Avance™ UltraStabilized™
750WB, 800, 800US² and 900

Site Planning Guide
North American Version

Version 001

This manual was written by

Razvan Teodorescu

This manual was desktop published by

Stanley J. Niles

Rheinstetten, Germany

P/N: Z31686_V1
DWG-Nr.: 1393001

Contents

Safety 1

Introduction 1.1

These safety notes must be read and understood by everyone who comes into contact with superconducting NMR Magnet Systems. Proper training procedures must be undertaken to educate all people, who are concerned with such equipment, about these requirements. It is essential that clear notices are placed and maintained to effectively warn people that they are entering a hazardous area. Please refer to **Bruker Biospin's General Safety Considerations for the Installation and Operation of Superconducting Magnets**, available from Bruker BioSpin.

The Magnetic Field 1.2

Since the magnetic field of the NMR magnet system is three dimensional, consideration must be given to floors above and below the magnet, as well as to the surrounding space at the same level. The magnetic field exerts attractive forces on equipment and objects in the vicinity. These forces, which increase drastically towards the magnet, may become strong enough to move large equipment and to cause small objects or equipment to become projectiles. The magnetic field may affect the operation of medical electronic implants, such as pacemakers, if exposed to fields above 5 gauss. Medical implants such as aneurysm clips, surgical clips or prostheses may also be attracted. In addition, implants in the environs of changing fields (e.g. pulsed gradient fields) may be impinged on by eddy currents resulting in heat generation. Ensure that all loose ferromagnetic objects are removed from the 5 gauss field zone of the magnet before the magnet is ramped to field. Human experience and reaction speed are totally inadequate to cope with the extremely nonlinear forces the magnet exerts on iron objects, therefore no ferromagnetic objects should be allowed to enter the magnet room after the magnet is energized to field.

Exclusion Zone 1.2.1

The **Exclusion Zone** is the area inside the magnet's 5 gauss field line, extended in all directions, including rooms above and below the magnet area.

Individuals with cardiac or other medically active implants must be prevented from entering this area. The exclusion zone must be enforced with a combination of warning signs and physical barriers.

Security Zone 1.2.2

The **Security Zone** is usually confined to the room that houses the magnet.

Ferromagnetic objects should not be allowed inside the security zone to prevent them from becoming projectiles.

Ventilation 1.3

A very large increase in volume accompanies vaporization of the cryogenic liquids into gas. The cryogenic gas to liquid volume ratios are approximately 700:1. Due to this large increase in volume the vapor may displace the air in an enclosed room, which may lead to asphyxiation. To prevent this, adequate ventilation of the magnet room must be provided. **All doors to the magnet room should open outwards** to allow safe exit in the event the room becomes pressurized by helium gas during a magnet quench.

Regular Ventilation 1.3.1

Regular HVAC systems should be able to handle 3-5 room air exchanges per hour, and provide temperature stability of +/-1°F. Please refer to ***"HVAC (Heating Ventilation Air Conditioning)" on page 50*** for more details.

Emergency Ventilation 1.3.2

Depending on the actual size of the magnet room, a large amount of He and N_2 gas could displace the air in the room in case of a quench, or during the initial cooling of the magnet and follow-up cryogen fills. Therefore, an emergency exhaust system may be required to avoid asphyxiation. Please refer to the section ***"Emergency Gas Exhaust" on page 51***, for more details.

Oxygen Sensors 1.3.3

Oxygen (O_2) sensors are required in the magnet room to detect low levels of O_2 due to cryogenic gases. Please refer to ***"Cryogens" on page 54*** for more details.

Safe Handling of Cryogenic Substances 1.4

Croygenic liquids are usually stored at their boiling temperature. As a result, a fraction of the liquid constantly evaporates into the gas phase, leading to a pressure build-up. The second most important feature of cryogens is the enormous increase of gas volume, which follows the raise in gas temperature starting from the boiling temperatures of the cryogenic liquids and going up towards room temperature. Cryogenic liquids must be handled and stored in **well ventilated areas**. Containers for cryogenic liquids must be constructed of non-magnetic materials and should be specifically designed for use with particular cryogens. Be sure to read and follow any specific instructions provided by the container manufacturer concerning their individual products.

Refill of Liquid Nitrogen *1.4.1*

Keep contact with air at a minimum. Air in contact with liquid nitrogen can condense and become as hazardous as liquid oxygen. The **pressure relief valve** for the nitrogen vessel should be mounted at all times, even when the vessel is being refilled.

When the vessel is being refilled, liquid nitrogen should not be allowed to spill onto the room temperature bore closure flanges. Place gum rubber or Teflon tubes on the nitrogen neck tubes during refill. The transfer should be stopped immediately when the vessel is full. Failure to observe this can lead to the freezing of the o-rings and a subsequent vacuum loss of the magnet cryostat.

The liquid cryogen transport dewars used to refill the magnet should be of the low pressure type. Never use high pressure gas-packs.

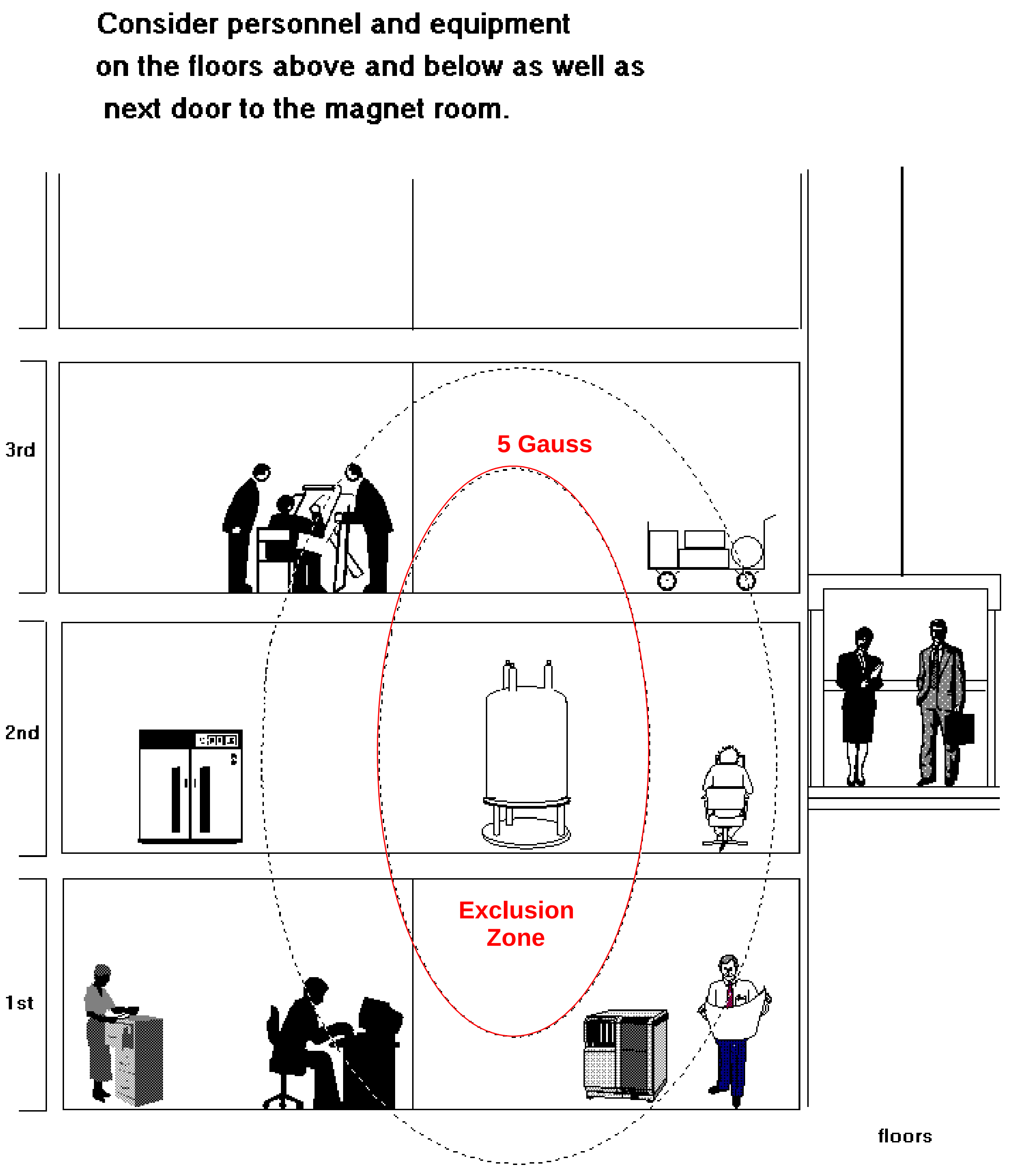
Refill of Liquid Helium *1.4.2*

Avoid contact with air. Air in contact with liquid helium will solidify. Vacuum insulated pipes should be used for transferring liquid helium. The helium vessel should be checked weekly for helium level and overpressure.

Two one-way valves are supplied and mounted in series on the helium manifold to ensure that no air or moisture enters the helium vessel, hence preventing ice from building and plugging the neck tubes. The 20 mbar valve must be mounted at all times even during a helium transfer.

Important Note: The transfer of liquid helium can be done easily and safely, provided the helium transfer line is in good condition and is handled correctly, and the transfer pressure does not exceed 3.5 psi. Never connect a warm helium transfer line as the warm helium gas could disturb the magnet temperature. Always allow the helium transfer line to cool down to helium temperature before connecting it to the short end inserted into the helium fill port. This short end is cooled down by inserting it - both ends open - into the magnet at the same time, while the long part of the transfer line is cooled from the supply vessel.

Figure 1.1. Stronger Stray Fields in Vertical Direction than in Horizontal Direction



Equipment 2

Introduction 2.1

This section describes the types and functions of the various sub-systems that are delivered as part of our AVANCE UltraStabilized NMR systems. These include the following:

- The superconducting magnet system.
- The console, monitoring & control unit.
- The CryoProbe^{TM} system.

Superconducting Magnet 2.2

This section describes the basic operation of an NMR superconducting magnet.

Purpose: The superconducting magnet is a complex system producing a very strong, homogeneous, and stable magnetic field, which is required for NMR.

Magnet temperature: The magnet uses both liquid nitrogen and liquid helium. The magnet coil is immersed in liquid helium inside a dedicated helium vessel. liquid nitrogen fills a different vessel and reduces the helium evaporation rate.

UltraStabilized Magnets: The magnet coil is immersed in a liquid helium bath at a sub-cooled temperature (~ 2 K). An additional liquid helium bath operating at a standard temperature of 4.2 K is located above the sub-cooled helium section.

Magnet current: After the initial charging with electrical current, the magnet runs in persistent mode. The current runs in a closed loop inside the system and the magnet itself is no longer connected to a continuous power supply.

Pump-line: The sub-cooled systems are equipped with a special pump line in order to reduce the liquid helium temperature from 4.2 K to ~ 2 K. The pump line connects one port of the magnet to a set of pumps. Pumping is done on a Joule-Thompson Cooling Unit located inside the cryostat in order to reduce the temperature of the liquid helium (by using this method the large volumes of liquid and gaseous helium in both temperature zones can be kept slightly above atmospheric pressure).

Maintenance: The magnet maintenance consists of refilling the system with cryogenic fluids at defined time intervals (refer to ***"Refill Time Intervals for UltraStabilized Magnets" on page 12***).

Table 2.1. Refill Time Intervals for UltraStabilized Magnets

	750WB	800	800US[2]	900
LN_2: Refill Volume Hold Time	230 liters 13 days	230 liters 13 days	400 liters 21 days	400 liters 21days
LHe: Refill Volume Hold Time	240 liters 56 days	245 liters 56 days	350 liters 60 days	350 liters 60 days

Console, Monitoring & Control Unit 2.3

Table 2.2 lists the various parts of the console, monitoring & control unit. Please also refer to the diagram ***"AVANCE UltraStabilized NMR Layout Example" on page 36***, which maps out the location of the parts in a typical room layout.

Table 2.2. Console, Monitoring & Control Unit

Item	Name	Function
“A”	AVANCE console main cabinet	Performs the actual NMR data acquisition.
“B”	Bruker Magnet Pump Control (BMPC)	* Monitors the magnet status and cryogenic parameters, * Controls the pump system, and * Interfaces between the magnet, pump system, and user.
“C”	Pump system	Drives the Joule-Thompson cooling unit in order to maintain the temperature of ~ 2K.
“D”	Uninterrupted Power Supply (UPS)	* Feeds the BMPC (item “B”), and provides continuous power in case of power failure, and * Acts as a power conditioner Item “D” must be on the emergency generator.
“E”	Workstation	* Acts as operational computer for the user, and * Sends/receives data to/from the acquisition computer in the main console (item “A”).
“F”	BCU-05 cooling unit	Provides cooling to allow proper temperature stability of the sample.
“I”	Imaging accessory cabinet	Houses the gradient amplifiers for micro-imaging applications.
“S”	High-Power Solids Accessory Cabinet	Houses the high power amplifiers for solids NMR applications.
“HPPR”	Preamplifier	Pre-amplifies the signal going to/coming from the NMR probe inside of the magnet bore.
“M”	Bruker monitoring system (BMS)	Monitors the BMPC (item “B”).

CryoProbe System 2.4

The Bruker CryoProbe^{TM} Accessory for the AVANCE NMR Spectrometers offers dramatic increases in signal to noise ratio, stability, and ease of use. For details of site planning for the CryoProbe Accessory, refer to the "CryoProbe^{TM} Purchase and Siting Guide".

The CryoProbe system consists of the following components:

Table 2.3. CryoProbe System

Item	Description and Function
CryoProbe^{TM}	* Represents the NMR probe inside the magnet bore, * Is cooled by cryogenic helium gas, and * Maximizes efficiency and reduces thermal noise, thus enhancing the signal-to-noise ratio.
CryoCooling Unit (“CRYO”)	* Contains a cryocooler, a cryocontroller, a vacuum system and He transfer lines, * Cools compressed helium gas by expansion, * Provides and maintains the vacuum insulation, and * Supervises all CryoProbe operations.
“BB”	Buck-Booster - 1kVA transformer to boost the 208V voltage to 230V for the Cryo unit.
He compressor (“He COMP”)	* Provides compressed helium gas to the CryoCooling unit, and * Connects to the CryoCooling unit by means of helium gas pressure lines.
Water chiller (optional)	Provides cooling capacity to remove ca. 7.5kW of heat generated by the He compressor.
High purity He gas cylinder	* Provides high purity and high pressure (min. 300 psi) helium gas for flushing the probe prior to a cool-down cycle, and * Includes a regulator, an outlet valve, and a charging hose.
Transfer line support (“TLS”)	* Provides support for the probe, and * Isolates probe against vibrations.

Magnet Access and Rigging

3

Off-loading on Site 3.1

When planning for offloading of the magnet on site, the following must be considered:

- An overhead crane is required to unload the magnet off the truck and position it correctly for access into the building. The size of the crane will depend on the magnet transport weight (***Table 3.2.***) and size (***Table 3.1.***), as well as the distance of reach (horizontal and vertical) to the access point into the building (access doors, hatch in the roof, etc.).
- The elevation of the loading dock relative to the NMR room will determine if a crane is required or if an elevator must be utilized as part of the route the magnet takes from the loading dock to the NMR room.
- The load bearing capacity of the loading dock or of a special slab at the access entrance into the building must be able to handle the load safely. Please refer to ***Table 3.2.*** for magnet transport weights.

Access to the NMR Room 3.2

Before delivery the customer must ensure that the system and magnet can be transported to the site. The table below gives the sizes of the crates in which the magnets are shipped. Should it be necessary to un-crate the system the corresponding minimum door dimensions are also given. The following must be considered:

- The access clearance (height x width) and floor loading capacity must be checked along the entire route that the magnet will take from the loading dock to the NMR room. Refer to ***Table 3.1.*** for minimum door sizes. Refer to ***Table 3.2.*** for magnet system transport weights.
- Elevator capacity and dimensions must also be considered if applicable.
- Transport will also be affected by any floor irregularities and the presence of door sills and steps. Use masonite sheets with air skates to traverse floor irregularities such as cracks and door seals.
- Special air-skates are often used to transport the magnet from the loading dock / slab at the entrance into the building to the final magnet location inside the NMR room. They require a large compressor (refer to the section "***"Rigging Equipment" on page 16***").

.

Table 3.1. Door Dimensions for Magnet Access

	Crate Size			Minimum Door Dimensions			
System	**L**	**W**	**H**	**Width Crated**	**Width Uncrated**	**Height Crated***	**Height Uncrated***
750 WB	6’ 7”	5’ 11”	9’ 11”	6’ 3”	4’ 7”	10’ 3”	9’ 6”
800 SB	6’ 7”	5’ 11”	9’ 11”	6’ 3”	4’ 7”	10’ 3”	9’ 6”
800 SB US^2	7’ 11”	7’ 3”	9’ 11”	7’ 7”	5’ 11”	10’ 3”	10’ 0”
900 SB	7’ 11”	7’ 3”	9’ 11”	7’ 7”	5’ 11”	10’ 3”	10’ 0”
SB= Standard Bore (54mm), WB= Wide Bore (89mm), US^2= UltraShield-UltraStabilized * Including air skates (cushions) required to move the magnet.							

Magnet Transport Weights — 3.3

The transport weights for each magnet type are listed below. For the weights of the rest of NMR equipment, please refer to ***"Dimensions and Weights of NMR Equipment" on page 27***.

Table 3.2. Magnet Transport Weights

Magnet Type	Transportation weights - crated (lbs.)
750WB	9,800
800	9,400
800US^2	15,000
900	15,000

Rigging Equipment — 3.4

All rigging equipment must be selected to handle the size (***Table 3.1.***) and transport weights (***Table 3.2.***) of the magnet system. For Ultra High Field magnet systems, a crane is required for offloading from the truck to the loading dock. Air skates should be used during transport over floors and through passage ways whenever possible. For lifting during installation, hydraulic lifts are preferred.

Rigging equipment is not included with the NMR system order. The following rigging equipment will be needed for the delivery and installation of an UltraStabilized magnet system:

- **Crane:** A crane able to handle magnet load is required to:

    - lift the magnet off the truck,

- place it on a flat ground surface for uncrating, and

- lift it again and place it on air-skates in front of the access doors.

- **Air-Skates:** A set of four air-skates is required to transport the magnet from the access doors onwards. The air-skates require an air-compressor capable of supplying up to 70 cfm flow at 25 psi pressure, depending on the magnet load.
- **Leveling Sheets:** Masonite (or other suitable material) sheets may be temporarily required to perfectly level the transport route from the access doors to the NMR room, in case of small imperfections.
- **Pallet Jack and/or Fork Lift**: For transporting system accessories to the NMR room.
- **Lifting Hook or Hydraulic Lifting System:** Lifting the magnet inside the NMR room for assembly purposes requires either a fixed lifting hook or a hydraulic lifting system capable of handling the magnet load within the given ceiling height requirements (please refer to ***"Minimum Ceiling Height Requirements and Lifting Weights" on page 19***).

Unloading the magnet crate off the truck and positioning it on the ground for uncrating.

Lifting the magnet and positioning it on air-skates in front of the access doors to the building.

Magnet positioned on air-skates prior to access into the building.

Ceiling Height Requirements 4

Ceiling Height 4.1

The assembly of a magnet system, the magnet energization and refills with liquid helium require minimum specified height clearances as listed in table 4.1.

- The ceiling height requirements need not be met over the entire NMR room. ***Figure 4.1.*** illustrates that the height requirements need only be met immediately above the magnet itself (and center of platform), and over an area that extends out in one direction to allow for the helium transfer line.
- The customer should provide a fixed lifting hook or a hydraulic lifting system capable of supporting the magnet to a sufficient height for the assembly of the magnet. The ceiling height required to lift the magnet with a hydraulic lifting system is generally less than when using a fixed lifting hook. This is based on the additional hand chain hoist needed with a fixed lifting hook. The table below lists the required minimum ceiling heights for operation, the minimum hook heights when using a fixed lifting hook (measured from the floor to the bottom of the hook) and corresponding magnet mass for the UltraStabilized magnets:

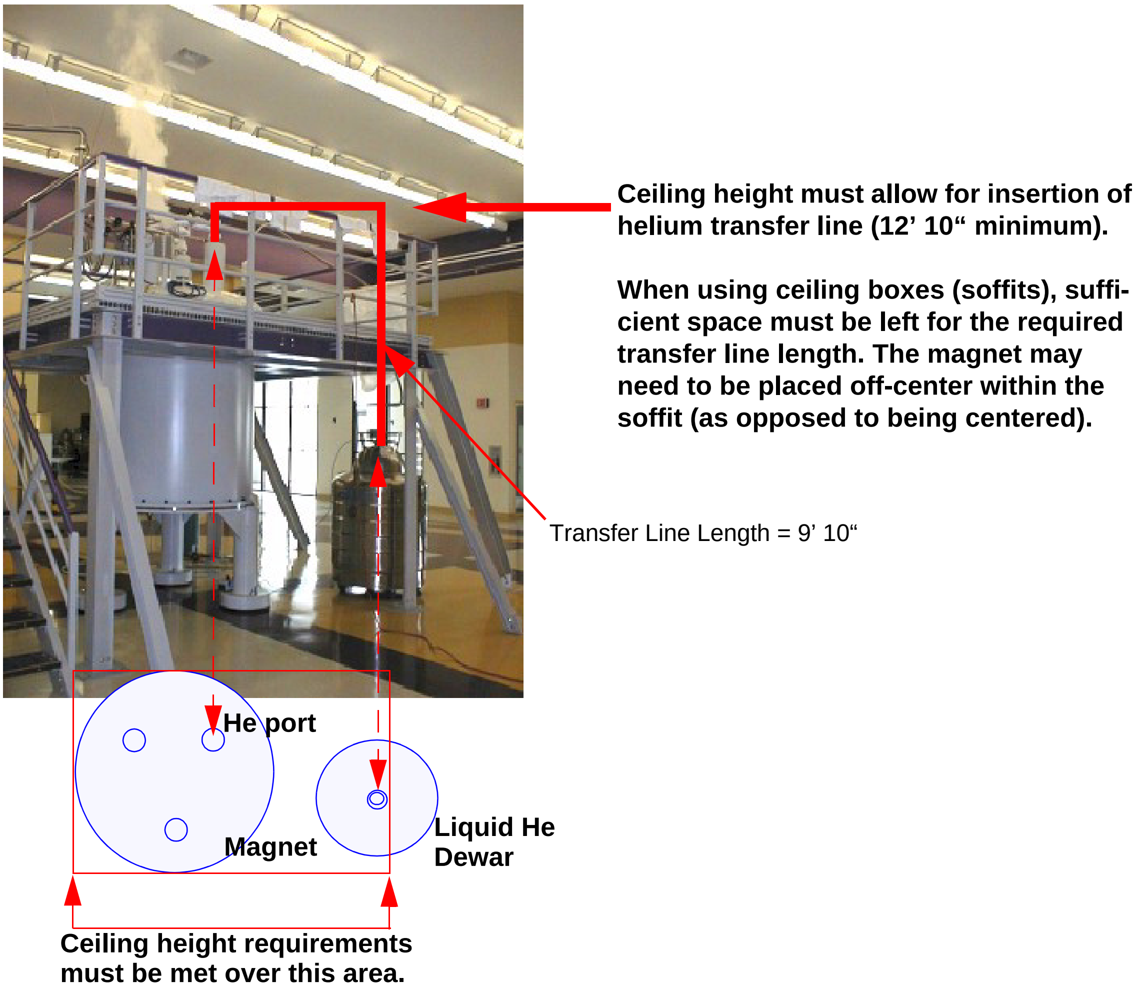
Table 4.1. Minimum Ceiling Height Requirements and Lifting Weights

Magnet Type	Minimum Ceiling Height above Magnet*	Minimum Height for Fixed Hook in the Ceiling***	Minimum Hook Height of Lifting System****	Minimum Ceiling Height above He Dewar	Total Lifting Weights (lbs)
750 WB	17’ 3“(16’ 3”)**	15’ 10”	14’ 4”	12’ 10”	8,900
800 SB	17’ 1“(16’ 0”)**	15’ 10”	14’ 4”	12’ 10”	8,500
800 SB US^2	18’ 3“(17’ 5”)**	17’ 9”	15’ 7”	12’ 10”	13,800
900 SB	18’ 3“(17’ 5“)**	17’ 9”	15’ 7”	12’ 10”	13,800

SB= Standard Bore (54 mm); WB= Wide Bore (89 mm); US^2= UltraShield-UltraStabilized

* This is the minimum ceiling height requirement for cryogen fills and magnet energization using standard equipment. This is typically sufficient for lifting the magnet during the assembly phase when using a hydraulic lifting system. Please consult with Bruker regarding magnet lifting solutions.
** **The values in parenthesis are the absolute minimum and require the use of special energizing equipment.**
*** This is the hook height measured from the floor to the bottom of a fixed hook in the ceiling if applicable.
**** This is the hook height measured from the floor to the bottom of the hook provided as part of the lifting system (i.e. hydraulic lift, or hoist and manual chain system).

Figure 4.1. Ceiling Height Requirements



Magnetic Stray Fields 5

Introduction 5.1

The magnetic stray fields are three dimensional. Stray fields extend further in the vertical direction than in the horizontal direction. ***Table 5.1.*** displays the horizontal stray field in the R-direction, while ***Table 5.2.*** displays the vertical stray field in the Z-direction

Table 5.1. Horizontal Stray Fields (distances are measured in radial directions)

Magnet type	50 G	30G	10 G	5 G	2 G	1 G	0.5 G
750 WB	9’ 6”	11’ 2”	16’ 1”	20’ 4”	27’ 6”	34’ 8”	43’ 11”
800 SB	9’ 2”	10’ 11”	15’ 9”	20’ 0”	26’ 10”	33’ 9”	42’ 8”
800 SB US^2	4’ 8”	5’ 1”	6’ 3”	7’ 2”	9’ 6”	12’ 5”	16’ 2”
900 SB	12’ 2”	14’ 2”	20’ 8”	25’ 7”	35’ 0”	43’ 11”	55’ 7”
SB= Standard Bore (54 mm); WB= Wide Bore (89 mm); US^2= UltraShield-UltraStabilized							

Table 5.2. Vertical Stray Fields (distances are measured in axial directions)

Magnet Type	50 G	30G	10 G	5 G	2 G	1 G	0.5 G
750 WB	11’ 10”	14’ 2”	20’ 5”	25’ 7”	34’ 11”	44’ 1”	55’ 2”
800 SB	11’ 8”	13’ 8”	19’ 8”	24’ 11”	33’ 8”	42’ 8”	53’ 8”
800 SB US^2	6’ 4”	7’ 2”	9’ 4”	11’ 2”	14’ 3”	17’ 2”	21’ 2”
900SB US	15’ 9”	17’ 11”	25’ 7”	32’ 2”	44’ 3”	55’ 5”	70’ 4”
SB= Standard Bore (54 mm); WB= Wide Bore (89 mm); US^2= UltraShield-UltraStabilized							

Figure 5.1. Magnetic Stray Field Plot 750 MHz / 89mm

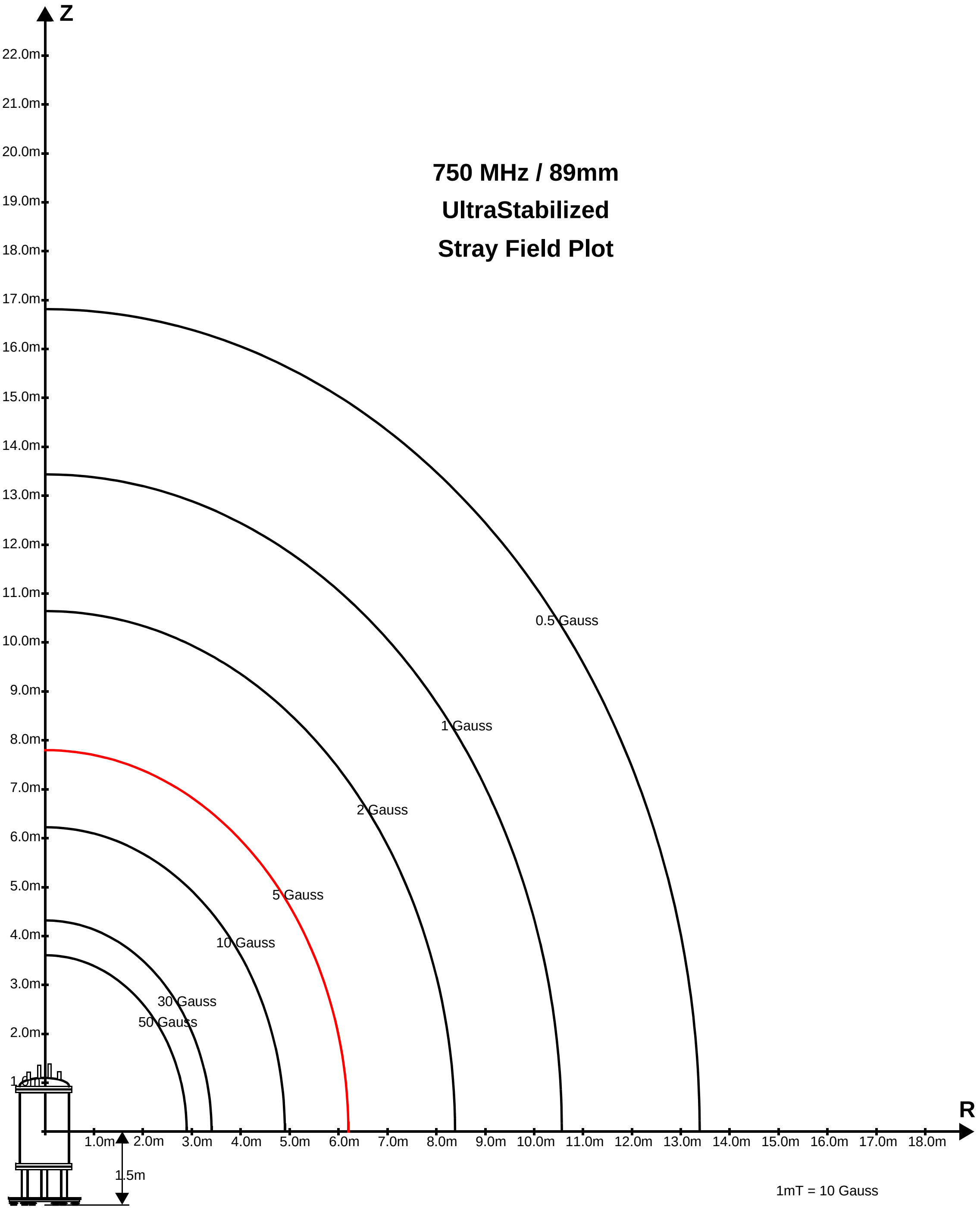


Figure 5.2. Magnetic Stray Field Plot 800 MHz /54 mm

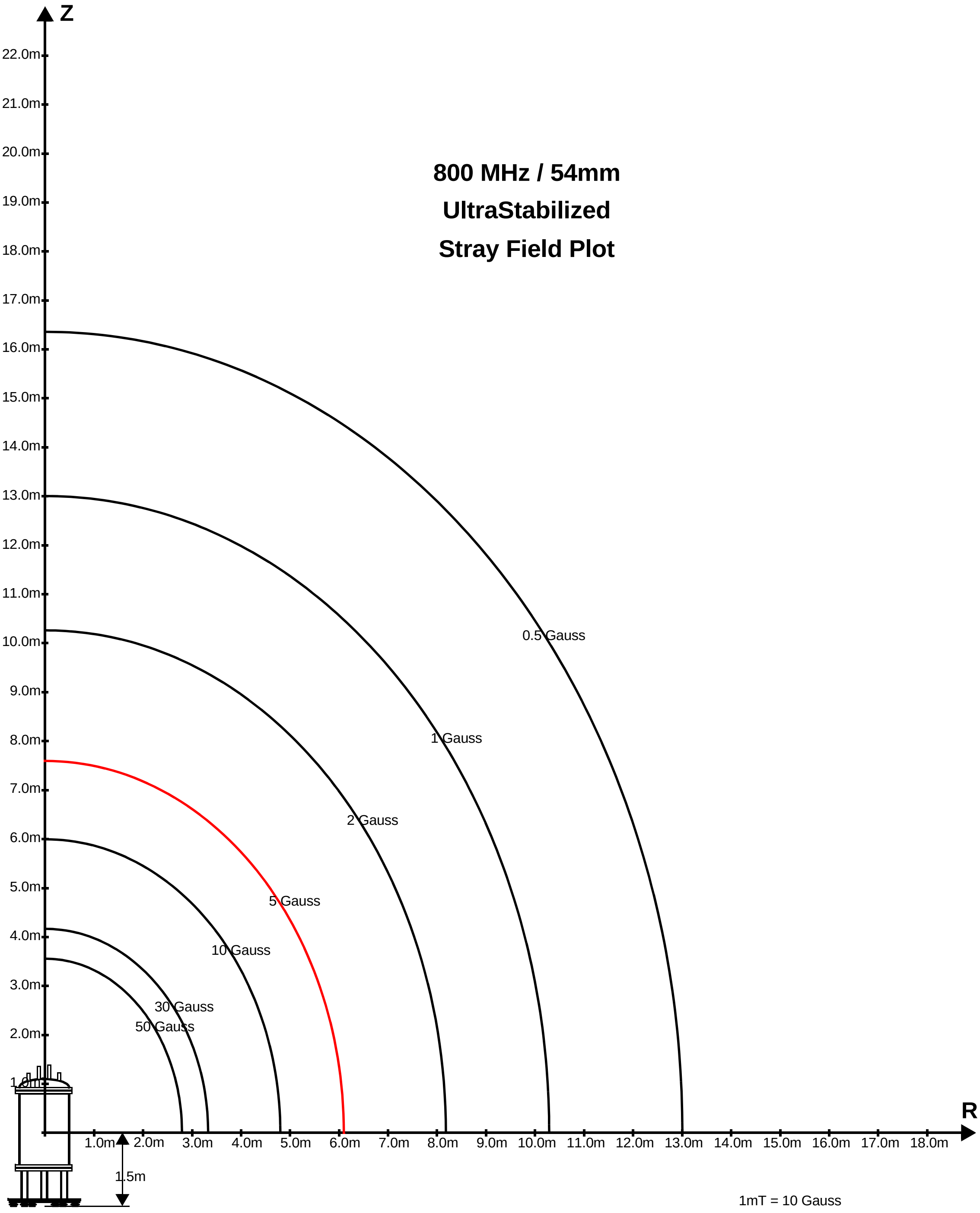


Figure 5.3. Magnetic Stray Field Plot 800 MHz /54 mm US²

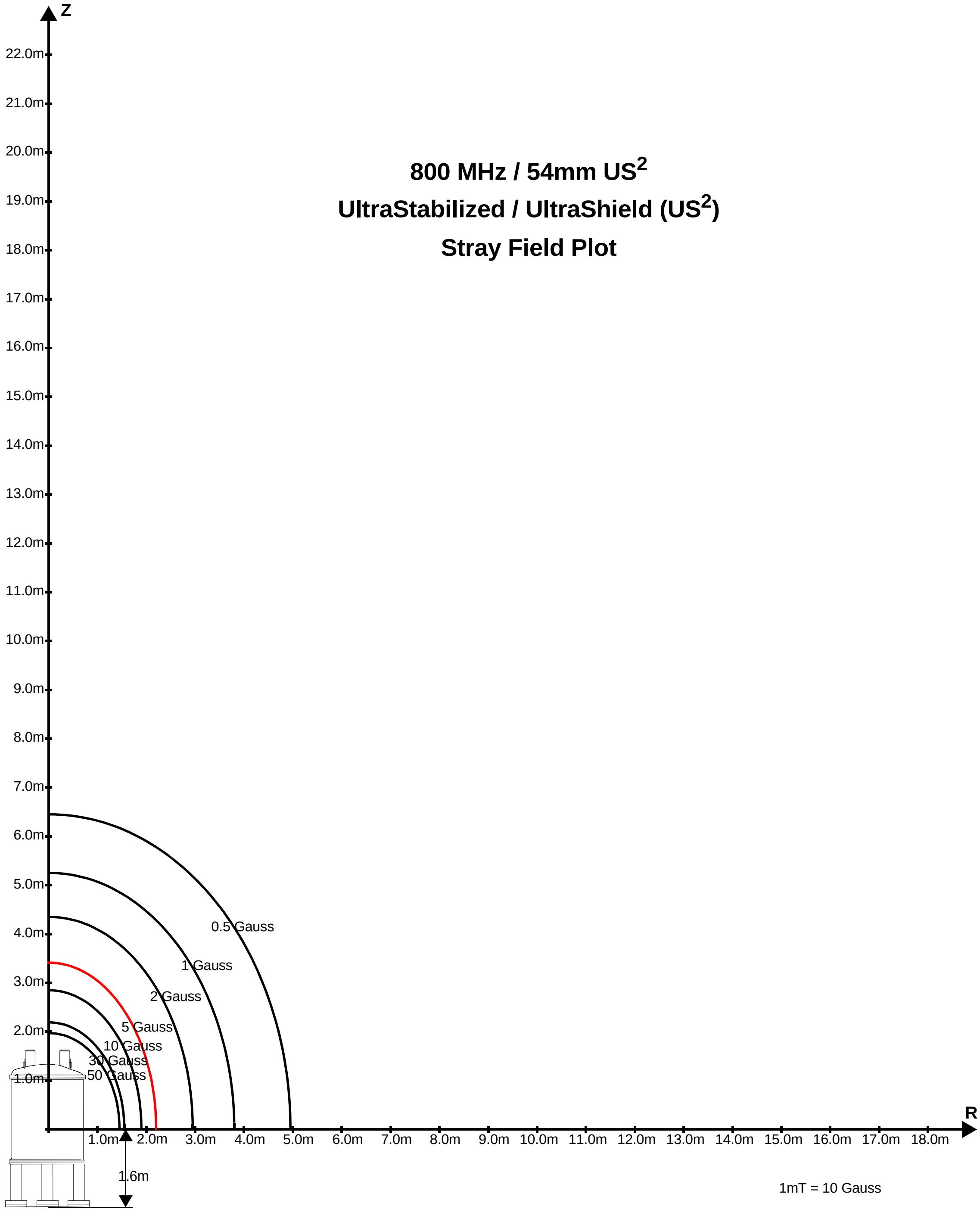
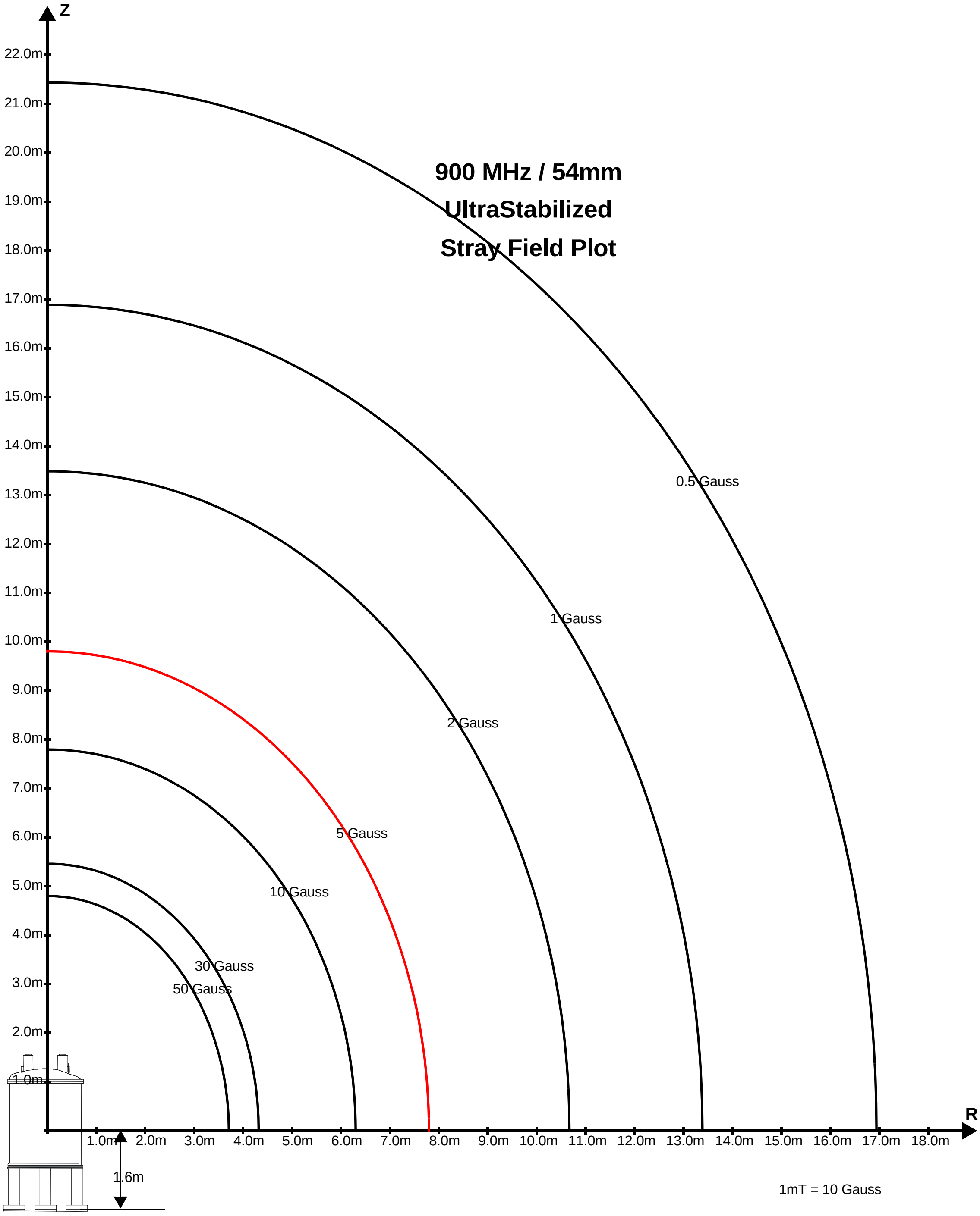


Figure 5.4. Magnetic Stray Field Plot 900 MHz /54 mm



Floor Plan 6

Size and Mass of Equipment 6.1

The floor of the NMR room must of course be sufficiently strong to support the console, magnet and ancillary equipment. ***Table 6.1.*** gives the dimensions and weights of NMR equipment. ***Table 6.2.*** gives the footprint and weight of magnets (filled with cryogens and including stand). The floor should also be as rigid as possible to reduce the effect of vibrations.

Table 6.1. Dimensions and Weights of NMR Equipment

Component	Width	Depth	Height	Weight (lbs)
AVANCE Cabinet	4’ 4’’	2’ 8’’	4’ 11’’	1000
Table / Workstation	4’ 0’’	4’ 0’’	2’ 6’’	150
High Power / MicroImaging Cabinets	2’ 2’’	2’ 8’’	4’ 11’’	450 / 330
Pump Control Unit (BMPC)	2’ 2’’	2’ 6’’	5’ 7’’	330
Magnet Pump Assembly	5’ 1’’	3’ 6’’	3’ 3’’	550
UPS	2’ 6’’	2’ 8’’	3’ 3’’	950
B-CU 05	1’ 8’’	1’ 10’’	1’ 7’’	110
Optional for CryoProbe:				
Cryocooling Unit	2’ 8’’	2’ 5’’	4’ 4’’	1000
Helium Compressor-Indoor Water or Air Cooled	4’ 2’’	2’ 8’’	2’ 4’’	300 / 350
Helium Compressor- Outdoor Air Cooled Indoor part Outdoor part	 1’ 8’’ 4’ 8’’	 4’ 4’’ 5’ 8’’	 3’ 4’’ 4’ 2’’	 253 100

Table 6.2. Mass of UltraStabilized Magnets

Magnets	Magnet Stand - Footprint Diameter	Total Magnet Weight Including Cryogens (lbs.)
750 WB	6' 0"	9,500
800 SB	6' 0"	9,100
800 SB US^2	6' 10"	14,000
900 SB	6' 10"	14,000
US^2= Ultrashield-UltraStabilized; SB= Standard Bore (54 mm); WB= Wide Bore (89 mm)		

Figure 6.1. 800 US^2 Magnet Dimensions (side view)

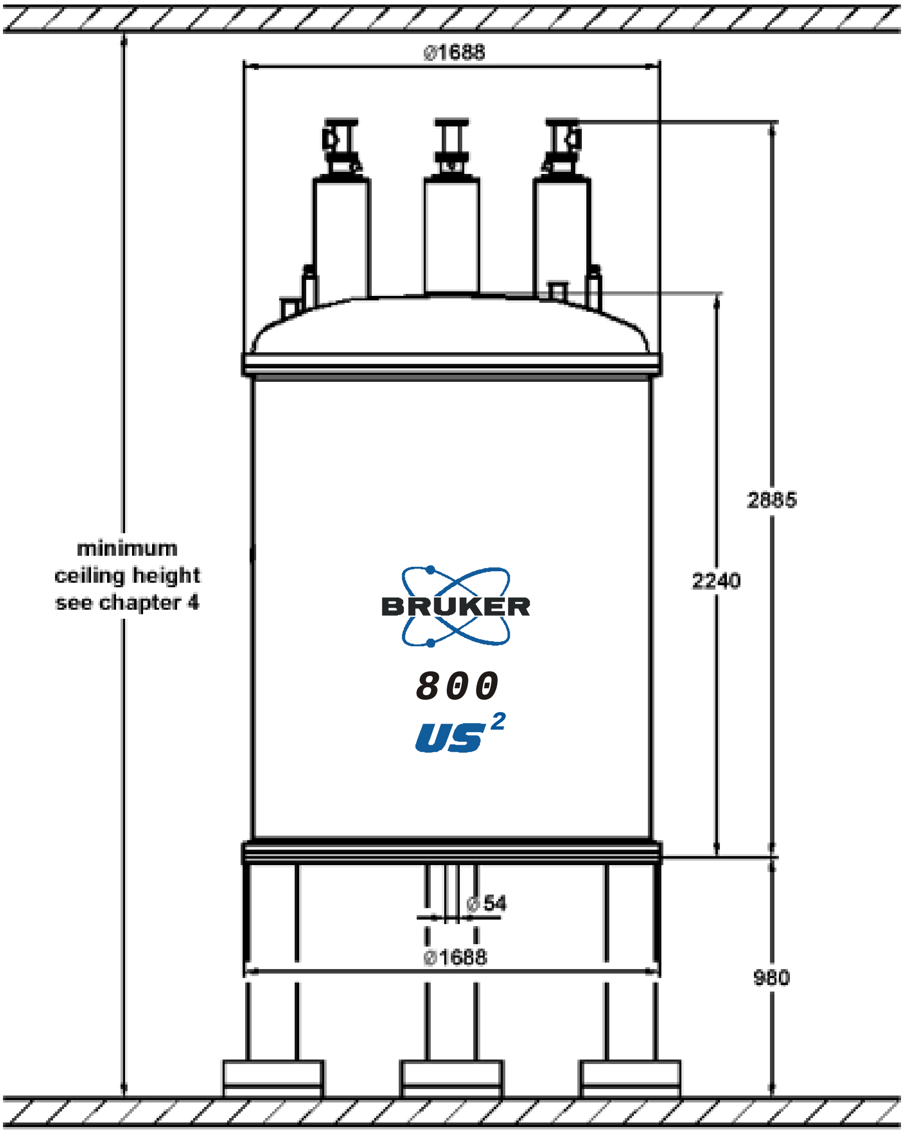
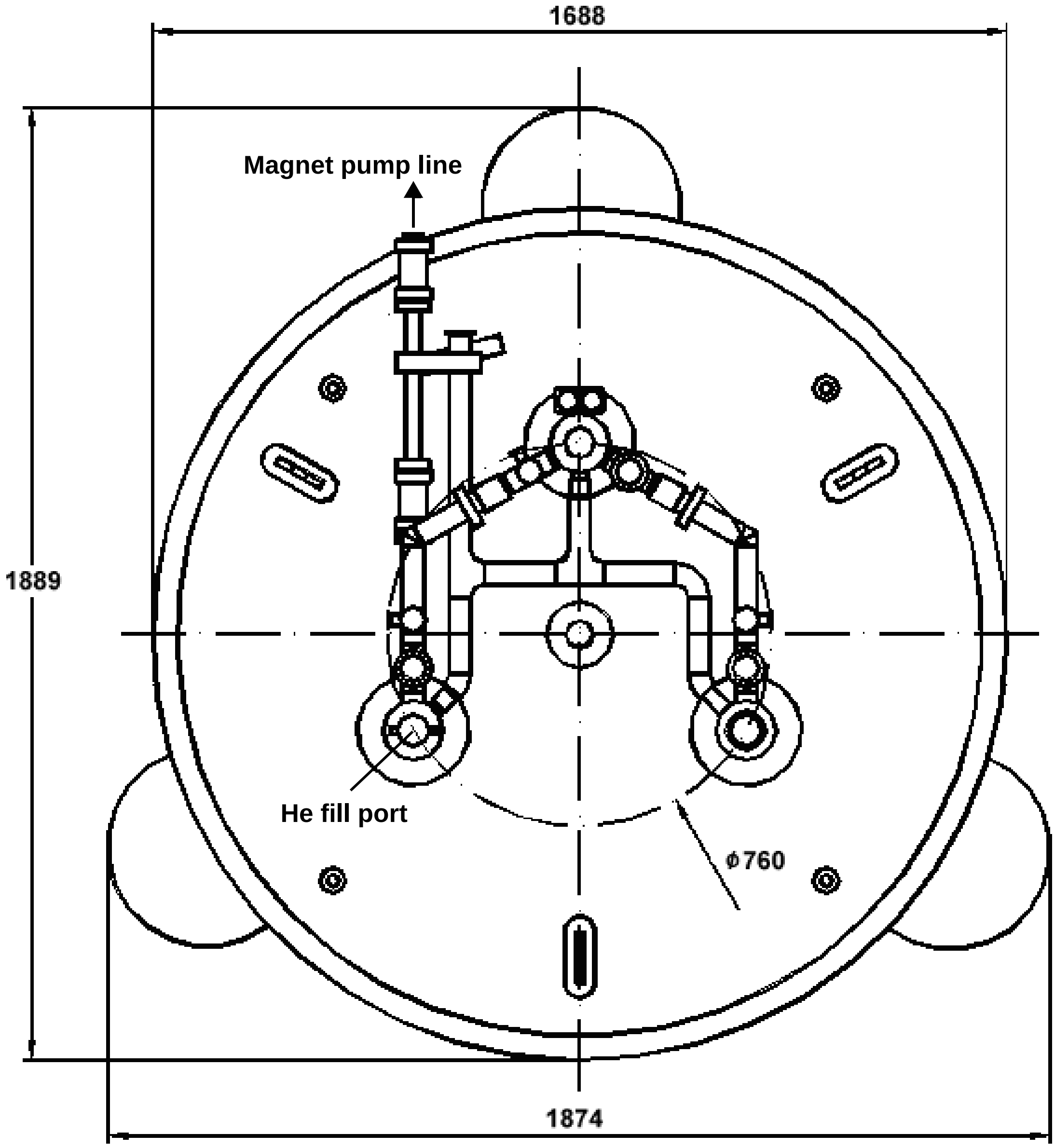


Figure 6.2. 800 US^2 Magnet Dimensions (top view)



Magnet Position 6.2

When locating the magnet consider the presence of permanent iron structures such as support beams in walls and floors. To increase temperature stability the magnet should not be placed in direct sunlight or near any artificial heat source. Where possible avoid a situation where a significant stray field (>5 G) extends into adjacent rooms. There should be free access to the magnet from all sides.

It is important to determine the optimal position in the NMR room, based on the following orientation elements:

- **The front of the manifold**: The He manifold has a front side defined by a U-shaped opening. The manifold connects the three He turrets at the top of the magnet.

- **The He fill port**: The left turret on the magnet is the helium fill port. A path for access of the liquid helium transport dewars to the left side, or front, of the magnet needs to be provided to accommodate the helium transfer line.
- **Magnet pump line**: The magnet pump line connects to the back of the manifold (see ***Figure 6.2.***).
- **The front of the stand**: The magnet stand also has a front side. The CryoProbe™ transfer lines coming from the “Cryo” unit connect to the probe on the front side of the magnet stand. The shim cable comes out through the back side, 180 degrees apart from the CryoProbe transfer lines.

NOTE: The front of the magnet stand does not necessarily have to match the front of the manifold.

Figure 6.3. 900 UltraStabilized Magnet

Magnet Slab 6.3

In larger buildings, it is strongly recommended to design and implement an isolated magnet slab that separates (isolates) the magnet from the rest of the floor and building, thus minimizing if not eliminating the vibrations that are transmitted to the magnet from the building (electromechanical equipment, HVAC, personnel, etc.). The slab must be large and strong enough to safely support the magnet load.

- **Dimensions**: The minimum recommended dimensions are as follows:

  750 WB and 800 SB:

  12’ (L) x 12’ (W) x 1’ (D)

  800 US^2 and 900 SB:

  12’ (L) x 12’ (W) x 2’ (D) or

  14’ (L) x 14’ (W) x 1.5’ (D)

  However, this is not a specification, and remains subject to approval by the project’s structural engineer.
- **Reinforcement**: The slab must be reinforced with non-magnetic reinforcement (e.g. fiberglass, or non-magnetic stainless steel).

If the magnet is sited in a small, simple purpose structure containing no sources of vibration, an isolated slab may not be necessary. Provisions to reduce air conditioner vibrations should be taken. Please consult with Bruker BioSpin regarding the magnet slab.

Magnet Platform *6.4*

The basic design requirements for the platform needed to access the top of the magnet for sample changers and magnet maintenance include, but are not limited to the following:

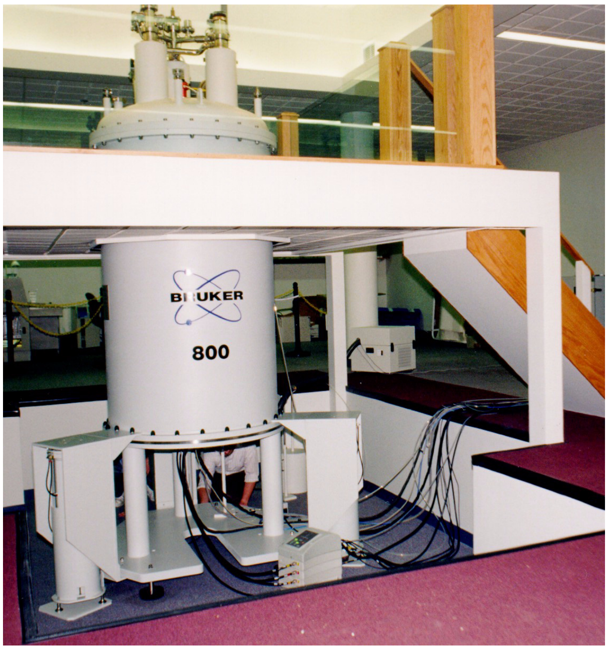
- **Material**: It must be non-magnetic. Most often used are aluminum and wood.
- **Height of platform deck**: The top of the deck must be 8' (for 750WB, and 800 SB) or 8' 6" (for 800 US^2, and 900) above the finished floor (AFF) to allow easy access to the top of the magnet.
- **Opening diameter**: The circular opening must be centered with the magnet and have the following diameters:

  750 WB and 800 SB: 52" diameter

  800 US^2 and 900 SB: 67" diameter

  This will leave ca. 2" clearance around the magnet.
- **Border around the opening**: A round border around the opening is recommended to avoid any tools or other objects dropped during installation or anytime afterwards while on the platform.
- **Stairs**: The access stairs shall be positioned to allow an easy access to the front of the upper manifold for sample changers.
- **Magnet Assembly Time**: The platform might be in the way of the rigging equipment when assembling or placing the magnet system in its final position. Soon after the first phase of magnet system assembly, the platform will be needed to complete the cryostat assembly and connections to the magnet before cool down. This requires a prefabricated platform which can be erected in two days or less. Please contact Bruker BioSpin for more information on the design and construction of the platform.

Figure 6.4. Magnet Platform and Pit



Magnet Pump Line 6.5

This section briefly describes the purpose, fabrication, and route of the pump line.

- **Purpose**: The pump line connects the magnet pump assembly to the Joule Thompson cooling unit located inside the He bath of the magnet system.
- **Fabrication**: It is custom made out of stainless steel to fit the site.
- **Route**: The pump line connects the rear helium port of the magnet to the pump unit and needs to be supported accordingly, depending on the route option that is chosen:

  - Down vertically near the magnet stand, then continue across the floor to the wall, and then further along the wall to the pump unit (preferred route, safest way of keeping building vibrations away from magnet), or

  - Elevated from the magnet to the wall, then brought down to the floor, and continue along the wall to the pump unit.

Magnet Pits 6.6

When the ceiling height is not sufficient, and/or the stray fields in the room above are beyond the acceptable range, then a magnet pit may be a consideration. Important issues that need attention include but are not limited to the following:

- Special rigging equipment and a temporary platform to support and lower magnet inside the pit.
- Ventilation/exhaust system inside the pit to prevent O_2 depletion due to cryogen gases.
- Magnet refills, and access for transport dewars.

- Cable lengths.
- Tuning and matching the probe.
- Siting the BCU05 cooling unit.
- Siting the CryoPlatform^{TM}.

Consult your local Bruker Installation Engineer for pit design and construction details.

AVANCE and Ancillary Cabinets 6.7

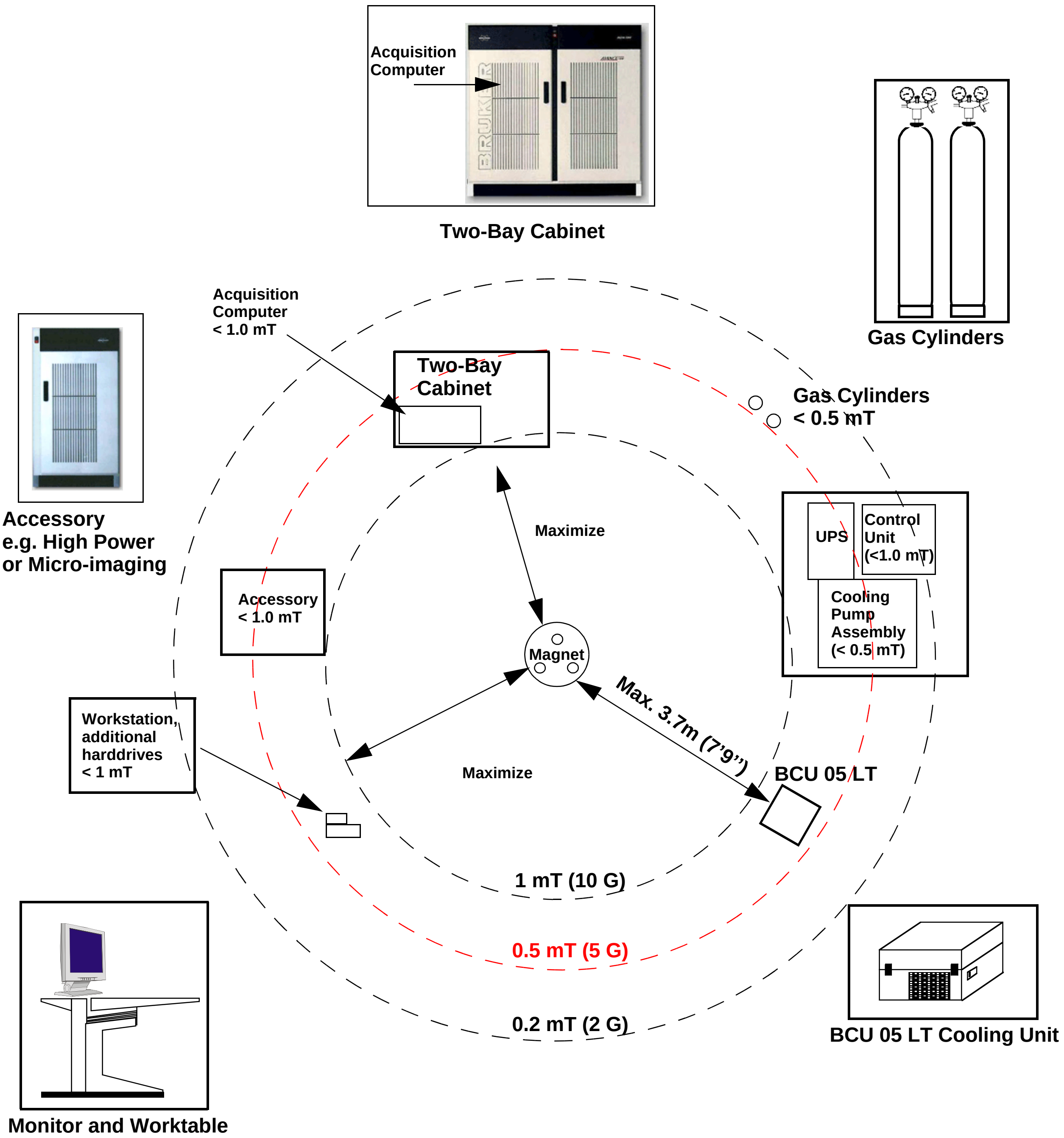
Protection of motors and electronics from the magnet stray field is crucial. Therefore, the AVANCE cabinet, BMPC (pump control and monitoring unit), and cooling pumps must be positioned outside the 10G stray field contour line. Any ancillary cabinets such as Micro-Imaging or High Power should also be placed outside the 10 Gauss line.

Worktable Position 6.8

Magnetic storage devices are sensitive to the stray field and attention must be given to their position relative to the magnet.

- The flat LCD panel should be turned (or able to be turned) towards the magnet so as to be visible when tuning and matching.
- The workstation and additional disks, CD-ROM Drives, etc., which are normally placed on the worktable, should not be exposed to fields greater than 10 G.
- For convenience of operation, no direct light should fall on the LCD panel, nor should there be a strong light source at the back of the panel. A separate dimmer or at least partial switching is recommended for the lights in the worktable area.

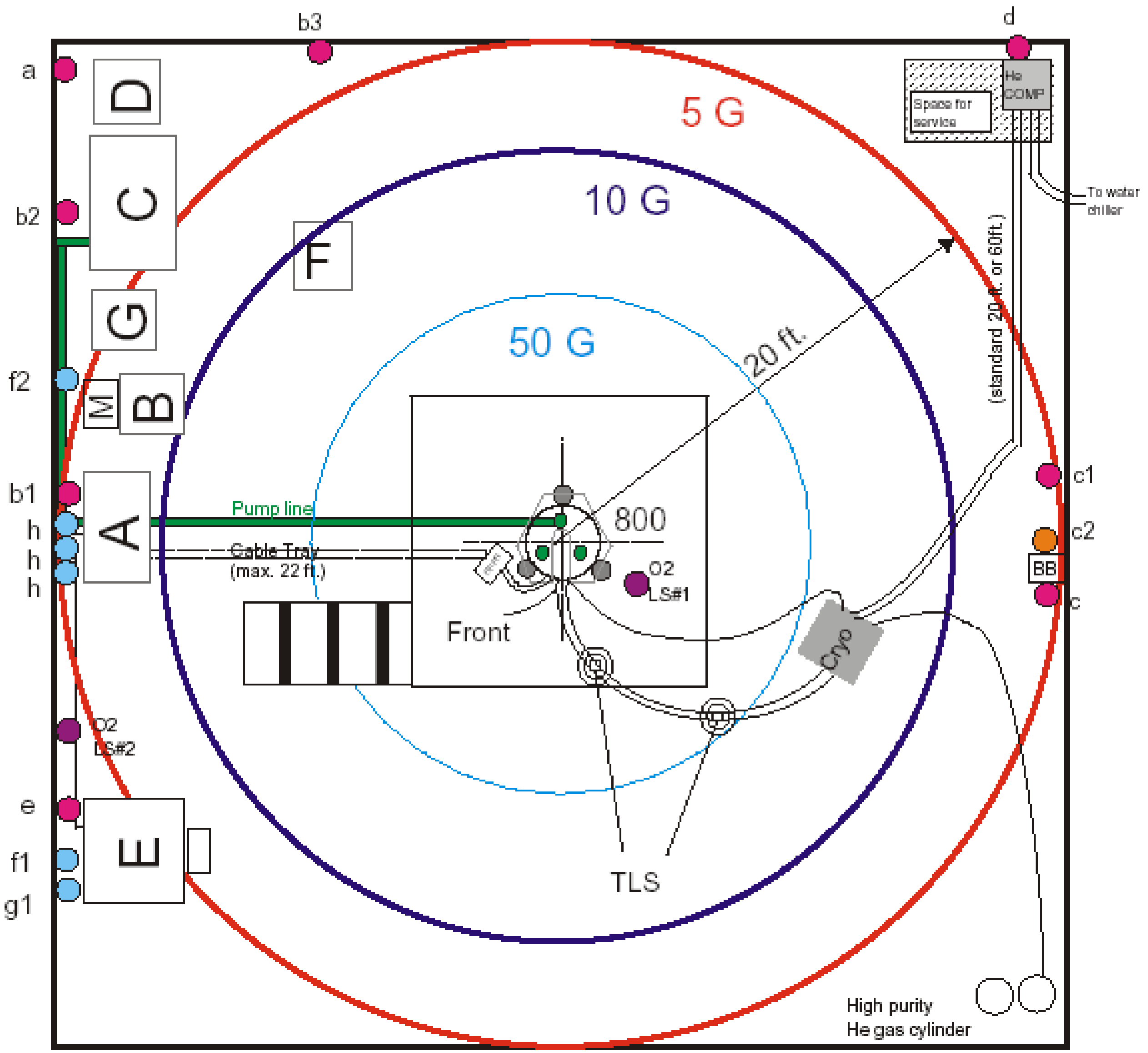
Figure 6.5. Stray Field Limits for Siting AVANCE UltraStabilized NMR Systems



Note: Stray field not to scale, magnet does not have to be placed in center of room.

Layout Examples *6.9*

An 800 UltraStabilized NMR system layout including the equipment and utilities. A description of each of the NMR system components is presented in the chapter ***"Equipment" on page 11***, while the details regarding the utility requirements are presented in the chapter ***"Utility Requirements" on page 45***.



Scale 1/8 in. = 1 ft.

LEGEND

a	●	Disconnect Box 208V/60A single phase (on emergency generator)
b1, b2, b3	●	208V/60A single phase
c	●	230V/20A single phase (output from BB)
c1	●	208V/20A single phase (input to BB)
c2	●	connector only
d	●	Disconnect box 208V/60A (fuse)/3 phase
e	●	110V/20A single phase
f1	●	Telephone port
g1	●	Data port
f2	●	Dedicated analog modem (fax) port
h	●	Regulated line for compressed gas (min. 80 psi.)

A	AVANCE Cabinet
B	BMPC Unit
C	Cooling Pump Assembly
D	UPS Unit
E	Workstation and table
F	BCU05 Unit
G	Gradient Unit
HPPR	Pre-amplifier
M	Bruker Monitoring System
BB	Buck-booster transformer (from 208V to 230V)
Cryo	CryoCooling Unit
He COMP	Helium Compressor
TLS	Transfer Line Support
O2 LS#1	Oxygen level sensor (above magnet)
O2 LS#2	Oxygen level sensor (near floor)

Figure 6.6. AVANCE UltraStabilized NMR Layout Example

Environment and Site Survey Measurement

7

Introduction 7.1

This chapter covers the various site survey topics, measurements and associated guidelines including the following:

- Vibrations
- Magnetic Environment
- Electromagnetic Interference: DC and 60Hz AC EMF
- RF Interference

Vibrations 7.2

External vibrations may cause the fields at the sample to be modulated. This may result in vibration sidebands on either side of a main signal peak.

- Ideally the site should be at ground or basement level to minimize building vibrations.
- Possible sources of vibrations are generators, compressors, fans, machinery etc. Vibrations from external sources such as cars, trains, airplanes, and construction sites can also cause problems.
- Measuring the extent of vibrations at the magnet location is a relatively simple matter and if you suspect that you have a problem you should contact your local Bruker Biospin office.
- Various measures to dampen floor vibrations are available. Please refer to ***"Vibration Damping Measures:" on page 38***.

VIbration Guidelines 7.2.1

Measurements of floor accelerations (mm/sec^2) are required in both vertical and horizontal directions over a frequency range of 0 to at least 100Hz. Ambient measurements as well as transients with various vibration sources being active should be carried-out. Recording both average and peak-hold values is recommended.

All magnets are equipped with vibration dampers in order to reduce the vibrations on the magnet. The isolation performance is given by a transmissibility characteristic for the specific dampers integrated within the magnet. The higher the frequency of floor vibrations, the better the damping (the smaller the transmissibility factor). Also, the smaller the natural frequency of the dampers and the smaller their "Q" (amplification factor at their natural frequency), the higher the isolation performance.

The acceleration peaks measured directly on the proposed magnet floor must be multiplied by the transmissibility factor of the dampers at the specific frequencies at which these acceleration peaks have been recorded. The results must then be compared to the **guideline of max. 0.1 mm/sec^2** that can be tolerated on the magnet itself.

Vibration Damping Measures: *7.2.2*

All UltraStabilized magnet systems are equipped with pneumatic vibration dampers (vibration isolation units). Two options are available:

- Air-Spring dampers with a natural frequency of ~2.5Hz, and which begin to be effective at floor vibration frequencies above 4Hz
- Advanced dampers - vibration isolation columns with a natural frequency below 1.5Hz, and which begin to be effective at floor vibration frequencies above 2.5Hz. This superior isolation solution is suitable for very low frequency vibrations, in both vertical and horizontal directions.

It is strongly recommended to design and implement an isolated magnet slab that separates (isolates) the magnet from the rest of the floor and building, thus minimizing if not eliminating the vibrations that are transmitted to the magnet from the building (electromechanical equipment, HVAC, personnel, etc.). For specifics on the magnet slab please refer to the section ***"Magnet Slab" on page 30***.

Magnetic Environment *7.3*

The presence of any ferromagnetic materials in the immediate vicinity of the magnet will decrease the magnet´s homogeneity and may degrade overall performance. Although minimum requirements for routine NMR are not stringent. The magnet environment must be optimized if more sophisticated experiments need to be carried out. The effect of such objects as metal pipes, radiators etc. can be overcome by appropriate shimming but where possible this should be avoided.

To assist in site planning two sets of guidelines are given below: “**minimum requirements**“ and “**acceptable environment**”.

If minimum requirements can not be met, the customer should consider a different site because NMR performance is likely to be reduced. By acceptable environment we mean an environment with which most customer sites comply. This is a situation which is desirable, though not always achievable.

Minimum Requirements *7.3.1*

Static Iron Distribution

There should be no iron present within a region of 12’ radius. The customer should consider removing iron piping that is likely to experience such fields prior to installation. If the magnet must be located close to iron or steel support beams a proper alignment is important. Support beams should pass through or be symmetric to the magnet axis.

A static mass of iron up to 500 lbs. must be at least at 12’ distance from the magnet center. For greater masses the limiting area must be extended accordingly. The presence of static magnetic material close to the magnet assumes that these masses are firmly secured e.g. radiators, pipes.

Moveable Magnetic Material

No moveable masses should be located within a region of 20’ radius. Potential sources of moving iron are metal doors, drawers, tables, chairs etc. For larger iron masses (> 500 lbs.) distorting effects may be experienced when those masses are moving as far as 40’ or more from the magnetic center.

For high precision work (e.g. NOE difference experiments) extending the region within which there are no moveable magnetic material even further may be justified.

Acceptable Environment *7.3.2*

Static Objects

Table 7.1. gives a list of common sources of magnetic distortion and the recommended limits outside of which these sources should be located. It must be emphasized however, that such recommendations represent a situation that may not always be achievable. Please consult with Bruker BioSpin for possible solutions if one or more of these recommendations cannot be satisfied.

Table 7.1. Recommendations for Static Magnetic Objects

Object	Actual distance from magnetic center
Iron or steel Beams	> 14’
Steel reinforced walls	> 12’
Radiators, Plumbing pipes	> 14’
Metal table, metal door	> 14’
Filing cabinet, steel cabinet	> 14’
Massive objects e.g. Boiler	> 14’

Moving Objects

The table below serves as a guideline for moveable magnetic material.

Table 7.2. Recommendations for Moveable Magnetic Objects

Object	Actual distance from magnetic center
Steel cabinet doors	> 20’
Large metal door, hand trolley	> 30’
Elevators*	> 45’
Cars, Fork-lifts	> 45’
Trains, Subways, Trams*	> 120’

** Note that D.C. operated elevators, trains, and trams may cause disturbances over much larger distances (see* ***Table 7.3.****). In addition, these may also cause vibrational disturbances.*

Electromagnetic Interference 7.4

Possible sources of interference are power lines which may carry fluctuating loads, heavy duty transformers, large electric motors, air conditioning systems, power transformers, etc. The fluctuating electromagnetic fields arising from such devices can interfere with the magnet homogeneity. Of particular concern are sudden changes in load as may be produced by elevators, trams, subways etc. Some laboratory equipment such as mass spectrometers and centrifuges will also give rise to fluctuating fields. Other sources of interference include radio and television stations, satellites and other RF transmitters that may operate in the vicinity of NMR frequencies of interest.

If you suspect that you have a source of interference located near the proposed magnet site then you should contact Bruker Biospin for a site survey.

Types of EMF Interference

- DC Interference

- 50Hz / 60Hz Interference

- RF Interference

DC EMF Interference 7.4.1

DC interference generally comes from devices operated on DC, such as elevators, trains, subways, trams, etc. The locations of both the device and its power supply & lines relative to the proposed NMR site are essential to the amplitude and orientation of DC fields and how they may interfere with the NMR system. DC feeder lines are just as disturbing as a subway, and they do not run necessarily parallel to the track.

Measuring DC Fluctuating Fields

DC EMF measurements should be conducted using a **fluxgate magnetometer**. The fluxgate sensor is capable of accurately measuring magnetic field changes below 1mG. The sensor is connected to a magnetometer, and the voltage output from the meter is then converted into digital form. The magnetic field is recorded and plotted on a computer display in real time.

Reducing DC Interference

Given the amplitude of the “full external perturbation” (peak-to-peak) - measured with the fluxgate magnetometer at the proposed magnet location but in the absence of magnet - there are two levels of compensation against these external DC field perturbations:

1. First, the magnet screens itself against external perturbations, hence only a fraction of the full perturbation is left at the magnet center. We call this *residual field perturbation after magnet screening*. It’s value is relevant to NMR experiments *without lock*, like many solids experiments, as well as high resolution experiments using gradients and requiring the lock to be off for limited time.
2. Second, the advanced digital NMR lock is further shielding against the residual field perturbation after magnet screening. The digital lock is less susceptible to field perturbations than the older analog lock. The final response may depend on the lock substance and concentration.

Guidelines: DC Interference

When determining the effect of fluctuating magnetic fields, two parameters are important: the size of the fluctuation and the rate of change (gradient).

- Field changes up to 5 mG, regardless of rate of change, are generally considered harmless for standard NMR work.
- Field changes larger than 5mG will be compensated by the digital NMR lock, as long as their rate of change is less than 10 mG/sec.
- Field changes faster than 10 mG/sec need to be addressed in more detail along with the types of NMR experiments to be performed, in order to better assess whether the NMR performance will be affected. **Please consult with Bruker Biospin to assess the level of interference and explore solutions**.

Table 7.3. lists the minimum distances at which the magnet should be located from possible sources of DC interference.

Table 7.3. Minimum Distances from Sources of DC EMF Interference

Source of Interference	Recommended Minimum Distance from Magnet Center
DC Trains, subways, trams*	> 600’
DC Elevators*	> 45’
Mass Sprectrometer (slow ramp)	> 45’
Mass Spectrometer (sudden flyback)	> 100’

** Elevators, trains, subways, and trams are also a source of vibrational interference.*

50Hz / 60Hz EMF Interference 7.4.2

The 50Hz / 60Hz interference generally comes from electrical wiring, transformers and fluorescent lights located in the vicinity of the magnet area as well as the NMR cabinets and workstation areas. The magnetic field further modulates this interference, increasing the likelihood of disturbances.

Measuring 50Hz / 60Hz Fluctuating Fields

The proposed NMR room should be mapped regarding the amplitude and orientation of the 50Hz / 60Hz fluctuating fields as well as identifying the sources. Specific locations that must be checked carefully include:

- Magnet area

- Console area

- Along the wall inside the NMR room at ~ 2” from wall, and 4” from wall

- Approximately 2” below the existing lights in the room

- Near the main outlets (208V) locations at the wall (most of the time) or at the “utility island” in the room when applicable.

Guidelines: 50Hz / 60Hz Interference

The amplitude threshold for causing interference is ~ 1.8mG RMS, which is based on laboratory tests. Thus, acceptable limits should be well below this whenever possible.

The magnet should also not be placed directly under fluorescent lights, which may cause interference, and additionally may switch off temporarily during a quench.

RF Interference 7.4.3

The NMR instrument is effectively a very sensitive radio frequency receiver. Possible sources of interference are local radio or television broadcasts, low Earth orbit satellite systems, as well as signals emitted by personal paging systems. Of particular concern will be interference at frequencies at which NMR experiments are carried out. Although the interference effects will depend greatly on the strength of the transmitter, as a rule of thumb only broadcasting transmitters located within a radius of approximately 3 miles would normally be a possible source of interference.

RF interference may also occur between two or more spectrometers located in close proximity and operating at the same nominal 1H resonance frequency.

Measuring RF Fluctuating Fields

Radio Frequency Interference measurements should be conducted using a spectrum analyzer. The analysis should be done for the resonance frequency of each of the nuclei of interest (corresponding to the given 1H resonance frequency of the spectrometer), with a frequency sweep of min. 400kHz. Any peaks with RF fields above -80dBm should be recorded, as well as any broad frequency ranges with any level of RF signals.

Table 7.4. contains a list of the most common studied nuclei at the corresponding frequencies for the 750WB, 800SB, and 900SB NMR systems.

Guidelines: RF Interference

As a general guideline the level of any RFI should be attenuated to an electrical field strength of -65dBm at the side of the magnet. However, past experience has shown that smaller RF fields over a broad frequency range around a frequency of interest may interfere with the NMR experiments. Therefore, it is important to address any of these when measurements are to be above -80dBm.

Reducing RF Interference

Screening a site for possible RF Interference is complicated and expensive. Shielding of the NMR room with a Faraday cage is a possible solution, though having to take such measures is quite rare.

When designing and manufacturing the Bruker BioSpin spectrometers, care is taken to provide adequate shielding and the instruments rarely suffer from interference in normal RF environments. Furthermore, the advanced BSMS digital lock system - included with all Bruker BioSpin AVANCE spectrometers - allows a shift in the 2H lock frequency with certain limits. This may often allow enough variation in the absolute magnet field strength to shift the NMR signal away from that of local broadcasting frequencies.

When RF interference may occur between two or more spectrometers located in close proximity and operating at the same nominal 1H resonance frequency, problems can be avoided by energizing (parking) the different magnets at slightly different fields, such that their operational frequencies are separated by ~ 200 ppm of the nominal 1H resonance frequency.

Table 7.4. List of Most Commonly Studied Nuclei and Corresponding Resonance Frequencies

Nuclei	**NMR Frequency (MHz)**			
Magnets	**750 WB**	**800**	**800US[2]**	**900**
1H	750.131	800.131	800.131	900.131
2H	115.151	122.827	122.827	138.177
11B	240.697	256.740	256.740	288.828
13C	188.631	201.204	201.204	226.350
15N	76.145	81.221	81.221	91.372
19F	705.948	753.003	753.003	847.113
27Al	195.603	208.647	208.647	234.718
29Si	149.202	159.147	159.147	179.037
31P	303.963	324.224	324.224	364.745

Utility Requirements

8

Electrical Power Requirements 8.1

The Bruker UltraStabilized systems operate at a reduced temperature which can only be maintained by the uninterrupted power to one helium pump. These systems will stay operational for several hours, but it requires a knowledgeable person to bring them back to normal operating conditions. A longer failure of the cooling system will inevitably result in a quench (loss of fluid). Though all precautions have been taken to prevent damage to the system is such a case, several weeks downtime and a reinstallation would be the consequences.

The standard system is equipped with 9 hours of backup capacity for the magnet pump assembly. If power failures longer than 9 hours are likely in the area of installation, it is the responsibility of the customer to take appropriate provisions.

The power for the AVANCE UltraStabilized NMR systems are exclusively controlled by the BMPC (Bruker Monitoring and Pump Control) Unit. This unit provides the required power to the main AVANCE two-bay cabinet, the cooling pumps, and ancillary units such as the BCU-05 cooling unit.

Table 8.1. summarizes the electrical power requirements.

Figure 8.1. displays the BMPC and the various units that it feeds power to.

Other important considerations include:

- All power is routed through the UPS which also has the advantage of serving as a line conditioner. In the event of a power failure, the power source automatically switches to the UPS batteries.
- If the power failure exceeds 6 minutes the supply to the two-bay cabinet will be cut off automatically. This will enable the UPS to power the helium pump for typically 9 hours. As most power failures (more than 90%) are much shorter than 6 minutes, this compromise reserves most of the battery capacity for the magnet and allows NMR measurements to run undisturbed despite short power interruptions.
- The customer is required to provide backup emergency power (from the building emergency generator or from a small generator dedicated to the NMR lab)

to maintain the operation of the helium pumps in the case of power failures which are longer than 9 hours. If a power failure continues for more than 4 hours, the customer will be alarmed by telephone through the Bruker Monitoring System (BMS).

- Depending on the layout of the various cabinets and accessories, the customer may be required to provide electrical power conduits if the placement of the cabinets does not allow for the use of standard length power and communication cables that are supplied with the spectrometer.

Figure 8.1. Main Electrical Power Requirements Flowchart

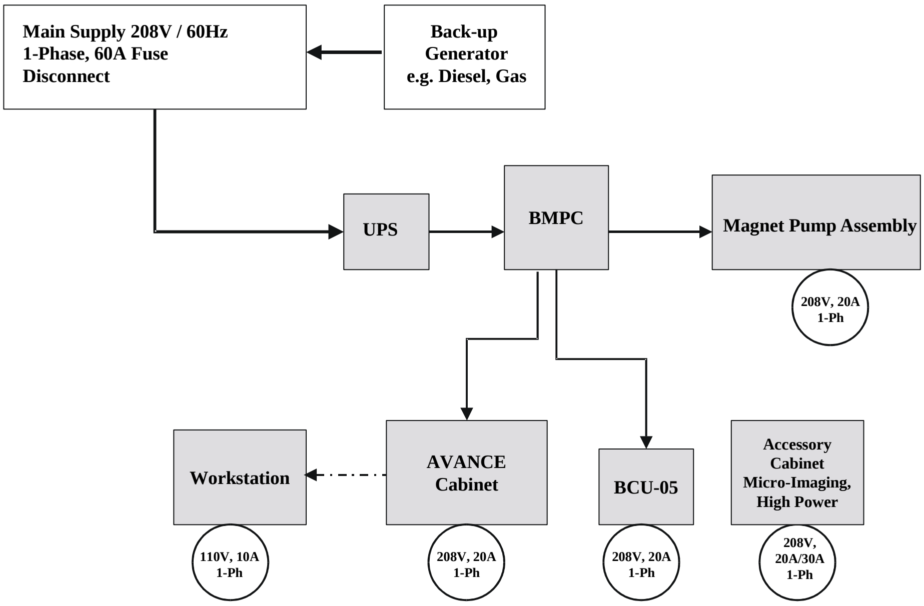


Table 8.1. Electrical Power Requirements

Item* (Figure 6.6.)	Specifications	Outlet/ Disconnect Box	Code	Purpose
a	208V/60A/single phase	Disconnect box with side arm safety switch	-	Power the UPS (item “A”)
b1	208V/30A/single phase	Wall outlet, 2 pole, 3 wire	NEMA L6-20R	System service
b2	208V/20A/single phase	Wall outlet, 2 pole, 3 wire	NEMA L6-30R	Power pump 3 as emergency service (inside item “C”)
b3	208V/20A/single phase	Wall outlet, 2 pole, 3 wire	NEMA L6-20R	Power the BCU-05 (item “F”)
b4	208V/20A or 30A/ single phase	Wall outlet, 2 pole, 3 wire	NEMA L6-20R	Power the High Power (“S”) or Micro-Imaging (“I”) Cabinet

Item* (*Figure 6.6.*)	Specifications	Outlet/ Disconnect Box	Code	Purpose
CryoProbe (optional):				
c	(230V/20A/single phase output from buck-booster)	Receptical, 2 pole, 3 wire (outlet of the buck-booster	NEMA L6-20R Cordbody	Power the CryoCooling unit (item “Cryo”)
c1	208V/20A/single phase	Wall outlet, 2 pole, 3 wire	NEMA L6-20R	Power the buck-booster
c2	(inlet cord of buck-booster	Connector, 2 pole, 3 wire	NEMA L6-20P	Plug the buck-booster into the wall
d	208V/60A/ 3 phase, 5 wire	Disconnect box with side arm safety switch	-	Power the He compressor (item “He COMP”)
e	110V/20A/single phase	Wall outlet (doublet)	-	Power the workstation (item "E")

(Refer to the AVANCE UltraStabilized NMR layout in* ***"Layout Examples" on page 35****).*

The AVANCE cabinet comes supplied with four electrical outlets (230V/10A - European connections) which can be used to power standard ancillary equipment. Two outlets are designed to power the NMR Workstation and (optional) Imaging Cabinet. This leaves two outlets free for accessories such as a printer or Automatic Sample Changer etc.

Telephone / Data:

Please refer to the AVANCE UltraStabilized NMR layout in ***"Layout Examples" on page 35***. The following ports are required:

f1 / g1: telephone/data ports behind the workstation (item "E")

f2: dedicated analog modem (telefax) line port behind the monitoring unit ("M").

Compressed Gas *8.2*

General Requirements

- Compressed nitrogen gas needed for temperature control with VT experiments in order to achieve optimal NMR performance. The BCU-05 cooling unit requires a DEW point of -60°F for the compressed gas.
- Compressed air or nitrogen gas for spinning.
- Compressed air or nitrogen gas for sample ejection, and for the magnet’s vibration isolation units.

Compressed Gas Options 8.2.1

Option 1 (preferred):

Nitrogen gas only: 2 scfm for non-MAS experiments, or 8 scfm for MAS experiments, pressure of 80-120 psi (typical consumption 0.3 scfm for high resolution work in biological temperature range).

Option 2:

Nitrogen gas for VT work only: flow 0.2 - 1.2 scfm, minimum pressure 60 psi.

Dry air for the rest.

Option 3:

Dry air only: minimum flow 3 scfm for non-MAS experiments, pressure 80-120 psi.

Note:

A nitrogen separator (supplied by Bruker BioSpin) built-in the AVANCE cabinet is available for option 3, in order to produce the nitrogen gas required for VT work. However, this may not be suitable for larger flow rates required by MAS experiments.

Additional Requirements 8.2.2

Compressed gas line: The standard AVANCE system requires one compressed gas line with regulated output, preferably with at least two secondary connectors.

Regulators: Watts Regulator R119-03C (Watts Fluid Air Company), pressure range 0 - 125 psi, with gage head included.

- If use of a Bruker Automatic Sample Changer (BACS) in high throughput mode is planned, a second regulator, T-split from the same supply line, is recommended.
- For MAS (Double Bearing) a second regulator is mandatory. Make sure the supply line cross-section is sufficient to deliver the necessary volume at the required pressure.

Specifications 8.2.3

Oil Content:

< 0.005 ppm (0.005 mg/m^3)

Water Content

For the BCU05 cooling unit the compressed gas should have a DEW Point of –60°F.

For room temperature work and higher: Dew Point of < 39.2°F

For low temperature work: The Dew Point must be at least 68°F below the operating temperature.

If a cooling unit is used, then the Dew Point of the compressed nitrogen should be at least 50°F below the temperature at the heat exchanger output.

Solid Impurities:

Use 5 micron filters for high resolution NMR. For MAS probes use 1 micron filters. The filters should retain a minimum of 99.99% of the specified particles.

Table 8.2. Compressed Gas Requirements

System	Operating Pressure (psi)	Average Consumption (cfm)	Recommended Minimum Air Supply after Dryer at ~73 psi
Two-Bay	80-120	~1.6	~2 cfm
Two-Bay + BACS* or NMR CASE	80-120	~1.8	~2 cfm
Two-Bay + MAS (DB**)	80-120	~8	~11 cfm
* Bruker Automatic Sample Changer **DB= Double Bearing			

Water 8.3

If the system is equipped with the CryoProbe option and the compressor is water cooled, then cooling water is needed to remove the ca. 7.5kW of heat output from the water-cooled type He compressor used in conjunction with the CryoProbe.

The cooling water requirements are:

- Min. flow: 7 liters/min.
- Recommended flow: 10 liters/min.
- Pressure drop in "He COMP" unit: 1.6 bar (23.2 psi) without calcification
- Recommended pressure: 3.2 bar (46.4 psi)
- Maximum inlet pressure: 6.67 bar (96.7 psi)
- Cooling power 7.5kW
- Water temperature at "He COMP" inlet: 39.2 - 82.4 ^{o}F
- Recommended water temperature at inlet: 59 ^{o}F
- Water temperature at "He COMP" outlet: -429 ^{o}F higher than at inlet
- Water connectors: pipe thread 3/8"

The chemical properties of the cooling water must satisfy the following specifications:

- PH value: 6.5 - 8.2
- Hardness: < 200 mg CaCO3/liter
- Molybdate-reactive silica: < 50 mg/liter

- Suspended matter: < 10 mg/liter

The specifications above assume a max. of 30% glycol of the water/glycol mixture.

Lighting 8.4

Florescent lighting should not be used in the area considered for the magnet. Operation is most convenient when the Graphics Monitor may be viewed under subdued lighting. However normal office lighting will of course be needed in other areas of the NMR room. The most convenient arrangement is to have separately switchable lights using standard light bulbs. Make sure that reflections from strong artificial light do not fall upon the monitor screen. Care should also be taken to minimize reflections from sources such as windows.

- Please do not direct intense spotlight onto the magnet, which could change the surface temperature.
- Consideration should be given to the relative placement of lights to the air conditioning inputs, which mostly contain the temperature sensors for the air conditioners. Otherwise the switching of lights might result in a system overreaction and a considerable temperature change.
- Lights are generally not recommended within a radius of 10’ from the magnet.

HVAC (Heating Ventilation Air Conditioning) 8.5

Constant temperature is important for high performance operation.

Room temperature should not fluctuate more than +/-1 °F per hour. The temperature cycle of any air conditioning system should not exceed +/-1 °F close to the magnet and cabinet. It should also be noted that air drafts, particularly those created from air conditioning or heating systems also can have negative effects on the magnet. The magnet room should be as draft-free as possible.

The heat output of the standard AVANCE UltraStabilized system for high resolution work is about 4.6kW (18,000 BTU/hr.). This includes the main AVANCE cabinet, the BMPC, the BCU-05, and the workstation. It does not include the heat output from the He compressor that is either being handled by water or air cooling (external to the cooling of the NMR room).

The heat output of the AVANCE UltraStabilized system equipped with High Power amplifiers for solids NMR is between 6kW (25,000 BTU/hr.) to 10kW (40,000 BTU/hr.) depending on the high power configuration.

The heat output is constant and it is essential to minimize or avoid short term oscillations of the HVAC system, and provide a continuous slow flow of air that in turn reduces the speed of any temperature changes. In other words, it is recommended to have a continuous and slow exchange of air in the NMR room, hence minimizing fluctuations.

Most of the heat is generated in the AVANCE cabinet, the magnet pump assembly and the BCU05. The magnet itself does not dissipate any heat. Care must be taken not to direct any air flow onto the magnet, as this might cause instability.

A minimum of 30% humidity is required with a maximum of 80%. Conditions other than these may warrant the installation of an air conditioner with appropriate humidity controls.

Fire Detection System and Fire Extinguishers 8.6

Rooms containing NMR magnets should be equipped with **temperature sensors** for fire detection. These must respond *only* to a sudden rise of temperature, and not be triggered by a quench (sudden drop of temperature).

Optical sensors cannot discriminate between smoke from a fire and fog caused by a quench.

Fire extinguishers in the vicinity of the magnet room must be **non-magnetic** (stainless steel or aluminum). It is the obligation of the customer to inform the local fire department about the dangers of magnetic fields. These magnets stay at field for a long time even in a most blazing fire!

Emergency Gas Exhaust 8.7

Due to the large amount of liquid He contained in the magnet, an emergency exhaust system may be required to prevent O_2 depletion during a magnet quench. ***Table 8.3.*** lists the amount of LHe and He gas after a quench for the UltraStabilized magnets.

Table 8.3. He Gas After a Quench

UltraStabilized magnets	Amount of LHe (liters)	He gas after a quench (ft^3)
750 WB	~ 450	~ 11,200
800	~ 450	~ 11,200
$800US^2$	~ 850	~ 21,000
900	~ 700	~ 17,300

Regarding the emergency gas exhaust, important considerations include, but are not limited to, the following:

- **Amount of liquid He**: Taking the $800US^2$ magnet as an example, the total amount of liquid He is 850 liters. In case of a quench, the liquid transforms into gas and expands by a factor of 700. Therefore, the total amount of He evaporated gas in case of a quench will be ca. 21,000 ft^3.

- **Maximum He gas flow**: The maximum flow of He gas is calculated on the assumption that half of the volume of liquid evaporates in 1 minute, thus the maximum flow would be 10,500 cfm for the 800US^2 magnet. The gas should be removed from the room immediately through an emergency exhaust system.
- **O_2 level sensors**: Oxygen level sensors are required to detect low O_2 levels within the NMR room for each system. One sensor is needed above the magnet for detecting low O_2 levels due to He gas exhaust in case of a quench or during He fills. An additional sensor is needed close to the floor for detecting low O_2 levels due to N_2 gas exhaust during magnet cooling or regular N_2 fills. In case of placing the magnet inside a pit, a third sensor is needed inside a pit to detect low O_2 levels from N_2 gas.
- **Emergency exhaust solutions**: The following exhaust solutions are recommended:

  Passive exhaust: This system is based on louvers in the ceiling, or upper parts of outside walls, that open up due to the pressure of He gas.

  Active exhaust: In addition, an active system based on a motorized fan in, or close to, the ceiling is recommended. This way, adequate exhaust of cryogenic gases will be provided not only during a quench, but also during the initial cooling of the magnet and regular cryogen refills of the magnet.

  Normally it is sufficient to operate this fan manually, as the probability of an unattended quench after the installation is rather low.

  If a customer wishes to use automatic switching of this fan, it should:

  a) be installed in addition to the manual switch.

  b) depend on a logical combination with the fire detection temperature sensor to prevent the fan from being turned on during a fire.

  Quench pipes: This solution may be required when the NMR room is small and any of the other options are not sufficient to ensure safety after a magnet quench.

  This solution is based on a pipe connected directly to the magnet, which is then routed to the outside of the building. It is important to note the following:

  - The helium exhaust from the magnet should be vented directly to the outside of the building in case a quench occurs.
  - The ducts to the outside of the building should be of large enough diameter to avoid excessive pressure build-up due to the flow impedance of the duct.
  - The location of the exit end of the duct must not be accessible to anyone other than service personnel. In addition the exit opening should be protected from the ingress of rain, snow or any debris which will block the system.
  - It is also essential that any gas which vents from the exhaust duct cannot be drawn into the air conditioning or ventilation system intakes. The location of the duct's output should be carefully sited to prevent this from happening during any adverse atmospheric conditions and winds.
  - Insulation of accessible exhaust piping should also be provided to prevent cold burns during a quench.

Figure 8.2.Emergency Quench Pipes

Please contact Bruker BioSpin for further information.

Oxygen Monitor and Level Sensors 8.8

An oxygen monitor or level sensor is required inside the magnet room. At a minimum the following sensors should be provided:

Above the magnet on the wall:	One oxygen level sensor should be above the magnet, to detect low oxygen levels caused by high He gas levels.
Close to the floor on the wall:	One oxygen level sensor approx. 30cm off the floor of the magnet room.
Down in the pit:	One additional oxygen level sensor approx. 30cm off the bottom of the pit, in case the magnet is located inside a pit.

Figure 8.3. Example of some Oxygen Monitors and Level Sensors

These monitors and sensors generally should be located outside the 0.5mT (5 G) line. Check with original equipment manufacturer for information on the effects of magnet fields on these devices.

Cryogens *8.9*

Liquid helium and nitrogen are used to cool the magnet so that it remains superconducting. Topping up of the liquid levels is a regular maintenance required by the magnet and the procedures to be used represent an important site planning consideration. ***Figure 8.4.*** shows the cryogens equipment. Some customers prefer to contract the cryogen maintenance out to local suppliers. The following items will be required to maintain the cryogen levels within the magnet.

1. Two cylinders (one containing gaseous helium, the other gaseous nitrogen):

   Nitrogen cylinder: ~2 cu.ft, 3000 psi with reducing valve to deliver pressure of ~8 psi.

   Helium cylinder: ~2 cu.ft, 3000 psi with reducing valve to deliver pressure of ~3 psi.

   Gases used should be of the following purity: Nitrogen 99.9999%, Helium 99.996%.

***SAFETY NOTE*: The gas cylinders must always be kept away from the magnet and outside the exclusion zone defined by the 5 G line in order to prevent accidents.**

2. Two transport dewars (one for liquid helium, one for liquid nitrogen) are also required.

   These **must** be made of non-magnetic material as they are normally brought close to the magnet when topping up. Such dewars are often provided by the cryogen supplier and need not be purchased.

Liquid Nitrogen Dewar

Various transport dewars are available, with capacities ranging from 60 to 500 liters. The dewars should be of low pressure type for liquid withdraw only. Do not use high pressure “gas packs”. The dewar should have a fixture for pressurizing and transferring via rubber hose (3/8” inner diameter). Where possible the dewar should be self pressurizing. The correct transport dewar pressure for transferring liquid nitrogen is 10 - 20 psi.

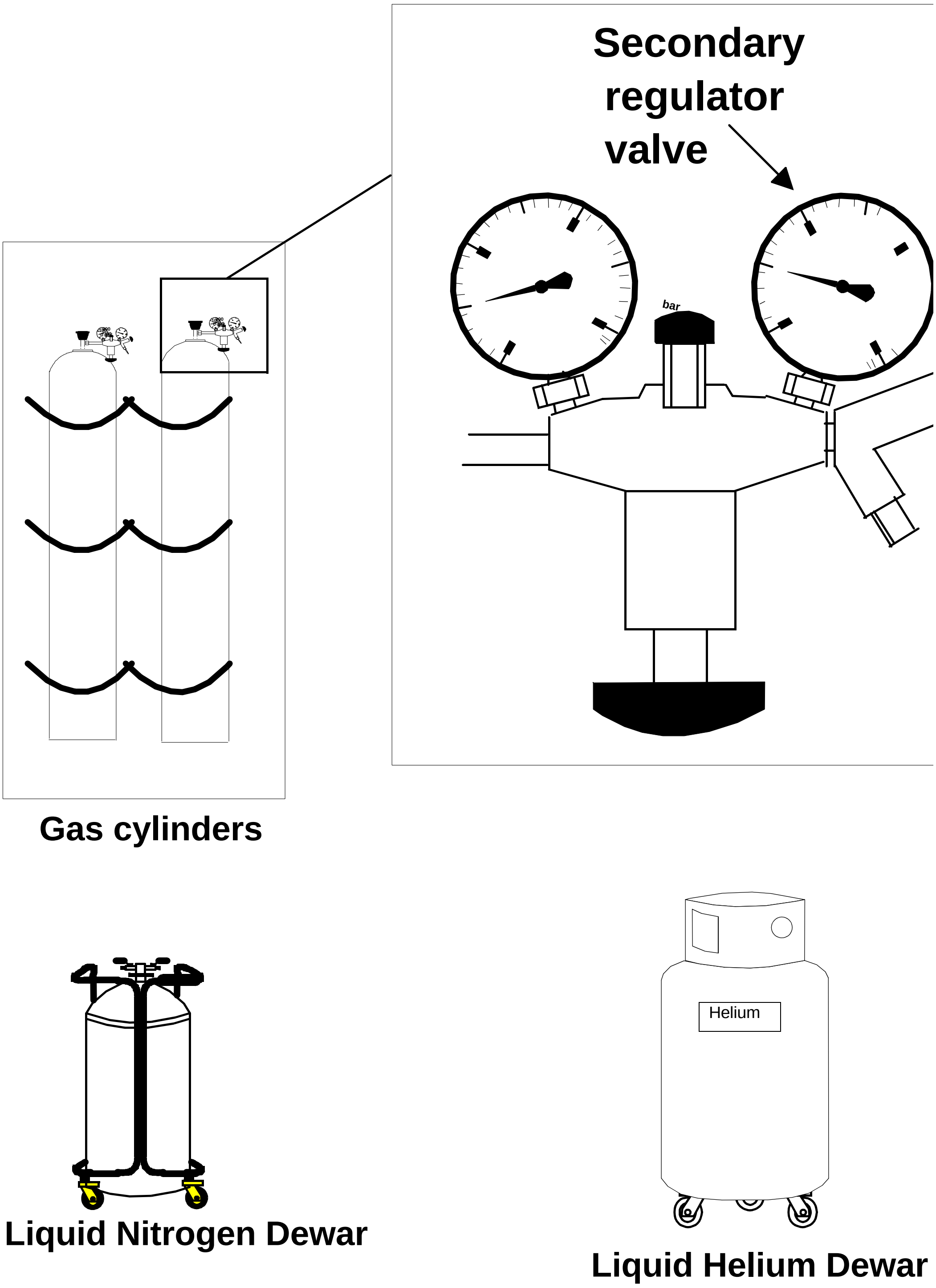
The liquid cryogen transport dewars used to refill the magnet should be of the low pressure type. Never use high pressure gas-packs. Pressures higher than the maximum rated pressure of 7 psi in the magnet nitrogen tank could lead to an explosion and destruction of the magnet!

NOTE: Five hundred (500) liter liquid nitrogen dewars are strongly recommended for the magnet precooling during the installation.

Liquid Helium Dewar:

Two hundred-fifty (250) liter stainless steel transport dewars are most convenient for the Ultra High Field magnets. The dewar outlet must be compatible with the He transfer line (outer diameter of 1/2“) or with the NW25 adapter that is supplied.

Figure 8.4. Cryogen Equipment



Installation 9

Introduction 9.1

Please fill out and return the Site Planning Checklist prior to the delivery of the magnet system. If you have not been provided with this checklist, please contact your Bruker BioSpin representative immediately.

All general requirements such as power supply, compressed air supply, etc. must first be completed before the system can be delivered. Installation requirements such as cryogen supplies are totally separate from normal operation requirements. The system can only be delivered and installed after the completion of all construction work in the lab. The lab must be cleaned from all remaining dirt, dust, particles, etc.

The magnet transport crates should be kept indoors out of direct sunlight. The crates should not be opened without the presence of a Bruker BioSpin magnet engineer. Failure to do so may invalidate the warranty. The crates are shipped with Shockwatch^{TM} and Tiltwatch^{TM} indicators.

Overview 9.2

The spectrometer will arrive at the site in crates. The crates should be uncrated only by the Bruker BioSpin service engineer. The commissioning of the magnet involves several stages as outlined in ***Table 9.1.***. The durations listed below for the different stages of installation are only approximate, and correspond to the larger magnets (i.e. 800 MHz US^2 and 900 MHz). For the 750WB and 800 non-shielded magnets, the overall installation time may be up to one week less.

Table 9.1. Magnet Installation Stages

Days	Procedures
Day 1	Delivery of the magnet
Days 2 - 5	Assembly of the magnet
Days 6 - 12	Flushing, vacuum, leak detection, installation of the pump line
Days 13 - 17	Precooling with liquid N_2
Days 18 - 19	Cooling with liquid He
Days 20 - 23	Subcooling to reduced temperature
Days 24 - 28	Energizing and Cryoshimming

Accessibility 9.3

Before the arrival on site, you must ensure the equipment can be delivered, and transported safely to the final location inside the NMR room. Please refer to Chapter 3 (Magnet Access and Rigging) for the details.

Checklist of Installation Requirements 9.4

For the installation the customer must provide the following:

- Lifting equipment and minimum ceiling height as outlined in ***Table 9.2.***
- Pallet jack and/or fork lift for transporting system accessories.
- Two cylinders of N_2 gas ~2 cu.ft, 3000 psi with reducing regulator valves to deliver pressure of ~8 psi, as specified in Section 9.7.
- Six cylinders of He gas ~2 cu.ft, 300 psi with reducing regulator valves to deliver a pressure of ~3 psi, as specified in the section ***"Cryogens" on page 54***.
- Quantities of liquid helium and nitrogen as specified in ***Table 9.2.***.
- Liquid helium and nitrogen transport dewars as specified in ***"Cryogens" on page 54***.
- One power outlet 208V/60Hz/30A single phase and two other power outlets 208V/60Hz/20A single phase are needed to run a vacuum pump, a heat gun and power supply unit. These power outlets must be available in addition to the main power source used to run the spectrometer. Please note that there should already be three outlets b1, b2, b3 present as required in section ***"Electrical Power Requirements" on page 45***. These outlets may be used for installation, as well as any follow-up service.
- Minimum two doublets standard outlets 110V/60Hz/20A
- Step ladder (non-magnetic e.g. aluminum, fiberglass, or wood).
- Platform to access the top of the magnet with opening suitable for magnet placement. Please refer to Section 6.4 for more details.

Where possible the customer should provide the following:

- Heat gun or hand held hair dryer (min. 1200 W)
- Roughing pump (14.5 x 10^{-5} psi)
- Pair of insulated gloves

Installation Procedure 9.5

The various steps and procedures mentioned in ***Table 9.1.*** will be further discussed. Topics included are:

- Magnet assembly
- Magnet evacuation and flushing with nitrogen gas
- Cooling the magnet to liquid nitrogen temperature
- Cooling the magnet to liquid helium temperature

- Sub-cooling and charging the magnet

Magnet Assembly 9.5.1

Once the magnet is off-loaded from the delivery truck using a large overhead crane, it will usually be uncrated by the Bruker BioSpin magnet engineers outside the building.

It will then be transported using special air-skates to the NMR room, or if access is through a hatch in the roof, the crane will be used to lower it safely inside the room at its final position. The crane will then be used further during the magnet assembly phase.

A hydraulic lifting device (when access is NOT through hatch in the roof above the magnet location) or a fixed lifting hook must be provided to lift the magnet for assembly. The assembly area should be clean, dry and free of dust. Under certain circumstances, with limited ceiling height, hydraulic lifting equipment may be provided by Bruker Biospin. ***Table 9.2.*** lists the minimum ceiling height, minimum hook height, and the weight for each magnet.

When arranging suitable lifting gear, the customer is asked to ensure a safety margin of at least 100%.

Magnet Evacuation and Flushing with Nitrogen Gas 9.5.2

Once the magnet has been assembled and placed in the magnet room, rough pumping of the cryostat can begin. At the same time the cryostat is flushed through with dry nitrogen gas. The customer must provide a ~2 cu.ft, 3000 psi cylinder of dry nitrogen gas (99.9999% purity). The cylinder should be fitted with a secondary regulator valve to deliver a pressure of ~8 psi.

For some installations the customer is asked to provide a roughing pump, e.g. rotary pump capable of reducing pressures within the cryostat to 10^{-3} mbar. Further pumping of the cryostat is then carried out to reduce the internal pressure to 10^{-6} mbar. It is convenient, if the customer can provide a suitable pump such as a diffusion or turbo pump. If such a pump is available the customer should contact Bruker Biospin to confirm its suitability. Where no such pump is available then it will be supplied by Bruker BioSpin.

Cooling the Magnet to Liquid Nitrogen Temperatures 9.5.3

This next stage involves filling the magnet with liquid nitrogen. The quantity of liquid nitrogen required is listed in ***Table 9.2.***. The transfer dewars used for precool have generally a capacity of 250 - 500 liters with fixture for pressuring and transferring via a rubber hose of ~3/8” diameter.

Cooling the Magnet to Liquid Helium Temperatures 9.5.4

For this procedure, the customer must provide the following:

Six cylinders of helium gas: ~2 cu.ft, 3000 psi (99.996% purity) with secondary regulator value to deliver pressure of max ~3 psi.

Quantities of liquid helium as specified in ***Table 9.2.***.

Liquid helium dewar: 250 - 500 liter capacity, with NW25 flange or suitable outlet compatible with the 1/2“.

When ordering the helium the customer should arrange to have it delivered immediately before the cooling phase to liquid helium temperature. If delivered to the site much earlier, losses due to evaporation will occur and must be taken into account (usually 1% of nominal volume/day).

Sub-cooling and Charging the Magnet 9.5.5

The final stage involves sub-cooling the magnet to reduced temperature (~ 2K) and bringing the magnet to field. During the charging there is a possibility for the magnet to experience a quench. The quantities of liquid helium for final cool down and energization/cryoshimming as well as extra liquid helium required after one quench are specified in ***Table 9.2.***. The customer is required to provide the cryogens needed for the complete installation including up to two training quenches.

The values of liquid nitrogen and helium in ***Table 9.2.*** are the minimum requirements. An extra 20-30% of each is advisable, particularly as many suppliers will take back unused cryogens.

Table 9.2. Installation Requirements for the UltraStabilized Magnets

Magnet Type	Minimum Ceiling Height	Minimum Hook Height of Lifting System	Magnet Weight (lbs) empty with restraints	Liquid N_2 needed for precool (liters)	Liquid He needed for cool down and energization (liters)	Additional liquid He after a training quench (liters)	Magnet Weight (lbs) full with stand
750 WB	16’ 3”	14’ 4”	8,900	2,500	2,500	1,000	9,500
800 SB	16’ 0”	14’ 4”	8,500	2,500	2,500	1,000	9,100
800 SB US^2	17’ 5”	15’ 7”	13,800	4,000	4,000	1,500	14,000
900 SB	17’ 5”	15’ 7”	13,800	4,000	4,000	1,500	14,000
SB= Standard Bore (54 mm); WB= Wide Bore (89 mm); US^2= UltraShield-UltraStabilized							

Figures

Tables

Index

A

B

C

L

M

N

O

P

Q

U

V

W