Site Planning for AVANCE Systems

300-700 MHz
User Guide

International Version 003

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Introduction 1

General 1.1

The fundamentally superior precision of fully digital signal generation and processing has been introduced and established by the precedent-setting series of Bruker BioSpin AVANCE^{TM} NMR spectrometers. With its digital advantage, the AVANCE^{TM} series sets revolutionary standards for performance, long-term reliability and ease-of-use, whether for routine applications or the most demanding research.

Through its advanced modular design the AVANCE^{TM} can be optimally configured for any modern application: from classical analytical work to the most demanding structural proteomics; from high-throughput screening to high-power solids NMR to microimaging. Depending on the required techniques and the laboratory space available, the AVANCE^{TM} can be delivered in a variety of configurations, ranging from a minimum-footprint micro-bay system (for applications utilizing one, two, or three frequency channels) up to a three-cabinet instrument fully equipped for high-power solids NMR with four or more channels.

How to Use This Manual 1.1.1

This manual contains information about site planning and preparation prior to delivery of a Bruker BioSpin AVANCE^{TM} system. After reading this manual you should have enough information to make an initial decision as to whether a proposed site is suitable for locating an AVANCE^{TM} spectrometer and magnet. The manual should be read through carefully as mistakes made initially may be costly to remedy at a later stage.

The system's covered by this manual are AVANCE^{TM} spectrometers in the range of 300-700 MHz. **A separate manual is available for 750, 800 and 900 MHz systems**.

If you are considering a CryoProbe System be sure to request a copy of our latest **CryoProbe System Site Planning Guide**.

Chapters 1-14 of this manual deal with various points that need to be considered for successful system operation. They have been included to familiarize you with general principles of successful site planning.

Appendix A contains some example sample room layouts for AVANCE^{TM} 300-700 MHz systems. Appendix B contains emergency planning information that will aid in preparing an **Emergency Plan** for a laboratory.

If you have a specific question, try using the ***"Contents"*** or ***"Index"*** section of this manual.

For specific questions that may not be addressed in this manual, or for further information on a topic, do not hesitate to contact your local Bruker BioSpin office.

Units Used Within This Manual 1.1.2

The SI Unit **Tesla** (mT) is used throughout this manual whenever magnetic field strengths are discussed. Some readers may however be more familiar with the **Gauss** (G) Unit.

For comparison the conversion fact is: **1mT=10G**

Likewise the unit **kilowatt** is used for the measure of heat energy (e.g. amount of heat generated by a device per hour). Some readers may be more familiar with these measurements in **BTU/hour**:

For comparison the conversion factor is: **1 BTU/hour=0.000293 kW.**

(BTU = British Thermal Unit which is the required heat to raise 1 pound of H_2O by 1 degree Fahrenheit).

If your are located within the USA, please inquire about a **USA version** of this manual which includes American Standard measurements.

Recommendations regarding site planning are based on the experience gained by Bruker BioSpin engineers through the years. Every effort has been made to make the site requirements realistic and readily achievable. It must be stressed however, that **the figures quoted are only recommendations**. Likewise, any performance values that are used are **minimum values that should be readily achievable by every system**. Predicting NMR performance is complicated by the fact that every site is unique. This manual has been written to help you plan the site, but it carries no guarantee of ultimate NMR performance.

While every effort has been made to ensure the information contained herein is accurate, Bruker BioSpin accepts no liability for consequential loss or damage arising from its use. Specifications are subject to change without notice and where a value (e.g., ceiling height) lies close to a recommended minimum value you are advised to check with Bruker BioSpin before final delivery

Safety 2

Introduction 2.1

Superconducting magnets may be operated in complete safety as long as correct procedures are adhered to, negligence can however result in serious accidents.

Safety is an important site planning consideration as the customer must ensure that the site is sufficiently spacious to allow safe and comfortable operation.

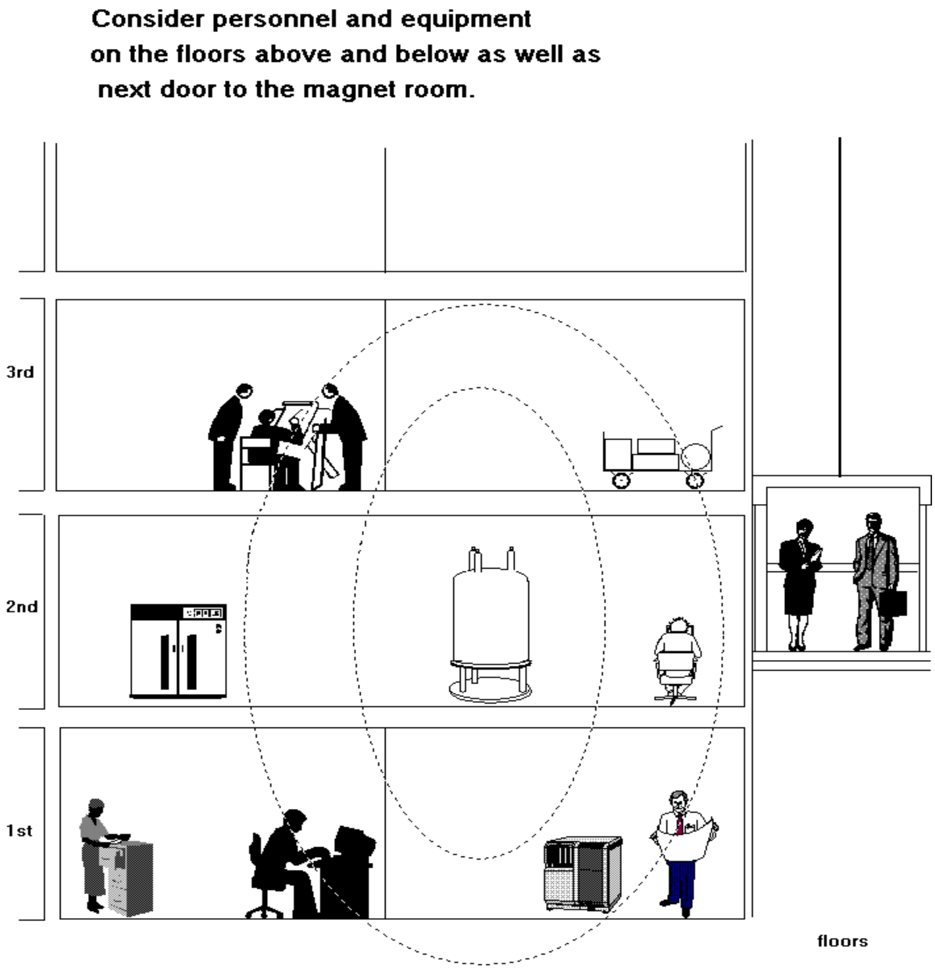
It is the sole responsibility of our customers to ensure safety in the NMR laboratory and to comply with local safety regulations. Bruker BioSpin is not responsible for any injuries or damage due to an improper room layout or due to improper operating routines.

The magnet is potentially hazardous due to:

1. The effect of the magnetic field on people fitted with medical implants (see section ***2.1.1***).
2. The large attractive forces it may exert on metal objects (see section ***2.1.2***).
3. The effect magnetic fields have on certain equipment (see section ***2.1.4***).
4. The large content of liquid cryogens (see section ***2.1.5***).

A magnetic field surrounds the magnet in all directions. This field (known as the stray field) is invisible, hence the need to post adequate warning signs in areas close to the magnet. The extent of the stray field will depend on the magnet: the higher the frequency and the larger the bore (Standard, Wide, Super Wide), the larger the stray field. You should note that the stray field exists in three dimensions and is often greater in the vertical plane than in the horizontal plane. Since the stray field will permeate walls, ceilings and floors, remember to consider personnel and equipment on the floors immediately above and below, as well as next door to the magnet (refer to ***Figure 2.1.***).

Figure 2.1. Magnet Site Considerations: Personnel Equipment



Note that the stray field is stronger in the vertical direction than in the horizontal direction.

Medical & Surgical Implants 2.1.1

The operation of electronic, electrical or mechanical medical implants, such as cardiac pacemakers, bio-stimulators, and neuro-stimulators may be affected or even stopped in the presence of either static or changing magnetic fields.

Not all pacemakers respond in the same way or at the same field strength if exposed to fields above 0.5 mT (5G).

The 0.5 mT (5G) line represents a suitable safety limit for medical devices. However, **normally people with medical devices should not be allowed in the magnet room!** Under no circumstances should people fitted with cardiac pacemakers be allowed to approach the magnet. **The customer must ensure that areas within which the stray field exceeds 0.5mT (5G) are not open to the public.**

Besides electronic, electrical, and mechanical implants, other medical surgical implants such as aneurysm clips, surgical clips or prostheses, may contain ferromagnetic materials and therefore are subject to strong attractive forces near the NMR magnet system, which could result in injury or death.

In the vicinity of rapidly changing fields (e.g. pulsed gradient fields), eddy currents may also be induced in the implant, which may result in heat generation and a possible life-threatening situation.

Table 5.3. column 5 and ***Table 5.4.*** column 6, display how far from the magnetic center the 0.5 mT (5G) stray field extends for a range of magnets. Display warning signs giving notice of the presence of magnetic fields and the potential hazards at all access points to the 0.5 mT (5G) region. These signs (***Figure 2.2.***) are normally delivered with the magnet or can be obtained from Bruker.

Figure 2.2. Typical Warning Signs Required in Magnet Area

Attractive Forces — 2.1.2

Large attractive forces may be exerted on ferromagnetic objects brought close to the magnet. The closer to the magnet and the larger the mass, the greater the force. The attractive force may become large enough to move objects uncontrollably towards the magnet. A plastic chain surrounding the magnet is a very simple but effective way of ensuring that no metal objects are brought too close.

The recommended safety limit for large magnetic objects that are easily moved (e.g. chairs, gas cylinders, hand carts) is 0.5 mT (5G). The use a metal chair in the magnet room is not recommended.

Gas cylinders (containing e.g. gaseous nitrogen and helium) should be stored outside of the magnet room. If cylinders must be located in the magnet room they should be located as far as possible away from the magnet and securely strapped to the wall. Smaller handheld objects such as screwdrivers, nuts, bolts etc. must never be left lying around on the floor close to the magnet. Dewars containing liquid helium and nitrogen are normally brought close to the magnet when refilling liquid cryogen levels. **These dewars must be constructed of non-magnetic material**. **Any ladders used when working on the magnet should be made of non-magnetic material such as aluminium or wood!**

Effect of Magnetic Fields on Personnel 2.1.3

A number of studies have been carried out on the long term effects of magnetic fields on personnel. The Swiss standards organization SUVA defines the MWC-value (**M**aximum **W**orkstation **C**oncentration) as:

„The highest tolerable average concentration of a substance in the air in form of gas, dust or vapor, based on present knowledge during working hours from 8 hours daily up to 42 hours weekly or over a longer period of time without putting a risk on a normal persons health.“

As a rule the working place (e.g. workstation, sample preparation area etc.) should be placed outside the **0.5 mT (5G)** line. For further information on acceptable magnetic field limits contact your countries health authorities or your area Bruker office.

Effects of Magnetic Fields on Equipment 2.1.4

Various devices are affected by the magnet and should be located outside the limits specified in the following section (see ***Table 5.3.*** and ***Table 5.4.*** for corresponding stray field distances). For comparison the earth's magnetic field is 0.05 mT (0.5G).

Table 2.1. Effects of Magnetic Fields on Equipment

Stray Field Distance	Device	Effects
5mT (50G)	Magnet power supply, RF power amplifier.	Electrical transformers which are a component of many electrical devices may become magnetically saturated in fields above 50 Gauss (5 mT). The safety characteristics of equipment may also be affected.
2mT (20G)	Magnetic storage material	The information stored on tapes may be destroyed or corrupted.
1mT (10G)	Computers, X-ray tubes, credit cards, bank cards, watches, clocks, cameras.	The magnetically stored information in computers and credit cards may be corrupted in fields greater than 1mT (10G). Small mechanical devices such as watches or cameras may be irreparably damaged. (Digital watches may be worn safely).
0.5mT (5G)	Cathode Ray tubes, Monochrome computer displays.	Magnetic fields greater than 0.5mT (5G) will deflect a beam of electrons leading to a distortion of the screen display.

Table 2.1. Effects of Magnetic Fields on Equipment

Stray Field Distance	Device	Effects
0.2mT (2G)	Color computer displays	Color displays are more sensitive to distortion than monochrome displays. The precise threshold field strength at which computer displays are distorted will depend on shielding and orientation relative to the magnet.(see ***"Room Layout"***).
0.1mT (1G)	Only very sensitive electronic equipment such as image intensifiers, nuclear cameras and electron microscopes will be affected.	

Cryogens *2.1.5*

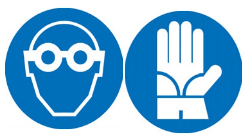
Superconducting magnets use liquid helium and nitrogen as cooling agents, keeping the magnet core at a very low temperature. Cryogenic liquids can be handled easily and safely provided certain precautions are followed. The safe handling of cryogenic liquids requires some knowledge of the physical properties of these liquids, common sense, and sufficient understanding to predict the reactions of such liquids under certain physical conditions. These liquids expand their volume by a factor of 700 when they are evaporated and then allowed to warm up to room temperature.

The gases are nontoxic and completely harmless as long as an adequate ventilation is provided to avoid suffocation. During normal operation only 3-5m^3/day of nitrogen are evaporated, but during a quench (***"Emergency Ventilation During Magnet Installation and Quenches"***) 50-100 m^3 of helium are produced within a short time.

Refer to the chapter ***"Cryogens & Magnet Maintenance"*** for more information on Cryogens and Cryogen handling.

Safety During Cryogenic Refilling

Refilling of the liquid helium and nitrogen levels within the magnet is effectively the only magnet maintenance required. Ensuring adequate safety procedures when handling cryogens must be taken into account at the site planning stage:



1. When refilling the cryogen levels, large dewars must be brought close to the magnet. Ensure that the magnet room is suitably spacious to allow easy access for the dewars. If a platform is not used then there must also be enough room for a ladder. As a rule of thumb the magnet should be accessible to a distance of 2m over at least half of its circumference and be no closer than 0.77m to the nearest wall (see ***Figure 6.1.***).
2. All magnets release evaporated helium and nitrogen gas. Adequate ventilation must be provided, even though these gases are non-toxic (refer to the chapter ***"Service Access and Ventilation" on page 43***). The magnet must never be located in an airtight room. Even in the case of a **quench**, whereupon the room may suddenly fill with evaporated gases, doors and windows should usually

provide sufficient ventilation. The door must be accessible from all parts of the magnet room, and should swing outwards to avoid a dangerous situation after a quench (if the room is too small and gets overpressurized quickly, the door may be blocked if installed to swing in). For smaller rooms it is highly recommended that quench gas pipes be installed (refer to ***"Emergency Ventilation During Magnet Installation and Quenches" on page 45*** more information).

Figure 2.3. Provide Adequate Ventilation During Refilling

3. When using a pit (***"Pits"***) it is particularly important to provide additional ventilation, as gas may build up during refilling. An oxygen warning device should also be installed (refer to the section ***"Oxygen Monitor and Level Sensors"***).
4. Ventilated storage space for the liquid nitrogen and helium dewars must also be planned for. Most modern dewars are made of non-magnetic material. If you have older dewars made of metallic material that may be drawn to the magnet, they should be stored outside the magnet room.
5. It is highly recommended that non-magnetic gas cylinders be used, and stored outside the magnet room. If gas cylinders must be stored in the magnet room they must be secured to a wall as far away from the magnet as possible.
6. Special attention is required for the transportation of cryogens by elevator (no one should be allowed to be in the elevator with a cryogen dewar).

Other non-safety aspects of site planning related to cryogen supplies will be dealt with in the chapter ***"Cryogens & Magnet Maintenance" on page 77***.

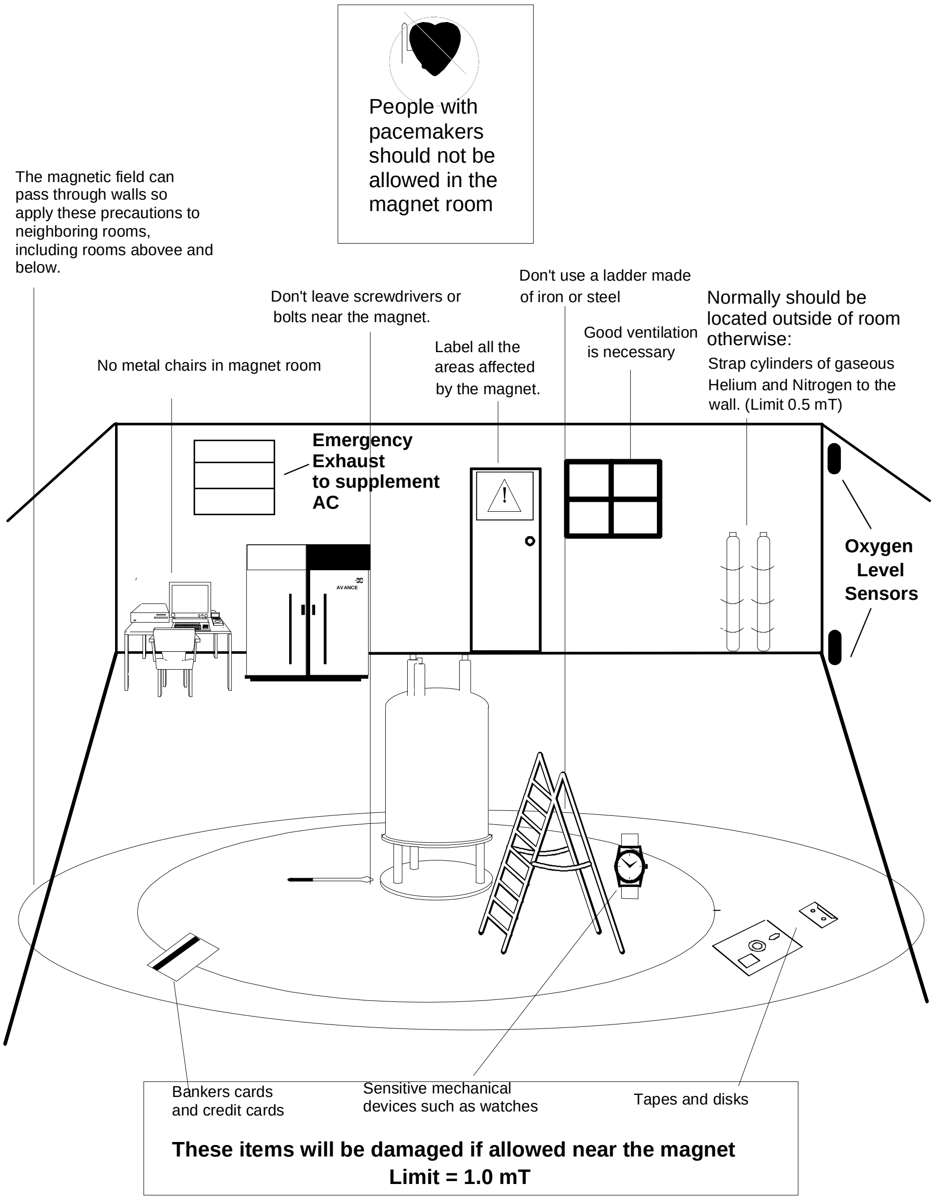
Recommended Safety Procedures 2.2

When planning the site for a new AVANCE^{TM} system, the primary consideration should always be safety. With this in mind we recommend the following procedures:

1. Refer to ***Table 5.3.***. and ***Table 5.4.***. for the extent of the stray magnetic field appropriate to the magnet type which you have ordered.
2. Determine the position of the 0.5mT (5G) (medical exclusion zone) relative to the proposed location of the magnet. Do not forget that the stray field exists in three dimensions. Take every precaution to ensure that no members of the public are exposed to fields greater than 0.5mT (5G). Apart from posting adequate warning signs, you need to limit access by means of locked doors and other suitable barriers such as plastic chains etc. Generally, **access to the magnet room should be for trained personnel only**.
3. Generally heavy moveable magnetic objects, e.g. furniture, gas cylinders, or other metal objects, should not be located in the magnet room. In any case it is **critical** that these objects remain outside the 0.5mT (5G) zone.
4. Ensure that the site is adequately spacious so that cryogen containing dewars can easily be moved in and out of the magnet room. Check that there is adequate working space immediately around the magnet.
5. Take an inventory of equipment in the NMR lab itself and in adjoining rooms that may be affected by the stray field.
6. Ensure that all relevant personnel are adequately informed of the potential hazards of superconducting magnets (for more information refer to the ***"Emergency Planning" on page 14***). This must include people working in adjoining rooms as well as cleaning and security staff. When non-NMR staff have access to the magnet room, there should always be at least one NMR staff member present in case of problems. A contact telephone number should always be posted near the door to the NMR room (preferably close to a telephone).
7. Position the worktable, cabinet, and magnet such that people can have access to the worktable without having to pass through the 0.5mT (5G) field zone.
8. Provide an adequate emergency exhaust system that can provide proper ventilation of cryogenic gases in case of a **magnet quench**. Please note that the cryogenic gases evaporate with an increase in volume of approx. 700 times greater than that of the liquid state. (For more information refer to ***"Emergency Ventilation During Magnet Installation and Quenches" on page 45***.)

For additional information on safety please refer to the Bruker BioSpin document „**General Safety Considerations for the Installation and Operation of Superconducting Magnets**“, available from your Bruker representative.

Figure 2.4. General Overview of Safety



Emergency Planning *2.3*

Due to the strong magnetic fields and presence of cryogens when using NMR systems, it is important to define and communicate what to do in case of problems or an emergency. An **Emergency Plan** can be defined as a documented set of instructions on what to do if something goes wrong. Emergency Plans are often defined as part of the Standard Operating Procedures (SOP), or as a stand-alone document. In any case every NMR laboratory should have an Emergency Plan in effect in case of problems or emergencies.

The Emergency Plan should be made up of **at least** the following sections:

1. Emergency list of contacts.
2. Instructions for employees and external workers.

3. Instructions on Fire Department notification.
4. Information on handling medical emergencies.

As every organization has its own policies and procedures, as well as varying laboratory layouts, an Emergency Plan should be individually defined for each laboratory as appropriate. Some general guidelines for an Emergency Plan are outlined in the Appendix ***"Emergency Planning" on page 107***.

Earthquake Safety *2.4*

In regions where there is a potential risk of earthquakes, additional measures should be taken to reduce the chance of personal or property damage through movement or tipping of the magnet.

Many countries or regions have documented regulations, including building codes, regarding earthquakes. Before installing a magnet system, it is highly advisable that you check with local authorities on whether your area is prone to earthquakes and if there are any regulations in effect.

If your area is regarded as an earthquake area there are several shock absorbing measures or riggings available to reduce the likelihood of damage during an earthquake. Please contact Bruker for more information on earthquake securing equipment.

Transportation and Shipping 3

Magnet System Delivery 3.1

When planning for offloading of the magnet and console during delivery, the following factors must be considered:

- The **transport weight** (***Table 3.4.***) and the size of the magnet system, console and their respective crates (***Table 3.2.***). These factors will affect the choice of forklift, crane or other rigging equipment required for offloading.
- The **elevation of the loading dock** relative to the NMR room. This will determine if a crane is required, or if an elevator is need for the movement of the magnet from the loading dock to the NMR room. The crane size will depend on the transport weight of the magnet system and console.
- The **load bearing capacity** of the loading dock. Please refer to ***Table 3.4.*** and ***Table 3.5.*** for transport weights of the magnet system, console, and accessories.
- The **size and overhead clearance** of the loading dock. This will influence the choice of forklift, crane, or other rigging equipment required to off load the magnet and system crates.
- The magnet system is off-loaded from the truck and placed on the ground or the loading dock for uncrating. The crates should be moved in an upright position, using a forklift, pallet mover, or air skates (shown below). The air skates will require a large air compressor capable of supplying 1.72bar (25 psi) at ca. 2 cu.meter/min.
- The console should also be moved in an upright position using a forklift or pallet mover.

Figure 3.1. Moving the Magnet on Air Skates Through the Laboratory Door

Dimensions for Transportation to Magnet Room 3.2

Before delivery, you must ensure that the site provides adequate access for delivery of the system and magnet. Some consoles and all magnets are shipped in crates. ***Table 3.2.*** provides the dimensions for the crates in which the spectrometer is shipped. Should it be necessary to uncrate the system the corresponding minimum door dimensions are also given. In the latter case the system can be placed on a pallet jack for transportation. The following factors must be considered:

- The access clearance (height and width) and floor loading capacity must be checked along the entire route that the magnet and console will take from the loading dock to the NMR room.
- Elevator capacity and dimensions must be considered if applicable.
- The transport will also be affected by the floor level and the presence of door sills and steps. Use metal sheets when using air skates to traverse floor irregularities, such as cracks and door seals.

Note: For the following tables it should be noted that the pallet is now integrated in the crate.

Table 3.1. Spectrometer Transport Width, Height and Crate Size

	Crate Size (m)			Dimensions (m) for Transport to Magnet Room			
Spectrometer System (spectrometer crate)	L	W	H	Width Crated[1]	Width Uncrated[1]	Height Crated with Pallet Jack[2]	Height Uncrated (top and sides only) with Pallet Jack[2]
AVANCE OneBay	1.00	0.92	1.53	1.02	0.71	1.66	1.46
AVANCE for Solids	1.54	1.03	1.78	1.05	0.82	1.90	1.71
AVANCE Standard	1.54	1.03	1.54	1.05	0.82	1.67	1.46
AVANCE MicroBay	1.01	0.83	1.16	0.85	0.71	1.19	1.13

[1] Transport width = Width indicated + minimum 1cm clearance on each side. These are the widths if the console is inserted lengthways through the entrance.
[2] Transport height = Height indicated + 1cm clearance on top + minimum 2cm for pallet jack. The height will vary depending on how high the spectrometer needs to be jacked up to clear any floor irregularities (e.g. cracks).

Table 3.2. Magnet Shipping Crate Dimensions and Transport Height

	Crate Size (m)			Magnet Transport Dimensions (m) (for transport to the magnet room)		
Magnet System (magnet crate)	L	W	H	Transport Width Uncrated	Transport Height Uncrated (top and sides only) with Pallet Jack	Transport Height Uncrated with Pallet Jack
300 MHz/54 mm US LH	0.91	0.91	1.59	0.72	1.13	1.36
300 MHz/54 mm US ULH	0.91	0.91	1.97	0.72	1.47	1.80
300 MHz/89 mm US LH	0.91	0.91	1.97	0.72	1.52	1.75
400 MHz/54 mm US LH	0.91	0.91	1.97	0.72	1.47	1.70
400 MHz/54 mm US ULH	0.91	0.91	2.05	0.72	1.69	1.92
400 MHz/89 mm US LH	0.91	0.91	1.97	0.72	1.61	1.84
500 MHz/54 mm US LH	0.91	0.91	1.97	0.80	1.50	1.76
500 MHz/89 mm US LH	1.40	1.40	2.05	1.10	1.86	2.04
600 MHz/54 mm US LH	1.01	0.99	2.05	0.91	1.74	1.89
600 MHz/89 mm US LH	1.60	1.60	2.18	1.37	1.91	2.12

Table 3.2. Magnet Shipping Crate Dimensions and Transport Height

	Crate Size (m)			Magnet Transport Dimensions (m) (for transport to the magnet room)		
Magnet System (magnet crate)	**L**	**W**	**H**	**Transport Width Uncrated**	**Transport Height Uncrated (top and sides only) with Pallet Jack**	**Transport Height Uncrated with Pallet Jack**
700 MHz/54 mm US LH	1.60	1.60	2.18	1.37	1.91	2.12
LH= Long Hold, ULH= Ultra Long Hold, US= UltraShield^{TM} For information on other magnets not listed, please contact your nearest Bruker BioSpin office. Note: The heights listed with pallet jack assume that the floor is level, thus the magnet needs only to be jacked up approx. 2cm for transport. If the floor is uneven, the magnet may need to be jacked up accordingly, which could add as much as 10-15cm to the transport height.						

Table 3.3. Magnet Stand and Accessories Crate Dimensions and Transport Height

	Accessories Crate Size - including stand if applicable (m)		
Magnet Stand & Accessories	**L**	**W**	**H**
300 MHz/54 mm US LH	0.91	0.91	1.59
300 MHz/54 mm US ULH	0.91	0.91	1.97
300 MHz/89 mm US LH	0.91	0.91	1.97
400 MHz/54 mm US LH	0.91	0.91	1.97
400 MHz/54 mm US ULH	0.91	0.91	2.05
400 MHz/89 mm US LH	0.91	0.91	1.97
500 MHz/54 mm US LH (2 boxes)	1.15 Stand 1.72 Acc.	0.77 Stand 0.52 Acc.	0.34 Stand 0.34 Acc.
500 MHz/89 mm US LH	1.43	0.98	1.16
600 MHz/54 mm US LH	1.33	0.82	0.73
600 MHz/89 mm US LH	1.57	1.07	1.26
700 MHz/54 mm US LH	1.57	1.07	1.26
LH= Long Hold, US= UltraShield^{TM} Pallet is integrated in crate. Add 2-10cm for pallet jack depending on floor quality. Allow **at least 1cm** clearance on the sides and above the crate. For information on other magnets not listed, please contact your nearest Bruker BioSpin office.			

Included in magnet case (applies to the 300 MHz and 400 MHz rows)

Table 3.4. Transport Weights of Magnets and Accessories

Magnet Type	Magnet Weight with Crate (kg)	Magnet Weight without Crate & Stand (kg)	Magnet Weight Empty with Magnet Stand (kg)	Magnet Weight Filled with Magnet Stand (kg)	Weight of Accessories
300 MHz/54 mm US LH	332	205	242	310	Included in magnet crate
300 MHz/54 mm US ULH	386	261	298	379	Included in magnet crate
300 MHz/89 mm US LH	463	231	375	434	Included in magnet crate
400 MHz/54 mm US LH	474	323	386	464	Included in magnet crate
400 MHz/54 mm US ULH	485	346	397	494	Included in magnet crate
400 MHz/89 mm US LH	587	465	500	584	Included in magnet crate
500 MHz/54 mm US LH	779	568	648	749	approx. 290
500 MHz/89 mm US LH	1550	1300	1520	1700	approx. 350
600 MHz/54 mm US LH	1326	996	1150	1300	approx. 545
600 MHz/89 mm US LH	approx. 2300	1985	2285	approx. 2500	approx. 450
700 MHz/54 mm US LH	3000	2513	2700	3200	approx. 450

LH= Long Hold, ULH= Ultra Long Hold, US= UltraShield^{TM}

The weights of the accessories are approximations. The actual weight may vary depending on the options and accessories that are ordered.

For information on other magnets not listed, please contact your nearest Bruker BioSpin office.

Table 3.5. Transport Weights of NMR Cabinets and Accessories

Unit	Weight
AVANCE for Solids	460 kg*
AVANCE Standard	400 kg*
AVANCE OneBay	210 kg*
AVANCE MicroBay (varies according to options)	approx. 210*
MAS Cabinet	160 kg
Imaging Cabinet	150 kg
HP Cabinet	200 kg
UPS (optional - highly recommended when with CryoProbe system)	260 kg + 165 kg
Sample Changer (depending on model and options, e.g. B-ACS/60 = 93 kg, B-ACS/120 = 95 kg)	93-150 kg
LC-NMR Unit, LC-NMR Console (MicroBay), LC-NMR Control Unit (host computer), plus any additional options/accessories	50-250 kg + weight of MicroBay
Gilson	39.9 kg + crate and accessories
BCU-05	50 kg
CryoCooling Unit	400 kg
UPS for Cryocooling Unit	260 kg + 165 kg
CryoProbe System He Compressor	120-140 kg - varies for air and water cooled models
Emergency Generator (backup) for the He compressor and chiller (highly recommended)	Depends on manufacturer.
Weights include pallets and packing material as required. * Weights are for a standard AVANCE™ configuration, actual weights may increase depending on options selected.	

Rigging Equipment *3.3*

All rigging equipment must be selected to handle the size (***Table 3.1.***, ***Table 3.2.***) and transport weights (***Table 3.4.***, ***Table 3.5.***) of the magnet system. For larger magnet systems, a crane may be required for offloading from the truck to the loading dock (whereas the top and sides of the crate need to be removed while the system is still on the truck, as shown in the figure below).

Figure 3.2. Unloading the Magnet from the Delivery Truck

Whenever possible, air skates should be used during transport over floors and through passage ways. For lifting during installation, hydraulic lifts are preferred.

Rigging equipment is not included with the NMR system order. For larger magnets (e.g. 500WB and >600 MHz) the following rigging equipment will be needed for the delivery and installation (see ***"Installation" on page 97***) of the magnet system:

- **Crane:** A crane meeting the load requirements for the specific magnet. The crane will be required to lift the magnet off the truck, place it on a flat surface for uncrating, and for lifting the magnet again for placement on air skates or a pallet.
- **Air Skates:** A set of four air-skates (***Figure 3.1.***) is required to transport the magnet from the access doors to the NMR site. The air skates will require a large air compressor capable of supplying 1.72bar (25 psi) at ca. 2 cu.meter/min.
- **Leveling Sheets:** Masonite (or other suitable material) sheets may be temporarily required to level the transport access route over irregular floors to the NMR site.
- **Lifting Hook:** Lifting the magnet inside the NMR room for assembly purposes requires either a fixed lifting hook or a hydraulic gantry capable of handling the magnet load with the given ceiling height requirements (***Table 14.2.***).

Bruker can provide rigging equipment, such as air skates, lifting hooks and A-frames (***Figure 14.2.***) at many sites upon request (see ***"Magnet assembly" on page 99*** for more information).

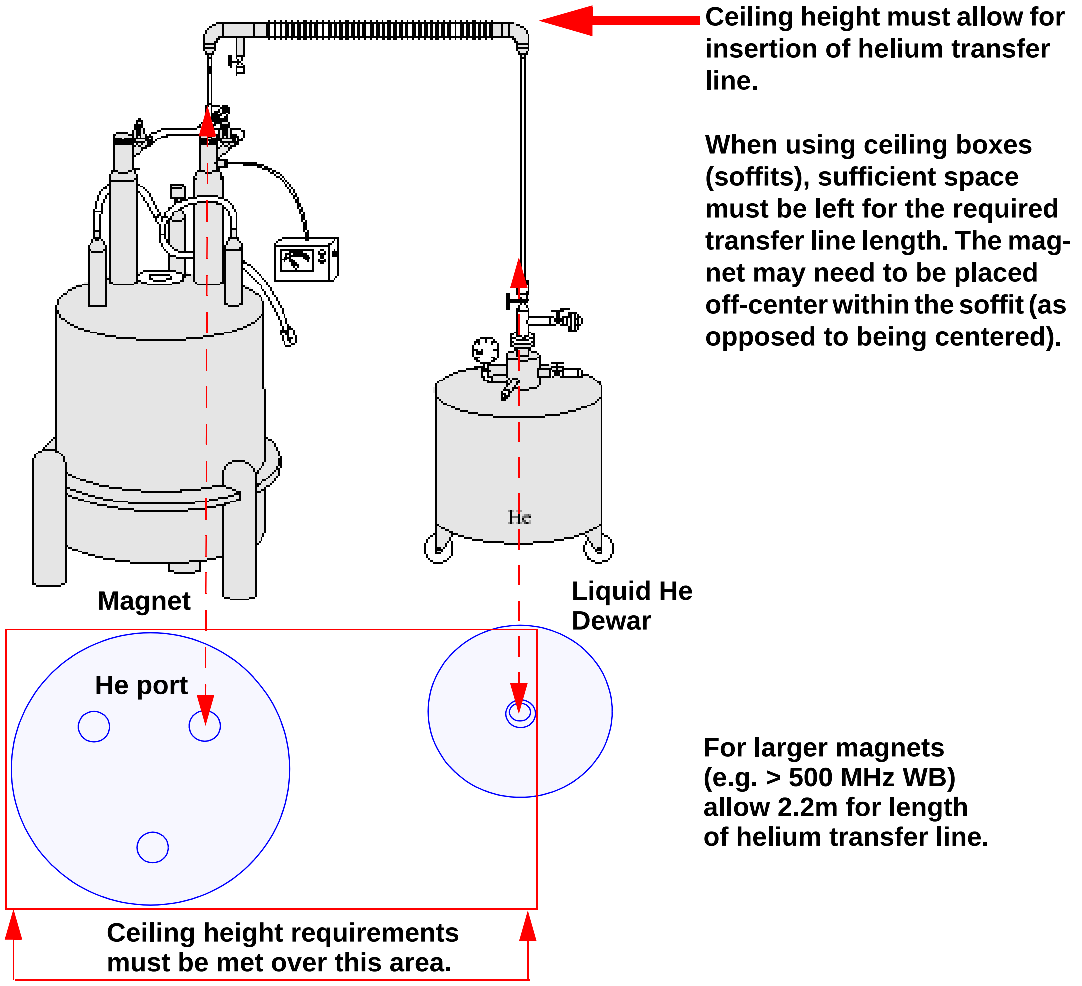
Ceiling Height 4

Introduction 4.1

The minimum ceiling height requirements depend on the clearance needed above the magnet for assembly, energizing, and filling with liquid helium. The requirements for each magnet are listed in ***Table 4.1.***. However, when planning the site, an extra 0.3-0.4m above the minimum requirements is helpful. This extra margin will make the procedure safer and more convenient.

1. Note that the ceiling height requirements need not be met over the entire NMR room, rather only over the area immediately above the magnet itself (and platform if installed), and over an area that extends out in one direction to allow for the helium transfer line (see ***Figure 4.1.***). A length of 2.2m will normally suffice for currently available magnets.

Figure 4.1. Ceiling Height Requirements



2. For the assembly of the magnet you should provide a hook capable of supporting the magnet if possible. Refer to the ***"Magnet assembly"*** section in the transportation chapter for details.

Ceiling Height Requirements *4.1.1*

The **minimum ceiling height** is calculated by adding the height of the shim upper part that has to be inserted into the cryostat, to the height of the top flange of the cryostat.

The ceiling height requirements for each magnet are listed in ***Table 4.1.***. Note that the ceiling heights above represent the **absolute minimum**. As mentioned previously, an extra 0.3-0.4m above minimum requirements will make all procedures safer and more convenient.

The **reduced ceiling height** is calculated by adding the height of the separable shim upper part that has to be inserted into the cryostat to the height of the top flange of the cryostat. In this case, bendable energizing rods and special helium transfer lines with flexible extensions must be used. It should be noted that the use of flexible extensions will reduce the transfer efficiency by up to 10%.

When using MAS transfer rods, the **minimum ceiling height for MAS transfer systems** is calculated to the top of the MAS transfer system.

For all wide bore systems, the minimum ceiling height is calculated to the top of the upper part reduction **adapter WB -> SB**.

For information on other magnets not listed, please contact your nearest Bruker BioSpin office.

Table 4.1. Ceiling Height Requirements

Magnet Type	Minimum Ceiling Height (m)	Reduced Ceiling Height (special equipment) (m)	Minimum Ceiling Height for MAS Transfer Systems (m)	Minimum Ceiling Height for Adapter WB -> SB (m)	Minimum Hook Height (for assembly) (m)
300 MHz/54 mm US LH	2.62	2.42	2.42	---	2.42
300 MHz/54 mm US ULH	3.00	2.80	2.80	---	2.80
300 MHz/89 mm US LH	3.05	2.85	2.85	2.85	2.85
400 MHz/54 mm US LH	3.00	2.80	2.80	---	2.80
400 MHz/54 mm US ULH	3.20	3.00	3.00	---	2.90
400 MHz/89 mm US LH	3.10	2.90	2.90	2.90	3.00
500 MHz/54 mm US LH	3.00	2.80	2.90	---	2.90
500 MHz/89 mm US LH	3.70	3.45	3.45	3.54	3.45
600 MHz/54 mm US LH	3.25	3.05	3.05	---	3.00
600 MHz/89 mm US LH	3.99	3.35	3.99	3.99	3.45

Table 4.1. Ceiling Height Requirements

Magnet Type	Minimum Ceiling Height (m)	Reduced Ceiling Height (special equipment) (m)	Minimum Ceiling Height for MAS Transfer Systems (m)	Minimum Ceiling Height for Adapter WB -> SB (m)	Minimum Hook Height (for assembly) (m)
700 MHz/54 mm US LH	3.63	3.25	3.45	---	3.45
LH= Long Hold, ULH= Ultra Long Hold, US= UltraShield[TM] For information on other magnets not listed, please contact your nearest Bruker BioSpin office.					

Note: The ceiling height required to assemble the magnet may vary depending on the rigging equipment (i.e. lifting gantry) provided. For example, a minimum ceiling height for a 600/54 US LH magnet with flexible transfer lines is 3.05m, with a minimum hook height of 3.0m. However if the total ceiling height is 3.05m, a hook in the ceiling or a special lifting gantry must then be provided.

Ceiling Boxes (Soffits) *4.1.2*

In some rooms the ceiling height requirements may be met through use of a ceiling box (soffit).

When using soffits, sufficient space must be left for the required transfer line length. The magnet may need to be placed off-center within the soffit (as opposed to being centered).

When defining the soffit and magnet placement, one also needs to consider the space required by the gantry, A-frame, hooks etc. when assembling the magnet.

Figure 4.2. A Soffit (including gantry used for installation)

Room Layout 5

Introduction 5.1

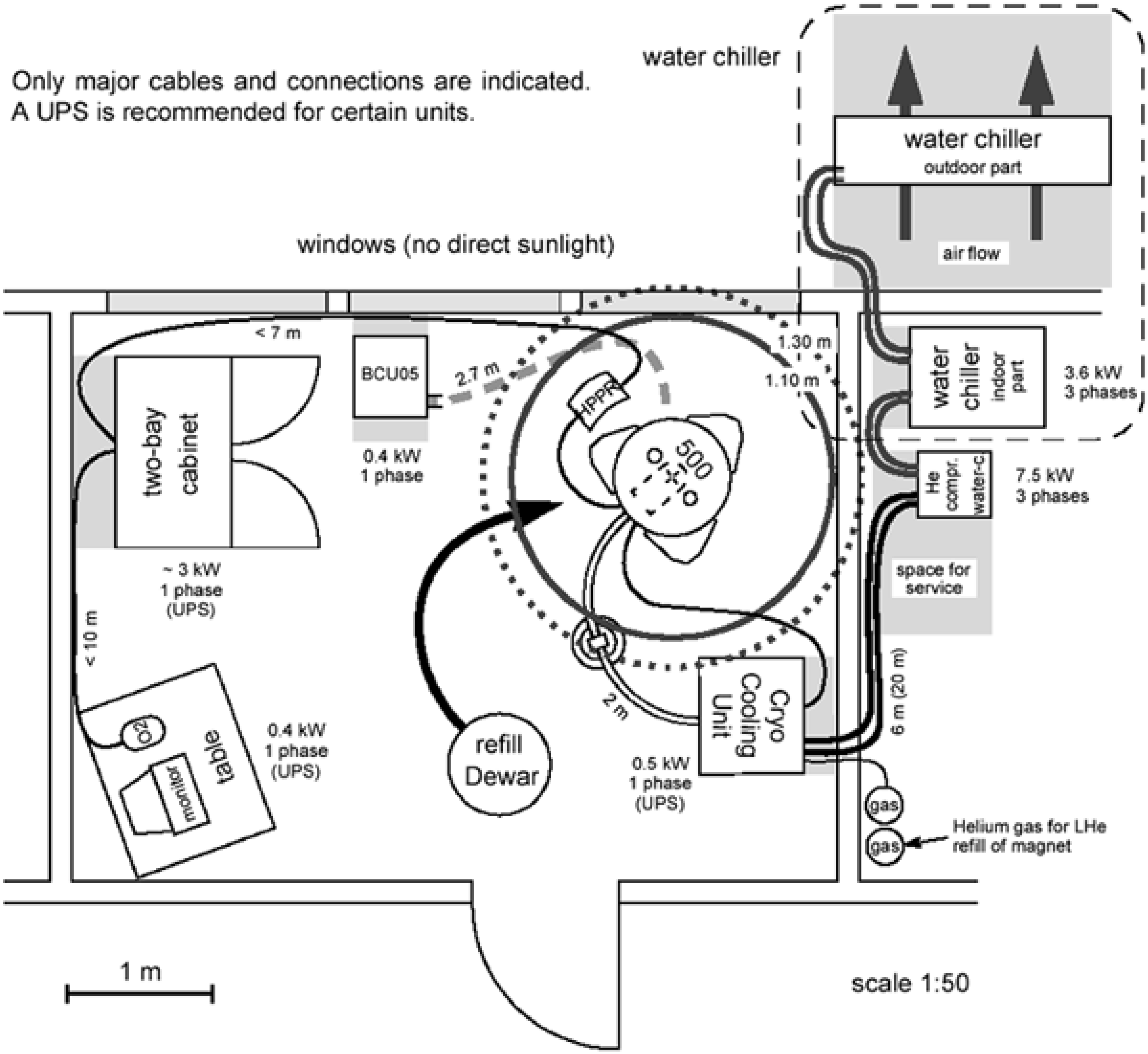
This chapter has been included to give an overview of a suitable room layout. More precise details will be discussed in subsequent chapters. The reader may also wish to refer to ***"Sample Room Layouts" on page 103*** which contains room layouts for various magnets. The standard AVANCE[TM] spectrometer consists of three main units: the magnet (section ***5.2.1***), the cabinet (section ***5.2.2***), and the worktable (section ***5.2.3***).

Figure 5.1. Main Units: Cabinet, Worktable and Magnet

Floor Plan 5.2

To adequately plan the lab you should draw a scaled floor plan of the proposed site (you may use the blank form in the ***"Site Planning Checklist"***). ***Table 5.1.*** shows the maximum field strength at which standard NMR equipment should be operated or located. ***Table 5.2.*** shows the dimensions of various NMR units.

Figure 5.2. Site Planning Example (shown with CryoProbe System)



Use the magnet stray field data from ***Table 5.3.*** and ***Table 5.4.*** to check that all equipment can be positioned outside the limits as specified in ***Table 5.2.***. When drawing the floor plan refer to ***Table 7.1.*** for the magnet diameter.

Table 5.1. Maximum Field Strength for NMR Equipment

Unit	Maximum Field Strength
AVANCE Cabinet	1.0mT (10G) line
Color Monitor (unshielded)	0.2mT (2G) (for optimal picture)
Color Monitor (shielded) or TFT panel	1.0mT (10G)
Computers e.g. NMR workstation, PC	1.0mT (10G)
CPMAS, Micro-imaging, High Power units	1.0mT (10G)
Printer Plotter	1.0mT (10G)
Gas cylinders	0.5mT (5G)
Movable metal chair	not recommended in magnet room
Heavy metal office furniture e.g. filing cabinet*	0.5mT (5G) - not recommended in magnet room
BCU 05	located 2.7m max. from magnet center
LC-NMR System & Accessories	0.5mT (5G)
Gilson	0.5mT (5G)
CryoProbe System Components (e.g. He steel cylinder and its transport path)	0.5mT (5G)
CryoCooling unit	5.0mT (50G)
** Use wooden furniture if access during critical measurements is required.*	

Table 5.2. Dimensions of NMR Equipment

Unit	Width*	Depth*	Height*
AVANCE for Solids	1.31m	0.83m	1.55m
AVANCE Standard	1.31m	0.83m	1.29m
AVANCE OneBay	0.69m	0.83m	1.29m
AVANCE MicroBay	0.64m	0.83m	0.96m
Work table	1.20m	1.00m	0.75m
CPMAS Cabinet with Heightening	0.69m	0.83m	1.55m
High Power Cabinet with Heightening	0.69m	0.83m	1.55m
Micro imaging Cabinet with Heightening	0.69m	0.83m	1.55m
B-CU 05	0.50m	0.55m	0.48m
LC-NMR Unit plus any additional options/accessories**	0.72m diverse	0.80m diverse	0.72m diverse

Table 5.2. Dimensions of NMR Equipment

Unit	Width*	Depth*	Height*
Gilson	0.914m	0.61m	0.558m***
CryoCooling unit	0.80m	0.72m	1.30m

* All conversions from Metric/American Standard were rounded up.
** Accessories for the LC-NMR vary based on options that are ordered, but may include Cap-LC Interface, SPE-Interface, Autosampler's, Detector's, Injector's, Pump's and the host computer.
***Maximum height. Z-arm height is adjustable to accommodate vessel heights between 1 and 150 mm (dependant on installed Z-arm).

Magnet Position 5.2.1

When locating the magnet, take into consideration how close the magnet will be to permanent iron structures such as support beams and columns, as well as reinforced walls, floors and ceilings. The presence of any ferromagnetic materials in the immediate vicinity of the magnet will decrease the magnet´s homogeneity and may degrade overall performance. Refer to the section ***"Presence of Ferromagnetic Materials" on page 67*** for details.

Smoke detectors, fire detectors and sprinklers should not be located within the 0.5mT (5G) line.

To increase temperature stability, the magnet should not be placed in direct sunlight or near any artificial heat source. Likewise, to avoid line frequency Electro Magnetic Interference (EMI), the magnet should not be placed directly under fluorescent lights.

Where possible avoid a situation where stray fields > 0.5mT (5G) extend into adjacent rooms (see ***Figure 2.1.***). There should be open access to the magnet from all sides, and a minimum of 77cm clearance to any adjacent wall should be provided. Sufficient space for access to the cryogen dewars needs to be provided as well (see ***"Service Access Requirements"***). It is recommended that the magnet be located outside the main traffic area of a room, for example in a corner, to limit magnetic fluctuations.

Magnet Platforms

If a magnet platform is required, e.g. due to the size of a magnet (normally 600MHz and above), it should be large enough (depending on the magnet) to accommodate the magnet and provide proper access all around the system. A non-magnetic floor level platform should be built around the magnet to allow access for changing samples and filling with cryogens. Consult your Bruker BioSpin office for further guidelines when using a magnet platform.

Figure 5.3. Example of a Simple Magnet Platform

Pits

If a pit is required due to limited ceiling height or to prevent stray fields from affecting the floor above, it should be large enough (depending on the magnet) to accommodate the magnet. The magnet should be located in the center of the pit and there should be adequate space for proper access all around the system. The wall of the pit should be outside the 1.0mT (10G) line, or built with non-magnetic material.

A non-magnetic platform should be built around the magnet to allow access for changing samples and filling with cryogens. In some cases a half platform will suffice. To provide adequate safety when using a pit, a stairway should be built allowing easy access to the pit. Likewise, a rail system should be installed to prevent personnel from falling into the pit.

It is extremely important to provide good ventilation when a pit is used. This is particularly true when refilling nitrogen. An oxygen warning device (see ***Figure 6.6.***) should be installed in the pit.

Another complication with pits concerns the CryoCooling unit for the CryoProbe: it should ideally be located at the same level as the magnet. The pit should be large enough to accommodate both the magnet and the CryoCooling unit.

The BCU05 also must be considered when using a pit. The hoses from a BCU05 are not very flexible, thus a pit should be large enough to provide sufficient space for the BCU05 and it's hoses. The BCU05 cooling unit should be as far as possible from the magnet so as to minimize influence from stray fields.

Please contact Bruker when considering a pit.

Figure 5.4. Example of a Magnet Pit

Cabinet Position 5.2.2

The various units within the AVANCE™ cabinet, especially the acquisition computer, must be kept at a minimum distance from the magnet. Protection of the acquisition computer and digital electronics from the magnet's stray field is best achieved by positioning the cabinet so that the acquisition computer is no closer than the 1.0mT (10G) line. Any ancillary cabinets such as microimaging or high power should also be placed outside the 1.0mT (10G) line (see ***Table 5.1.***). The preamplifier (e.g. HPPR/2) should be placed to the left side of the magnet.

Figure 5.5. shows the location of the acquisition computer in the AVANCE™ cabinet.

To allow adequate ventilation for the cabinet, it should be positioned no closer than 15cm from the back of the cabinet and any walls. In some circumstances it may be necessary to install supplementary exhaust systems, such as a passive exhaust system (***Figure 6.4.***) or a commercial ventilation system (***Figure 6.3.***). For service access to the rear, there must be sufficient space for the cabinet to be pulled out from the wall (see ***"Service Access Requirements" on page 43***).

For ease of cabling, locate electrical outlets and compressed air supply close to the rear of the cabinet.

The same criteria apply to the single door cabinet, although the orientation of the magnet is not so critical.

Worktable Position 5.2.3

Based on acceptable MWC (**M**aximum **W**orkstation **C**oncentration) values, the working place should be placed outside of the 0.5mT (5G) line (refer to the section ***"Effect of Magnetic Fields on Personnel" on page 10***).

The workstation and additional disks, tapes, CD-ROM drives, etc. which are normally placed on or under the worktable should not be exposed to fields greater than 1.0mT (10G).

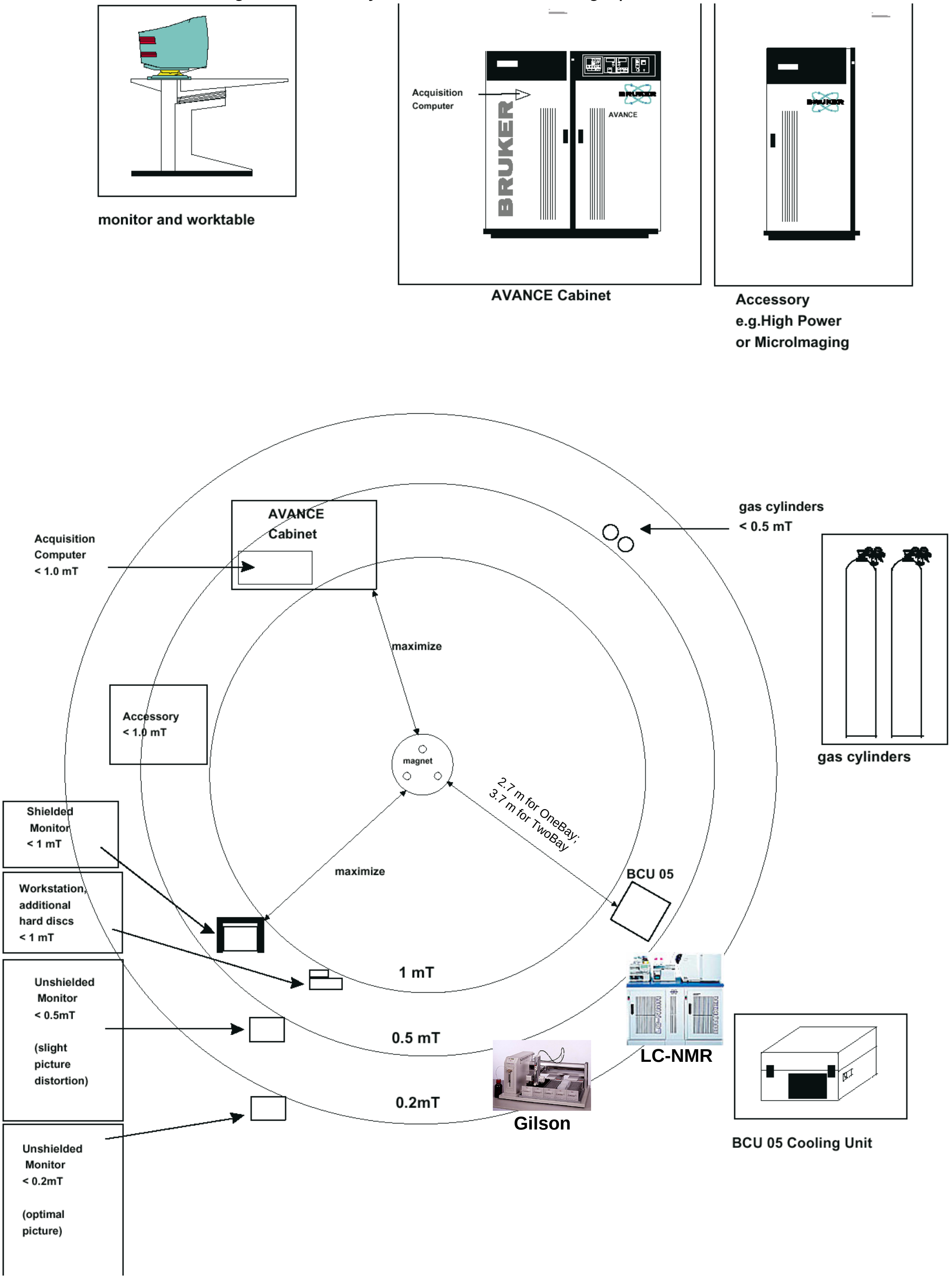
The graphics monitor is sensitive to the stray field, thus attention must be given to its position relative to the magnet. The monitor should be turned towards the magnet so as to be visible when tuning and matching. If unshielded, the monitor should ideally be placed no closer than the 0.2mT (2G) line for optimal picture. With correct orientation you may locate the monitor as close as 0.5mT (5G), though color distortion may result. Shielded monitors, as well as TFT flat panel monitors, can be safely placed as close as 0.5mT (5G), or even 1.0mT (10G), though slight picture distortion may occur.

Stray Field Limits *5.3*

The following diagram and tables provide information on the stray field limits for locating spectrometers.

Note: Stray fields correspond to the latest magnet designs as of the release date of this manual. For older systems, please refer to previous version of the Site Planning Guide, or contact your Bruker BioSpin representative.

Figure 5.5. Stray Field Limits for Locating Spectrometers



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

Table 5.3. *Horizontal Stray Fields of Various Magnets*

Magnet type	5.0mT (50G)	3.0mT (30G)	1.0mT (10G)	0.5mT (5G)	0.2mT (2G)	0.1mT (1G)	0.05mT (0.5G)
300 MHz/54mm US LH	0.44	0.47	0.50	0.6	0.80	0.90	1.10
300 MHz/54mm US ULH	0.44	0.47	0.50	0.6	0.80	0.90	1.10
300 MHz/89mm US LH	0.80	0.90	1.00	1.10	1.50	1.80	2.20
400 MHz/54mm US LH	0.70	0.77	0.84	1.00	1.30	1.60	1.92
400 MHz/54mm US ULH	0.70	0.77	0.84	1.00	1.30	1.60	1.92
400 MHz/89mm US LH	0.90	1.07	1.25	1.40	1.78	2.20	2.67
500 MHz/54mm US LH	0.90	1.03	1.16	1.30	1.70	2.10	2.50
500 MHz/89mm US LH	0.90	1.30	1.50	1.80	2.50	2.90	3.50
600 MHz/54mm US LH	0.90	1.15	1.40	1.80	2.50	3.20	4.10
600 MHz/89mm US LH	1.30	1.75	2.20	2.70	3.60	3.95	4.10
700 MHz/54mm US LH	1.60	2.00	2.30	2.50	3.40	4.00	4.80

LH= Long Hold, ULH= Ultra Long Hold, US = Ultra Shield™

All measurements in meters! *Distances are measured in **radial** direction from magnetic center.*

Table 5.4. *Vertical Stray Fields of Various Magnets*

Magnet type	MC to Floor	5.0mT (50G)	3.0mT (30G)	1.0mT (10G)	0.5mT (5G)	0.2mT (2G)	0.1mT (1G)	0.05mT (0.5G)
300 MHz/54mm US LH	0.91	0.52	0.66	0.80	0.90	0.96	1.36	1.56
300 MHz/54mm US ULH	0.91	0.52	0.66	0.80	0.90	0.96	1.36	1.56
300 MHz/89mm US LH	1.04	0.88	1.02	1.36	1.60	2.04	2.40	2.88
400 MHz/54mm US LH	0.95	0.80	1.05	1.30	1.50	1.96	2.36	2.76
400 MHz/54mm US ULH	0.95	0.80	1.05	1.30	1.50	1.96	2.36	2.76
400 MHz/89mm US LH	1.02	1.20	1.44	1.69	2.00	2.56	3.00	3.56
500 MHz/54mm US LH	1.01	1.10	1.35	1.60	1.90	2.40	2.90	3.40
500 MHz/89mm US LH	1.28	1.50	1.80	2.10	2.50	3.30	3.80	4.50
600 MHz/54mm US LH	1.12	1.50	1.80	2.10	2.50	3.30	4.10	5.10
600 MHz/89mm US LH	1.36	1.80	2.30	2.80	3.50	4.60	5.20	6.10

Table 5.4. Vertical Stray Fields of Various Magnets

Magnet type	MC to Floor	5.0mT (50G)	3.0mT (30G)	1.0mT (10G)	0.5mT (5G)	0.2mT (2G)	0.1mT (1G)	0.05mT (0.5G)
700 MHz/54mm US LH	1.23	2.20	2.68	2.95	3.50	4.40	5.20	6.20

LH= Long Hold, ULH= Ultra Long Hold, US = Ultra Shield™

All measurements in meters! *Distances are measured in **axial** direction from magnet center.*

Mass of Equipment 5.4

The site floor must be sufficiently strong to support the AVANCE™ cabinet, the magnet (including cryogens and magnet stand) and the ancillary equipment. The weights for the various cabinets are listed in ***Table 3.5.***. For the total weight of the magnet (including cryogens and stand) refer to ***Table 7.1.***. The floor should also be as rigid as possible to reduce the effect of vibrations.

Positioning other Standard NMR Equipment 5.5

Micro Imaging, High Power Cabinets

These accessories are not as sensitive to the magnet stray field as the units contained in the main AVANCE™ cabinets. In terms of performance they will operate satisfactorily at fields of up to 2mT. However at this distance they may interfere with the magnet homogeneity and so it is recommended that they be kept beyond the 1mT line. The standard layout shown in ***Figure 5.7.*** places emphasis on making the cabling as convenient as possible. Where space is a problem, give priority to the position of the main cabinet over the accessory cabinet. Since these accessory cabinets are mobile the customer should consider securing the wheels if they are operated close to the magnet.

Automatic Sample Changer

The sample changer is designed to be located in front of the magnet and so its position is fixed. No extra ceiling height requirements are needed. You should note however that access to the magnet from one side will be slightly restricted. The sample changer has a width of 0.95m and extends to a distance of 0.45m from the magnet outer surface.

Cooling Unit: B-CU 05

This unit is connected to the magnet probe via a heat exchanger of 2.7m in length. This effectively fixes the position of the cooling unit to a max.radius of approximately 2.7m from the magnet. The precise distance from the magnet centre can be reduced by placing a bend in the heat exchanger.

LC-NMR/MS

The LC-NMR/MS system is available in a variety of configurations and can include many diverse accessories. Most configurations can be setup on existing tables and/or the LC-NMR/MS cabinet. Some general space requirements include:

- Approximately 60x100cm is required for the installation of the chromatography system and the desktop version of the LC-NMR/MS interface (BPSU-12, BSFU). The table or LC-NMR/MS cabinet must be positioned close to the magnet (but outside 0.5mT (5G) line).
- Approximately 60x80cm is required on an office desk or table for the computer controlling the chromatography system and the LC-NMR/MS interface. The desk of the NMR computer can be used.
- Two 230V power outlets are required for computer and monitor.

In addition, certain considerations must be given in positioning the LC-NMR/MS instruments.

- The maximum distance between the PC and console should be < 10m, determined by the length of the cable.
- The LC-NMR/MS system should not be located more than 10m from the PC. The distance is normally determined by the length of the cable.
- The maximum distance between the LC-NMR/MS interface and the probe should be approx. 3m, determined by the standard length of the delivered capillary (a longer capillary can be used, but capillary connections should be as short as possible).
- The maximum distance between the LC system and the LC-NMR/MS interface is based on the 5 Gauss line of the magnet.
- The control unit screen should be visible from the NMR computer and vice versa.
- The HPLC equipment should be visible from the PC (it is not necessary that the HPLC PC is near the HPLC equipment).

Gilson Liquid Handler

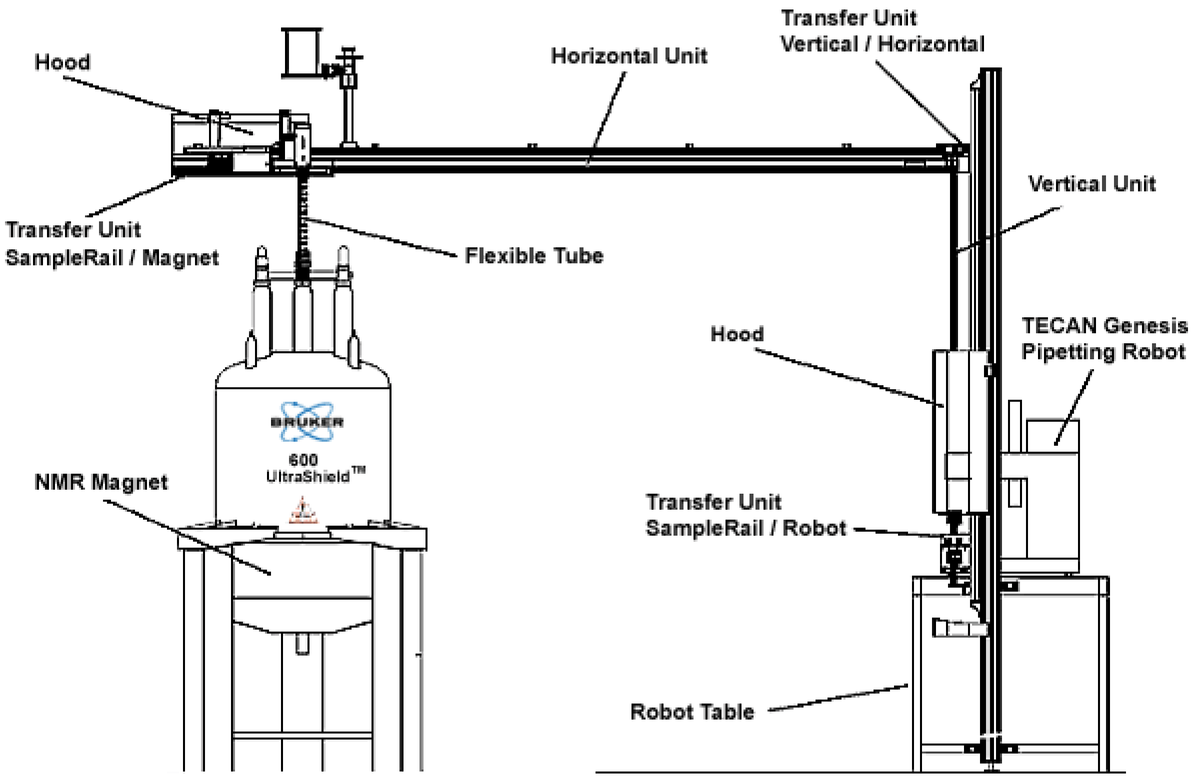
The Gilson 215 Liquid Handler is an XYZ robot that can automate any number of liquid handling procedures. There are generally no specific room layout considerations for the Gilson, other than locating it outside of the 0.5mT (5G) line.

SampleRail

The SampleRail™ is part of a system for preparing an NMR sample, transporting it into an NMR magnet, performing NMR experiments on it and transporting it back to the preparation system - all in automation, for example, in automated protein screening.

The main site planning consideration for the room layout is that the room is long enough or wide enough to support the length of SampleRail. The height of the SampleRail generally should fall within the normal ceiling height requirements. For further information on SampleRail requirements, check with your Bruker representative.

Figure 5.6. Bruker SampleRail



CryoProbe

The CryoProbe^{TM} accessory consists of three major components: the CryoProbe, CryoPlatform^{TM} and a compressor.

The **CryoProbe** is similar to a standard probe, however it contains cryogenically cooled RF coils and electronics. The CryoPlatform, which provides cryogenic cooling for the CryoProbe, is made up of:

- CryoCooling Unit with control electronics
- Helium compressor (along with any associated cooling equipment)
- Helium gas cylinder (for purging of the CryoProbe)
- Helium transfer lines and transfer line support
- CryoProbe mounting bracket

There are basically four major steps in site planning for the CryoProbe Accessory:

1. Review the magnet area to determine if space is available to accommodate the CryoCooling Unit.
2. Determine the type and location of the helium compressor.
3. Verify that adequate free space is available under the magnet to allow for the installation of the CryoProbe.
4. Determine the location for the helium cylinder.

These steps are discussed in detail, along with other considerations in the separate **CryoProbe System Site Planning Guide**, available from your local Bruker dealer.

Figure 5.7. Cable Layout for Standard AVANCE^{TM} *Systems*

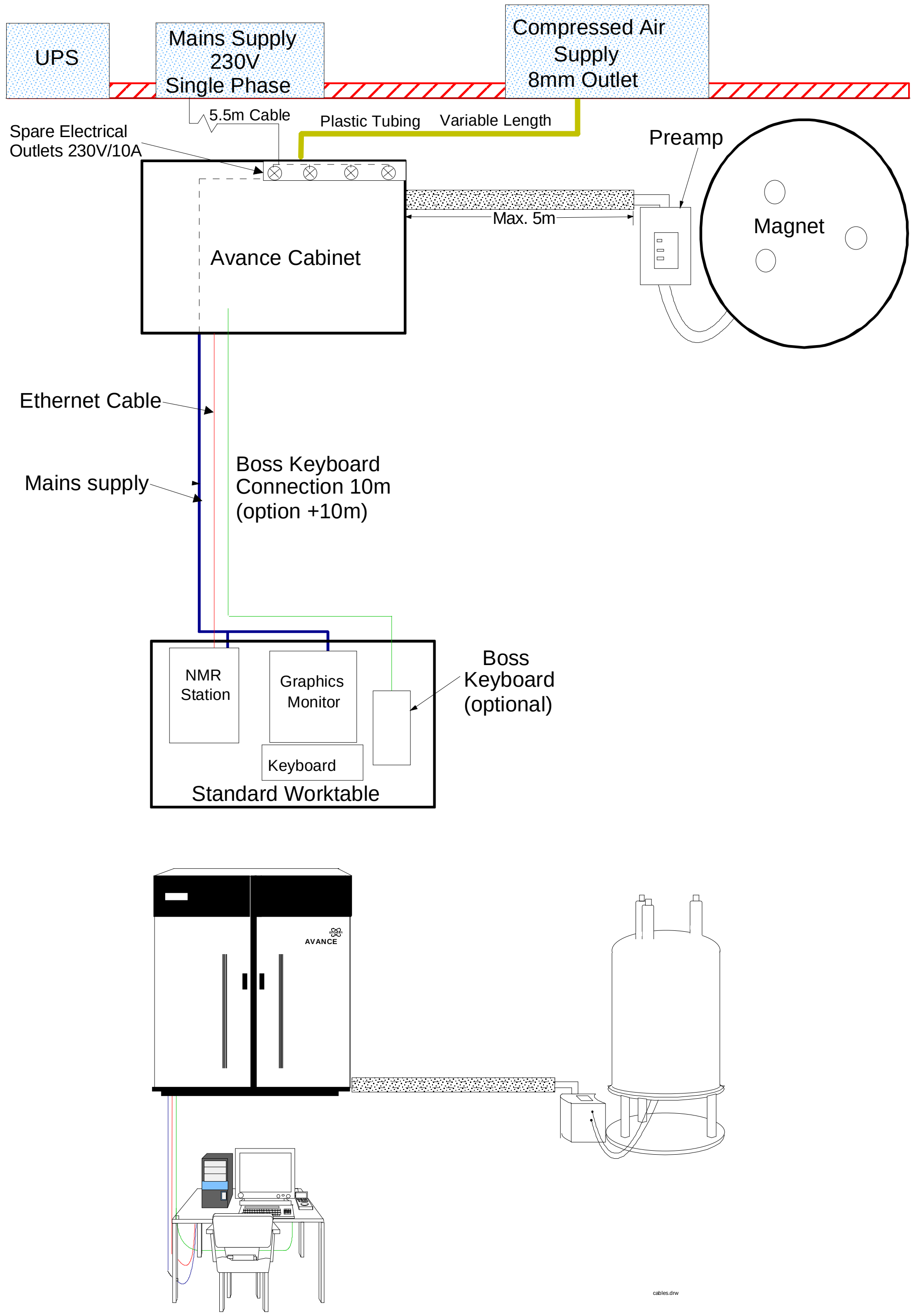
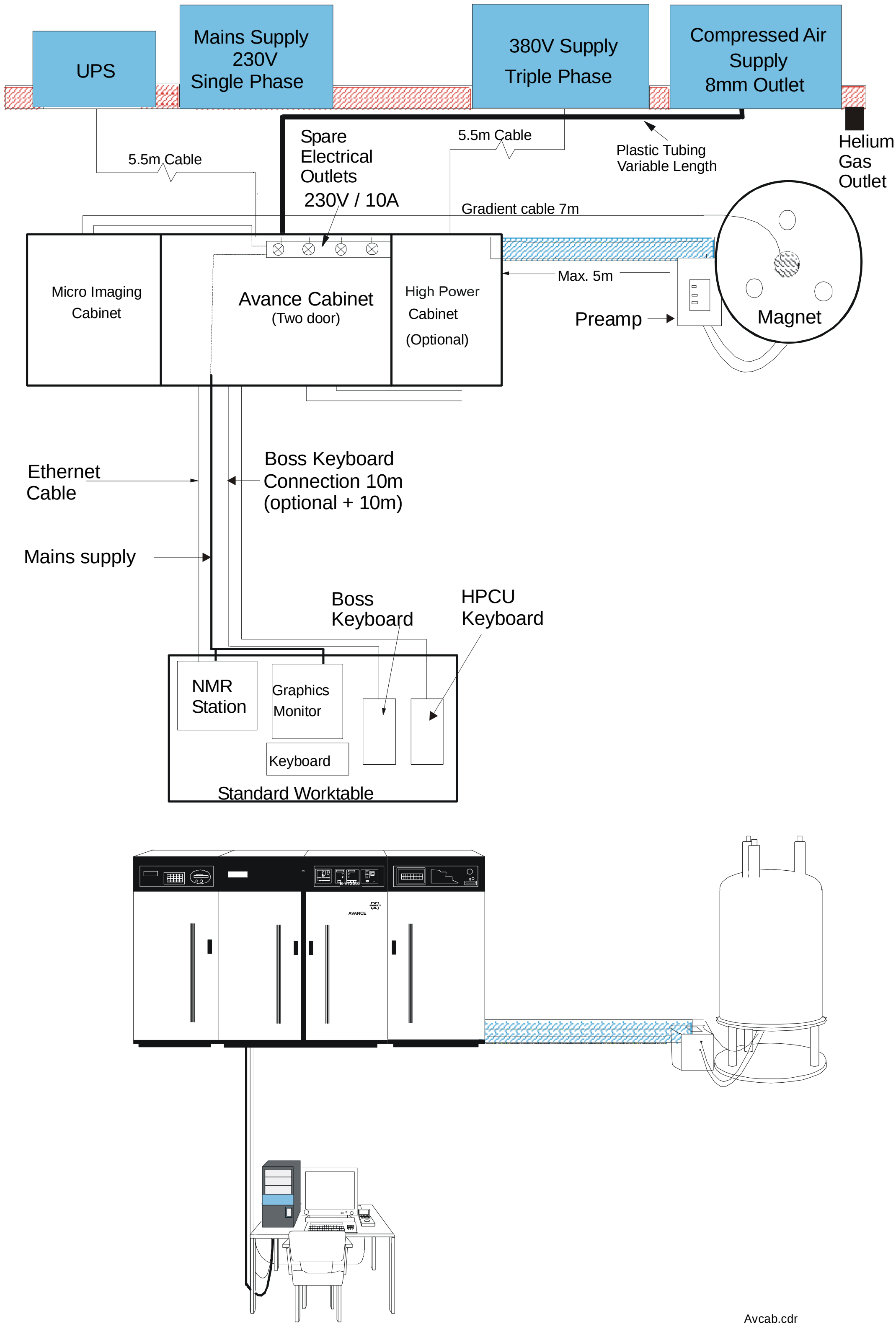


Figure 5.8. Cable Layout for AVANCE™ *Systems with High Power and Micro Imaging*



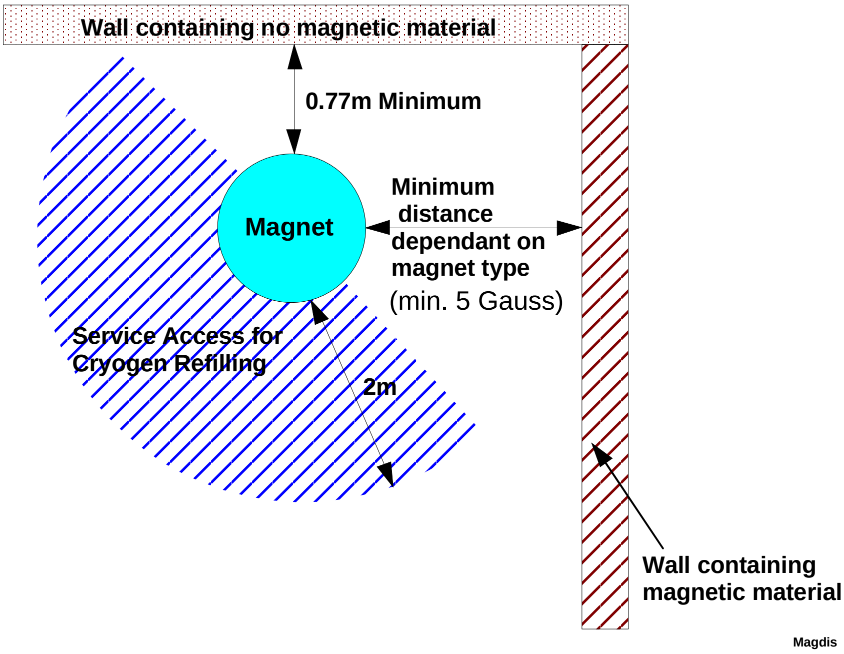
Service Access and Ventilation 6

Service Access Requirements 6.1

The following recommendations will ensure that there is sufficient space for accessing the system, as well as providing adequate ventilation:

- Leave a minimum of 30cm between the back of the cabinet and any walls. This is to ensure adequate ventilation. To provide for service access to the rear, there must be sufficient space for the cabinet to be pulled out from the wall (approximately 60 cm). Service access to the sides is not required.
- There should be open access to the magnet from all sides, and a minimum of 77cm clearance to any adjacent wall should be provided. Sufficient space for access to the cryogen dewars needs to be provided as well.

Figure 6.1. Service Access Requirements for Magnet



- For ease of cabling, locate electrical outlets and compressed air supply close to the rear of the cabinet and by the magnet.
- The door to the magnet room should be easily accessible from all parts of the room. It is advantageous to have the doors located so that traffic though the room does not approach the magnet.

- As a rule gas cylinders should be stored outside the room. If for any reason they must be placed in the magnet room they should be located as far away from the magnet as possible and secured properly to the wall.
- Ensure that convenient and safe pathways are available so that cryogen transport dewars can easily be moved into and out of the magnet room.
- Make provision for sample/solvent preparation and storage space, documentation storage space, personal computers, printer/plotter tables, workstations etc.
- Under no circumstances should movable office chairs made of magnetic material be used in the NMR room.
- Make provision for installing a telephone and lines for, e.g. Internet access. It is most convenient if the operator can use the phone while sitting at the spectrometer worktable.
- Finally, before a final layout is decided, consider future equipment that may need to be installed. Remember that once installed, the magnet should not be moved.

Ventilation Requirements 6.2

Superconducting magnets use liquid nitrogen and liquid helium as cooling agents. It can be expected that a boil-off of liquid cryogens occurs during the normal operation of the magnet system as follows:

- Normal boil-off of liquids contained in the magnet based on the given boil-off specifications.
- Boil-off of cryogens during the regular refills with liquid nitrogen and liquid helium.

The gases are nontoxic and completely harmless as long as **adequate ventilation** is provided. To prevent **suffocation**, the following rules for ventilation during normal operation include:

- The NMR magnet system should never be in an airtight room. The magnet location should be selected such that the door and the ventilation can be easily reached from all places in the room.
- Room layout, ceiling clearance and magnet height should be such that an easy transfer of liquid nitrogen and helium is possible. This will considerably reduce the risk of accidents.

General Safety Rules Concerning Ventilation 6.2.1

General safety rules concerning ventilation include, but are no limited to:

- Cryogenic liquids, even when kept in insulated storage dewars, remain at a constant temperature by their respective boiling points and will gradually evaporate. These dewars must always be allowed to vent or dangerous pressure buildup will occur.
- Cryogenic liquids must be handled and stored in well ventilated areas.

- The very large **increase in volume** accompanying the **vaporization** of the liquid into gas and the subsequent process of warming up is approximately **740:1 for helium** and **680:1 for nitrogen**.
- For personnel safety, **oxygen level sensors** should be located in the magnet room, particularly when using a pit. These should normally be located at a height of 2-2.5 meters. Contact Bruker for additional information.
- **Exit doors must open to the outside**, otherwise during a quench the pressure buildup would make it impossible to open the door.
- It should be noted that a quench may set off **fire alarms**. The fire department should be notified accordingly. The fire department should also be informed that during a quench water should not be sprayed on the magnet, as this may cause rapid icing. It is recommended that you post this information in plain site near the entrance of the magnet room as well (see ***"Emergency Planning" on page 107***).

Helium Buildup 6.2.2

An inadequately ventilated room will cause an **excess buildup of helium**, which diffuses into the vacuum of the magnet (due to the helium molecules being very small). The long term effect of helium buildup is that the **vacuum will go soft**, which means the vacuum installation of the magnet may no longer be efficient and the liquid helium boil off will start to increase. To help prevent helium buildup, ventilation should be provided in the upper-most portion of the room where the magnet is located, such as in the ceiling or upper wall.

Emergency Ventilation During Magnet Installation and Quenches 6.3

A separate emergency ventilation system should be provided to prevent oxygen depletion in case of a quench or during the magnet installation.

During a **quench**, an extremely large quantity of helium gas (i.e. 43 m^3 to 595 m^3 depending on the magnet type) are produced within a short time.

During the installation and cooling of superconducting magnets, under certain conditions, large volumes of nitrogen or helium gases may be generated.

Although these gases are inert, if generated in large enough quantities, they can displace the oxygen in the room causing potential danger of suffocation. The table below illustrates this with examples.

Table 6.1. Example of Gas Released During Pre-cool, Cooling, and a Quench

Magnet Type	N2 gas released during pre-cool	Time to release N2 gas during pre-cool	He gas released during cooling and filling	Time to evolve He gas during cooling and filling	He gas released during a „quench“	Time to release He gas during a „quench“
UltraShield 300/54	102 m^3	4 hours	150 m^3	3 hours	40 m^3	0.5 minutes
UltraShield 700/54	892 m^3	24 hours	850 m^3	6 hours	335 m^3	1 minute

Notes:

- The values in the table are approximate and may not reflect actual conditions. They are to be used for example only.
- Pre-cool times vary.
- Quench times are generally longer.
- Please consult with Bruker for values associated with your NMR magnet system.

Figure 6.2. Quench at 600 MHz WB (Widebore magnet)

The following table lists the maximum helium capacity and the typical gas flow rates for helium gas during a quench for current magnet systems. Generally, the gas flow rate is equal to half the volume in one minute.

Table 6.2. Maximum Helium Capacity and Gas Flow Rate

Magnet	Maximum Helium Capacity (m^3)	Gas Flow Rate (liters/minute)
300 MHz/54 mm US LH	37.1	18.6
300 MHz/54 mm US ULH	71.0	35.5
300 MHz/89 mm US LH	56.0	28.0
400 MHz/54 mm US LH	56.0	28.0
400 MHz/54 mm US ULH	75.0	37.5
400 MHz/89 mm US LH	51.8	25.9
500 MHz/54 mm US LH	54.6	27.3
500 MHz/89 mm US LH	198.0	99.0
600 MHz/54 mm US LH	111.3	55.7
600 MHz/89 mm US LH	315.0	157.5
700 MHz/54 mm US LH	348.0	174.0

LH= Long Hold, ULH= Ultra Long Hold, US= UltraShield™

For information on other magnets not listed, please contact your nearest Bruker BioSpin office.

Emergency Exhaust 6.4

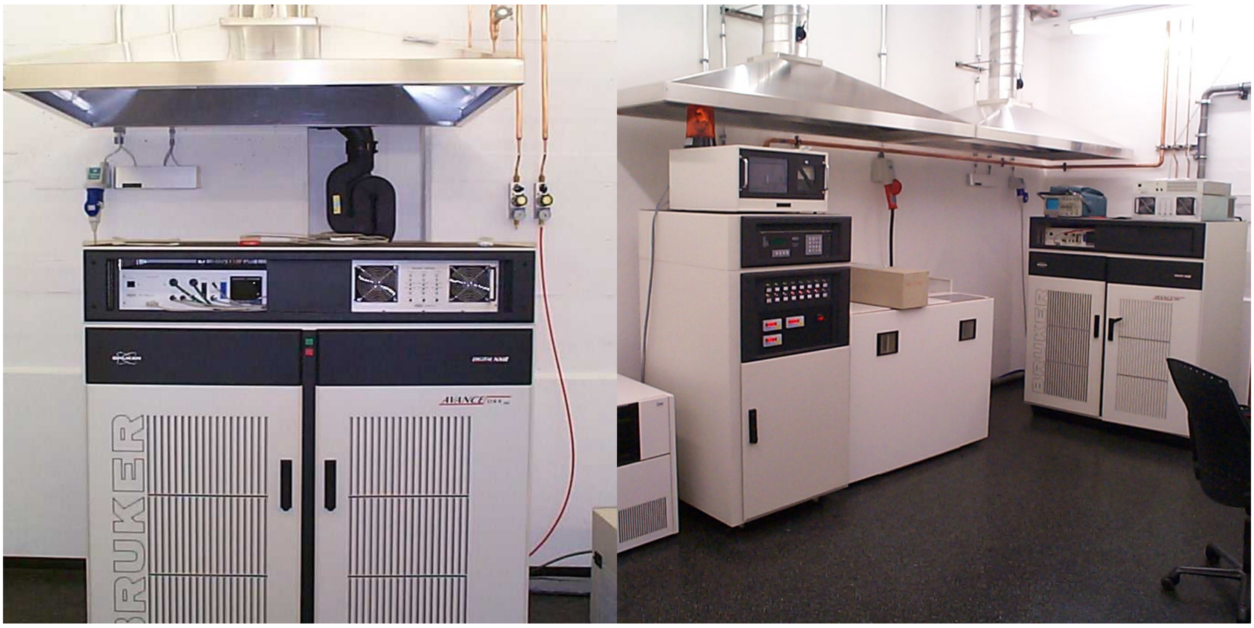
In many cases doors and windows will provide sufficient ventilation in larger rooms. For smaller rooms, or rooms not connected to the outside, it is highly recommended that an emergency exhaust system be installed. There are various types of emergency exhaust that can be implemented to avoid oxygen depletion during a quench or during the installation of the magnet system. These include, but are not limited to:

Active Exhaust Solutions

This solution is based on a motorized fan, vents and exhaust duct pipe that is not connected to the magnet itself. The exhaust should be activated both automatically by an O_2 sensor, as well as manually by a switch in the room. The later is needed during magnet installation and regular refills to prevent cryogen build-up in the room by evacuating them faster than the regular HVAC (Heating Ventilation Air Conditioning) system.

A commercial ventilation system much like those found in the kitchen of modern restaurants is a good example of an active exhaust system. These devices draw the heat generated by electronic devices in the room (e.g. consoles and accessories) out of the room, as opposed to recirculating the air as with some air conditioning systems. During a quench these systems will also aid in dispersing the gases rapidly.

Figure 6.3. Commercial Ventilation Systems



Passive Exhaust Solutions

This solution is based on louvers in the ceiling that open by the gas due to the overpressure of helium gas during a quench.

An example of a passive exhaust solution is an exhaust which can be mounted to the corridor and opens with an overpressure of 10mbar.

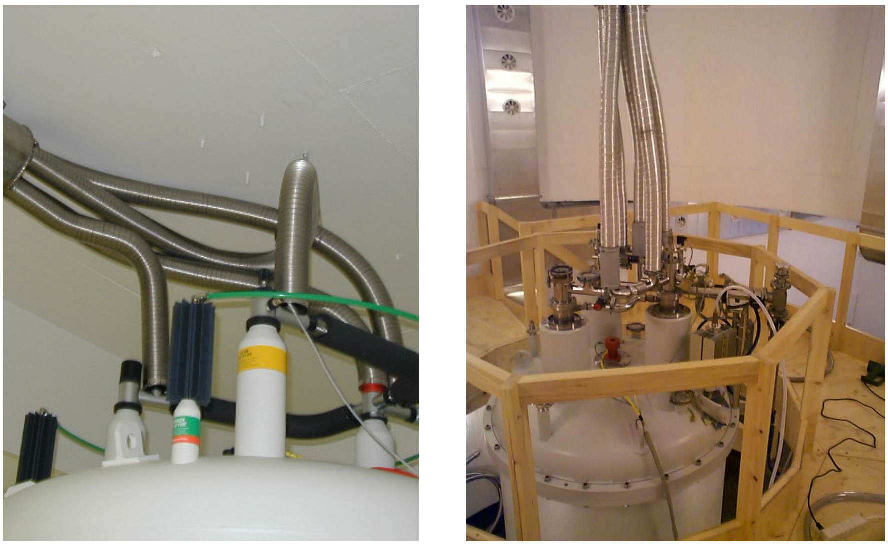
Figure 6.4. A Passive Exhaust Commercial Ventilation System

Quench Pipes

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:

- Ideally 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 buildup 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 6.5. Emergency Quench Pipes



Exhaust for Magnet Pits

Special attention to ventilation and emergency exhaust must be given when magnets are placed inside pits. Magnet pits are confined spaces with a possibility of increased risk of oxygen depletion if appropriate exhaust measures are not taken.

- Nitrogen is heavier than air and starts filling the pit from the bottom during the magnet pre-cool or regular nitrogen fills.
- **It is essential to provide an exhaust system down inside the pit to efficiently evacuate the nitrogen gas and to prevent oxygen depletion and suffocation.**

Air Conditioning as an Exhaust

It is recommended that the air conditioning system be adequate to dissipate the sudden gas buildup during a quench. In addition the air conditioning should have a safety feature which **draws all the air out** of the room and **brings fresh air in** during a quench, rather than just recirculating the old air through the system. The air conditioning system could, for example, be connected to an oxygen level sensor.

Oxygen Monitor and Level Sensors *6.5*

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

Above the magnet:	One oxygen level sensor should be above the magnet, to detect low oxygen levels caused by high He gas levels.
Close to the floor:	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 6.6. 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.

Air Conditioning 6.6

Constant air pressure and temperature are important considerations for high performance operation. Ideally, an **absolute room temperature** should be selected from a range of 17-25°C. The room temperature should then be kept within +/- 1°C for 300-500 MHz systems, and +/- 0.5°C for 600 Mhz and above.

An air exchange rate of 3-5 times the room volume per hour should be maintained.

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 filters. The power supply for the air conditioning system must be separate to the spectrometer supply. If installing an air conditioning system an important consideration is the heat generated by the AVANCE™ electronics, ***Table 6.3.*** lists the heat generated by various systems. The system should operate continuously to stabilize the temperature and humidity of the magnet environment and should not cycle rapidly. Do not allow the air flow from any heating or cooling system to blow directly onto the magnet or console.

The standard AVANCE™ system and accessories can create significant heat as shown in the table below.

Table 6.3. Heat Generated by AVANCE™ *Systems*

System	Heat Generated
AVANCE (with 3 channels & BCU05)	2.93kw average
Imaging Cabinet	1.0kw average
High Power Cabinet	1.5kw average
BCU05	0.5kw average
Gilson	approx. 0.5 kw average
CryoProbe CryoCooling Unit	0.5kw average 1.5kw peak
He Compressor	7.5kw average 8.5kw peak

The temperature of any air or nitrogen flow attached to the probe should be stable. This is particularly relevant if the compressed gas flow is piped into the magnet room from outside the building.

Atmospheric Pressure Changes 6.6.1

Rapid changes in the temperature may result in atmospheric pressure changes. High atmospheric pressure could reduce the helium boil off if the magnet cryostat is not equipped with an electronic atmospheric pressure device. The boil-off rate could be even lower than the minimum value which could be measured by the flow meter. Electronic atmospheric pressure devices, which hold the pressure at 1030 HPa, stabilize field drift and helium boil-off when changes in atmospheric pressure occur. The atmospheric pressure device is currently standard with 700MHz Bruker magnets and is available as an option for other magnets.

Floor and Foundation 7

Introduction 7.1

There are a number of factors that should be considered concerning the floor and foundation. Among these are the capacity of the floor and foundation where the magnet and equipment will be located, the location of the magnet in regards to ferrous metals in the structure, and any external influences on the floor and foundation.

Minimum Floor Capacity 7.1.1

As discussed in the section ***"Mass of Equipment" on page 38***, the floor must be sufficiently strong to support the mass of the equipment plus the weight of any installation devices, e.g. forklifts, hoists etc.

A sheet of **stainless steel** under the magnet will increase the minimum floor capacity. Check with your Bruker BioSpin representative for details if this a concern at your site.

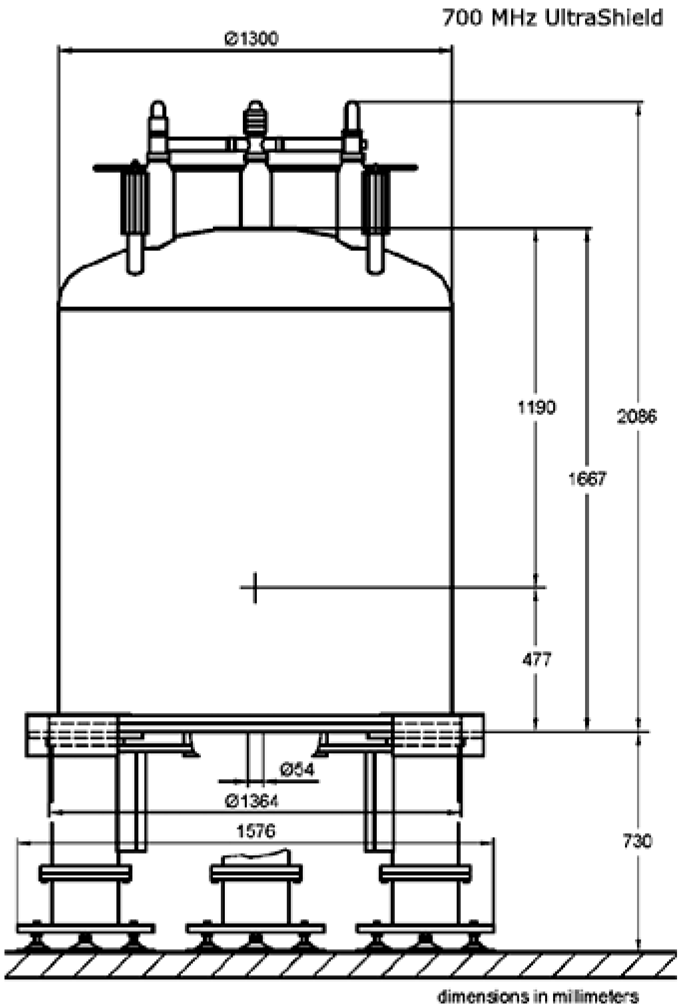
Table 7.1. Diameter, Weight of Magnets (filled) and Minimum Floor Capacity

Magnet	Magnet Diameter (m)	Magnet Diameter Including Pneumatic Stand (m)	Magnet Weight Filled with Magnet Stand and Vibration Damping System (kg)	Minimum Floor Capacity kg/m^2
300 MHz/54 mm US LH	0.72	0.72	310	431
300 MHz/54 mm US ULH	0.72	0.72	379	527
300 MHz/89 mm US LH	0.72	0.72	434	603
400 MHz/54 mm US LH	0.72	0.72	464	645
400 MHz/54 mm US ULH	0.72	0.72	494	686
400 MHz/89 mm WB LH	0.72	0.72	515	716
500 MHz/54 mm US LH	0.80	1.05	749	1026
500 MHz/89 mm US LH	1.10	1.10	1700	749
600 MHz/54 mm US LH	0.91	1.22	1300	1383

Table 7.1. Diameter, Weight of Magnets (filled) and Minimum Floor Capacity

Magnet	Magnet Diameter (m)	Magnet Diameter Including Pneumatic Stand (m)	Magnet Weight Filled with Magnet Stand and Vibration Damping System (kg)	Minimum Floor Capacity kg/m^2
600 MHz/89 mm US LH	1.37	1.94	2500	860
700 MHz/54 mm US LH	1.37	1.94	3200	1100
LH= Long Hold, ULH= Ultra Long Hold, US = Ultra Shield™ For information on other magnets not listed, please contact your nearest Bruker BioSpin office. **All measurements in meters!**				

Figure 7.1. Example of 700 MHz UltraShield Magnet



Location of Magnet in Regards to Floor/Foundation Structures 7.1.2

When locating the magnet take consideration of the presence of permanent iron structures such as support beams in walls and floors, reinforced concrete or pipes and cables in the floor. Likewise, the location of any radiators and air conditioning units should be checked, as they should not be located within the 5mT (50G) line.

Floor Types 7.1.3

Generally a liquid nitrogen resistant floor material should be used, such as PVC or wood that has been painted or varnished. Unfinished wood should not be used as this will absorb liquid nitrogen. This also implies that wood floors should be regularly maintained to help prevent absorption.

Electrostatic Discharge (ESD)

Many of the system components contain highly sensitive electronic devices that must be protected from ESD by proper floor covering and grounding practices. The effects of static electricity may macroscopically be familiar experiences, such as an electric storm, but microscopically, static events do occur everyday. Typical experiences may include the clinging of clothes, the dust build-up on our computer monitors, the unexpected "static" shock as we touch an object such as a door knob, or other object.

When contact and separation occurs between two materials, a transfer of electrons from the atoms on the surface will take place. This process is referred to as triboelectric generation. The resulting imbalance of electrons is what is called an **electrostatic charge**. This electrostatic surface charge is either positive or negative depending on whether there is a deficiency or abundance of free electrons respectively. We refer to this charge state as **static electricity** because it tends to remain at rest or static, unless acted upon by an outside force.

The amount of charge generated through the process of friction and separation will be influenced by the extent of the contact, the materials involved, relative humidity, and the texture of the materials. Static charges of up to 30,000V are not uncommon and can be generated by the simple act of walking across a floor; yet a discharge of only 10V can destroy a class 1 ESD Sensitive device.

The following table illustrates some normal activity within a room regarding triboelectric charging levels of operators and objects given in voltages and dependent on relative humidity.

Table 7.2. Typical Electrostatic Voltages

Event	**Relative Humidity**		
	10%	**40%**	**50%**
Walking across carpet	35,000V	15,000V	7,500V
Walking across vinyl floor	12,000V	5,000V	3,000V

Table 7.2. Typical Electrostatic Voltages

Event	Relative Humidity		
	10%	**40%**	**50%**
Motions of worker at desk	6,000V	800V	400V
Source: Terry Welsher, Bell Labs, Lucent Technologies, 12/2/97			

Static electricity is in essence invisible, although we often see its effects and can feel and measure its presence or electrostatic field. Since it is created by putting the surface's electrons into a state of imbalance, it is not in a natural or stable state. Material with an imbalance of electrons will, when possible, return to a balanced state. When this is done rapidly a zap or spark associated with rapid ESD occurs. We may feel these zaps if the discharge that occurs is over 3,000 Volts. Electrostatic discharges below that level are below the threshold of human sensation but are still lethal to electronics and associated semiconductor devices.

Controlling ESD

A material that inhibits the generation of static charges from triboelectric generation is classified as antistatic. ESD is controlled through several methods, charge prevention, grounding, shielding and neutralization.

- We can **prevent charge generation** through the elimination of unnecessary activities that create static charges, the removal of unnecessary materials that are known charge generators and the use of antistatic materials.
- **Grounding** works only on conductors. It simply means that we tie all conductors together (at a common point) so that electrostatic charges will flow from and through conductors to a common point and will therefore all end up at the same level. The human body is a common conductor that must be grounded, i.e. before working inside the spectrometer console.
- **Shielding** is used to prevent a sensitive device from being charged by exposure to an external electrostatic field or being touched by a charged object during transport or storage. This is done using the Faraday Cage concept. Metallized shielding bags are commonly used to protect static sensitive electronic components and assemblies by creating a Faraday Cage effect. Bruker boards and accessories, for example, are shipped in shielding bags.
- Nonconductors must be **neutralized** in some other manner. As they do not conduct electricity, grounding won't work. The most common method of neutralizing insulators is through ionization. An area is flooded with alternating positive and negative charged particles (ions). A charged material will then attract ions of the opposite polarity and quickly become neutralized. Generally such extreme measures are only required in electronic production areas.

To prevent ESD damage in the magnet room, the system should be installed on an ESD resistant flooring such as vinyl, and properly grounded. One of the most important characteristics of an **ESD resistant floor** is its ability to conduct charges to ground. The second most important aspect is its **anti-static property**. One of the main mechanisms of charge generation is **triboelectric generation** or tribocharging. Some examples of **tribo-charging** are people walking along a floor and carts carrying sensitive devices rolling across a floor. Depending on where the materials in contact with the floor are in the tribo-series, voltages of over 30,000V can be attained. If a floor has the property of being anti-static, tribocharging becomes a much smaller concern. The standards documents to help choose a floor are ANSI/ESD S7.1-1994, AATCC Step Test - Method 134-1979, ANSI/EIA-625-1994, MIL-STD-1686, MIL-HDBK-263B, and the AT&T Electrostatic discharge Control Handbook.

External Factors Effecting the Floor and Foundation *7.1.4*

When a magnet is to be located in an area where high vibrations can not be avoided, e.g. in proximity to an elevator, street car etc., use at least 40cm thick concrete in the foundation surrounded on the sides with insulation material.

Vibrations 8

Introduction 8.1

External vibrations may cause the field at the sample to be modulated. This may result in vibration sidebands on either side of a main signal peak. The sidebands, which will be located at the vibration frequency, always display the same pattern, i.e. the left and right sidebands are inverted with respect to each other. Vibrational sidebands are not phase coherent and their relative height will be reduced by increasing the number of scans.

When assessing potential vibration problems the following procedure is recommended.

1. Identify possible sources of vibration (refer to the section ***"Sources of Vibrations" on page 60***).
2. If a problem is anticipated, then consider measuring the level of vibration at the NMR site (refer to the section ***"Vibration Measurements on Site" on page 60***).
3. Having established the strength and frequency of the vibrations, you might then consider installing vibration damping equipment (refer to the section ***"Vibration Damping Measures" on page 61***).

The site floor must be sufficiently strong to support the AVANCE™ cabinet, magnet and ancillary equipment (see ***Table 3.4.*** and ***Table 3.5.***). The floor should also be as rigid as possible to reduce the effects of vibration. Wooden floors tend to have resonance frequencies of 10-15Hz, whereas concrete floors display a resonance frequency in the 30-50Hz range. Since higher frequencies are much more easily dampened by various devices, concrete floors will lead to less vibration problem than wooden floors.

The floor underneath the magnet must be level. Pay particular attention if you are locating the magnet in a chemistry department. Some laboratory floors may have a gradient to assist water flow.

The Effects of Vibrations 8.2

The effect of vibrations on NMR performance will depend on several factors:

1. **Customer requirements**: Ultimately the customer should decide what constitutes significant vibrational sidebands in NMR spectra. This will greatly depend on the type of work being carried out. Inverse experiments and 2D experiments are much more sensitive to vibration interference than standard 1D experiments.
2. **Type of system**: The effect of vibrations will depend on the construction, design and size of magnet. Larger magnets (e.g. 500, 600, 700MHz) due to their increased sensitivity, tend to be more susceptible to vibration problems.

3. **Building Materials**: The materials used in the construction of the NMR site will play a significant role in determining to what extent external vibrations are transmitted to the magnet.

Sources of Vibrations *8.3*

1. Random vibrations may be caused by moving chairs, doors, tables etc. in or around the magnet room. This type of vibration is usually controllable, but when planning the site you will need to take into consideration activities in rooms adjacent to the magnet room.
2. Sources of more regular vibrations are generators, compressors, fans, machinery etc. Compressors should **not** be located in the NMR room and, if close enough, you should consider mounting such items on vibration damping material. Air vibration can be caused by ventilation or fans, (refer to the section on air conditioning requirements). Windows in the magnet room should be located and constructed in such a way that no sudden pressure fluctuations are produced by winds.
3. Ideally the site should always be at ground or basement level to minimize building vibrations. High rise buildings may oscillate at frequencies below 1Hz. Such oscillations may be noticeable in upper floors and are impossible to control. For XY oscillations, special dampers are now available, contact Bruker BioSpin for details.
4. Vibrations from external sources such as cars, trains, airplanes, building sites etc.; Here the critical factor is the distance from the source to the NMR site, as well as the type of ground over which the vibrations are transmitted.

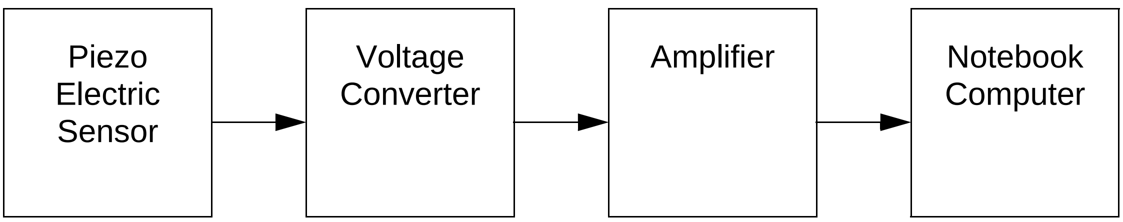
Vibration Measurements on Site *8.4*

Measuring the extent of vibrations at the magnet location is a relatively simple matter. You will need a sensitive accelerometer coupled to a signal analyzer.

Bruker BioSpin has developed a portable system (see ***Figure 8.1.***) which may be used at the site to measure vibrations. Contact your local Bruker BioSpin office for more information on this service.

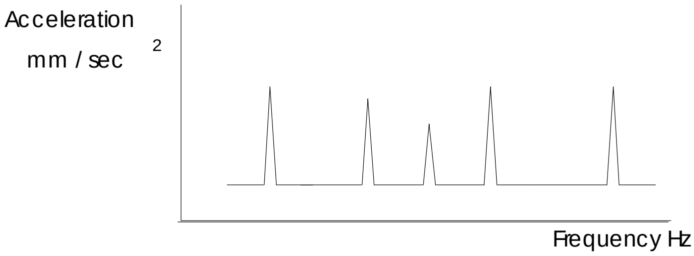
It is important to note that **measurements are necessary in both vertical and horizontal directions**.

Figure 8.1. Schematic of the Vibration Measuring System



The piezoelectric sensor is simply placed on the ground at the magnet site and a 10 second acquisition is carried out. If the magnet is already situated and vibration problems have occurred, then you can clamp the sensor directly onto the base of the magnet. Fourier transformation of the FID results in a plot of acceleration versus frequency as in the figure below.

Figure 8.2. Frequency Spectrum of Vibrations



The frequency of vibration is very useful in determining the potential success of various measures that can be taken to dampen vibration disturbances. These measures will now be discussed.

Vibration Damping Measures 8.5

When required, passive damping of vibrations may be achieved by mounting the magnet on rubber blocks, inflatable pneumatic dampers, or vibration isolator posts (VIP).These devices can be easily retrofitted to an existing system if required.

Passive damping of vibrations may be achieved by three methods

1. Placing ***"Anti-vibration Pads"*** beneath the magnet stand
2. Mounting the magnet on inflatable ***"Pneumatic dampers"***
3. Mounting the magnet on a ***"Vibration Isolator Posts (VIP)"***

Regardless of what measures may be taken, the vibrations can only ever be reduced to an acceptable level, they are rarely completely removed.

Passive damping devices will reduce vibrations above a certain frequency. However lower frequencies, and particularly those corresponding to the resonance frequency of the damping device, will actually be amplified. Therefore it is important to choose the correct damping device to suit the frequency of the disturbing vibrations.

Anti-vibration Pads 8.5.1

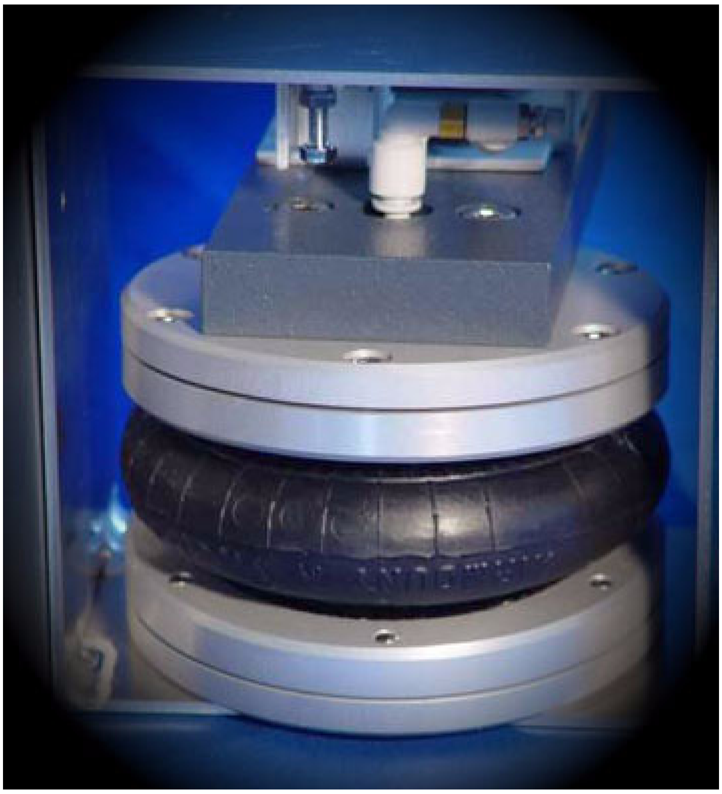
The magnet stand is fitted with circular anti-vibration pads, primarily to protect the floor. These will however provide some damping for frequencies above 15-20Hz.

Additional soft rubber anti-vibration pads may successfully dampen frequencies above 8-15Hz. However, since soft rubber pads may have a resonance frequency in the 8-15Hz range, thus may be unsuitable if external vibrations at these frequencies are present.

Pneumatic dampers *8.5.2*

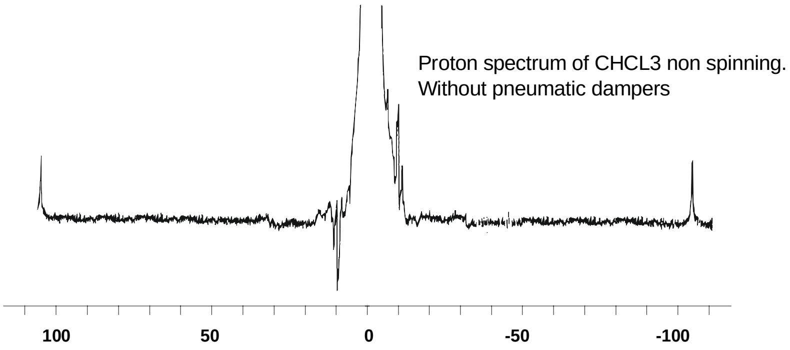
Supplied by Bruker BioSpin, these dampers can achieve damping factors of up to 10 for vibrations at 8Hz and above.

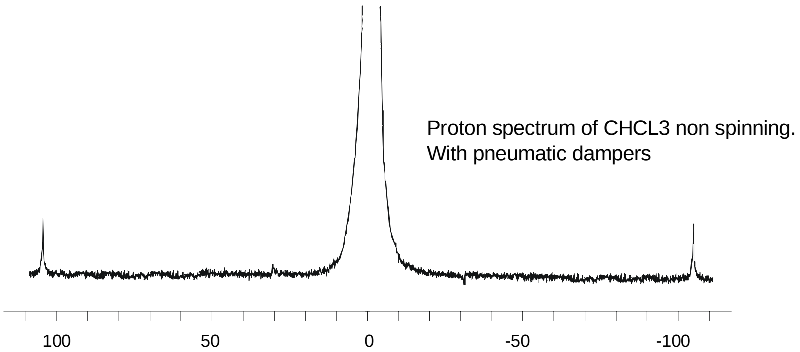
Figure 8.3. Pneumatic Dampers



The magnet is supported on three rubber feet inflated to a pressure in the region of 6 bar. The dampers may however enhance vibrations at or below their resonance frequency of 4-6Hz. ***Figure 8.4.*** is an example of the effect of pneumatic dampers on vibration sidebands.

Figure 8.4. Effect of Pneumatic Dampers





Vibration Isolator Posts (VIP) *8.5.3*

This is a rather more elaborate system, and is designed to improve performance of NMR spectrometers exposed to disturbing floor vibrations in the frequency range of 2-20Hz. The advantage of the VIP over other systems is the superior damping in the range below 10Hz. At these low frequencies other vibration dampers are ineffective. ***Figure 8.5.*** demonstrates the levels in damping vertical vibrations by pneumatic dampers and vibration isolation post respectively. Note, however, that some frequencies below 2Hz will actually be amplified.

Figure 8.5. Damping of Vibration Isolator Post

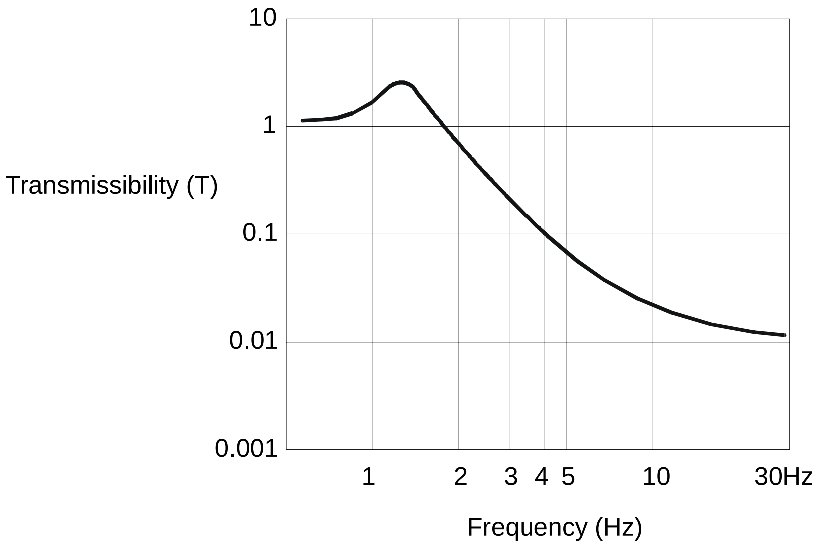


Figure 8.6. Damping Characteristics of Current Pneumatic Dampers

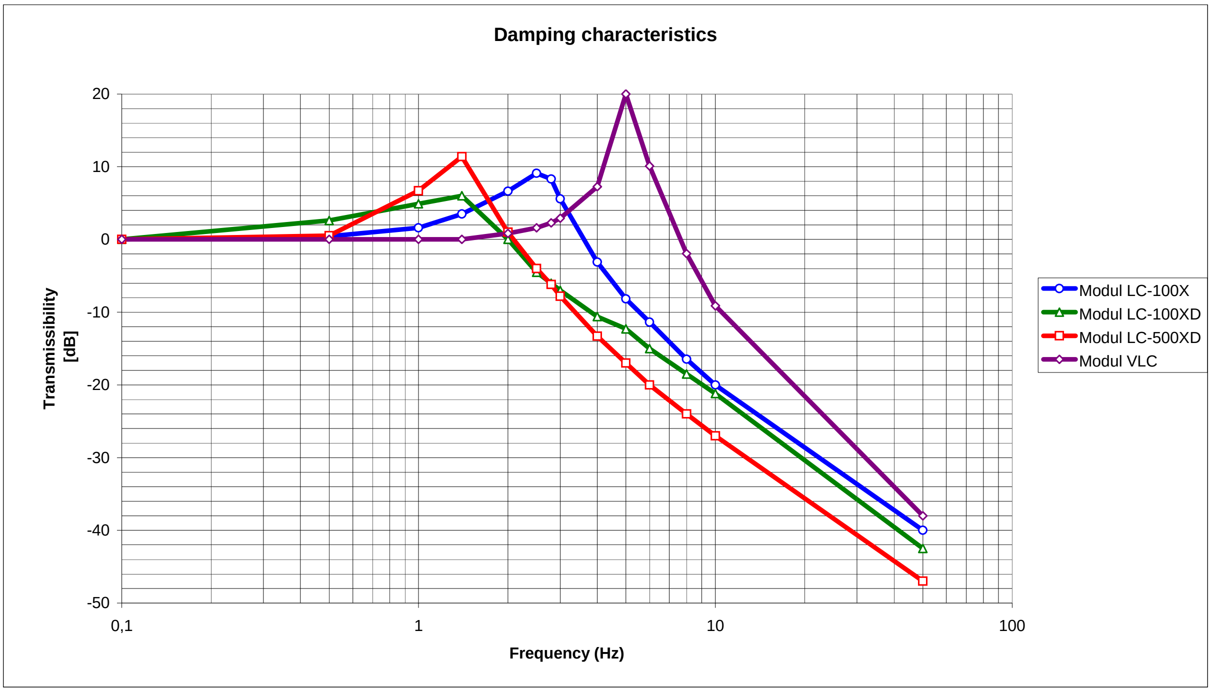


Table 8.1. summarizes the magnet frequency ranges over which various damping measures have proven to be effective.

Table 8.1. List of Available Damping Measures by Magnet Frequency

Magnet	Rubber Pads	LC50	LC50XD	LC100	LC 100XD	LC 500
300 MHz/54mm	Optional	Optional	---	---	---	---
300 MHz/89mm	Optional	Optional	---	---	---	---
400 MHz/54mm	Optional	Optional	---	---	---	---
400 MHz/89mm	Optional	Optional	---	---	---	---
500 MHz/54mm	Included	Optional	Optional	---	---	---
500 MHz/89mm	---	---	---	Included	Optional	---
600 MHz/54mm	---	---	---	Included	Optional	---
600 MHz/89mm	---	---	---	---	---	Included
700 MHz/54mm	---	---	---	---	---	Included

Guidelines *8.5.4*

It is extremely difficult to predict the effect of measured vibrations on NMR performance. Studies have been carried out by Bruker BioSpin which show large variations in disturbance, depending on the frequency and strength of vibrations, as well as the type of magnet. In these studies calculations were made on the acceleration required to produce what were considered significant vibration sidebands. A significant sideband was defined as a signal whose height was 10% of the height of the 13C satellites in a Proton spectrum of $CHCl_3$. The results of these studies were as follows:

Interpretation of results from vibration analysis:

Maximum accelerations are compared to a threshold value required to achieve optimum NMR performance

Threshold value:

1mm/sec^2 upon activating the vibration dampers or posts

Expected accelerations on the magnet:

The vibration dampers will reduce the floor accelerations. The floor accelerations must be multiplied by the damper’s transmissibility factor, which depends on the frequency.

Transmissibility factor:

The higher the frequency, the smaller the transmissibility (the better). Please see ***Figure 8.5.***. Acceleration peaks at very low frequency of 0 – 2Hz are not desired since the natural resonance frequencies of the various types of isolation posts are within this range. This amplifies floor vibrations at such frequencies instead of reducing them.

Notes:

1. All Bruker BioSpin anti-vibration devices can be easily retrofitted to an existing system if required. Many spectrometers, and particularly those with fields of 300MHz, require no such devices.

The latest range of high field magnets are designed to enable vibration isolation modules to be fitted to the base. These are available as standard with some 600-700MHz magnets and as an option for 500MHz magnets. In performance they are comparable to the VIP (see ***Figure 8.5.***) but offer several advantages. They are much easier to retrofit in the field and require less extra space around the magnet.

Magnetic Environment

9

Introduction 9.1

While minimum requirements for routine NMR operation are not particularly stringent, it is worthwhile to optimize the magnet´s environment if more sophisticated experiments need to be carried out. The proposed site may appear quite adequate for present needs but future developments in NMR must always be considered. The trend will undoubtedly be towards higher field strengths with subsequently more demanding environments.

Every site is unique and customer requirements differ. Very often a customer must make a compromise between system performance and practical realities. It may not be feasible to remove previously installed structures.

Presence of Ferromagnetic Materials 9.1.1

The presence of any ferromagnetic materials in the immediate vicinity of the magnet will decrease the magnet´s homogeneity and may degrade overall performance. The effect of objects such as metal pipes, radiators etc. can be overcome by appropriate shimming but where possible this should be avoided.

When estimating the effect of ferromagnetic materials the following points should be noted:

1. The strength of interaction depends most strongly on distance (by the 7th power) whereas it varies in direct proportion with mass. Distance of the object from the magnet is far more critical than the mass of the object itself.
2. Moving magnetic material will cause a much greater problem than static masses. Distortion caused by a stationary mass e.g. radiator can usually be overcome, whereas the effect of moving masses (e.g. metal doors, elevator, chairs etc.) is unpredictable.

To help in site planning two sets of guidelines are given in the upcoming sections: a) **minimum requirements**, and b) **acceptable environment**.

By „acceptable environment“ we mean an environment with which most customer sites comply. This is a situation which is desirable, though not always achievable.

If minimum requirements can not be met then the customer should consider a different site because NMR performance is likely to be reduced.

Minimum Requirements 9.1.2

Static iron distribution:

There should be none present within the 50 Gauss (5mT) region. You should consider removing iron piping that is likely to lie within 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.

The 5mT (50G) limit is suitable for a mass of up to 200kg. For greater masses the limiting area must be extended accordingly. (The presence of static magnetic material close to the magnet presupposes that these masses are firmly secured e.g. radiators, pipes).

Moveable magnetic material:

For all magnet systems, no moveable masses should be located within the 0.5mT (5G) region. Potential sources of moving iron are metal doors, drawers, tables chairs etc. For larger masses (> 200kg), distorting effects may be experienced at fields as low as 0.1mT (1G). For high precision work (e.g. NOE difference experiments) extending the region for no moveable magnetic material to 0.05mT (0.5G) may be justified. ***Table 9.2.*** serves as a guideline for moveable magnetic material.

Acceptable Environment 9.1.3

Static Objects

Table 9.1. 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.

Table 9.1. Recommendations for Static Magnetic Objects

Object	Actual Distance from Ultra-shielded Magnet
Iron or steel beams	4m
Steel reinforced walls	4m
Radiators, plumbing pipes	4m
Metal table, metal door	4m
Filing cabinet, steel cabinet	4m
Massive objects e.g. boiler	4m

Moving Objects

Table 9.2. serves as a guideline for moveable magnetic material.

Table 9.2. Recommendations for Movable Magnetic Objects

Object	Actual Distance from Ultra-shielded Magnet
Steel cabinet door	3m
Large metal door, hand trolley	4m
Elevators*	8m
Cars, fork-lifts	8m
Trains, trams*	8m

** These are more likely to be a source of vibrational or electromagnetic interference. Note that D.C. operated trains will cause disturbances over much larger distances.*

Electromagnetic Interference 10

Overview 10.1

Electro Magnetic Interference (EMI) can be defined as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. It can be induced intentionally, as in some forms of electronic warfare, or unintentionally, as a result of a spurious emissions and responses, intermodulation products, and the like. Additionally, EMI may be caused by atmospheric phenomena, such as lightning and precipitation static and non-telecommunication equipment, such as vehicles and industry machinery.

Effects of Electromagnetic Interference 10.1.1

Fluctuating electromagnetic fields (EMF) from such devices can interfere with the magnet stability. Of particular concern are sudden changes in load as may be produced by elevators, trams, subways etc. Subways and trams, operating on DC, generate drastic changes in magnetic fields, primarily during the starting and stopping of carriages (systems operating on AC do not cause such problems).

Sources of Electromagnetic Interference 10.1.2

Possible sources of electromagnetic interference are power lines which may carry fluctuating loads, heavy duty transformers, large electric motors, air conditioning systems etc. Some laboratory equipment such as mass spectrometers and centrifuges will also produce fluctuating fields.

Types of EMF Interference

- DC Interference
- 50Hz / 60 Hz Interference
- RF Interference

DC Interference 10.2

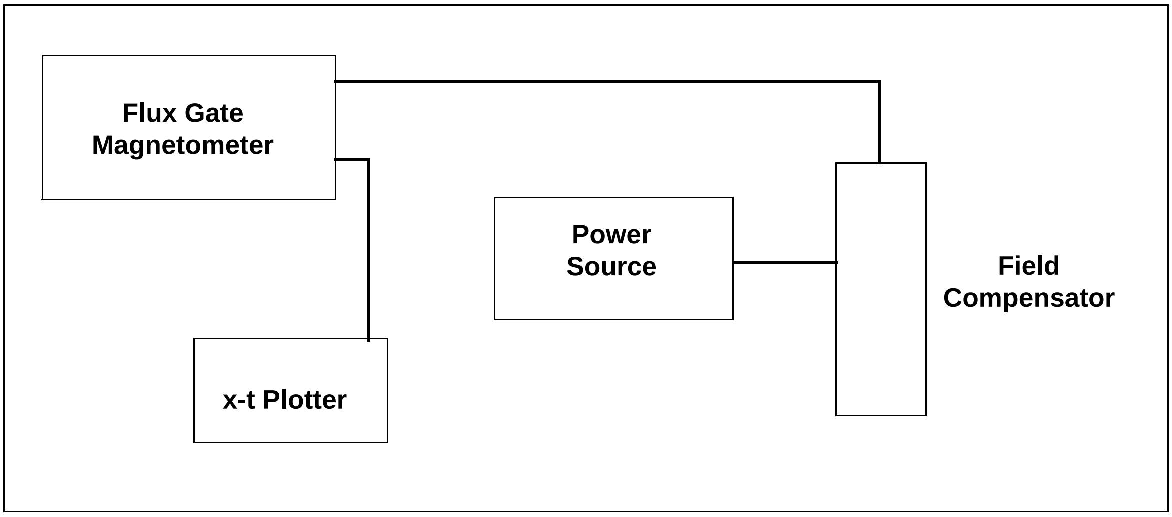
DC interference generally comes from devices operating on DC, such as elevators, trams, subways, trams etc. As mentioned previously, the result is often large or small changes in the magnetic field, primarily during the starting and stopping of carriages.

Another potential problem is that of fluctuating gradients if the perturbation is not homogenous.

Measuring DC Fluctuating Fields 10.2.1

DC EMF measurements should be conducted using a fluxgate magnetometer. The following figure is a simple representation of how local variations in magnetic field may be measured at the proposed site. In certain regions this service may be provided by Bruker BioSpin.

Figure 10.1. Measurement of Local Magnetic Field Variations



The variations in magnetic field strength against time are plotted on the x-t plotter.

The field compensator is used to nullify the earth's magnetic field which might otherwise swamp any local variations. (If the magnet has already been installed, and problems have arisen, then the field compensator may be operated at a distance of 2-3m from the magnet.)

Guidelines: DC Interference 10.2.2

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

Note: 10G = 1mT

1. Field changes of between 0-5mG, regardless of the gradient, are generally considered harmless for standard NMR work. Likewise with Ultrashielded magnets (only), field changes up to 10mG are considered harmless. The effect of such changes would be observable in only the most critical of experiments such as NOE difference experiments.

2. For field changes larger than 5mG the lock system will compensate the fluctuation, as long as the gradient is less than 5mG/sec. (10mG for UltraShield magnets).
3. For field gradients greater than 5mG per second (10mG for Ultrashielded magnets), NMR performance may be affected.

Table 10.1. lists minimum distances at which the magnet should be located from possible sources of electromagnetic interference.

Table 10.1. Minimum Distances from Sources of Electromagnetic Interference

Source of Interference	Recommended Minimum Distance from Ultrashielded Magnet
Trams, subways *	100m
Elevators, fork-lifts**	8m
Mass Spectrometer (slow ramp)	10m
Mass Spectrometer (sudden fly-back)	30m
**** Trams and subways are also a source of vibrational interference (refer to the section "The Effects of Vibrations" on page 59).*** ** Depends on the lift geometry and material. These specifications may vary.	

Reducing DC Interference 10.2.3

Generally, the use of an Ultrashield magnet will greatly reduce the problem of DC interference. Other methods exist, and some are under study, but up to now all have proven to be less effective than Bruker UltraShield magnets. For further information please contact your Bruker representative.

50/60 Hz Interference 10.3

Interference from 50/60Hz generally comes from electrical wiring, transformers and fluorescent lights in the magnet system area. The magnetic field further modulates this interference, increasing the likelihood of disturbances.

Measuring 50/60Hz Fluctuating Fields 10.3.1

50/60Hz EMF measurements should be conducted in the proposed NMR room with power lines active using a hand-held meter. Specific locations that should be checked include:

- Magnet
- Console
- Wall inside the NMR room

  2” from wall

4” from wall

- Approximately 3.8cm below room lights in the x, y and z directions.
- Near the 230V (wall) in the x, y and z directions.

Guidelines: 50/60 Hz Interference 10.3.2

The amplitude threshold for causing interference is ca. 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 some 50/60Hz EMF, and more importantly may switch off temporarily during a quench.

Reducing 50/60 Hz Interference 10.3.3

The general goal of reducing 50/60Hz interference is to shield the source of the interference from the magnet system. Soft iron has been found to be effective in reflecting 50/60Hz interference, and thus providing an effective shield for the magnet. Bruker is currently looking at new ways of measuring and reducing the effects of 50/60Hz interference.

RF Interference 10.4

Since the NMR instrument is effectively a very sensitive radio frequency receiver, another possible source of interference is **Radio Frequency Interference** (RFI). Most RFI comes from local radio or television broadcasts, as well as signals emitted by personal paging systems or cellphones. Electrical devices located in the immediate area may also be a source of some interference.

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 5km would normally be a possible source of interference. Of particular concern will be interference at frequencies that NMR experiments are carried out.

A further source of interference is between two spectrometers located in close proximity and operating at the same frequency. Where possible this situation should be avoided.

Measuring RF Fluctuating Fields 10.4.1

Radio Frequency Interference measurements should be conducted using a spectrum analyzer.

Guidelines: RF Interference *10.4.2*

As a general guideline a site should be checked at the respective frequencies shown in ***Table 10.2.***. The level of any RFI should be attenuated to an electrical field strength of - 64 dBm at the side of the magnet.

Table 10.2. NMR Spectrometer Operating Frequencies

Frequency (MHz)	Frequency Range (MHz)
300	12 to 325
400	12 to 430
500	12 to 538
600	12 to 645
700	12 to 751

As an example, consider that many countries transmit FM radio signals in the 80-110MHz range. On a 400MHz machine the 13C NMR frequency is 100.577MHz and so 13C measurements may pick up interference from local radio broadcasts. Screening a site for possible rf interference is complicated and expensive. When designing instruments care is taken to provide adequate shielding and the instruments rarely suffer from interference in normal rf environments. Furthermore, the BSMS digital lock system delivered as standard with all AVANCE™ instruments allows a shift in the 2H lock frequency within 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 site planning, take into consideration the distance from the site to local radio or TV transmitters and also the frequencies at which signals are transmitted. ***Table 10.3.*** contains a list of the most commonly studied nuclei and the corresponding frequencies for a range of systems.

Reducing RF Interference *10.4.3*

If rf interference is a problem, then shielding of the NMR room with a Faraday cage is a possible solution, though having to take such measures is quite rare.

Resulting problems from locating two spectrometers in close proximity can often be overcome by altering the field strength of one of the magnets slightly when it is being charged at the customer site. In this way the resonance frequencies of the two spectrometers no longer coincide.

.

Table 10.3. List of Commonly Studied Nuclei and Corresponding Resonance Frequencies

Nuclei	NMR Frequency (MHz)				
1H	300.000	400.000	500.000	600.000	700.000
2H	46.051	61.402	76.753	92.102	115.128
11B	96.251	128.335	160.419	192.502	240.627
13C	75.432	100.577	125.721	150.864	188.580
15N	30.398	40.531	50.664	60.796	75.996
19F	282.231	376.308	470.385	564.462	705.576
27Al	78.172	104.229	130.287	156.344	195.429
29SI	59.595	79.460	99.325	119.190	148.986
31P	121.442	161.923	202.404	242.884	303.606

It may be possible to reduce EMI noise by shielding or perhaps turning the noise source off if generated by equipment near the spectrometer.

If you suspect that you have a source of interference located near the magnet then you should contact your Bruker BioSpin office.

Guidelines: BSMS Digital Lock 10.5

The effect of field electromagnetic interference has been greatly reduced with the introduction of the digital lock which is fitted as standard in all AVANCE™ spectrometers.

The digital lock is less susceptible to external magnetic field disturbances than the conventional lock. The effect of any instabilities is considerably decreased by a factor which depends on the lock substance. Lock substances with high concentrations and long relaxation times show the best improvement. Therefore meeting the conventional lock guidelines (***Table 10.1.***) will more than suffice if a digital lock

Mass Spectrometers 10.6

Quadruple mass spectrometers do not produce a sweeping magnetic field and are unlikely to interfere with NMR performance. Scanning mass spectrometers do however emit a sweeping field and are more likely to cause problems.The influence of such an instrument will depend on size, orientation and mode of operation. Spectrometers with a slow ramping up and down should be located at least 10m from the magnet. Of greater concern are those systems that switch off the field suddenly (flyback) as opposed to using a slow ramp-down. Such an instrument should not be located within 30m of the magnet.

Cryogens & Magnet Maintenance 11

General Properties of Cryogenic Substances 11.1

Superconducting magnets use liquid helium and nitrogen as cooling agents, keeping the magnet core at a very low temperature. Cryogenic liquids, even when kept in insulated storage vessels (dewar vessels), remain at a constant temperature by their respective boiling points and will gradually evaporate. These liquids expand their volume by a factor of 700 when they are evaporated and then allowed to warm up to room temperature.

The gases are nontoxic and completely harmless as long as an adequate ventilation is provided to avoid suffocation. During normal operation only 3-5 m^3/day of nitrogen are evaporated, but during a **quench**, an extremely large quantity of helium gas (i.e. 43 m^3 to 595 m^3 depending on the magnet type) are produced within a short time. Windows and doors are sufficient for ventilation even after a quench, but the NMR magnet system should never be in an airtight room.

The magnet location should be selected such that the door and the ventilation can be easily reached from all places in the room.

Do not use cryogens that have been stored in high pressure containers for cryogenic liquids! If no other containers are available, the pressure must be released completely before connecting the high pressure transport container to the cryostat. Failure to do this could present an explosive hazard for the magnet system and could lead to severe damage.

"Room Layout", ***"Ceiling Height"*** and magnet height should be such that an easy transfer of liquid nitrogen and helium is possible. This will considerably reduce the risk of accidents.

Employees working with cryogens should be aware of the following properties of these substances:

Table 11.1. Table of Properties of Cryogenic Substances

Properties	Nitrogen	Helium
Molecular weight.	28	4
Normal boiling point [°C / °K].	-196 / 77	-269 / 4.2
Approximate expansion ration (volume of gas at 15°C and atmospheric pressure produced by unit volume of liquid at normal boiling point).	680	740
Density of liquid at normal boiling point [kg m^{-3}].	810	125
Color (liquid).	none	none
Color (gas).	none	none
Odor (gas).	none	none
Toxicity.	very low	very low
Explosion hazard with combustible material.	no	no
Pressure rupture if liquid or cold gas is trapped.	yes	yes
Fire hazard: combustible.	no	no
Fire hazard: promotes ignition directly.	no	no
Fire hazard: liquefies oxygen and promotes ignition.	yes	yes

Refer to the magnet manual for more information on cryogens.

Introduction to Magnet Maintenance *11.2*

Liquid helium and nitrogen are used to cool the magnet so that it remains superconducting. Refilling of cryogens is the only regular maintenance required by the magnet. The procedures to be used for fills represent an important site planning consideration.

Some customers prefer to contract the cryogen maintenance out to local suppliers. Other customers may decide to install a permanent on site supply of cryogens. Helium, in particular, is expensive and recycling of evaporated gas is often economically viable. Financial considerations depend mostly on price and availability of liquid helium, and must be considered in each case individually. In general however, a low loss magnet in an area with regular helium supply will not consume enough helium to pay off the installation costs of a **Helium Gas Recovery System**. For further information regarding such a system contact Bruker BioSpin.

Storage tanks of course must be situated well away from the magnet room. Where an in-house nitrogen supply is available, the customer must decide whether to pipe the liquid nitrogen directly to the magnet room or to use transport dewars. Experience has shown that the latter option is simpler. Using transport dewars it is easier to keep track of the cryogen evaporation rate when the magnet is filled regularly from a dewar of fixed volume.

Please visit our Internet site at ***http://www.bruker-biospin.com/nmr/products/magnets.html*** or read the magnet manual that is delivered with your system to learn more about cryogen filling procedures.

Storage of Cryogenic Liquids 11.3

The key point in storing and using cryogenic liquids is that **good ventilation is essential!**

Liquid Nitrogen

Store and use in a well ventilated area. If sufficient gas evaporates from the liquid in an unventilated area (e.g. overnight in a closed room) the oxygen concentration in the air may become dangerously low. Unconsciousness may result suddenly without prior warning symptoms and may be fatal. For example, the evaporation of 40 liters of liquid nitrogen produces 27,000 liters of nitrogen gas. If this vaporization takes place in an unventilated room of $27m^3$ (3m x 3m x 3m) it can produce a very dangerous situation. Appropriate multiplication of these parameters will indicate actual site conditions. It is highly recommended that an Oxygen Level Sensor be used.

Liquid Helium

Liquid helium is the coldest of all cryogenic liquids. It will therefore condense and solidify any other gas (air) coming in contact with it. The consequent danger is that pipes and vents may become blocked with frozen gas!

Liquid helium must be kept in specially designed storage or transport dewars. Dewars should have a one way valve fitted in the helium neck at all times, in order to avoid air entering the neck and plugging it with ice. Vacuum insulated pipes should be used for liquid transfer. Breakdown of the insulation may give rise to the condensation of oxygen.

The following items will be required to maintain the cryogen levels within the magnet.

Cylinders 11.3.1

Two cylinders (one containing helium gas, and one with nitrogen gas) are required:

> **Nitrogen gas cylinder**: 50l/200 bar with 2 stage regulator to deliver pressure of 0.5 bar (1-10 psi).
>
> **Helium gas cylinder**: 50l/200 bar with 2 stage regulator to deliver pressure of 0.2 bar (1-10 psi).

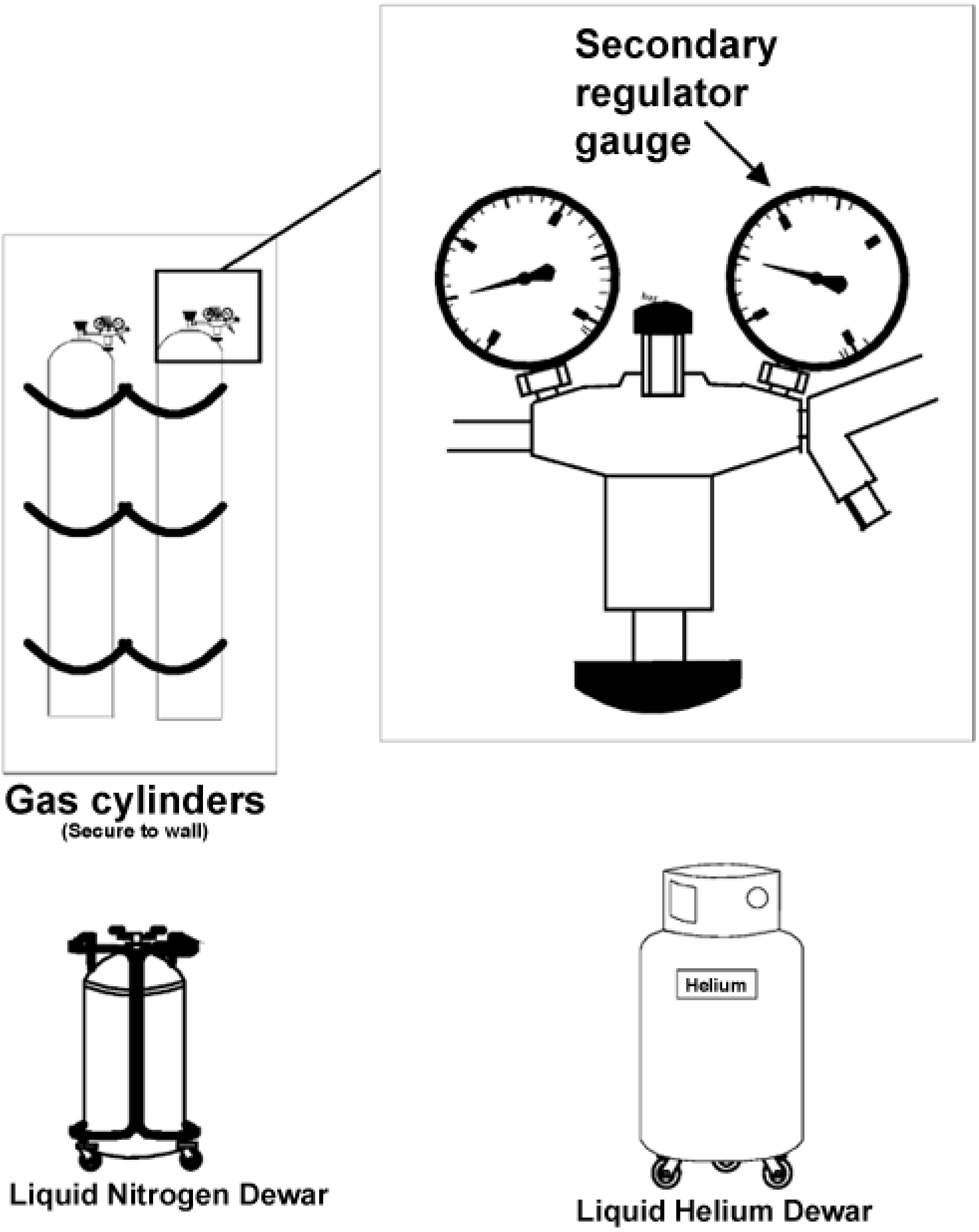
Gases used should be of the highest purity available (nitrogen 99.99%, helium 99.996%). The cylinders may be made of magnetic material such as iron or steel as long as they are kept well away from the magnet (maximum safe field strength 0.5mT (5G).

It is important that the 2 stage regulator (see ***Figure 11.1.***) on the gas cylinders be sufficiently sensitive so that fine control of the output pressure is possible. The 2 stage regulator should have a pressure range no greater than 0.5 bar (1-10 psi).

Dewars *11.3.2*

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 during cryogen filling. Such dewars are often provided by the cryogen supplier and do not need to be purchased.

Figure 11.1. Cryogen Equipment



Liquid Nitrogen Dewar:

Various transport dewars are available, with capacities ranging from 50-240 liters. The dewar should be of the **low pressure type** for liquid withdraw only. **Do not use high pressure** „gas packs“ (note: high pressure dewars can be used, if nothing else is available, if they are first slowly depressurized). The dewar should have a fixture for pressurizing and transferring via rubber hose (10mm inner diameter). Where possible the dewar should be self pressurizing. The correct transport dewar pressure for transferring liquid nitrogen is 0.35 bar (5 psi).

Maximum transfer pressure:

Typical: 0.10 - 0.20 bar (1-3 psi)

Maximum: 0.35 bar (5 psi).

Liquid Helium Dewar:

A 60 liter or 100 liter stainless steel transport dewar are the most convenient. The dewar outlet must be compatible with the helium transfer line (outer diameter of 9.6 mm, 3/8 inch or 12.7 mm, 1/2 inch depending on the magnet) or with the **NW25 adapter** that is supplied.

Summary of Cryogens and Refilling 11.4

When site planning consider the following points.

1. Refilling with helium requires a minimum ceiling height so that the transfer line may be inserted into the helium filling port and the liquid helium dewar. The minimum height requirement for your magnet is listed in ***Table 4.1.***.
2. For safe operation convenient pathways around the magnet and sufficient space for a ladder or platform (for larger magnets) must be available.
3. Ventilation: During normal operation relatively small amounts of the cryogens are evaporated. However should a quench occur, the room may suddenly fill with helium gas, producing the risk of suffocation if adequate ventilation is not provided. For this reason the magnet must not be located in an airtight room. Windows and doors normally should provide adequate ventilation, even after a quench (***"Emergency Ventilation During Magnet Installation and Quenches"***), but must be easily reached from all places within the room. During refilling the ventilation should draw the helium in the air out of the room as quickly as possible, as this will prolong the life of the magnet. If natural ventilation is inadequate, then additional ventilation (e.g. exhaust fans, air conditioning) should be provided (refer to the chapter ***"Service Access and Ventilation" on page 43*** for more information).
4. To assist temperature stability the magnet should not be located in direct sunlight or near an artificial heat source.
5. Storage space for the transport dewars, any reserve supplies of gases, and other accessories (e.g. transportation fixings, O-rings, clamps etc.) must also be planned for. Normally the storage location should be outside the magnet room. A storage space for the transfer line should also be planned. This should generally be located near the magnet.

Finally, it is important that the local supply of cryogens is reliable. It is good procedure to refill the **liquid nitrogen** level within the magnet on a **weekly basis**, regardless of the magnet type. **Liquid helium** levels need to be topped up much **less frequently**. In either case do not wait until the cryogen supply runs out.

Utilities 12

Electrical Power Requirements 12.1

When planning the electrical power requirements of your site make provision for extra equipment which you may install e.g. Personal Computers, workstations, air conditioning systems, etc.

The magnet requires electric power during charging or discharging only. ***Table 12.1.*** lists the power requirements and power consumption of various AVANCE^{TM} system configurations.

The power consumption quoted, includes the NMR workstation and graphics monitor, and was measured using 2 amplifiers operating at maximum output in CW mode. For systems fitted with additional amplifiers allow 300W for each additional amplifier.

For a 230V system a 16A slow-blow fuse or circuit breaker must be installed (for a 110V system a 20A slow-blow fuse or circuit breaker must be installed).

Table 12.1. Power Requirements of Basic System (2 Channels)

System and Amplifiers	Mains Supply	Power Consumption (kW)	No. of Spare Electrical Outlets	Length of Mains Cable
OneBay with BLA2BB	230V 50/60 Hz / 16A single phase	1.2 1.6	2	5.5m
OneBay with BLAXH100/50	230V 50/60 Hz / 16A single phase	1.6 2.2	2	5.5m
TwoBay with BLARH100 + BLAX300	230V 50/60 Hz / 16A single phase or 230V/400V 50/60 Hz/10A triple phase	2.6	2	5.5m
TwoBay with BLAXH300/50	230V 50/60 Hz / 16A single phase	2.2 9.6	2	5.5m
TwoBay optimized for solids 200 to 500 MHz	230V 50/60 Hz / 16A triple phase	9.6	4	5.5m
Imaging Cabinet	230 V / 50/60 Hz / 16 A single phase (power from AVANCE)	2.4	---	---
Bayvoltex Chiller for MicroImaging Systems	230V / 50/60Hz / 16A single phase	approx. 0.45kW	---	---

Table 12.1. Power Requirements of Basic System (2 Channels)

System and Amplifiers	Mains Supply	Power Consumption (kW)	No. of Spare Electrical Outlets	Length of Mains Cable
BCU 05	230V 50/60Hz / 16A single phase (power from separate outlet or AVANCE)	0.45 kW	---	---
CryoCooling Unit**	230V 50/60Hz / 16A single phase (do not use power from AVANCE)	0.5 kW average 1.5 kW peak	---	10m
He Compres-sor**	380V 50Hz / 12A triple phase	7.5 kW average 8.3 kW peak	---	
UPS for Cryo-Cooling Unit**	UPS requirements: 500W for CryoCooling Unit and at least 2.6 kW for the spectrometer cabinet (depends on configuration). The battery time should be selected according to the maximum duration anticipated for a power failure.			
UPS for Avance Spectrometer Cabinet				

* A step-up transformer to 400V is supplied by Bruker
** Refer to the **CryoProbe System Site Planning Guide** for more information.

Each AVANCE™ cabinet comes supplied with four electrical outlets (230V/10A) (The MicroBay and OneBay cabinets have only one external outlet.)which can be used to power standard ancillary equipment. Two outlets are designed to power the NMR Workstation and Imaging cabinet (optional). This leaves two spare outlets for accessories such as the Automatic Sample Changer etc. ***Table 12.1.*** lists the power requirements of other equipment which, because of their large power consumption, require power sources separate to that of the AVANCE™ cabinet.

For installation of the AVANCE™ system a 230V / 16A outlet is needed for the turbo-pumps, as well as an additional 230V / 16A outlet for the magnet power supply (during installation and service).

TwoBay with Solid Accessory 600/700 MHz

This spectrometer can be approximated to a standard TwoBay plus High Power cabinet and so the total power requirements is 9.6kW.

CP MAS:

The power requirements of this unit will depend on the amplifiers that are used. The control unit itself will not use more than 100W.

Voltage stabilizers

If line voltage fluctuations exceed -5% to +10% a voltage stabilizer must be used.

Even if the fluctuations are well within these limits, the purchase of a line conditioner may prove to be a good investment. The lifetime of the various electrical components in the spectrometer will be lengthened when the supply is stabilized. When deciding on a stabilizer you should take note of the following:

1. Power Requirement: The stabilizer must be capable of delivering the total power requirements of the various units you wish to protect. A surplus capacity of at least 10% is recommended.
2. Remember to consider future equipment that you may decide to install.
3. The stabilizer must of course be compatible with the input voltage, number of phases and A.C. frequency. Typically the stabilizers can cope with input fluctuations of 20%.
4. Output: The NMR units described in this manual normally use 230V/50-60Hz/single phase with the exception of the High Power Cabinet which uses 380V/50-60Hz/triple phase.
5. The regulation accuracy of the output need be no greater than 1% for single phase and 2% for three phase.
6. Single phase stabilizers use saturated transformers to regulate the voltage and should have fast response times, typically 10-20msec. Three phase stabilizers however use motors and have slower response times. A regulation speed of 15V/s is usually sufficient to overcome mains fluctuations in most countries.

Other considerations are lifetime, size, noise output, and maintenance requirements.

Contact your local Bruker BioSpin office for advice on a voltage stabilizer suited to your particular system.

If ordering a stabilizer you should specify:

- Input voltages.
- Number of phases.
- Special requirements, e.g. output connectors, meters, housing etc.
- Details of units and accessories that require protection.

UPS

Where total interruption of power occurs frequently, you should consider installing a UPS (Uninterruptable Power Supply) possibly linked to an automatic cut-in generator. This is particularly advisable when long-time experiments are to be run.

While a total loss of power will not damage the spectrometer hardware, NMR data acquired immediately prior to a power cut, and which has not been stored on the computer hard disk may be lost. The difference between UPS systems and a voltage stabilizer is that the UPS system contains a battery back-up pack which will maintain the power supply to the spectrometer for a limited period after a total loss of mains supply. Typically the battery back-up will last for up to 10 minutes at the rated power. This gives time for a generator to replace the mains power or for the spectrometer computer to be shut down according to the correct procedures. Additional battery packs which extend the back-up period to 30 minutes at the rated power are also available. As well as maintaining supply, the UPS system also serves as a line conditioner. Typical output voltage stability is 2% static and dynamic with frequency stability of 1%.

When selecting a UPS you must consider the power consumption of the system and amplifiers (see ***Table 12.1.***), your operating voltage, the desired run time during a power outage, as well as any future spectrometer power expansion requirements. Check with a reputable UPS dealer in your area for specifications on their products.

Note:

1. The power supply to the spectrometer should be "clean" (no spikes), i.e. it should not share with air conditioners, compressors, etc.
2. All grounding for mains in the lab should be connected together to avoid differences in earth potential. This will avoid problems when, for example, a Personal Computer powered externally is connected to the spectrometer via a RS232 link.
3. Some customers fit RCCB (residual current circuit breakers) to the spectrometer supply.These are designed to switch off the supply if there is an imbalance in the current in the live and neutral lines. If these are fitted to an AVANCE™ series spectrometer then they should be rated at 100mA. The lower value of 30mA commonly used is too sensitive for these spectrometers.

General UPS requirements: At least 2.6 kW for the spectrometer cabinet (depends on configuration) and 500W for CryoCooling Unit (if using CryoProbe system). The battery time should be selected according to the maximum duration anticipated for a power failure.

Requirements for Compressed Gas Supply — *12.2*

Sample ejection, spinning and temperature control are achieved by means of a stream of compressed air or nitrogen. The air/gas supply is piped via plastic tubing to the rear of the AVANCE™ cabinet. The standard tubing has an internal diameter of 6 mm and an external diameter of 8 mm and is supplied by Bruker. The site must contain a compressed air/gas outlet that is compatible with the 8 mm tubing. Although not critical it is convenient if the outlet is located close to the rear of the AVANCE™ cabinet. The required air/gas pressure and flow rate is detailed in ***Table 12.2.***. The AVANCE™ cabinet should never be subjected to a pressure of more than 10 bar. Install a pressure regulator valve followed by a gate valve on the final outlet of the compressed air supply line.

The Vibration Isolation units and CryoCooling unit also need compressed gas. Normally, two or three regulated lines are adequate to meet the compressed gas supply requirements. If Vibration Isolation units and a CryoCooling unit are used contact Bruker for verification on the adequacy of the planned compressed gas supply.

Nitrogen vs. Compressed Air

There are advantages to using **nitrogen** (required for 500 MHz and up), though for lower field magnets compressed air is most popular. In particular, a supply of gaseous nitrogen, obtained by evaporating air, will normally be very dry, making it particularly suitable for low temperature work. Where a customer uses air, then the process of achieving the required quality is much more difficult. For this reason this chapter will deal principally with providing a suitable supply of compressed air. The specifications of air quality are of course equally applicable to compressed nitrogen.

Table 12.2. Compressed Gas Requirements

System	Operating Pressure (Pa*)	Average Consumption (l/min)	Recommended Minimum Air Supply after Dryer at 5*10^5Pa
AVANCE	6-8*10^5Pa	45	57 l/min
AVANCE + BACS**	6-8*10^5Pa	52	57 l/min
AVANCE + MAS (DB ***, 5 kHz/7mm)	6-8*10^5Pa	220	300 l/min
AVANCE + NMR CASE	6-8*10^5Pa	52	57 l/min
AVANCE + SampleRail	6-8*10^5Pa	> 52****	100 l/min
AVANCE + Gilson	6-8*10^5Pa	46	57 l/min
Vibration Isolation Units	Please check with Bruker for latest specifications.		
LCNMR/MS	Please check with Bruker for latest specifications.		
CryoCooling Unit	6-8*10^5Pa	approx. 52	57 l/min

* Pa= Pascal (1 bar = 100,000 Pa)
** BACS= Bruker Automatic Sample Changer
*** DB= Double Bearing
**** Estimate - exact consumption was not available when this publication was written.

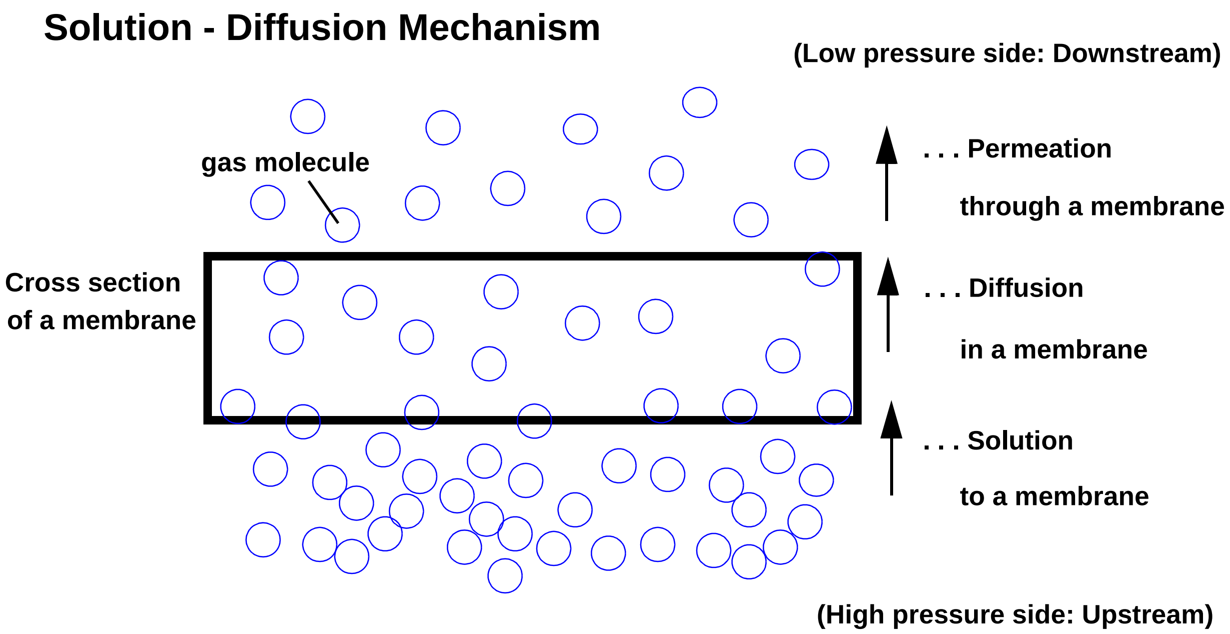
NOTE: One main compressed gas line with two separate regulated outputs (T split with two regulators) is required. An additional line may be required if using a CryoCooling unit.

Nitrogen (N2) Separators 12.2.1

If N2 gas is required, but only dry air is available, Bruker can provide N2 separators built-in to the consoles. Producing N2 gas from air is also much more cost effective than buying nitrogen gas.

How the separator works

Figure 12.1. Solution - Diffusion Mechanism



- Driving Force: Pressure difference (delta p) between Upstream and Downstream.
- Permeation rate: Q = P x delta p / l whereas l is the effective thickness of the membrane.
- Permeability coefficient: P = S x D -> a coefficient peculiar to a kind of gas (S = Solubility coefficient; D = Diffusion coefficient).
- Selectivity of TPX membrane: alpha = P(O2) / P(N2) = 4.2

Figure 12.2. Gas Separation by Using the N2 Separator

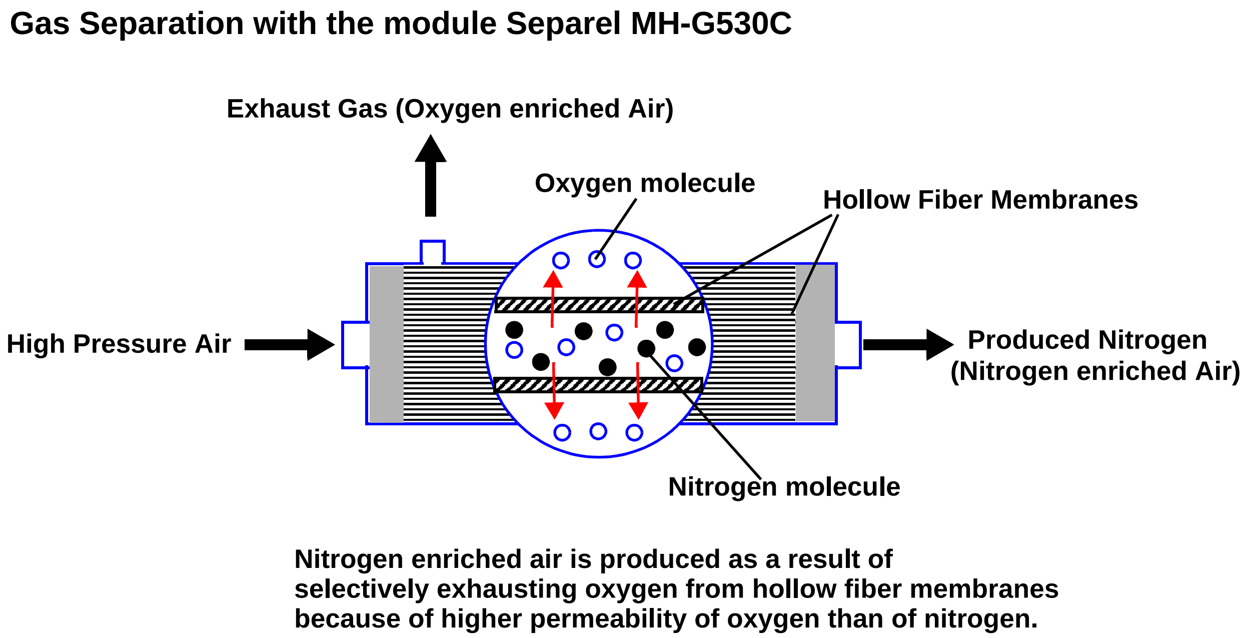


Figure 12.3. Nitrogen Separator

Operating Characteristics:

Maximum Feed Air Pressure: 8.5 kgf/cm^{2}G

Maximum Air Temperature: 35°C

Minimum Air Temperature: 10°C

Maximum Operating Temperature: 40°C

Required Air Quality:

Air which does not include oil mist, water vapor, dust, organic solvent vapor, corrosive gas etc.

Please note that **N2 separators may not be appropriate for HRMAS experiments**, and only for limited flow rates. Also note that the output of the N2 separator is not pure enough for use with the N2 exchanger for low temperature work. The residual Oxygen will freeze in the exchanger coil and block it, thus will become a hazard when warming up.

Air Quality 12.2.2

Trouble free operation can be guaranteed only when dry, oil-free, dust free compressed gas is used.

Besides the serious corrosion effects, water vapor in the compressed air may condense when operating at low temperatures. If this water freezes, the sample may become trapped inside the probe. If the probe fills with water this may ruin the ceramics of the probe. The BCU05 may also become blocked with water from the water vapor.

The effect of **oil impurities** is even more devastating as the oil film left in hoses or on surfaces inside the probe will make any measurements impossible. Oil contamination may lead to improper tuning, arcing, spinning hindrance and spurious signals, and will require a difficult and expensive cleaning of every single component. Oil in combination with high temperatures may form a solid deposit within the probe causing serious and permanent damage. Compressed air lines and valves that have been contaminated with oil can not be cleaned, they must be replaced. If you are locating the system in a site which already has a compressed air line, then it is likely that you will have to replace the existing lines and valves with new ones.

The consequences of dust in compressed air are particularly serious for MAS probes. Nozzles and valves get blocked, sediments cause valve leaks and wear of rotating parts. Ferrous dust from air tanks or pipes destroy the field homogeneity, and cannot always be removed when the magnets are on field.

Specifications 12.2.3

Oil Content:

< 0.005 ppm (0.005 mg/m^3)

Water Content

For room temperature work and higher: dew point of < 4°C

For low temperature work: The dew point must be at least 20°C below the operating temperature.

If a cooling unit is used then the dew point of the compressed air should be at least 10°C below the temperature at the heat exchanger output.

Note: For the BCU05 the compressed nitrogen should have a dew point of -50°C

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.

When designing a suitable compressed air system the following points should be taken into consideration:

1. To prevent magnetic impurities from entering the magnet use only copper or stainless steel lines. Do not use iron or steel pipes. Plastic piping is unsuitable where very low dew points are required. Water vapor in the air will permeate plastic piping limiting minimum dew points to typically -25°C.
2. To avoid surges in the air pressure (e.g. during sample lift) install a container of 10-20 liters in the air supply line to act as a buffer. Locate the buffer after the dryers in the supply line. **Buffer containers** should meet the appropriate safety requirements. They must have a working pressure of 16 bar and be proofed up to 30 bar. Use tanks which are internally coated with water and acid resistant material. This will prevent corrosion from impurities such as SO_2.

The three major components of a suitable compressed gas supply line are compressor, dryer and appropriate filters. Further details may be obtained from Bruker BioSpin.

In some regions Bruker BioSpin can supply you with a system suitable to your needs on request.

Compressors *12.2.4*

When installing a compressor the following points should be considered:

1. Ideally the compressor should be installed in a dust free, cool and dry place.
2. The compressor must be oil-free. This can be achieved by using membrane or Teflon coated piston compressors. The compressor should be fitted with a fine dust inlet filter.
3. The compressor must be capable of delivering the required flow rate and pressure suited to your particular system (see ***Table 12.2.***). Generally the compressor should be large enough so it does not run continuously (e.g. > 50% of the time), which will cause overheating and eventually equipment failure.

   The extra cost of choosing an oversized system may often be justified. The reduction in duty cycles will lower maintenance costs and extend the life of the system. A suitable compressor coupled to an adequate buffer will ensure a more **constant flow rate** leading to better performance. When spinning, the system uses a constant flow of air, but surges will occur during sample lift. When referring to ***Table 12.2.*** you should add on 10 l/min to the average consumption if the system is fitted with anti-vibration devices such as pneumatic dampers or a VIP system.
4. Take into account the pressure loss along the line between the compressor and the final gate valve. The pressure drop depends on the pipe diameters. An internal diameter of 8mm has been found to be suitable. The plastic tubing used to carry the supply from the final gate valve to the console has an outside diameter of 8mm and is supplied by Bruker BioSpin.

5. Some types of dryers, e.g., absorption dryers can use up to 25% of the air flow to regenerate the drying material. If this type of dryer is used then the output capacity of the compressor must be sufficient to supply this requirement.
6. Many compressors are fitted with dryer and a tray to collect excess water. Regular checking of the dryer and emptying of the water collector will ensure trouble free operation. This arrangement is quite satisfactory in environments with normal humidity (< 80%). However in areas of higher humidity (> 80%) a cooling coil with an *automatic* water drain must be fitted to the compressor outlet. This will ensure that filters do not become overloaded.
7. Although not directly concerned with air quality, compressors are a source of vibrations which may interfere with NMR performance (see ***"The Effects of Vibrations" on page 59***). You should consider using a compressor fitted with a vibration damping housing if it is to be situated close to the spectrometer. The output noise level should be < 75 dBA.
8. Some compressor systems, such as those supplied by Bruker BioSpin, may be purchased with integrated filters and dryers.

Dryers 12.2.5

As mentioned in the opening section of this chapter only dry air may be used for sample spinning and ejection. This will require the installation of dryers in the compressed air line. Several types of dryers are popular, Absorption dryers, refrigeration dryers, or a combination of both.

Absorption Dryers 12.2.6

The air is passed through cartridges of synthetic zeolite known as Molecular Sieves. The sieves are hygroscopic and retain water molecules when air is passed through them. Two sieves are normally used alternatively. A portion of the dry air output of sieve A is fed into sieve B to regenerate it. The amount used in regeneration is typically 15% but up to 25% may be required for very low dew-points.The process is automatically reversed at regular intervals with the output of sieve B used to regenerate sieve A.

Advantages

- Much lower dew points are achievable compared to refrigeration dryers.
- Automatic Regeneration: Normally the sieves will last for many years if they do not become contaminated with oil, e.g. from mist in the air.
- The drying agent may be easily replaced.

Disadvantages

- Up to 25% of throughput is used to achieve the automatic regeneration.
- Requires the use of more dust filters.
- Filters at the input (oil < 0.01mg/m^3) are required due to the susceptibility to oil contamination from mist in the air.

- The use of absorption dryers may lead to the generation of dust and so the dried air output must be fed through an appropriate filter (1micron).
- These dryers require more maintenance than refrigeration dryers.
- They can be noisy when switching between the two cartridges

Refrigeration Dryers. 12.2.7

This type of dryer removes moisture from gas by cooling to within a few degrees of the freezing point of water. The condensed moisture is removed in a separator and drain trap mechanism located immediately downstream of the dryer. This drain should be valve switched automatically.

Advantages

- None of the compressed gas is wasted in regeneration which is more suitable if the capacity of the compressor is marginal.
- Maintenance free
- Not as susceptible to oil mist contamination as adsorption dryers, thus do not have the same need for pre-filters.

Disadvantage

- These type of dryers are limited because of their inability to produce very low dew points. The recommended dew point for room temperature work of 4°C is only just achievable. Therefore if low temperature NMR is to be carried out, this type of dryer is unsuitable.

When making a final decision as to which type of dryer to choose take consideration of the following points:

1. The minimum dew point that is achievable
2. The throughout capacity of the dryer at the required pressure
3. Maintenance requirements.

Filters 12.2.8

Micro-filters should be fitted as the last element in the supply line. For specification see the section ***"Specifications" on page 90***.

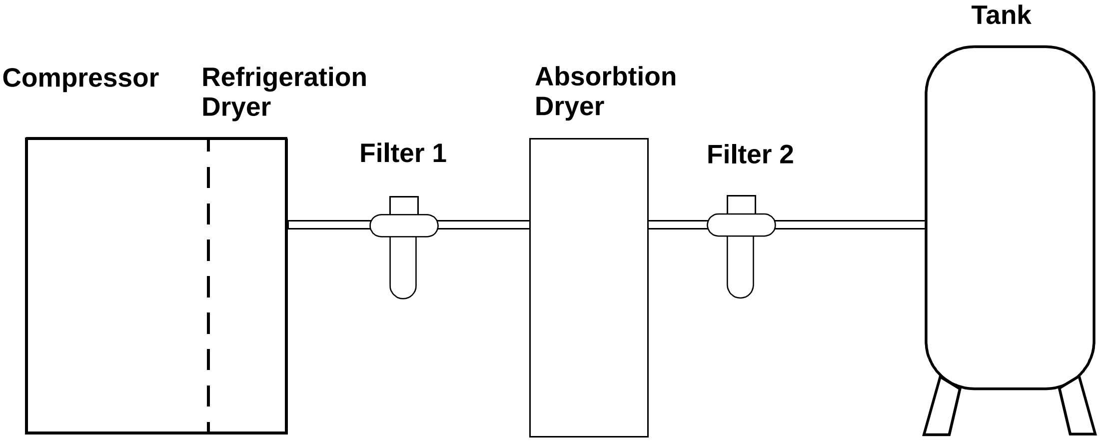
Absorption dryers in particular are prone to oil contamination and as such the input should be fitted with a oil filter (oil < 0.01mg/m^3 99.9% removal efficiency). To protect the dryers, regardless of type, you are advised to install a water filter and an oil filter between the compressor and the dryer. Adsorption dryers may generate dust and may need extra dust filters at the output.

The output of refrigeration dryers should be fed through a carbon activated filter.

Water filters should be fitted with automatic water drains as opposed to manual drains. Two types of automatic drains exist: floater switched or valve switched. The use of valve switched drains is strongly recommended. The floater switched drains have a tendency to become jammed and hence require regular maintenance.

If you are particularly concerned about oil contamination in the air supply then you should consider using a submicron filter followed by an activated charcoal filter as this combination is particularly effective in removing oil.

Figure 12.4. Example of a Typical Dryer/Filter System Setup



Filter 1: General purpose liquid and dust removal filter (0.1 mg/m^3 - 0.1 ppm, 1 micron)

Filter 2: High-efficiency dust, liquid and aeresol filter (0.1 mg/m^3 - 0.01 ppm, 1 micron)

Lighting *12.3*

Florescent lighting **should not be used** in the area considered for the magnet. Cold helium gas will cause the florescent lighting to turn off temporarily, particularly during a quench. For normal operation it 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.

Miscellaneous 13

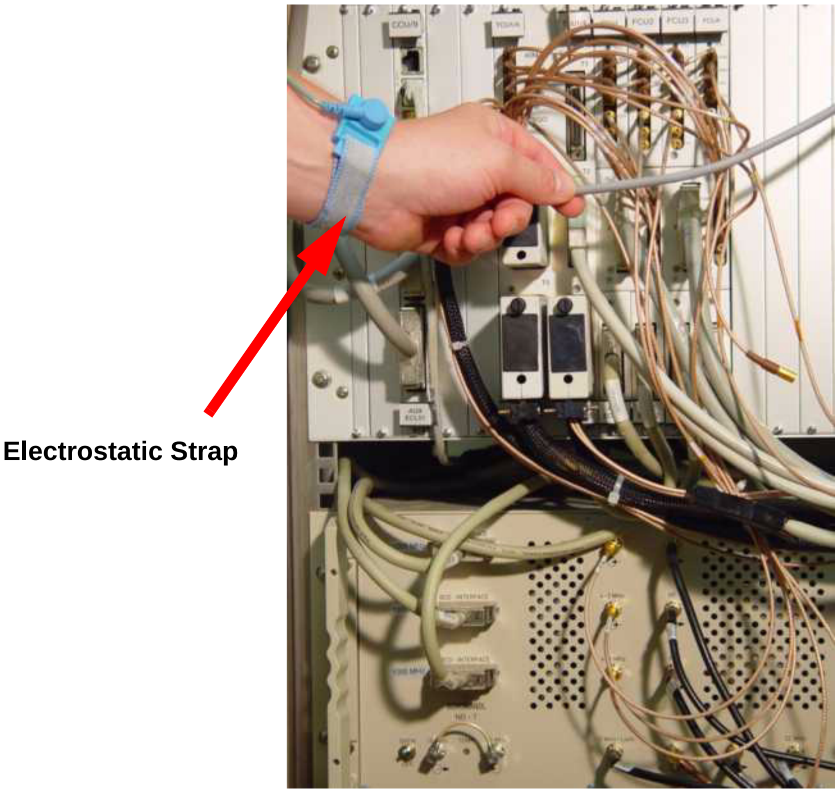
Static Electricity 13.1

Regarding static electricity discharges, you should treat the AVANCE^{TM} NMR electronics as you would any sensitive electronic components. In atmospheres with low humidity avoid the use of carpets that may lead to a build-up of static electricity.

Electrostatic Straps

Anytime that you work inside the console an Electrostatic Strap should be worn to prevent static electricity discharges. This is particularly true when changing boards or connecting and disconnecting cables.

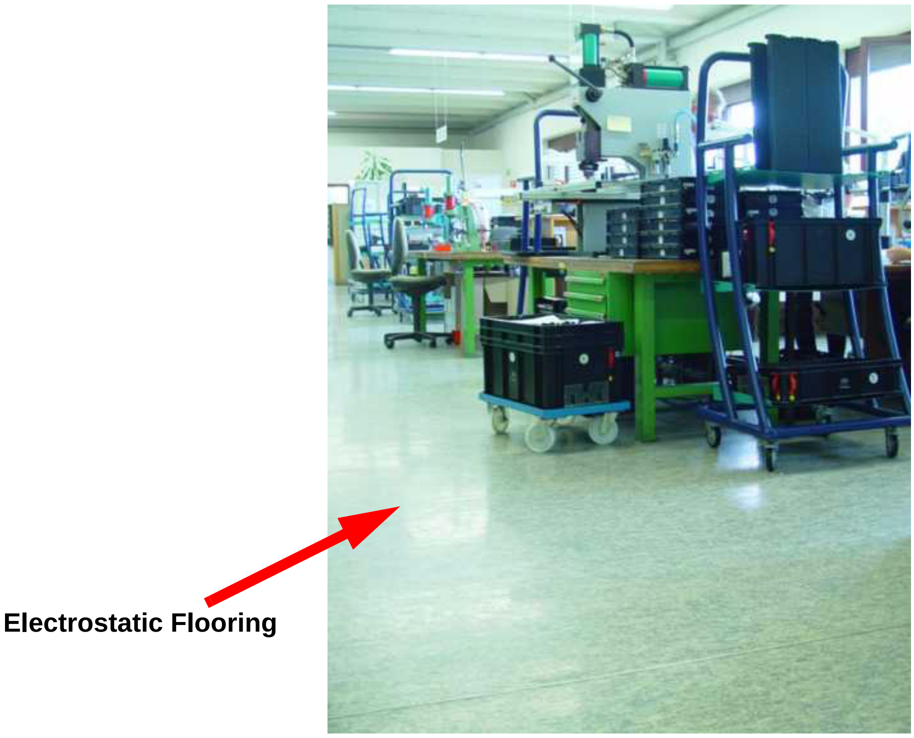
Figure 13.1. Using an Electrostatic strap



Electrostatic flooring

The use of electrostatic flooring, such as that found in many electronic production shops, greatly reduces the risk of electrostatic discharge. For more information check with your local Bruker dealer.

Figure 13.2. Electrostatic Flooring



Other Considerations 13.2

Make provision for sample/solvent preparation and storage space, documentation storage space, personal computers, plotter tables, workstations etc.

Finally, before a final layout is decided consider future equipment that may need to be installed. Remember that once installed, the magnet should not be moved.

Installation 14

Introduction 14.1

It is important to note that you must fill out and return the Site Planning Checklist (***"Site Planning Checklist"***) prior to delivery of the magnet system. If you do not have this checklist please contact Bruker immediately.

All the general requirements such as power supply, compressed air supply, etc. which were discussed in the preceding chapters must first be arranged before taking delivery of the system. It must be stressed that any installation requirements listed below such as cryogen supplies, are ***in addition*** to those needed for normal system operation.

Where necessary the customer is advised to contact the local Port Authorities to clarify arrangements for custom clearance. If the transport crates must be opened you must first contact Bruker, as the crates are shipped utilizing Shockwatch^{TM} and Tiltwatch^{TM}. Failure to do this may invalidate the warranty. If the transport crates are opened for any reason they should then be stored indoors (out of direct sunlight).

Overview 14.2

The spectrometer will arrive at the site in crates. The crates should not be uncrated as this must be assembled by a Bruker BioSpin engineer. The commissioning of the magnet involves several stages as outlined in ***Table 14.1.***. The precise duration of the various stages will depend on the size of the magnet.

Table 14.1. Overview of Magnet Commissioning

Duration	Procedure
ca. 3-8 hours	Transport fixtures are removed. Cryostat is assembled
2-4 days	The magnet is evacuated and flushed through with Nitrogen gas. The time required will depend on the magnet size.
1-3 days	Cool down of the magnet with liquid Nitrogen.
1 day	Cool down of the magnet with liquid Helium.

Table 14.1. Overview of Magnet Commissioning

Duration	Procedure
1-2 days	Charging of magnet.
1 day	Cryoshimming of magnet.

Accessibility *14.3*

Before delivery you must ensure that the equipment can be transported to the NMR site. ***Table 3.2.*** lists the crate sizes of various systems and magnets. Ensure that doorways, passageways and lifts have sufficient clearance. Extra large doorways are required for the larger magnets. Ensure that adequate lifting equipment such as forklifts or hydraulic pallet movers are available.

Checklist of Installation Requirements *14.4*

For the installation the customer **must** provide the following:

1. Lifting equipment and minimum ceiling heights as outlined in ***Table 4.1.***. On request Bruker can provide an A-frame for installation.
2. One cylinder of nitrogen gas (identical to that described in section ***11.3.1***).
3. One cylinder of helium gas (identical to that described in section ***11.3.1***).
4. Quantities of liquid helium and nitrogen as specified in the ***Table 14.3.***
5. Liquid helium and nitrogen transport dewars (identical to those described in section ***11.3.2***).
6. Three power sockets (230V/50 Hz / 16A single phase or 208V 60 Hz / 20A single phase in USA). These will be used to run a vacuum pump, a heat gun and a power supply unit. These power outlets must be available **in addition** to the power source used to run the spectrometer. Since they are only required during installation they may be installed temporarily.
7. Step ladder (non magnetic, e.g. aluminium or wood).

Where possible the customer should provide the following:

1. Heat gun or powerful handheld hair dryer (min. 800 W).
2. Roughing pump (10^{-2} mbar)
3. Pair of insulated gloves.

Installation Procedures *14.5*

The following section will discuss in detail the various steps outlined in ***Table 14.1.***.

Magnet assembly 14.5.1

When the magnet is delivered (do not uncrate it!) it must first be assembled by the installation engineer. The assembly area should be clean, dry and free of dust.

Minimum Hook Height

The assembly may require that the engineer works beneath the magnet and thus the customer normally should provide a hook and lifting equipment capable of supporting the magnet to a sufficient height.

For the installation of all NMR magnet systems, the minimum hook height needed during installation is calculated by adding the height of the body of the cryostat to the height of the different bore tubes that have to be inserted into the cryostat. In addition the pulley, the hook and the suspension aids have to be taken into account (see illustration in ***Figure 14.1.***).

Figure 14.1. Minimum Hook Height for Assembly

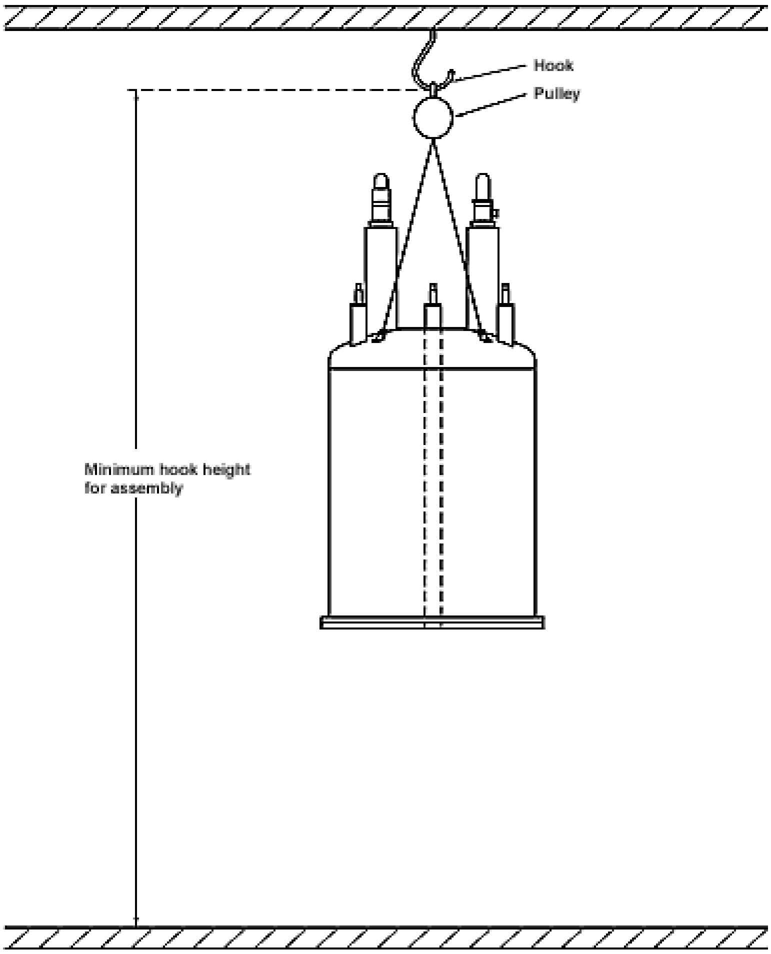


Table 14.2. lists the required minimum hook height required for your magnet.

Table 14.2. Minimum Hook Height Needed During the Assembly

Magnet Type	Minimum Hook Height for Assembly (m)
300 MHz/54 mm US LH	2.42
300 MHz/54 mm US ULH	2.80
300 MHz/89 mm US WB LH	2.85
400 MHz/54 mm US LH	2.80
400 MHz/89 mm US WB LH	2.90
400 MHz/54 mm US ULH	3.00
500 MHz/54 mm US LH	2.90
500 MHz/89 mm US WB LH	3.45
600 MHz/54 mm US LH	3.00
600 MHz/89 mm US WB LH	3.45
700 MHz/54 mm US LH	3.45
WB= Wide Bore (89mm), US= UltraShield™, LH= Long Hold, ULH= Ultra Long Hold	

As mentioned previously, normally the customer should provide the hook and lifting pulley to support the magnet during assembly. If a hook can not be provided, please check with Bruker BioSpin regarding special rigging equipment, such as the A-frame pictured below.

Figure 14.2. Bruker BioSpin - Special Rigging Equipment - The A-Frame

When arranging suitable lifting gear the customer is asked to ensure a safety margin of at least 100%. **For some magnets the assembly of the magnet requires higher ceilings than are needed for normal operation**. As a result of this some customers arrange for the assembly to take place in an adjacent room. After the assembly, the magnet can be transported by cart, trolley, or air skates to the NMR room. Note, however, that this is only feasible where no uneven passages have to be traversed and where no door jambs obstruct the way.

Magnet Evacuation and Flushing with Nitrogen gas. 14.5.2

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 50l/200 bar cylinder of dry Nitrogen gas (99.99% purity). The cylinder should be fitted with a secondary regulator value to deliver a pressure of 0.5 bar, see the section ***"Cylinders" on page 79***. 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^{-2} mbar.

Further pumping of the cryostat is then carried out to reduce the internal pressure to 10^{-6} mbar. It is convenient, particularly for foreign installations, 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 14.5.3

This next stage involves filling the magnet with liquid Nitrogen. The quantity of liquid nitrogen required is listed in column 3 of ***Table 14.3.***. To transfer the nitrogen a transport dewar is required. This must have a minimum volume of 50l with fixture for pressurizing and transferring via a rubber hose of 10mm diameter, refer to the section ***"Dewars" on page 80***.

Cooling the Magnet to Liquid Helium Temperatures 14.5.4

For this procedure the customer must provide:

a) One cylinder of helium gas: 50l / 200bar (99.996% purity) with secondary regulator value to deliver pressure of max 0.2 bar (see ***Table 4.1.***).

b) Quantities of liquid helium as specified in column 4 ***Table 14.3.***.

c) Liquid Helium dewar:

> 1) Bruker Magnets: 50l, 100l or 250l. Type SHS with NW25 flange or suitable outlet compatible with the 9.6mm helium transfer line.
>
> 2) Magnex 500WB, 600WB:250l Type SHS with NW25 flange or suitable outlet compatible with the special helium transfer line used (outer diameter 12.7mm, 1/2 inch)

When ordering the helium the customer should arrange to have it delivered immediately before the installation. Otherwise losses due to evaporation must be taken into account.

Charging the Magnet *14.5.5*

The final stage involves bringing the magnet to field. This will take 1-2 days depending upon the magnet. During the charging there is a possibility that the magnet may quench. The quantities of liquid helium specified in column 5 ***Table 14.3.*** allow enough for one quench. It is important that the customer ensures that, if required, extra supplies of liquid helium are available.

Note:

1. Values of liquid nitrogen and helium in ***Table 14.3.*** are the minimum requirements. An extra 20-30% of each is advisable, particularly as many suppliers will take back and refund you for unused cryogens.
2. Total liquid helium requirement is the total of column 4 and 5.

Table 14.3. Installation Requirements for a Range of Magnets

Magnet Type	Magnet Weight Empty with Legs - w/o Stand (kg)	Liquid Nitrogen for Cool down (l)	Liquid Helium for Cool down (l)	Liquid Helium Required after Quench (l)	Magnet Weight Filled with Magnet Stand (kg)
300 MHz/54 mm US LH	242	150	150	50	310
300 MHz/54 mm US ULH	298	250	250	100	379
300 MHz/89 mm US WB LH	375	300	300	150	452
400 MHz/54 mm US LH	386	300	300	100	464
400 MHz/54 mm US ULH	397	350	350	150	494
400 MHz/89 mm US WB LH	500	450	350	150	584
500 MHz/54 mm US LH	648	400	400	150	749
500 MHz/89 mm US WB LH	1300	700	600	400	1700
600 MHz/54 mm US LH	1150	700	700	350	1300
600 MHz/89 mm US WB LH	2285	1500	1400	600	2675
700 MHz/54 mm US LH	2663	1700	1600	700	3040
WB= Wide Bore (89mm), US= UltraShield™, LH= Long Hold, ULH= Ultra Long Hold					

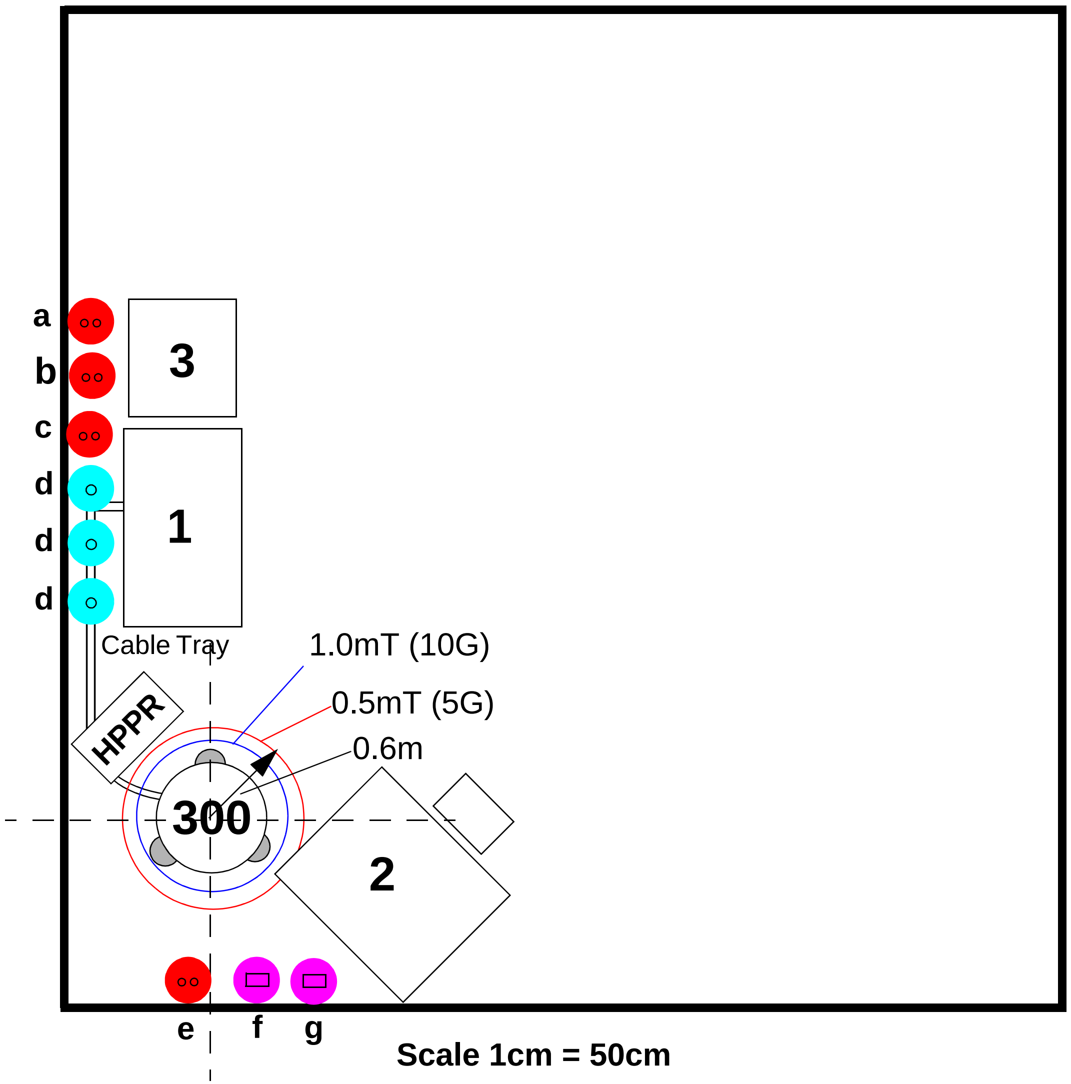
Sample Room Layouts

Introduction A.1

The following drawings illustrate some general layouts for basic AVANCE systems. Please understand that these are only examples, an individual room layout will dependent on a variety of factors that were outlined throughout this manual, as well as an individual buildings characteristics and layout. These examples, along with the chapter ***"Room Layout" on page 29***, should form a basis for planning your own individual layout. If you have further questions, or require assistance please contact your nearest Bruker sales representative.

If a CryoProbe System is planned, be sure to refer to the CyroProbe System Sight Planning Guide for specific information on CryoProbe site requirements.

AVANCE 300 MHz / 54mm EXAMPLE LAYOUT



Scale 1cm = 50cm

LEGEND

1: Avance Cabinet

2: Workstation and table

3: BCU05 Unit

a - 230V/16A single phase (optional for BCU05)

b - 230V/16A single phase (for maintenance and servicing)

c - 230V/16A single phase (for console)

d - Regulated line for nitrogen (min. 5.6 bar)

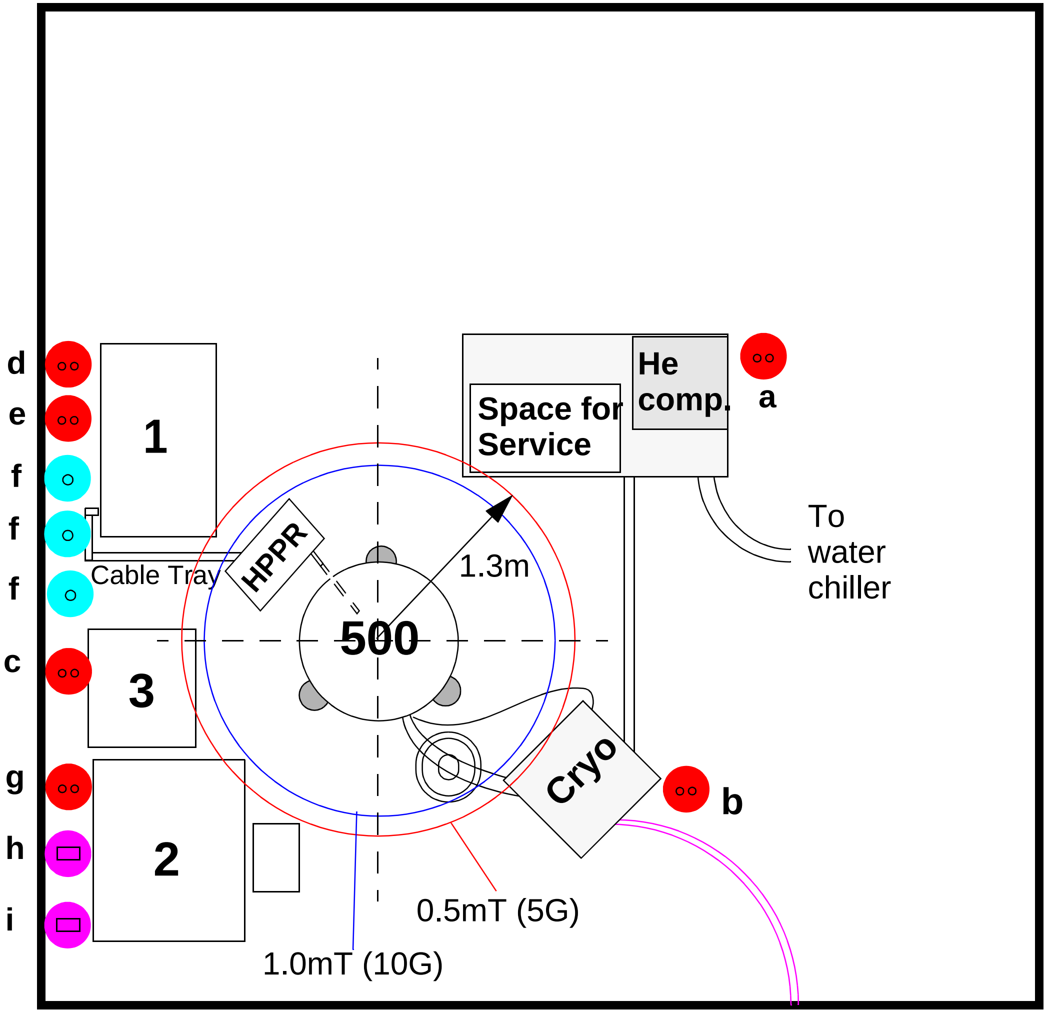
e - 230V/16A single phase

f - Telephone port

g - Data port

AVANCE 500 MHz / 54mm EXAMPLE LAYOUT

(shown with CryoProbe System)



Scale 1cm = 0.5m

LEGEND

1: Avance Cabinet

2: Workstation and table

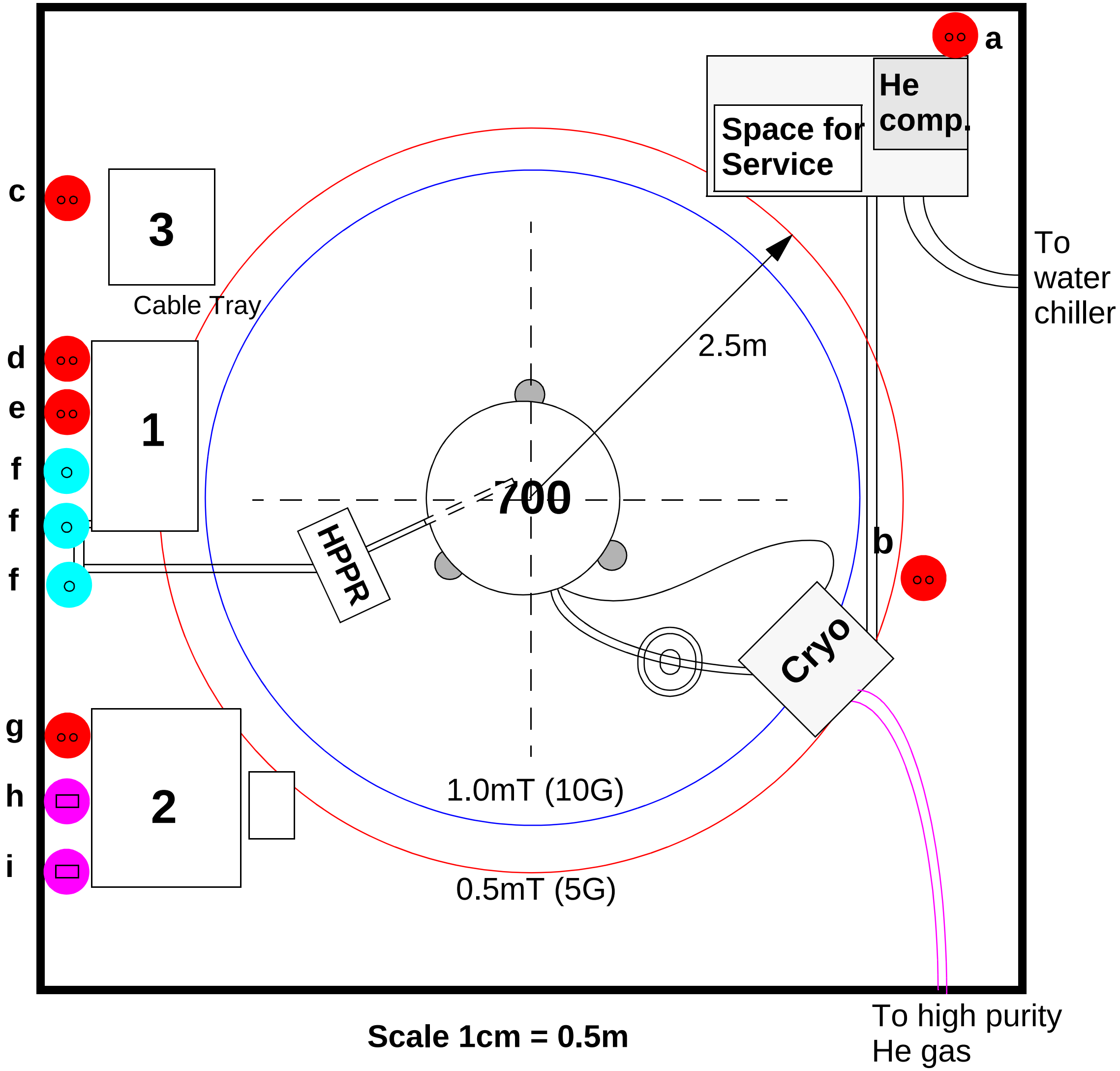
3: BCU05 Unit

- **a** - 380V/12A triple phase (He Compressor)
- **b** - 230V/16A single phase (through step-up transf. - Cryo-cooling unit)
- **c** - 230V/16A single phase (optional for BCU05)
- **d** - 230V/16A single phase (for maintenance and servicing)
- **e** - 230V/16A single phase (for console)
- **f** - Regulated line for nitrogen (min. 5.6 bar)
- **g** - 230V/16A single phase
- **h** - Telephone port
- **i** - Data port

Refer to the CryoProbe Site Planning Manual for additional information on locating the CryoProbe System

AVANCE 700 MHz / 54mm EXAMPLE LAYOUT

(shown with CryoProbe System)



LEGEND

1: Avance Cabinet

2: Workstation and table

3: BCU05 Unit

- **a** - 380V/12A triple phase (He Compressor)
- **b** - 230V/16A single phase (through step-up transf. - Cryo-cooling unit)
- **c** - 230V/16A single phase (optional for BCU05)
- **d** - 230V/16A single phase (for maintenance and servicing)
- **e** - 230V/16A single phase (for console)
- **f** - Regulated line for nitrogen (min. 5.6 bar)
- **g** - 230V/16A single phase
- **h** - Telephone port
- **i** - Data port

Refer to the CryoProbe Site Planning Manual for additional information on locating the CryoProbe System

Emergency Planning

General B.1

- NMR Laboratories should not be accessible to the public. Make sure access is restricted to qualified employees only.
- Instruct your employees at regular intervals.
- Strong magnetic fields involve various hazards. The danger zone should be labeled (as precise as possible) by the use of barriers, floor-taping or visual warning devices. Consult your safety manual for specific information concerning the danger zone (0.5mT Line).
- Mark all available pathways to the emergency exits clearly.
- Strictly enforce the smoking ban during refill procedures. While nitrogen and helium do not support combustion, their extreme cold dewar causes oxygen from the air to condense on the dewar surfaces, which may increase the oxygen concentration locally.
- If your Magnet System is installed in a small room or a confined space such as a pit, it is highly recommended to wear or install oxygen warning devices.
- Complete the **Emergency Contact List** (***Figure B.1.***) and keep it up-to-date. Hang the list in obvious places, so when an emergency occurs, the appropriate people/organizations can be notified immediately.

Emergency Contact List B.2

Figure B.1. Emergency Contact List

Emergency Contact List

In case of problems or emergencies ***DURING WORKING HOURS*** please contact the following personnel:

Name	Bureau/Department	Phone

In case of problems or emergencies ***DURING NIGHTS, WEEK-ENDS OR HOLIDAYS*** please contact the following personnel:

Name	Address	Travel-time	Phone

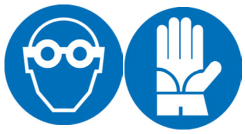
Fire Department →	
Police →	
Medical Service →	
Technical Service →	

Briefing Employees B.3

NMR-Laboratories should not be accessible to the public. Make sure access is restricted to qualified employees only.

Strong magnetic fields involve various hazards. The danger zone should be labeled (as precise as possible) through the use of barriers or other visual warning devices. Consult your safety manual for specific information concerning the danger zone (0.5mT line).

- Magnet systems attract metals such as iron, steel or nickel.
- The magnet system creates a very strong magnetic field. In a magnet's sphere of influence, metallic parts, tools, cleaning equipment, and other objects (keys, eyeglass frames) made of metal can develop strong, even uncontrollable forces which can turn them into dangerous projectiles.
- Persons carrying **cardiac pace makers and/or medical implants** are not **permitted** under any circumstances **to stay in the proximity of magnet systems**.
- Watches, electric-and electro-mechanical devices, as well as credit card and other magnetic storage media may be damaged or malfunction if brought inside the labeled area of the magnet.
- If an object does get drawn to the magnet and sticks, immediately inform the responsible individual. **Never try to remove the object by force**. This will cause only further damage to the magnet, to the object as well as to the individual.
- Magnet systems are cooled by the use of liquid nitrogen and helium. In liquid state, these gases have a temperature of -196°C and -269°C respectively. Skin contact with those liquids can lead to severe cold burns; eye contact could result in blindness.
- Do not touch any super cooled parts, as there is a danger of skin adhesion.
- When in direct contact with the system, always wear protective clothing and goggles.



- Nitrogen is colorless and odorless. In a closed room nitrogen will settle to the floor.
- Helium is also colorless and odorless, but has a lower density than air. In a closed room helium will raise to the ceiling. When in contact with moist air, the production of fog can be observed. A high concentration in the surrounding air can be observed by a significant raise of the voice.
- In a gaseous stage both substances displace oxygen. A sudden discharge of gas from the system in a closed or insufficiently ventilated room may result in suffocation. It is therefore compulsory to provide adequate ventilation (a room volume exchange of 3-5 times/hour.
- In case of a sudden discharge of gas from a magnet system, immediately open all available windows and doors and leave the room without delay.
- When working in the magnet room always keep the location of the nearest exit in mind. When escaping gases mix with ambient air, a fog may form, blocking the exits from view.
- During a quench liquid oxygen may be produced. It will drip from the top of the towers of the magnet. If the liquid oxygen comes in contact with oil or grease, spontaneous combustion may occur.

- Never step or climb on a magnet system.

Turning the system on and off only affects the electronic components, the magnetic field is always present!!

The MWC Value B.4

The “**M**aximum **W**orkstation-**C**oncentration (MWC-Value)“ is the highest tolerable average concentration of a substance in the air in form of gas, dust or vapor, based on present knowledge, (during the working hours from 8 hours daily up to 42 hours weekly, over a longer period of time) without putting a risk on a normal persons health.

The varying sensitivity and strain of the working person in connection with age, sex, constitution, marital status, climate, physical and psychic work load has been taken into account as much as possible when defining these values“.

(Source: SUVA, Grenzwerte am Arbeitsplatz 1999)

Effective value of the flow-density in the frequency range 0-1 Hz at exposure times from:

1 Hours/Day	2 Hours/Day	Continuous Exposure (8 Hours/Day)
212.2mT	127.3mT	67.9mT

- The workplace should be located outside the 0.5mT line.
- There is no increased risk for pregnant women.

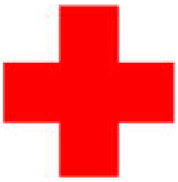
Fire Department Notification B.5

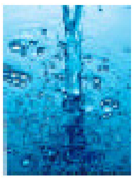
It is recommended that the magnet operator introduce the fire department and/or local authorities to the magnet site. It is important that these organizations be informed of the potential risks of the magnet system, i.e. that much of the magnetic rescue equipment (oxygen-cylinders, fire extinguishers, axe's etc.) can be hazardous close to the magnet system. On the other side, their expertise and experience can be invaluable in creating an Emergency plan.

- Within a NMR-Laboratory CO_2 magnetic fire extinguishers should NOT be used.

- Breathing equipment which uses oxygen tanks made out of magnetic material can be life threatening when used close to a magnet system which still has a magnetic field present.
- Helium gas escaping from the system should not be mistaken for smoke. Instruct the fire Department and technical service not to „extinguish“ the magnet system with water. The outlet valves could freeze over and generate excess pressure within the system.
- NMR laboratory windows which are accessible during an emergency should be clearly marked with warning signs, visible from the outside.

Medical Emergencies *B.6*





- Medical treatment should not take place close to a magnet system.
- Contact with cooling liquids, gases or vapors can lead to skin irritations similar to burns. The severity of the burn depends on the temperature and exposure time. In the case where liquid cryogens come in contact with the eyes, rinse thoroughly with clear water and seek immediate ophthalmological advice.

First Aid for Cold Burns

- Get the injured into a warm room (approx. 22° C)
- Loosen all clothing which could prevent blood circulation of the affected parts.
- Pour large quantities of warm water over the affected parts. (Never use hot water or dry heat!)
- Cover the wound with dry and sterile gauzes. Do not apply too tightly as to impair blood circulation!
- Immobilize the concerned body part.
- Seek immediate medical assistance.

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