been removed.

Once the liquid has gone remove the blow out tube and replace it with the plug. Evacuate the helium vessel this time to a pressure of about 1 mbar. It is recommended that the helium level probe be connected and energised at this point, leave it on the 10 second rate. This will have the effect of ensuring all traces of liquid nitrogen which may be trapped within the probe are vaporised. Small droplets of solid nitrogen remaining in the helium level probe can upset it's operation. Watch the pressure reduce on the dial gauge. A pause or reduction in the rate of decrease of pressure at about 90 to 120 mbar indicates that some residual liquid remains and is solidifying. If this is suspected stop pumping, vent to helium gas and try the blow out procedure again.

Once the helium vessel is evacuated admit helium gas to 1 atmosphere. Repeat this flushing procedure at least once to ensure all residual traces of nitrogen have been removed.