400/54 ACTIVELY SHIELDED PREMIUM NMR MAGNET SYSTEM

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400/54 Actively Shielded Premium NMR System Manual Contents

magnex scientific

WARNING

This device produces a high magnetic field. The stray field surrounding the magnet extends far beyond the confines of the vessel. The existence of this field produces several hazards. Firstly the field will interfere with sensitive electronic devices and will erase magnetic storage devices such as tapes and credit cards. In particular people with cardiac pacemakers should be kept well clear of the region of field. The FDA guideline for cardiac pacemakers is currently 5 gauss. Fields higher than this can cause malfunction of the pacemaker.

Secondly ferromagnetic objects in the vicinity of the magnet will become magnetised and will be attracted toward the magnet. The force on such objects is proportional to their mass so that even large objects will move toward the magnet with considerable velocity.

It is possible under fault conditions, for large amounts of helium and/or nitrogen to be released from the system e.g. during a magnet quench. Under these conditions the gas is very cold and will cause "cold burns". More importantly if the gas is not vented properly asphyxiation is possible due to the displacement of oxygen within the room. It is the responsibility of the user to ensure adequate venting of the gas is provided and adequate ventilation within the final installation site.

It is the responsibility of the user to take all necessary precautions to prevent accident or loss from use of the magnet. Magnex Scientific Limited accepts no responsibility for any loss or damage caused either directly or indirectly from use of the magnet. Whilst every effort is made that the information contained in this manual is correct, Magnex Scientific Limited accepts no responsibility for any inaccurate statements or omissions.

The magnet power supply should be limited to the operating current of the magnet plus 10% and the magnet should only be energised after completion of cooling.

Note:

Magnex Scientific Limited will make available technical information and parts for repair or maintenance where appropriate.

CE NOTICE

Marking by the symbol CE indicates compliance of this device to the PED (Pressure Equipment Directive) directive of the European Community. This unit is to be installed and operated as detailed. Any modification or maintenance procedure undertaken which is not approved by Magnex Scientific Ltd could nullify the CE marking of this product and lead to prosecution. A 'Declaration Of Conformity' in accordance with the above directive has been made and is located at Magnex Scientific, Yarnton, Oxfordshire, UK.

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SAFETY CONSIDERATIONS FOR THE INSTALLATION & OPERATION OF MAGNET SYSTEMS

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CONTENTS

1. INTRODUCTION

The site for a superconducting magnet system should be designed to meet national and state safety legislation as well as "best practice". Such recommendations primarily concern the magnetic fringe field and liquid cryogens. This document summarises these potential dangers and makes recommendations for the facility.

2. NATURE OF THE MAGNETIC FIELD

The greatest hazard presented by a superconducting magnet is the fringe magnetic field. Once the magnet is energised, the magnetic field is always present, even when all power to the system has been turned off. This magnetic field extends above, below and to the sides of the magnet. It extends through doors, walls ceilings, and floors.

The strength of the magnetic field increases dramatically as the magnet is approached. Objects and people at risk from the magnetic field are considered safe outside the 5 gauss line.

Please Note: A magnet that has been de-energised but remains at liquid helium temperatures will still exhibit a small residual magnetic field. Measurements of this field should be made, and public access restrictions should still be imposed as per national and state requirements. (See Section 4.)

Occasionally, fault conditions may cause magnets to lose their superconducting properties, which in turn will cause their magnetic fields to collapse. In the case of a magnet that is *actively shielded*, before the magnetic field collapses it can momentarily "bloom" slightly beyond its normal dimensions. For further details on this subject for any specific magnet, please consult Magnex Scientific Ltd.

3. HAZARDS PRESENTED BY THE MAGNETIC FIELD

The strong magnetic field creates hazards because it strongly attracts ferromagnetic metal alloys. Ferromagnetic metal alloys contain iron, nickel or cobalt. They are used in most types of tools and equipment and in some surgical implants.

The strong magnetic field can cause the following hazards:

- Projectiles
- Displacement of surgical implants
- Stoppage of electrical and mechanical implants and devices

A loose metal object (such as a wrench or pen) becomes a projectile if it gets too close to the magnet, as the force of the magnetic field pulls the object towards the magnetic centre. This metal projectile can seriously injure anyone standing between it and the magnet.

Ferromagnetic metals are sometimes used in surgical implants and prosthetic devices. The magnetic field can twist metallic implants out of place, causing tissue damage and pain to the person in whom they are implanted, possibly creating a life-threatening situation. Some cardiac pacemakers, biostimulators and neurostimulators are mechanically activated and may stop in the presence of the magnetic field. This could also create a life-threatening situation.

4. MAGNETIC FIELD SAFETY REQUIREMENTS

Note 1: National and state legislation & requirements may differ around the world. In the USA the requirements and guidance issued by the Food & Drug Administration (FDA) should be followed. In Europe, European Commission (EC) Directive 2004/40/EC applies, and the guidance issued by the International Commission on Non Ionising Radiation Protection (ICNIRP) should be followed.

Note 2: Prior to 1st April 2005 the United Kingdom's advisory body was the National Radiological Protection Board (NRPB) - a member of ICNIRP. From 1st April 2005 the NRPB merged with the United Kingdom's Health Protection Agency (HPA), and became its Radiation Protection Division.

The hazards described in the previous sections of this document should be controlled by establishing two secure and clearly marked zones:

- The exclusion zone
- The security zone

Exclusion Zone

The exclusion zone comprises the area (rooms, hallways and so on) inside the magnets 5-gauss line. *Individuals with cardiac or other mechanically active implants must be prevented from entering this area.*

The magnetic field surrounds the magnet in a three dimensional fashion. Access must be limited and warning given to individuals who are potentially at risk, not only at the same floor as the magnet, but also at the levels above and below the magnet.

The exclusion zone must be enforced with a combination of warning signs and physical barriers. Figure 1 shows the warning sign recommended by Magnex Scientific Ltd

Figure 1 Warning Sign

Note 3: At magnetic field strengths of approximately 10 Gauss or more, magnetic media may become wiped or damaged

Security Zone

The security zone is established to prevent ferromagnetic objects from becoming projectiles; it is usually confined to the room that houses the magnet. The security zone's threshold should usually be at a magnetic field strength of 30 Gauss. *Ferromagnetic objects should* ***not*** *be allowed inside the security zone.*

Occupational Exposure to Magnetic Fields.

National and state enforcement and advisory bodies should be consulted to ensure that any exposure limits are not infringed for (non patient) occupational workers.

5. NATURE OF LIQUID CRYOGENS

A superconducting magnet uses two types of cryogens, liquid helium and liquid nitrogen. Helium is a naturally occurring, inert gas that becomes a liquid at approximately 4K. It is colourless, odourless, non-flammable and non-toxic. In order to remain in a superconducting state the magnet is immersed in a bath of liquid helium.

Nitrogen is a naturally occurring gas that becomes liquid at approximately 77K. It is also colourless, odourless, non-flammable and non-toxic. It is used to cool the shield which surrounds the liquid helium reservoir.

During normal operation, liquid cryogens evaporate and will require replenishment on a regular basis. The cryogens will be delivered to site in dewars; ***it is essential that these dewars, including any carriers, are non-magnetic.***

6. HAZARDS PRESENTED BY CRYOGENS

Helium and nitrogen in both their liquid and gaseous forms, present the following hazards:

- A large quantity of gas released in an area that is not well ventilated can cause asphyxiation
- Liquids or cold gases can cause cryogenic burns.
- The filling procedure produces an oxygen-rich liquid, which is a fire hazard when it drops on a combustible material

The extremely low temperature of the liquids and their cold vapours can cause severe frostbite, or a cryogenic burn. This is mainly a danger during the filling process, when the fill line and other equipment freezes. Touching the fill line or any other piece of equipment during a transfer can freeze the skin or cause it to stick to the surface of the equipment. To prevent cryogenic burns, protective gloves and a face shield should be worn; long-sleeved clothing and long trousers/pants are also recommended.

During the filling process, atmospheric air condenses on the fill line or pipes, leaving an oxygen-rich liquid, or even liquid oxygen. If this should drip onto a combustible material, like oil or grease, a fire could start. (Liquid oxygen can spontaneously ignite upon contact with oils or greases.)

For these reasons it is strongly recommended that:

- All sources of ignition are excluded from magnet rooms.
- All tools and equipment used for transferring cryogenic liquids are kept clean and free from oils and grease.
- All sources of ignition should be excluded from the magnet room, which should also be a No Smoking zone.

Helium or nitrogen gas released in an area that is not well ventilated can displace air and reduce the oxygen content to an unsafe level, leading to asphyxiation. It is also worthy of note that, when cold, gaseous helium remains lighter than air, but gaseous nitrogen becomes heavier than air. The greatest risk of asphyxiation will be during commissioning of the magnet. However, after the magnet is in service, a risk of asphyxiation could still occur during a "quench".

A "quench" occurs when the magnet loses its superconductivity, and warms the liquid helium, causing it to turn to gas. This large amount of gas escapes through the magnet venting. The following section describes the safety recommendations that prevent the possibility of asphyxiation after a magnet quench.

7. SITING REQUIREMENTS

Vents or Quench Ducts

Ideally, the helium exhaust from the magnet should be vented to the outside of the building to reduce the risk of asphyxiation in the event of a quench occurring. The ducting to the outside of the building should be of large enough diameter to avoid excessive pressure build up due to the flow impedance of the duct. (This exhaust ducting is often referred to as a "quench duct".) Only service personnel should have access to the exit end of the quench duct; in addition the exit opening should be protected from the ingress of rain, snow or any debris which could block the system. It is recommended that the quench duct exit is inspected periodically to ensure that gas flow has not become restricted by the presence of any debris.

It is also essential to ensure that any gas which vents from the quench duct cannot be drawn in to any air conditioning or ventilation system intakes. The location of duct's exit should be carefully sited to prevent this from happening in all atmospheric conditions and winds.

Although "quenches" are short-lived and infrequent phenomena, as quench gases are liberated the temperature of the quench duct can become low enough to cause cold burns on unprotected skin. This cold might also damage electrical wiring or other services routed close enough to touch the quench duct. (Water pipes should **not** be routed near quench ducts.) It is therefore recommended that quench ducts are protected with suitable proprietary thermal insulation e.g. fibreglass cladding or similar. Such thermal insulation should be:

- Fire resistant (due to the possibility of condensation of liquid oxygen.)
- At least 50 mm thick.

- Resistant to deterioration upon contact with water. (Frost formed on the pipe within the thermal insulation will eventually thaw.)

Adequate Ventilation During Magnet Installation

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 create dangerous circumstances if they displace the oxygen in the room. The table below illustrates this with examples:

Magnet Type	Quantity of liberated N_2 gas during pre-cool	Time taken to liberate N_2 gas during pre-cool	Quantity of liberated He gas during filling	Time taken to evolve He gas during filling	Quantity of He gas liberated during a "quench"	Time to liberate He gas during a "quench"
800/89	3400 m^3	40 hours	1750 m^3	14 hours	800 m^3	1 min
900/52	13600 m^3	160 hours	7000 m^3	56 hours	315 m^3	1.5 min
4T940	5400 m^3	48 hours	5400 m^3	72 hours	900 m^3	10 min

For this reason, adequate means of transporting evolved gases from the magnet out of the magnet room and also good ventilation of the magnet room is essential.

Oxygen Monitor

An oxygen monitor is strongly recommended for the magnet room. The oxygen monitor sounds an alarm when the oxygen level in the room rises above or falls below a safe level. This would happen if the ventilation system malfunctions, either during a quench or during a normal boil-off, and a large amount of helium gas is released into the room.

Routine Maintenance Involving Transfer of Cryogens

For safety reasons, routine maintenance tasks involving transfer of cryogenic liquids MUST be performed by personnel formally trained to do so

Advice

Should you have any queries concerning your siting requirement, advice can be obtained from the Installation Manager or Technical Support Manager at Magnex Scientific Ltd.

8. ELECTRICAL SAFETY

The following precautions and safe practices **must** be observed:

- WARNING - Isolate or disconnect equipment from mains supply before opening this unit for any reason. LIVE PARTS INSIDE.
- WARNING - For continued protection against risk of fire or electric shock, always replace fuses with the same type, rating and UL listing.
- CAUTION - Magnets power supplies contain internal protection fuses, follow the guidelines in the trouble-shooting section of the magnet manual before replacement of these devices.
- CAUTION – Your magnet power supply has been pre-set to a voltage range suitable for your country's national supply. Should any fuses require replacement they must be of the correct type and rating.

You should consult the relevant chapter of your magnet manual for further specific details.

9. SAFE ACCESS WHEN WORKING AT HEIGHT

Safe access to the top of magnets is important for routine topping up of cryogens; the frequency of doing so will vary from magnet to magnet, but may needed as often as weekly. Safe access to the top of magnets is also essential for installation work. Experience has shown that normal ladders and stepladders are not best suited to this task: They often fail to offer a secure platform when working on top of magnets when both hands are occupied by tasks *other than* holding on.

Suitable access equipment should be selected and purchased *before* the arrival of the magnet. Remember that any such equipment must be non-ferrous and immune to magnetic attraction. Choosing the height and size of access equipment in advance of the magnet's arrival will be helped by referring to the magnet's System Interface Drawing sent in advance to all customers of Magnex Scientific.

10. CONSIDERATIONS FOR THE OUTBREAK OF FIRE

Specific precautions regarding fire safety will vary dependant on legislation and regulations in the country where the magnet is installed. The considerations discussed below are intended to help customers review their site(s) fire precautions following the installation of a superconducting magnet. **These considerations are advisory in nature.**

(Very) broadly speaking, there could be two types of fire that could affect a magnet room – small fires and large fires. For the purposes of this document "small fires" are defined as being of a size that a customer's staff might wish to fight with a first aid fire extinguisher. "Large fires" are defined here as major fires that only professional fire fighters should attempt to extinguish.

Small Fires. Most premises should already have fire & emergency procedures in place in accordance with current safety legislation. Within this context, any fire extinguisher provided in a magnet room, or likely to be taken into or through a magnet room in response to a fire, **must be of non-ferromagnetic construction** to avoid it becoming attracted to the magnet, possibly causing personal injury, and becoming useless for fire fighting purposes.

Large Fires. One again, each customer should already have in place fire and evacuation procedures in accordance with current safety legislation. **The most important advice that Magnex Scientific Ltd can offer its customers is to invite the Fire Department (or Fire Brigade) for a liaison visit to see for themselves the customer's building layout and the hazards associated with superconducting magnets.** The Fire Department (or Brigade) needs to understand – before attending a major fire at a magnet lab – the hazards *in addition to* flames and smoke that these installations represent. The hazards that should be discussed with professional fire fighters on such occasions should include the following:

Magnetic Attraction of Ferrous Equipment. Even assuming the magnetic field warning signs are still intact when fire fighters arrive to fight a fire, most firemen will probably have no conception of the strength of magnetic attraction that superconducting magnets can generate. In the worse case this could attract equipment, compressed air cylinders etc. possibly complete with fireman attached! The following web page illustrates this hazard only too well:

http://www.mrireview.com/docs/mrideath.pdf

Quenches. Quench ducts could fail in a large fire or be broken by falling debris. This could liberate quench gases into the magnet room with a risk of asphyxiation for any fire fighters present. Magnet rooms with several vertical magnets, which may not possess dedicated quench ducts, could be faced with more than one magnet quenching simultaneously, venting large quantities of nitrogen or helium gas into the magnet room. Because these gases are inert, with nitrogen comprising 80% of the air we breathe, most people do not realise that as few as three breaths of 100% inert gas can cause asphyxiation. Magnet rooms of very large volumes may represent a lower risk than magnet rooms of small volumes. Never the less, it is suggested that fire fighters should be made fully aware of the asphyxiation hazard, and may choose to wear breathing apparatus when fighting a fire in a magnet room.

Explosions. In a disaster scenario, magnets very close to or enveloped in flames will get (unsurprisingly) very hot; this could cause them to quench and release inert gases extremely rapidly, possibly faster than their pipes and fittings might normally permit. In the worse case, a magnet could become over pressurised and explode violently. It is therefore suggested that if magnets become physically hot in a fire they should be treated in a similar way to hot compressed gas cylinders: hosed down and kept cool.

Fire Doors and Exits. It is recommended that fire doors and exits from magnet rooms should open outwards. In a disaster scenario, should large quantities of gas be vented into the magnet room, the pressure in the room may temporarily rise, making inward-opening doors difficult to open. This could make access difficult for fire fighters, or potentially fatal for anyone still inside the magnet room under such circumstances.

NOTE: Large fires are usually considered very unlikely; all staff should normally be evacuated before a fire becomes fully established in accordance with customers' standard fire procedures or evacuation plans. The information contained within the section on "Large Fires" above is, therefore, likely to be more applicable to professional fire fighters than customers' employees.

MAINTENANCE MANUAL

for

400/54 Active Shielded Premium High Resolution NMR Magnet System

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CONTENTS

SECTION 1

GENERAL SAFETY

1 GENERAL SAFETY: POTENTIAL HAZARDS

1.1 Handling cryogens (liquid helium and liquid nitrogen)

- For reasons of safety, routine maintenance tasks involving the transfer of cryogenic liquids **MUST ONLY** be performed by personnel formally trained to do so.
- Wear safety goggles and loose fitting non-absorbent gloves
- Ensure adequate ventilation and oxygen monitoring of the area consistent with the volume of cryogens being used. If the oxygen level in the room falls below 19.5%, personnel should not enter the area without self-contained breathing apparatus or airline respirators.
- Do not smoke. Liquid oxygen can condense on cold surfaces and thereby cause a fire hazard.
- Never attempt to measure the helium level by "dipping" or "thumping" the helium can, always use the integral level probes in order to gauge the volume of liquid remaining.

1.2 Vacuum Hazards

- Keep cryostat exhaust ports free from blockages (ice, etc.)
- Ensure all safety devices (relief valves and drop-off plate) are maintained in working order.
- Do **NOT** tamper with any vacuum seals or attempt to unscrew vacuum feed-through connections for diagnostics, etc.

1.3 Magnetic Field

- Siting of the magnet must be consistent with local legislation on allowable levels of stray magnetic field.
- People with pacemakers must be excluded from the vicinity of the magnet.
- Keep gas cylinders away from the magnet (outside the 5G (0.5 mT) line).
- Keep all other large ferromagnetic objects away from the magnet. Use steel tools near the magnet only with great care and when non-magnetic alternatives are not available.
- All forms of magnetic storage media should be kept outside the 10G (1 mT) line; this includes credit cards, computer hard disks and floppy disks. Mechanical watches are also at risk.
- Due to the nature of shielded magnets there are very high field gradients in close proximity to the magnet, particularly at the ends of the bore tube, i.e. directly underneath and on top of the magnet.
- In the rare event of a magnet quench it is possible for the magnetic field to momentarily bloom beyond its normal limit, attracting ferromagnetic objects towards the magnet. For this reason we would recommend siting/storing ferromagnetic objects approximately 1 metre clear of the cryostat.

1.4 Air quality

- Maintain adequate ventilation of the room in which the system is sited.
- See **'Handling Cryogens'** (above).

- Oil mist from rotary vane vacuum pumps is a potential health hazard: the exhaust from pumps should be vented outdoors.

1.5 System mechanical stability

- The anti-vibration legs supplied with the system **MUST** be levelled and bolted to the floor using the relevant holes in the base fixing plate. **This needs to be done at the beginning of the magnet installation, before the magnet is energised.**
- Do not stand on the legs hoods at any time, as this will affect the stability of the system. Protective leg hood covers have been fitted to prevent this from happening.

1.6 Further Information

- Further information is provided in the document **"Safety Considerations for the Installation and Operation of Magnet Systems"** provided with this manual.

SECTION 2

GENERAL MAINTENANCE

2 GENERAL MAINTENANCE

Regular maintenance tasks are essential for the efficient and reliable operation of this system. These generally include checking cryogens, making sure the system is leak-tight, and checking that none of the parts become worn or damaged. A routine maintenance schedule is recommended.

2.1 Daily

- Check flow-rates and note cryogen levels to see whether refills are required. Note that flow rates will depend on atmospheric pressure changes if a manostat is not fitted to the system. Average flow rate is achieved over longer periods of time (say 1 week).

2.2 Weekly

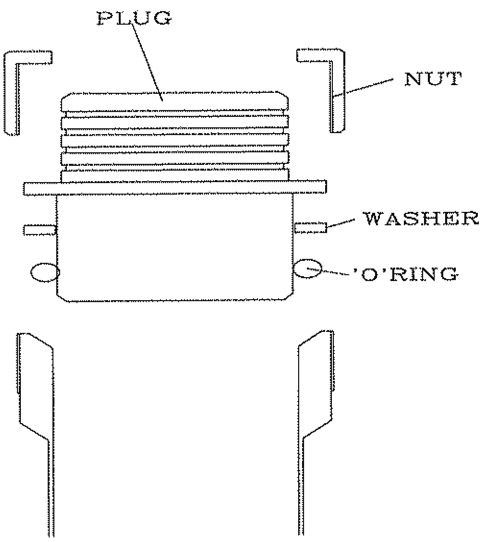
- Check that all safety valves are free and have not iced up.
- Check that all seals are air-tight, especially after a helium top-up.
- Check that the cryogen levels in the log are consistent, i.e. dropping regularly. A false reading can be given if ice develops on the helium probe, and the level will cease to drop. If this is suspected, contact Magnex Scientific Ltd. for advice.

2.3 During/after every nitrogen fill

- Check the O-rings on the heat sink assembly and the nitrogen safety valve (small silver valve) for wear and tear. If they become excessively worn or broken, they will need to be replaced.

2.4 During/after every helium fill

- Check the O-rings on the bung and baffle assembly for wear and tear. If any sign of wear is seen, this O-ring will need to be replaced.
- Check the condition of the baffles. If they become torn or cannot be straightened, then a replacement set should be considered.
- Check the nitrogen vent is clear and is not iced up.
- Check the helium monitor has been reset to the minimum sample rate ("normal")
- Check that the siphon entry fitting is tight (wait for the ice to melt to do this)
- Check that all seals have been correctly made and are leak-tight, i.e. that the O-ring and carrier between the manifold and non-return valve has been correctly tightened with the clamp, and that the bung and baffles have been correctly fitted with compression seals. The correct compression seal arrangement is shown overleaf.



2.5 Cryogen & Service Log

It is good practice to keep a log of cryogen usage and maintenance. An increase in cryogen consumption over a period of time may be the first sign that the vacuum space needs to be re-pumped. A reduction in boil-off could indicate a leak or blockage. In addition, it is useful to calculate the helium transfer efficiency during a helium fill, by comparing the volume of helium used from the dewar, compared to the volume increase in the magnet helium can (75% to 85% is usual). A degradation in helium transfer efficiency can indicate poor vacuum in the transfer siphon, or a damaged siphon.

A suggested layout for a cryogen and service log is shown below:

Date	**Helium**		**Nitrogen**		**Notes/Service Details**
	Level Probe	Quantity used for Refill	Level Probe	Quantity used for Refill	
1/1/11	646	-	2	-	
2/1/11	645	-	2	-	
3/1/11	642	-	1	-	
4/1/11	640	-	1	-	
5/1/11	638	-	1	-	
5/1/11	870	~60 litres	F	~90 litres	*Helium and Nitrogen filled*

2.6 Servicing

If you have any concerns about your system, please contact Magnex Scientific Ltd. for technical advice or to arrange a service visit. A list of contacts is provided at the beginning of this manual.

In order to avoid any difficulties and potential safety issues, only Magnex approved parts should be used on the system.

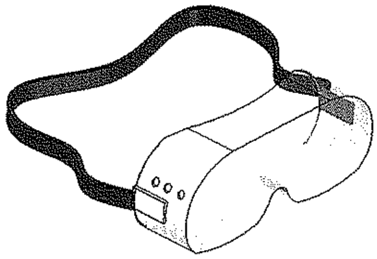
SECTION 3

CRYOGENIC FILLS

3 CRYOGENIC FILLS

3.1 Safety during cryogen fills

- For safety reasons, cryogenic top-ups **MUST ONLY** be performed by personnel formally trained to do so.
- Wear safety goggles and loose fitting non-absorbent gloves



- Ensure adequate ventilation and oxygen monitoring of the area consistent with the volume of cryogens being used. If the oxygen level in the room falls below 19.5%, personnel should not enter the area without self-contained breathing apparatus or airline respirators.
- Do not smoke. Liquid oxygen can condense on cold surfaces and thereby cause a fire hazard.

- Never measure the helium level in the magnet cryostat by "dipping" or "thumping" the helium can.

3.2 How to perform a routine LN2 fill

At no time must the pressure in the nitrogen can exceed 5 psi. Ensure that the transport vessel has suitable pressure control.

It is important to stop the transfer once LN2 is seen to issue from the nitrogen can. It is possible to freeze the OVC o-rings and cause a catastrophic loss of vacuum if the system is left unattended.

The procedure given below assumes that there is some liquid nitrogen left in the nitrogen can. To cool and fill an empty nitrogen can requires additional precautions. Please contact Magnex Scientific if you suspect that the liquid nitrogen has completely run out. Likewise the initial pre-cool of the magnet helium can and nitrogen can is a skilled task and should only be performed by suitably qualified personnel.

The liquid nitrogen reservoir must be refilled regularly and liquid nitrogen should remain in the reservoir at all times. The system needs to be refilled when (or before) the digital nitrogen monitoring system E5035 readout changes from 2 to 1. At this point there is typically 15% nitrogen remaining in the vessel. A nitrogen probe calibration chart and typical refill volumes and intervals are given at the end of this section.

To refill the reservoir, the nitrogen fill cap and the nitrogen transfer line (provided) will be required, as well as a non-magnetic nitrogen storage Dewar of suitable capacity. If the nitrogen Dewar is not of the self-pressurising type, then a regulated non-magnetic cylinder of helium or nitrogen gas will also be needed.

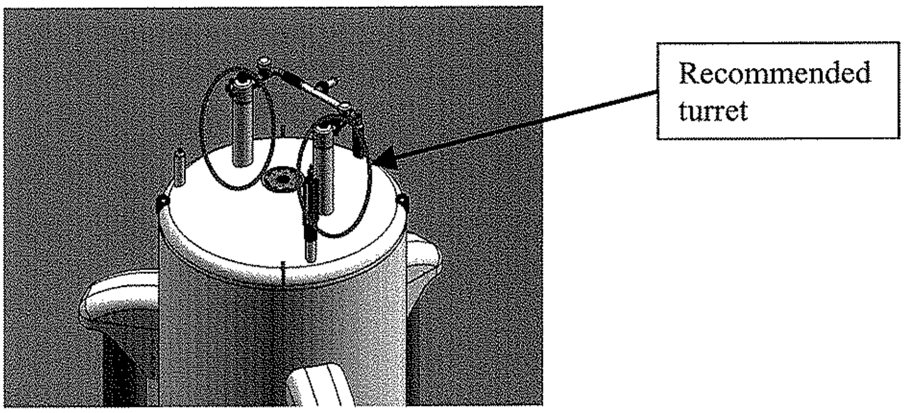
The top-up procedure is very simple. Remove the safety valve (small silver-coloured valve) by loosening the grub screw, and the heat sink assembly from the nitrogen turrets. This will provide two free turrets for the fill. The liquid outlet of the storage Dewar should then be connected to one of these ports via the transfer line and liquid nitrogen can then be transferred using a back-pressure in the storage Dewar of about 6 psig. The transfer should continue until liquid starts to overflow from the free port of the system nitrogen reservoir; this will take about 30 minutes on most systems. After the fill, return the heat sink assembly and the safety valve to the turrets after checking that the O-rings are in good condition. Tighten the grub screw on the safety valve.

Finally, check that the digital nitrogen monitor is reading full. If not, follow the simple instructions for recalibrating the nitrogen probe outlined in the E5035 manual provided.

3.3 <u>How to perform a standard Helium fills (Top-Ups)</u>

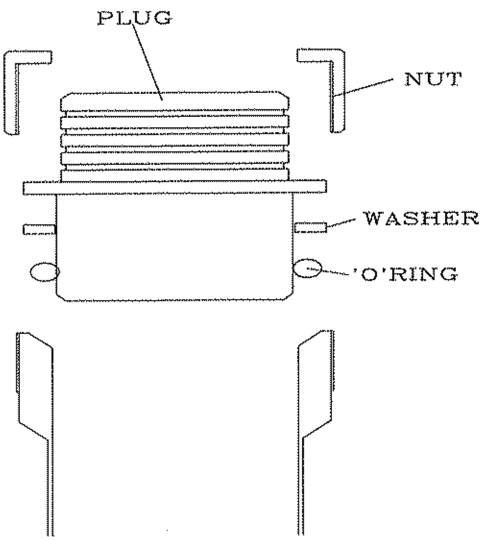
The calibration charts and minimum level for the helium probe(s) are given at the end of this section. A separate Helium level chart has also been provided for your reference to permanently locate near the magnet.

This system has two helium turrets, one with 10-pin seals fitted, the other with none. Our recommendation is to fill from the side without the 10-pin seals, however if this is logistically difficult then top-ups can be carried out from the other side if sufficient care is taken not to damage the electrical wires in the neck.

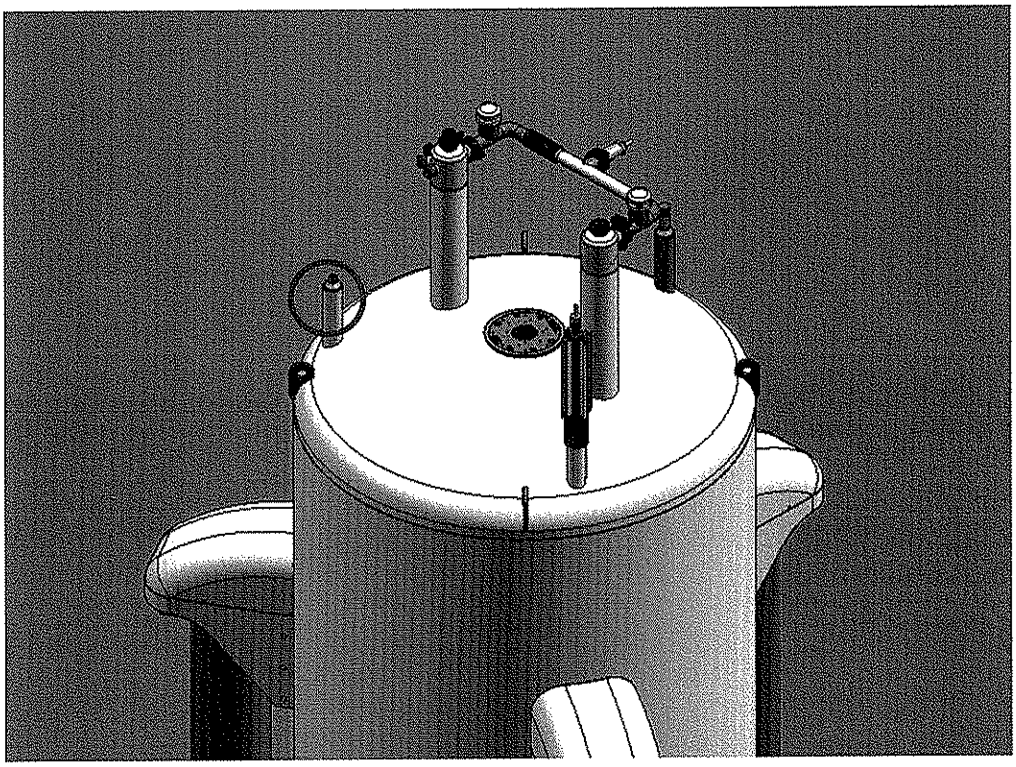


For the helium top-up, the helium siphon, phase separator and the helium fill adapter (all provided) will be required as well as a non-magnetic helium storage Dewar of appropriate capacity.

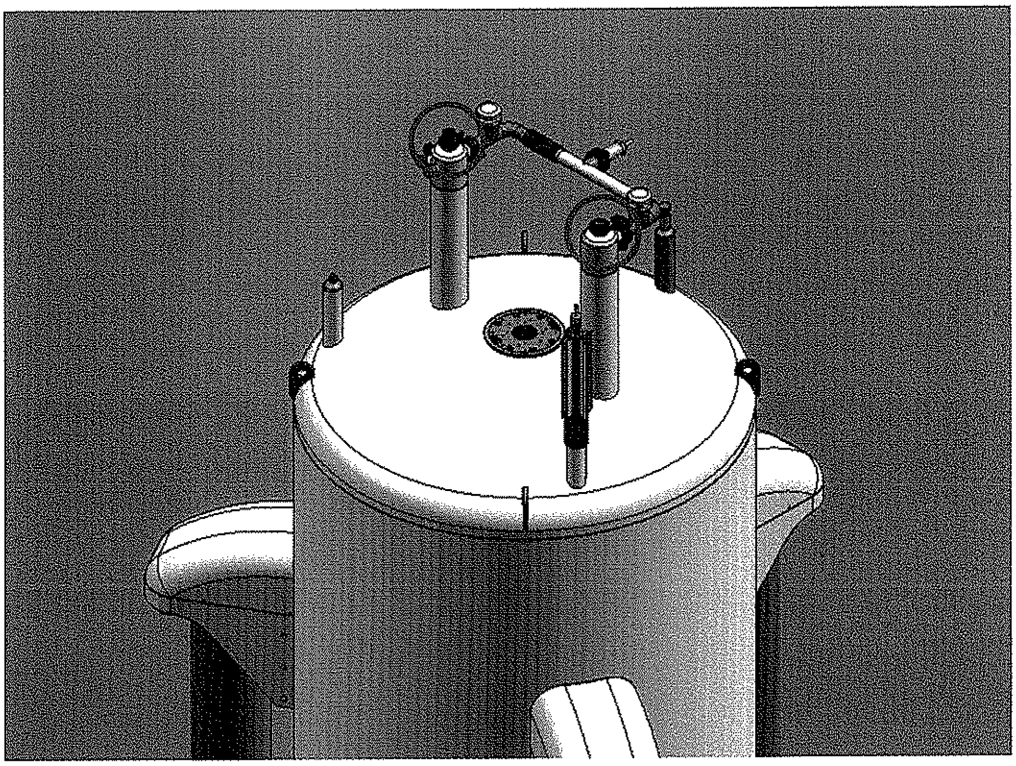
These instructions should be carefully followed to ensure the magnet is topped up quickly, cleanly and efficiently. This should minimise any exposure of the helium can to air, avoid damage to connectors and baffles, help maintain the original helium hold-time and keep the helium can clean and free of ice. It is important that the helium can remains leak tight at all times and therefore the compression seals must be fitted correctly as shown overleaf.



- Determine the amount of liquid helium required to top-up the helium can. The volume can be determined from the helium level chart provided. You should arrange to have enough liquid helium in a **NON-MAGNETIC** storage Dewar available to fill the helium can entirely plus transfer losses (normally transfers are 85% efficient). The liquid level in the helium transfer Dewar (NOT the magnet) can be determined with the "dipstick" or "thumper-tube" provided.
- Make sure all the nitrogen ports are well sealed before starting to helium fill. The liquid nitrogen may become super-cooled due to the thermal linking within the cryostat. . This results in zero boil off, which in turn can allow air to cryo-pump into the nitrogen can, forming air-ice and blocking the exhaust ports, creating a serious safety hazard.



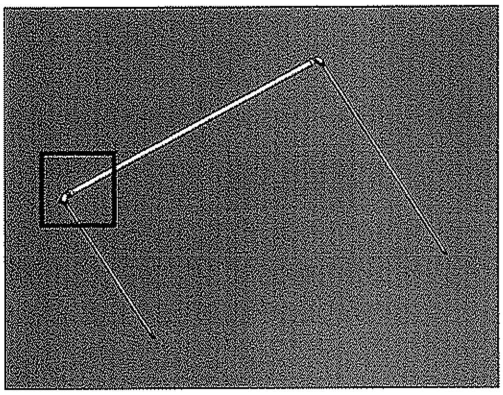
- Check all seals on the helium manifold are correctly fitted and tight before starting.

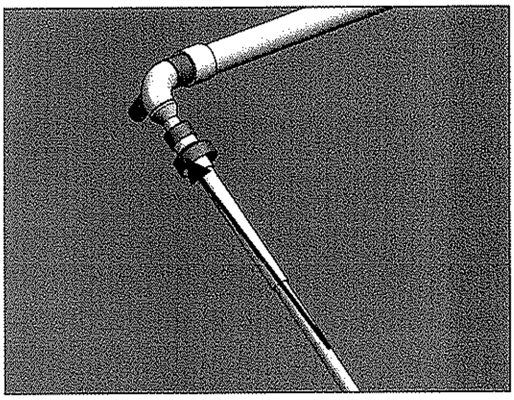


- The helium monitor should be set to read on "Fill".

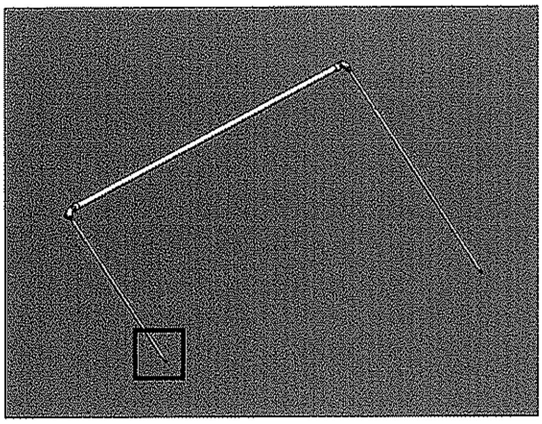
FILL

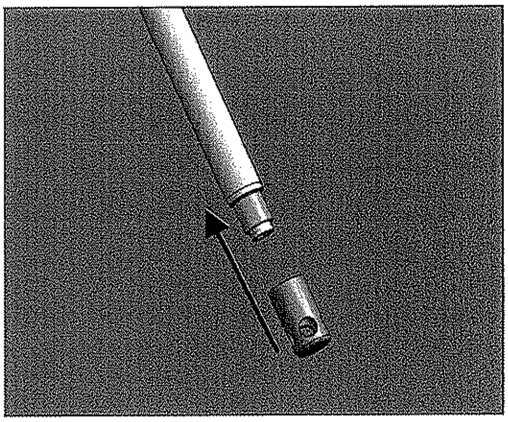
- The adapter and fittings should be fitted to the siphon in advance. Push the knurled compression nut, the brass washer, the o-ring and the special fill adapter (part number AUC330649) in this order, onto the leg of the siphon, which will go into the cryostat. Push them all of the way to the top of the siphon leg (the junction with the right-angled bend).



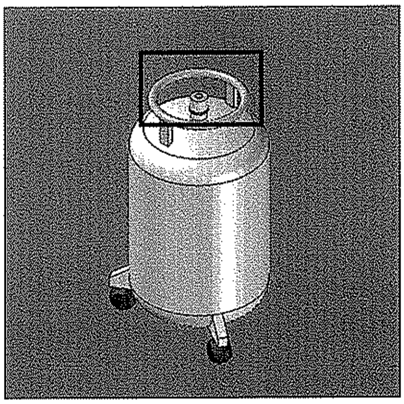


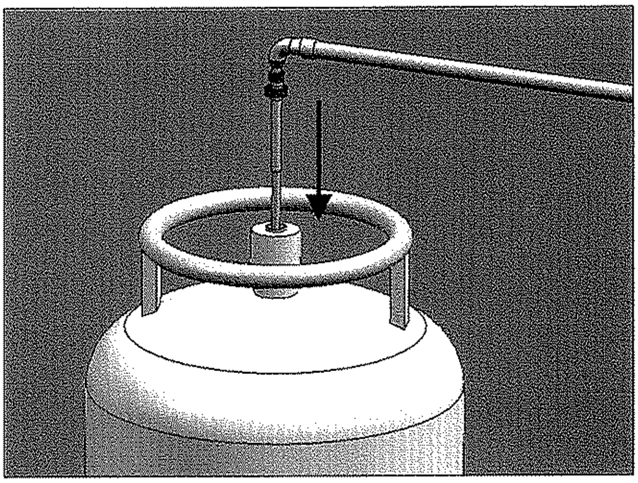
- Fit the phase separator or "deflector tip" (part number DTU400032) to the bottom of the siphon leg to go into the helium can. If required, fit the siphon extension piece to the siphon leg to be inserted into the dewar.

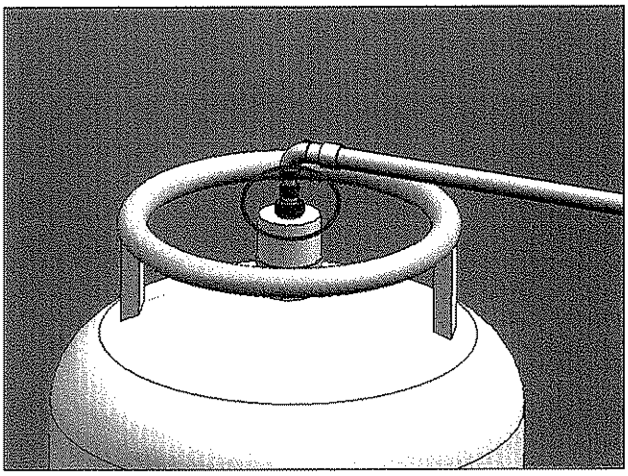




- Loosen the nut on the top hat assembly on the magnet, but do not remove.
- Pre-cool the siphon. Insert the transfer line into the transfer Dewar top seal and then open the top valve. Insert the transfer siphon into the liquid in the Dewar, which will cause the liquid to boil and the pressure to rise. As the siphon cools, the vapour will become denser and more opaque, and eventually the transition will be made from vapour to liquid. This usually takes a couple of minutes. The liquid will vapourise immediately on contact with air. If during this process the transfer line develops frost or is cold to touch, then the transfer siphon may have insufficient vacuum or may be damaged. If this is suspected, then stop the helium fill until the problem with the transfer siphon has been resolved. If there is insufficient vacuum in the transfer siphon, then it can be pumped down using a vacuum pump connected to the siphon using a siphon pump out tool (part number P222000008, available from Magnex Scientific Ltd.). If the siphon is damaged and has a touch, then a replacement may be required.

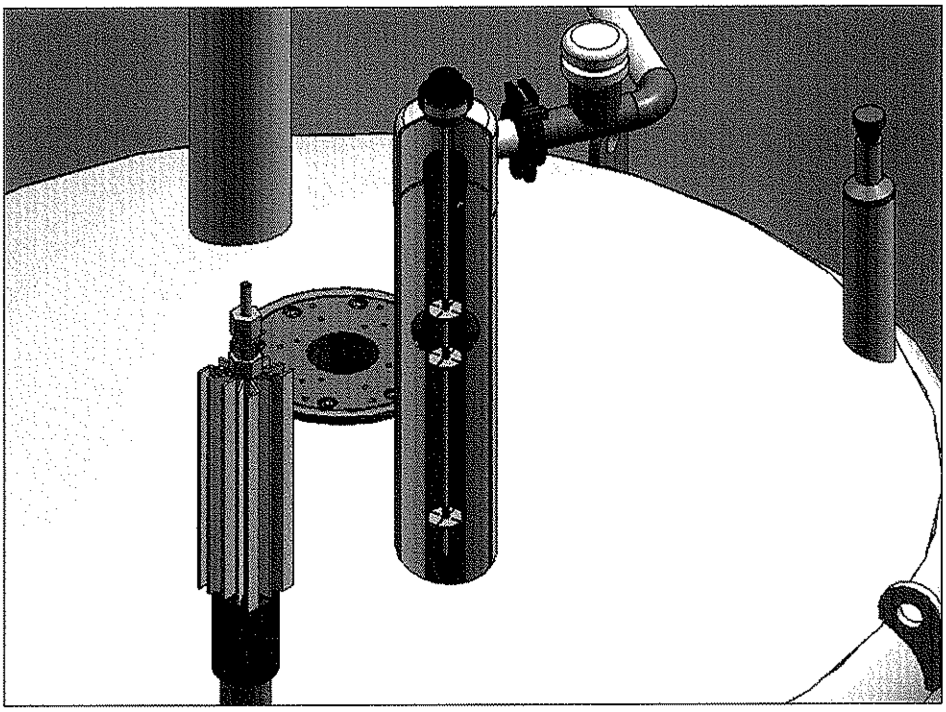


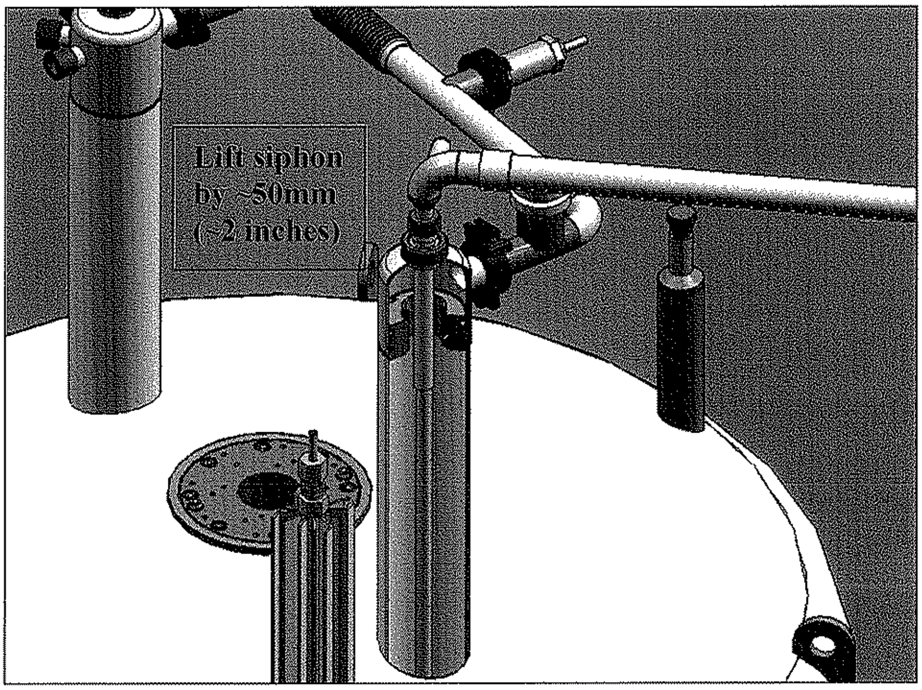




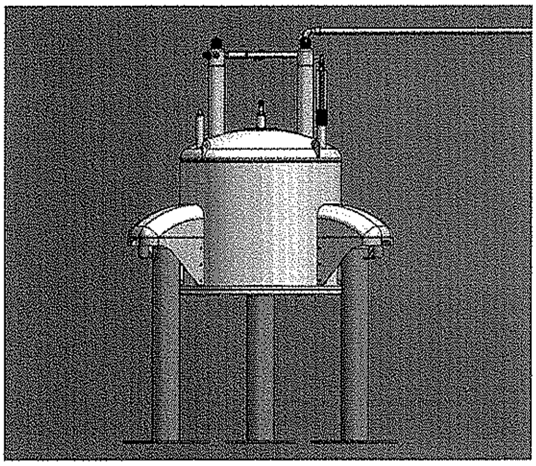
Failure to pre-cool the siphon may quench the magnet as the warm siphon is inserted into the helium can. If the siphon is suspected to be soft or have a touch, do not insert into the helium can, as this may also cause the magnet to quench.

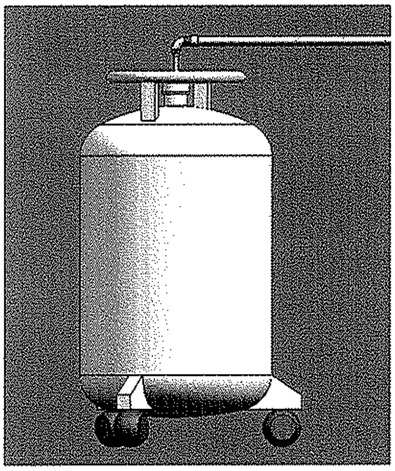
- After the siphon pre-cool is complete and helium liquid is issuing from the phase separator, remove the helium non-return valve from the manifold, remove the fill side bung and baffle assembly, and insert the siphon and adapter assembly, screwing down the nut to ensure a good compression seal.



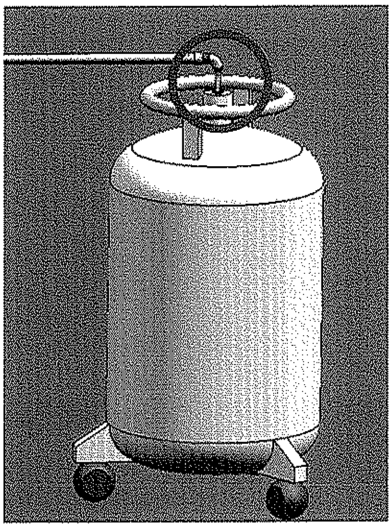


- The siphon should be gently pushed into the helium can until it is felt to touch a barrier (connector) and then needs to be withdrawn about 50 mm (~2 inches).
- Continually monitor the helium level to ensure the fill is progressing well.

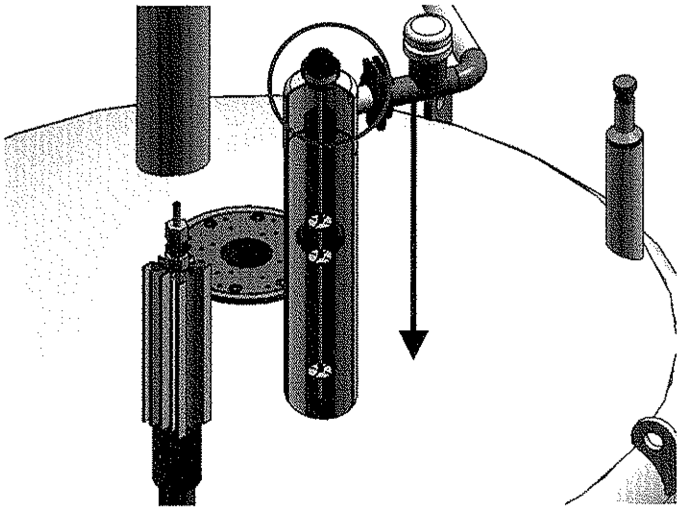


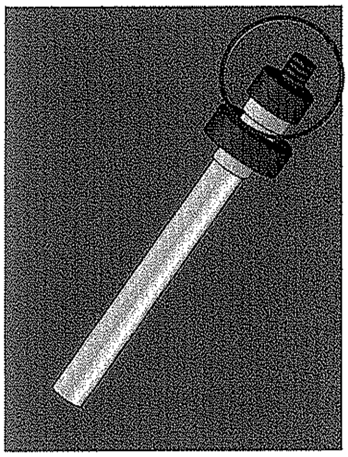


- When full, take the pressure off the transfer Dewar to stop the transfer.

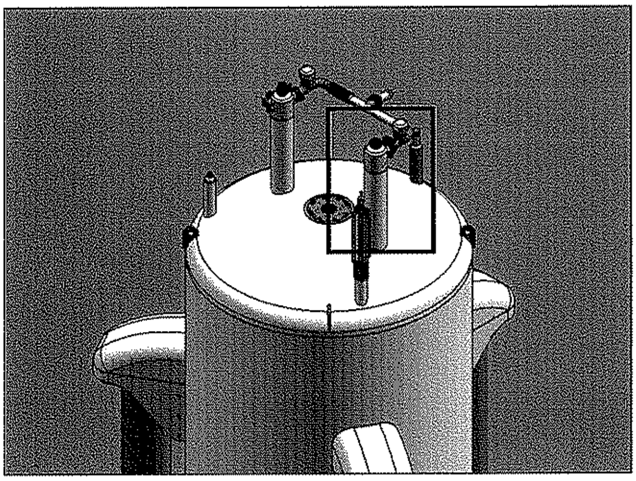


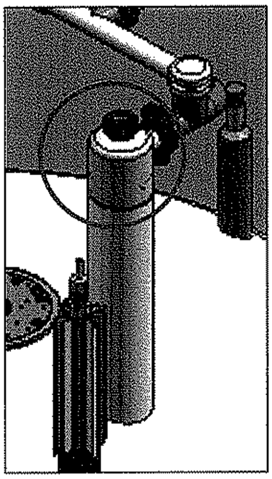
- Inspect the bung and baffle assembly for damage and ensure that it is warm and dry (no water droplets) before re-fitting. Remove the siphon and adapter, and replace the bung and baffle assembly, tightening the nut to form a good compression seal. If the baffles appear to be getting damaged such that they are broken or cannot be re-straightened, then a replacement set should be considered, and can be ordered using the parts order form in Section 4. The use of significantly damaged baffles (or omitting the baffles completely) will result in reduced performance of the system.





- Remember to change the helium probe reading back to "normal" again.
- Once the turret and top-hat assembly has warmed up after the fill, re-check the O-ring seal and re-tighten if necessary.





Owing to the excellent cryogenic efficiency of the cryostat in normal operation it is quite common for the helium and/or nitrogen boil-off to fall to zero immediately after a transfer or after magnet energisation. There is then a serious risk of air entering the helium and/or nitrogen reservoir. However, if the procedures detailed above are followed correctly any associated problems can be avoided.

OPERATING INSTRUCTIONS AND SPECIFICATIONS

for

Magnex Model E5011 Liquid Helium Level Monitor

Prepared : July 2004

Issue : J

Document : E5011MAN

Magnex Scientific Limited
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Oxford Industrial Park
Yarnton, Oxford OX5 1QU, UK

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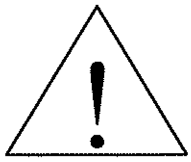
CONTENTS

1. SAFETY



Caution, refer to accompanying documents

1. WARNING - Isolate or disconnect equipment from mains supply before opening this unit for any reason. LIVE PARTS INSIDE.

2. WARNING – This equipment must be connected to an earthed mains supply. For continued protection against risk of fire or electric shock, replace fuses with the same type, rating and UL listing.

3. CAUTION - This unit contains internal protection fuses. Follow the guidelines in Trouble- shooting section before replacement of these devices. Only suitably trained personnel are permitted to remove covers on the equipment.

4. CAUTION - This unit has been pre-set to a voltage range suitable for the national supply. The unit has a selectable input voltage, 100V~ ; 120V~; 220V~ ; 240V~ or 115V~; 230V~. Fuses F1 and F2 must be rated to suit the input voltage, if selected to 100V~, 115V~, or 120V~. they must be rated at T250mA 250V. If selected to 220V~, 230V~, or 240V~. they must be rated at T100mA 250V.

   To select the mains supply voltage or replace mains fuses, prise open the flap on the mains input socket using a suitable tool in the slot provided. This affords access to the voltage select drum and two fuse trays.

   To select the supply voltage pull out the drum and rotate until the appropriate lettering is uppermost, ie. in line with the drum slots, and replace. When the socket flap is replaced the correct voltage must be visible through the window.

   To replace the input fuse, pull out the fuse trays and replace with the correct value of fuse. Re-insert the fuse trays, noting the correct orientation of the arrows.

5. This equipment is not suitable, and must not be used in areas with flammable mixtures.

2. IMPORTANT NOTICE

Please inspect goods immediately on arrival for possible transit damage and notify Magnex Scientific Limited within 3 days of receipt of goods.

Failure to do this will invalidate any possible claim.

DISCLAIMER

Every precaution has been taken in the preparation of this publication. Magnex Scientific Limited assumes no responsibility for errors or omissions. Neither is any liability assumed for damages resulting from the use of the information contained herein.

User serviceable spare parts are available upon request from :-

Magnex Scientific Limited
The Magnet Technology Centre
6 Mead Road
Oxford Industrial Park
Yarnton
Oxon OX5 1QU, UK

FCC NOTICE

Federal communications commission statement on Class A.

This unit has been tested and found to comply with the limits for a Class A digital device, pursuant to part is of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the unit is operated in a commercial, industrial or business environment.

Operating is subject to the following two conditions:

1) The unit may not cause harmful interference.

2) This device must accept any interference received, including interference that may cause undesired operation.

Note that FCC regulations provide that changes or modifications not expressly approved by Magnex Scientific Ltd could void your authority to operate this equipment.

CE NOTICE

Marking by the symbol CE indicates compliance of this device to the EMC (electromagnetic compatibility) and LV (low voltage) directives of the European Community. This unit is to be installed and operated as detailed. Any modification or maintenance procedure undertaken which is not approved by Magnex Scientific Ltd could nullify the CE marking of this product and lead to prosecution. A 'declaration of conformity' in accordance with the above directives has been made and is located at Magnex Scientific, Yarnton, Oxfordshire, UK.

3. DESCRIPTION AND OPERATING PRINCIPLE

Magnex Model E5011 Liquid Helium Level Monitor

Features

* Direct digital display of liquid helium level in mm.
* Variable interval sample and hold facility fill/normal.
* Adjustable low level alarm facility with visual and change-over relay output.
* Modular design.

Description

The model E5011 Monitor has been designed to operate with a superconducting level probe and provides a sampled digital display of liquid helium levels in cryogenic vessels. By the use of an adjustable interval sample and hold facility liquid helium consumption during operation is minimised. The instrument also incorporates an adjustable low level alarm facility with both visual and electrical outputs and can be offered for use with a range of superconducting level probes.

Operating Principle

The helium level probe consists of a length of superconducting wire with a heater wound around the top. A constant current is passed through the heater and probe wires. The heater maintains that part of the probe that is above the liquid level at a temperature above its critical temperature for super- conductivity. The part of the probe above the liquid therefore has resistance, the part immersed has none. A voltage signal is available from the probe which is proportional to the length of the probe not immersed in the liquid. This voltage is subtracted from a reference voltage and applied to a linear measuring circuit which drives a digital panel meter.

Heating the probe causes the liquid to boil, therefore to minimise this effect the helium level is read at intervals and ‘held’ on the display. The sample interval is derived and controlled by a timer and logic circuits, which allows current to flow into the probe heater until the temperature of the probe above the liquid helium level reaches a steady condition. A low level alarm system is driven from the measuring circuits.

4. SPECIFICATIONS

Magnex Model E5011 Liquid Helium Level Monitor

Output display		:	3 ½ digit L.C.D. scale in mm
Instant up-dating facility		:	Via front panel push button
Sample and hold interval	normal	:	7 hours (+/- 20%)
	fill	:	10 seconds (+/- 20%)
Interval selection		:	Via front panel switch
Maximum number of probes		:	2
Probe selection		:	Via front panel switch
Low level alarm indicator		:	Via flashing LED display
Low level alarm output		:	Relay change-over contacts Maximum switched voltage 30V dc Maximum switched current 1 A dc (mains failure will indicate an alarm condition)
Low level alarm adjustment		:	Via front panel multiturn preset. Span 0-95% of total length (factory set to 50%)
Mains input voltage		:	110/220V ~ selectable
Mains input current		:	80mA @ 220V ~ 170mA @ 110V ~
Mains input frequency		:	50/60 Hz
Fuse rating		:	F1, F2 T100mA 250V for 220V supply OR T250mA 250V for 110V supply F3 T800mA 250V F5 T200mA 250V

Environmental conditions

The equipment is designed to be safe under the following conditions:

Ambient temperature range	:	10°C to 40°C
Relative humidity range	:	30% to 95% non-condensing
Atmospheric pressure	:	700 hPA to 1060hPA

Dimensions :

Height	:	128mm (3U)
Width	:	106mm (21E)
Depth	:	220mm Plug in unit or stand alone

Probe Input Connector : 9 way 'D' socket
Connector details :

1	Probe 1	V +
2	Probe 1	I +
3	Probe 1	V -
4	Probe 1	I -
5	N/C	
6	Probe 2	V +
7	Probe 2	I +
8	Probe 2	V -
9	Probe 2	I -

<u>Liquid Helium Probe</u>

Probe resistance : 0.2-0.05Ω/mm

The probe wire resistance varies from batch to batch. If the exact probe resistance is required please contact Magnex Scientific Limited with the probe serial number.

Excitation current : 80-245mA dependent upon probe wire resistance

Probe length : 100mm to 2000mm

Probe output connector : 10 way SIL plug

E5011 MONITOR CABLE
C0025AXXX.X

9D Plug	Colour	10- Pin Socket
1	Brown	A
2	Red	B
3	Yellow	C
4	Green	D
5	N/C	N/C
6	Blue	E
7	Violet	F
8	White	H
9	Black	J

9d Plug	Colour	10 Pin Socket
1	Red	A
2	Blue	B
3	Green	D
4	Yellow	E
5	N/C	N/C
6	N/C	N/C
7	N/C	N/C
8	N/C	N/C
9	N/C	N/C

5. CALIBRATION

The instrument is normally supplied pre-calibrated to a particular probe before leaving the factory. If recalibration is required it must be carried out using a test unit to simulate the probe, the circuit of which is (Figure 1) shown on page 9.

Equipment Required

- Multimeter
- Helium monitor calibration unit
- Insulated adjustment tool

Method

Connect the calibration unit to the helium monitor via the 9 'D' PROBE plug at the rear of the helium monitor.

Calculate the resistance for the active length of the helium probe for which calibration is required and set the variable potentiometer on the calibration unit to this resistance.

Set the monitor READ time to NORMAL.

The probe current (as listed in 'Specifications' section or advised by Magnex) is set by adjusting the rear panel potentiometer PROBE CURRENT or on earlier models potentiometer VR1 on the power supply PCB. The probe current is measured as a voltage across the 10Ω HEATER resistor on the calibration unit (hold the READ button in when adjusting probe current).

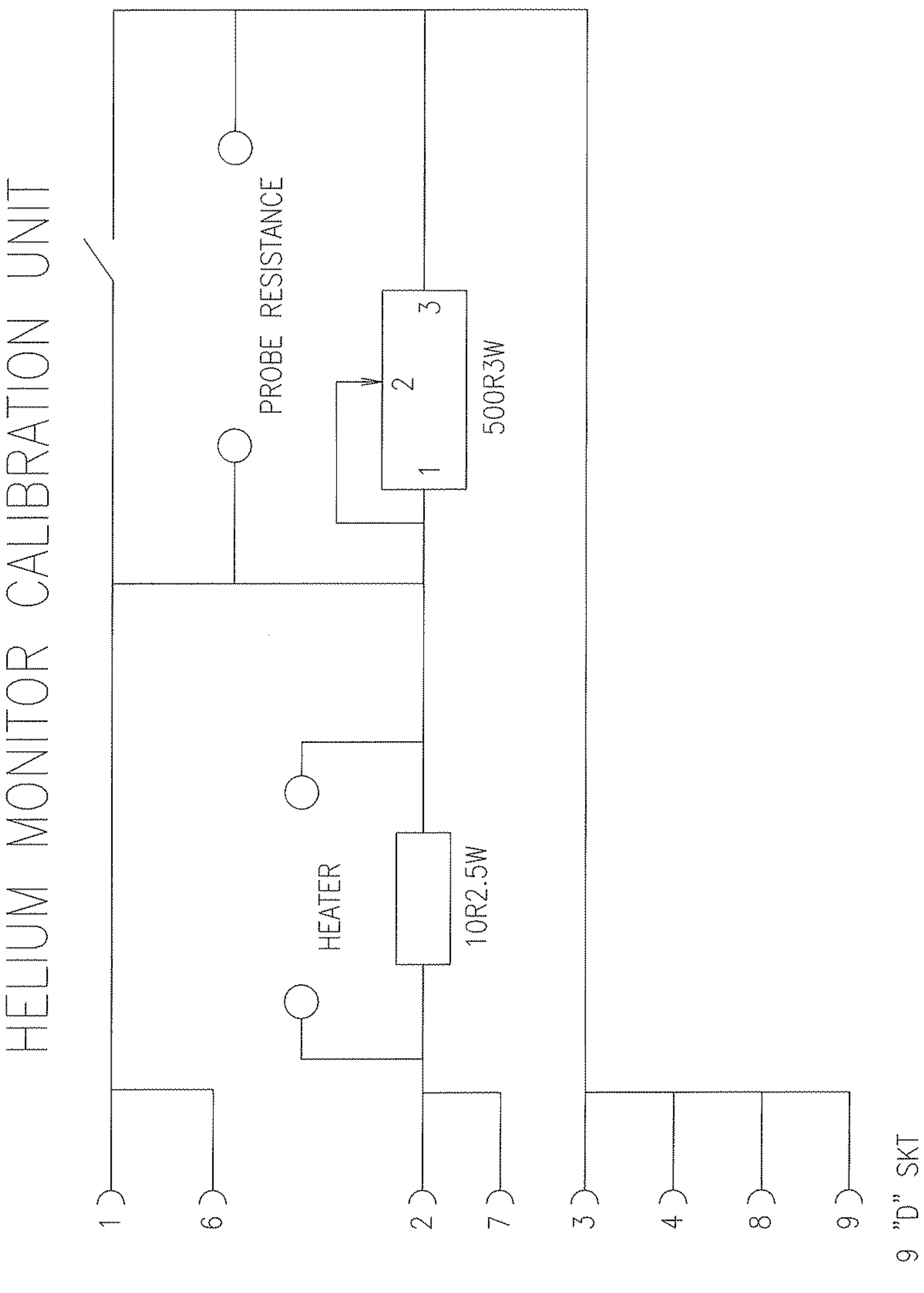
CAUTION : MIS-ADJUSTMENT OF THE PROBE CURRENT CAN UPSET THE OPERATION OF THE INSTRUMENT AND CAUSE SPURIOUS READINGS

To select the required probe operate the front panel switch marked PROBE 1-2.

The helium monitor digital panel meter (DPM) is set to read zero with the calculated resistance set on the calibration unit. Place the calibration unit PROBE switch to the RESISTANCE position. Adjust the appropriate rear panel mounted PROBE ZERO potentiometer until the DPM reads zero (hold the READ button in when adjusting for zero).

Place the calibration unit PROBE switch to the S/C position and adjust the rear panel mounted DPM SPAN potentiometer until the DPM reads the active length of the helium probe (hold the READ button in when adjusting for the active length).

FIGURE 1


HELIUM MONITOR CALIBRATION UNIT
PROBE RESISTANCE
1
2
3
500R3W
HEATER
10R2.5W
1
6
2
7
3
4
8
9
9 "D" SKT

6. SETTING THE LOW LEVEL ALARM

The helium monitor alarm level can be set by pressing the DISPLAY button and changing the ADJUST potentiometer until the DPM reads the desired level (hold the DISPLAY button in when adjusting for the alarm level). Once the alarm level has been set, press the READ button to display the current probe level.

An alarm state is indicated by the flashing ALARM LED on the front panel and the operation of the rear panel alarm relay contacts, which allow the inclusion of additional external alarm indicators. During normal operation contacts 1 & 2 will be connected and 2 & 3 open circuit.

During alarm conditions contacts 2 & 3 will be connected and 1 & 2 open circuit.

7. TROUBLE-SHOOTING

For loss of continuity in the probe circuit the front panel display can give an indication of the problem.

Display	**Possible Fault**
No LCD display No POWER LED	Loss of F1, F2 (rear panel mounted) or F3 (PCB mounted) *
ALARM LED flashes. Display reads 'Full'. READ LED does not operate	Loss of I+ / I- connection or F5 (PCB mounted)*
The READ LED operates normally and the ALARM LED remains off. The level reads full continuously	Loss of V+ connection
The READ LED comes on continuously. ALARM LED remains at the last reading shown	Loss of V- connection

For any of the above symptoms first check that proper connection is made to the instrument and to the probe or cryostat.

If these tests do not prove to be the cause of the problem then check the continuity and resistances of all combinations at the cryostat connector. Refer to the cryostat manual for the wiring diagrams.

* To change PCB mounted fuses

1. Remove mains supply lead.
2. Remove unit top cover.
3. Locate fuse (refer to pcb layout).
4. Remove fuse installation cover, remove 'blown' fuse and replace with fuse of correct ratings.
5. Replace fuse installation cover and unit top cover.

Nitrogen probe calibration chart

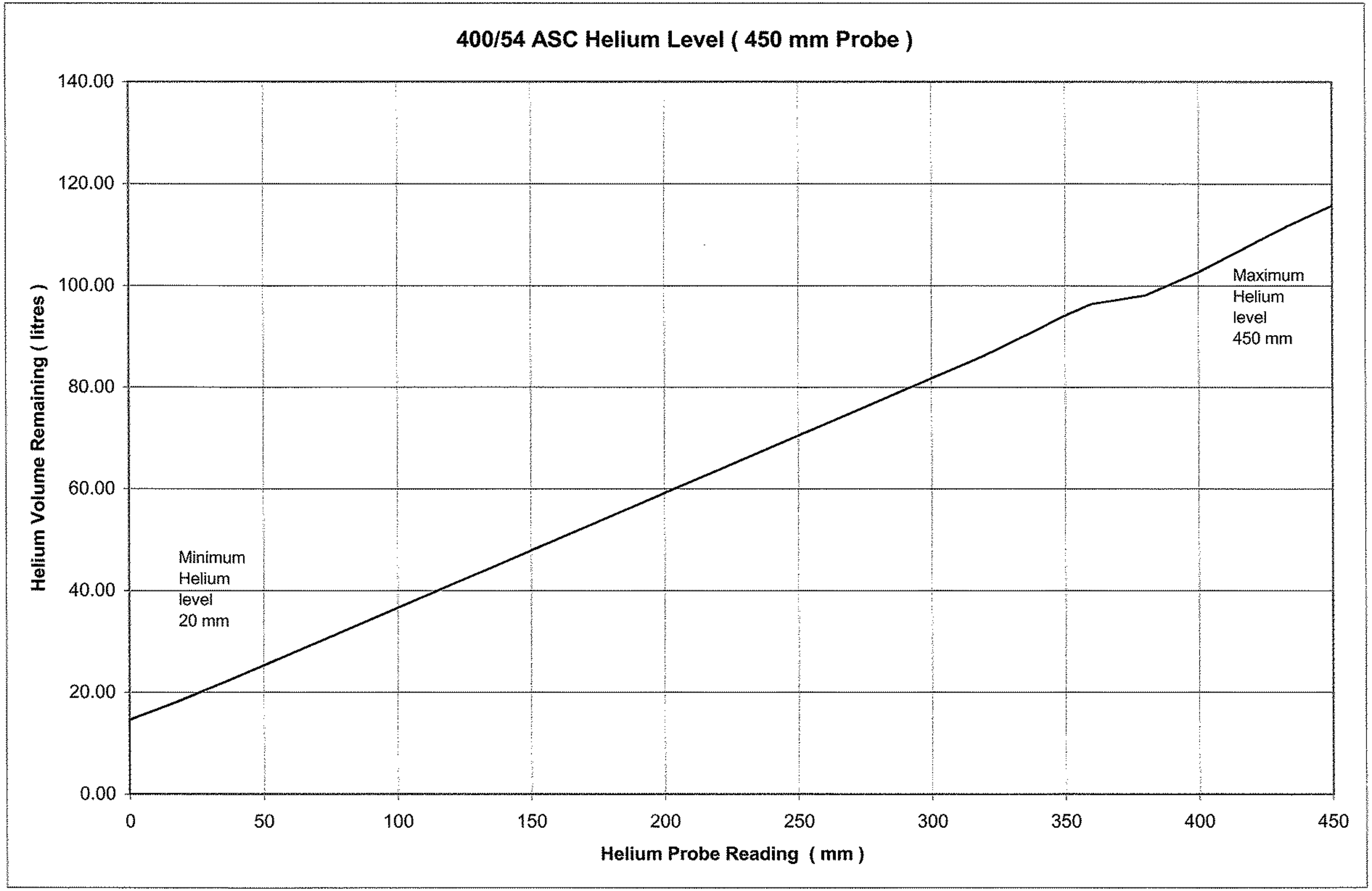
System should be refilled when digital reading changes from 2 to 1.
Maximum refill volume is 51 litres.
Minimum hold time is 14 days

Nitrogen probe	Height on probe	Height range for nitrogen probe reading (mm)		Volume range remaining (l)	
digital readout	(mm)	min	max	min.	max.
0	0	0	30	0.0	2.7
1	61	30	91	2.7	8.2
2	121	91	152	8.2	13.7
3	182	152	212	13.7	19.2
4	242	212	273	19.2	24.6
5	303	273	333	24.6	30.1
6	364	333	394	30.1	35.6
7	424	394	455	35.6	41.1
8	485	455	515	41.1	46.5
9	545	515	576	46.5	52.0
F	606	576	606	52.0	54.7

Helium probe calibration chart

Probe reading (mm)	He level in can (mm)	Volume remaining (l)		
			active length =	450mm
0	0	0.00	bottom of helium can	
0	4	0.47		
0	24	2.56		
0	44	6.53		
0	64	10.56		
0	84	14.58		
20	104	18.61	normal refill level	
40	124	22.98		
60	144	27.50		
80	164	32.02		
100	184	36.53		
120	204	41.05		
140	224	45.57		
160	244	50.09		
180	264	54.61		
200	284	59.13		
220	304	63.64		
240	324	68.16		
260	344	72.68		
280	364	77.20		
300	384	81.72		
320	404	86.24		
340	424	91.39		
348	432	93.56	min level energising / shimming	
360	444	96.38		
380	464	98.07		
400	484	102.67		
420	504	108.10		
433	517	111.63	Maximum Helium level	
450	534	115.70		
450	535	115.83	top of Helium can	

Maximum refill volume is 95 litres (excluding transfer losses)
Minimum hold time is 270 days


400/54 ASC Helium Level (450 mm Probe)
Helium Volume Remaining (litres)
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
50
100
150
200
250
300
350
400
450
Helium Probe Reading (mm)
Minimum Helium level 20 mm
Maximum Helium level 450 mm

SECTION 4

PARTS LIST AND ORDER FORMS

4 PARTS LIST & ORDER FORM

The following lists give part numbers for replacement parts for use with this magnet. The format is such that the forms can be photocopied and faxed or sent to the Sales Department at Magnex Scientific Ltd for quotation. The parts listed are the general consumables and ancillaries required for normal operation. Please contact the service department for any other parts required.

Please remember to copy **both** the order form and the contact details and send them through to the Sales Department.

Magnex Scientific Limited

Tel: (+44) 1865 853800
Fax: (+44) 1865 842466
E-mail: sales@magnex.com

MRCA 400/54 "Active Shielded Premium" Parts Quotation Request

Part	Description	Quantity required
P171042115	Fluorosilicone O-ring for helium relief valve cap	
P170OR2056	O-ring for 10-pin seals in top-hat	
P171064530	O-rings for connecting top-hats to helium turret	
P170OR3100	O-ring for bung (with baffles) O-ring for helium fill adapter (seal body assembly)	
DUC400007	Seal nut 25.4mm for P170OR3100	
P208000012	O-ring/centring ring for KF25 flanges	
P208000002	Aluminium KF25 clamp for P208000012	
P170OR3050	O-ring for siphon entry of helium fill adapter	
DUC400015 DUC400014	Seal nut and washer for P170OR3050	
P171037624	O-ring for heat-sink assembly (nitrogen port ice preventor) O-ring for nitrogen turret filling cap assembly	
P170OR2050	O-ring for nitrogen safety valve (silver valve)	
ANC331172	Bung and baffle assembly	
AUC330649	Helium fill adapter (seal body assembly)	
AUC500207	Helium non-return valve	
P222000072	Helium transfer siphon (and extension tube)	
DTU400032	Phase separator	
P222000008	Helium siphon pump-out tool	
P222000075	2 part thumper tube (dipstick) - for use in fill Dewar only	
ANC327909	Nitrogen turret filling cap assembly	
ATU327906	5m Nitrogen transfer line – flare fitting	
AUC500209	Nitrogen safety valve (small silver valve)	
ANC300397	Nitrogen port ice preventor (heat-sink) with non-return valve fitted	
C0025085	Cable for double helium probe	
C0443120	Cable for E5035 data/power	
C0444010	Cable, power supply unit E5035	
AKZ50000014	Fuse spares kit	

Magnex Scientific Limited

Tel: (+44) 1865 853800
Fax: (+44) 1865 842466
E-mail: sales@magnex.com

MRCA 400/54 "Active Shielded Premium" Parts Quotation Request

Magnet Serial Number ______________________________

(see serial number plate on cryostat, or system manual)

Name: ______________________________

Site: ______________________________

Contact Address: ______________________________

____

____

____

Telephone number: ______________________________

Fax number: ______________________________

Email address: ______________________________

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REFERENCE MANUAL

for

400/54 Active Shielded Premium High Resolution NMR Magnet System

Prepared : September 2006

Document : TS1468refV01.doc

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CONTENTS

SECTION 1

GENERAL SAFETY

1 GENERAL SAFETY: POTENTIAL HAZARDS

1.1 Handling cryogens (liquid helium and liquid nitrogen)

- For reasons of safety, routine maintenance tasks involving the transfer of cryogenic liquids **MUST ONLY** be performed by personnel formally trained to do so.
- Wear safety goggles and loose fitting non-absorbent gloves
- Ensure adequate ventilation and oxygen monitoring of the area consistent with the volume of cryogens being used. If the oxygen level in the room falls below 19.5%, personnel should not enter the area without self-contained breathing apparatus or airline respirators.
- Do not smoke. Liquid oxygen can condense on cold surfaces and thereby cause a fire hazard.
- Never attempt to measure the helium level by "dipping" or "thumping" the helium can, always use the integral level probes in order to gauge the volume of liquid remaining.

1.2 Vacuum Hazards

- Keep cryostat exhaust ports free from blockages (ice, etc.)
- Ensure all safety devices (relief valves and drop-off plate) are maintained in working order.
- Do **NOT** tamper with any vacuum seals or attempt to unscrew vacuum feed-through connections for diagnostics, etc.

1.3 Magnetic Field

- Siting of the magnet must be consistent with local legislation on allowable levels of stray magnetic field.
- People with pacemakers must be excluded from the vicinity of the magnet.
- Keep gas cylinders away from the magnet (outside the 5G (0.5 mT) line).
- Keep all other large ferromagnetic objects away from the magnet. Use steel tools near the magnet only with great care and when non-magnetic alternatives are not available.
- All forms of magnetic storage media should be kept outside the 10G (1 mT) line; this includes credit cards, computer hard disks and floppy disks. Mechanical watches are also at risk.
- Due to the nature of shielded magnets there are very high field gradients in close proximity to the magnet, particularly at the ends of the bore tube, i.e. directly underneath and on top of the magnet.
- In the rare event of a magnet quench it is possible for the magnetic field to momentarily bloom beyond its normal limit, attracting ferromagnetic objects towards the magnet. For this reason we would recommend siting/storing ferromagnetic objects approximately 1 metre clear of the cryostat.

1.4 Air Quality

- Maintain adequate ventilation of the room in which the system is sited.
- See **'Handling Cryogens'**.

- Oil mist from rotary vane vacuum pumps is a potential health hazard: the exhaust from pumps should be vented outdoors.

1.5 System Mechanical Stability

- The anti-vibration legs supplied with the system MUST be levelled and bolted to the floor using the relevant holes in the base fixing plate. This is the responsibility of the customer, and needs to be done before the magnet is energised
- Do not stand on the legs hoods at any time, as this will affect the stability of the system. Protective leg hood covers have been fitted to prevent this from happening.

1.6 Further Information

- Further information is provided in the document **"Safety Considerations for the Installation and Operation of Magnet Systems"** provided with this manual.

SECTION 2

COMMISSIONING & DECOMMISSIONING OF THE MAGNET

2 COMMISSIONING & DE-COMMISSIONING OF THE MAGNET

Under no circumstances attempt to take the system out of the crate or de-transit the magnet since this is a skilled task to be performed only by suitably trained personnel both for reasons of safety and to avoid damage to the internal fixtures in the cryostat.

2.1 Storing Transit Fixtures

Once the system has been de-transited, the transit fixtures must be safely stored for future usage. If the magnet is moved, these will be required to ensure no damage is caused during transportation. Transit bungs can be individually machined to fit each system and are not easily replaced if lost. See the table below for a list of all of these transit features. Space is provided in this table to record briefly the storage location of each item for future reference.

Transit feature	Part number	Quantity	Storage location
Transit bung	DNC119812	3	
Blanking plate	DNC318628	1	
O-ring	P171126030	3	
Screws and washers etc	-	-	

2.2 De-commissioning of the magnet

If the magnet needs to be moved or shipped, this should be carried out by suitably trained personnel. The system may become damaged if the system does not have all the transits correctly fitted, or if it is packed or shipped incorrectly. Magnex Scientific Ltd. offer a service for de-commissioning and re-commissioning magnets and should be contacted for details.

SECTION 3

TECHNICAL SPECIFICATION

3 TECHNICAL SPECIFICATION

Technical Specification Document:	TS1468DV01
Customer Interface Drawing:	CNZ331842D

3.1 Dimensions and specifications

Length of bore of cryostat:	839±3mm
Height of system without legs:	1288mm
Floor to base of bottom plate:	762mm
Height including legs:	2050mm
Diameter of cryostat (excl. flange):	810mm
Max. diameter of cryostat (incl. flange):	860mm
Room temperature clear bore (without shims):	54mm minimum along length
Room temperature bore-tube material:	Brass
Centre of field to base of bottom plate:	320±3mm
Hook height requirement SWOBTR (bung transportable):*	Lift from below

Minimum ceiling heights with 762mm system height from floor:

For standard demountable current leads	2936mm
For standard helium siphon	2886mm
Using special low-ceiling height service leads and split siphon:	2610mm (approx.)

System weights

Magnet in cryostat:	450kg
Cryogens (when full):	100kg (approx.)
Anti-vibration legs:	270kg (approx.)

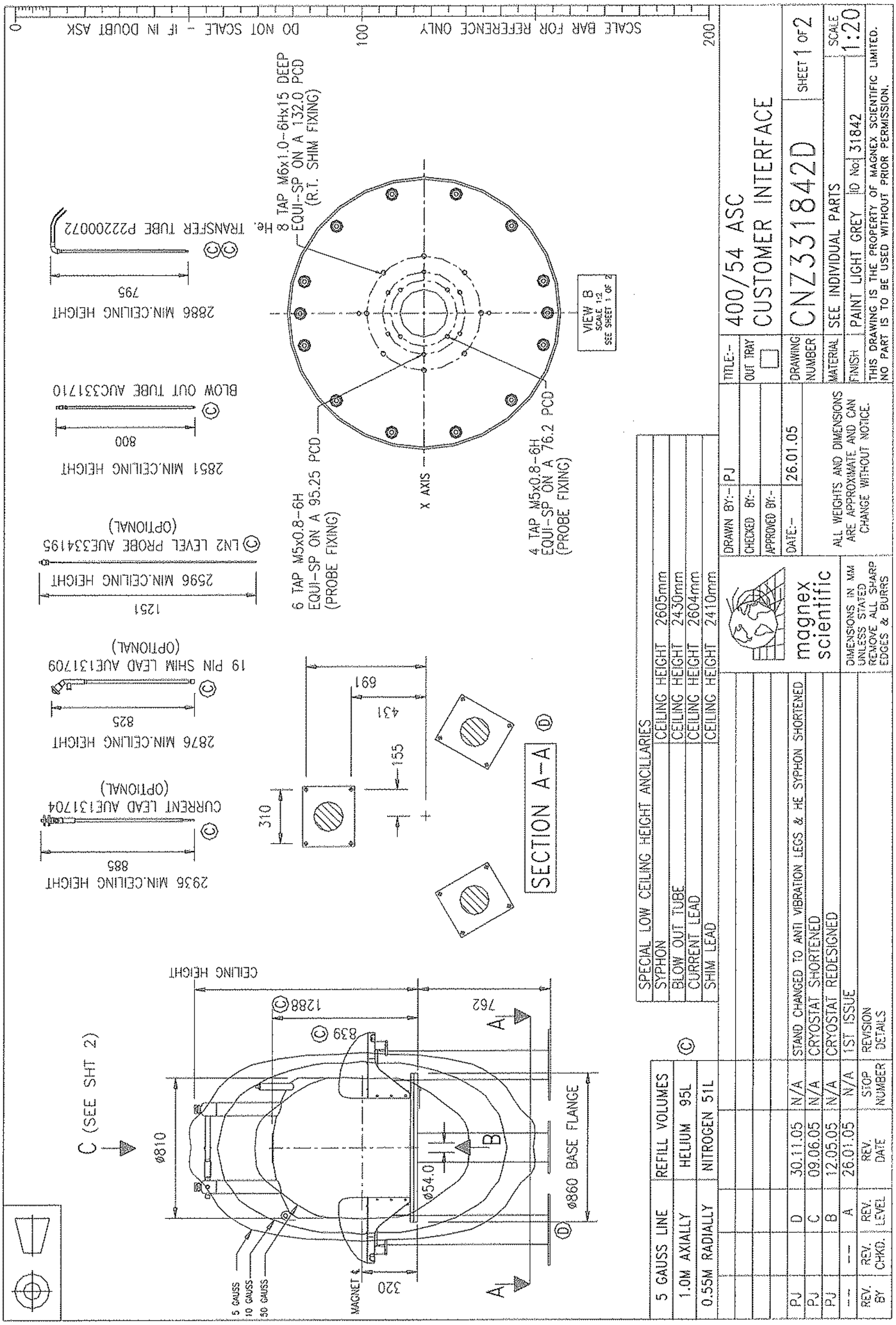
3.2 Liquid helium cryogen details

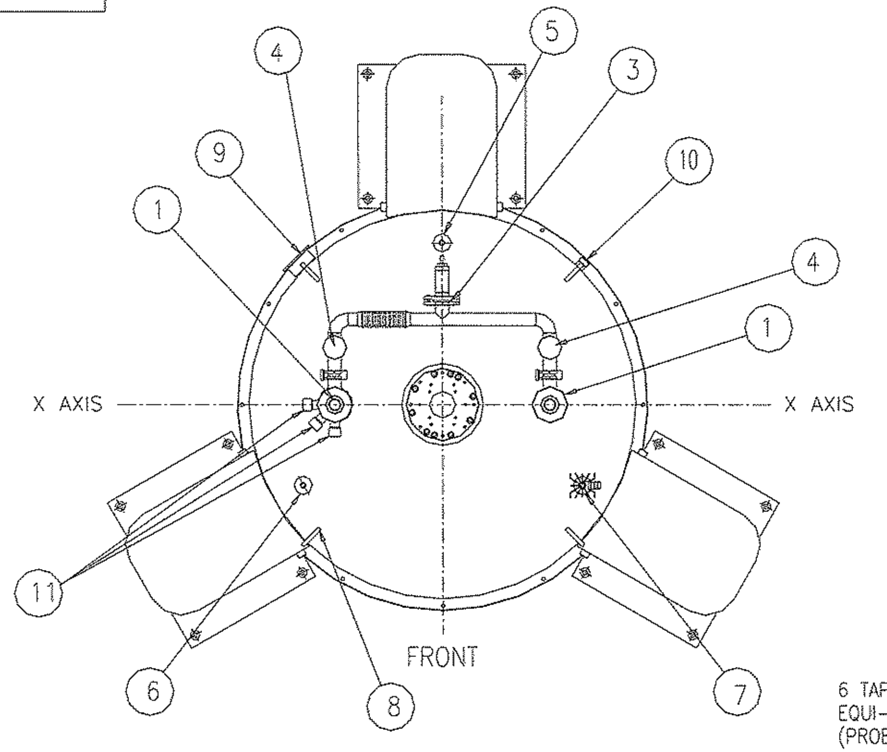
Minimum. helium level for normal operation:	20mm
Minimum helium level for energising or shimming	348mm
Siphon leg diameter	0.5" (12.7mm)
Volume required for installation: (Includes cooling magnet to 4.2K after nitrogen pre-cool, filling helium reservoir after energisation.)	250 litres (approx)
Recommended refill volume during normal operation:	95 litres (nominal)
Hold-time during normal operation (static magnetic field, leads withdrawn):	Greater than 180 days

3.3 Liquid nitrogen cryogen details

Total volume of nitrogen required for installation:	300 litres (approx.)
(a) For pre-cool of magnet:	200 litres (approx)
(b) For cool and fill of nitrogen can:	100 litres (approx.)
Volume of reservoir	54 litres
Refill volume	51 litres
Hold-time in static condition	Greater than 14 days

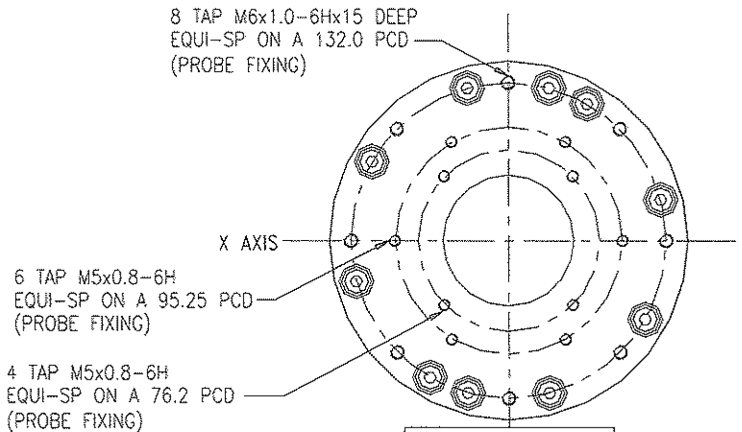
3.4 Customer Interface Drawings





VIEW ON ARROW C

1	SHIM LEAD / ENTRY
2	CURRENT LEAD / He TRANSFER TUBE / BLOW-OUT TUBE
3	He EXHAUST NW25
4	He EXHAUST SAFETY VALVE
5	LN2 SAFETY VALVE
6	LN2 FILL/VENT (OPTIONAL NITROGEN LEVEL PROBE)
7	LN2 HEAT SINK
8	LIFTING EARS 4 OFF
9	PUMP OUT PORT (D)
10	10 PIN SEAL (D)
11	10 PIN SEAL (DIAGNOSTICS) (D)



VIEW C
SCALE 1:2
SEE SHEET 1 OF 5

DO NOT SCALE - IF IN DOUBT ASK
SCALE BAR FOR REFERENCE ONLY
0 100 200

REV. BY	REV. CHKD.	REV. LEVEL	REV. DATE	STOP NUMBER	REVISION DETAILS
PJ		D	30.11.05	N/A	STAND CHANGED TO ANTI VIBRATION LEGS & HE SYPHON SHORTENED
PJ		C	09.06.05	N/A	CRYOSTAT SHORTENED
PJ		B	12.05.05	N/A	CRYOSTAT REDESIGNED
--	--	A	26.01.05	N/A	1ST ISSUE

magnex scientific

DIMENSIONS IN MM UNLESS STATED
REMOVE ALL SHARP EDGES & BURRS

DRAWN BY:- PJ
CHECKED BY:-
APPROVED BY:-
DATE:- 26.01.05

ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE AND CAN CHANGE WITHOUT NOTICE.

TITLE:- 400/54 ASC CUSTOMER INTERFACE
OUT TRAY
DRAWING NUMBER CNZ331842D SHEET 2 OF 2
MATERIAL SEE INDIVIDUAL PARTS
FINISH PAINT LIGHT GREY ID No: 31842
SCALE 1:10

Magnet Specifications

Magnet type:	Compensated self-screened solenoid
Central field:	9.39 Tesla (400 MHz ^{1}H)
Field stability:	Less than 0.02 ppm/hour drift (8 Hz/hour ^{1}H)
Design operating current:	97.4 Amps (nominal)
Typical time to energise magnet to full field:	Less than 300 minutes
Design Inductance:	38.1H

Design fringe field is shown on Customer Interface Drawing

3.5 Superconducting shim coils

These coils are positioned on a separate former surrounding the main coil in the helium reservoir. Each coil set is fitted with a superconducting switch for persistent mode operation.

Coil Details:-

Shims provided:	B0, Z1, Z2, Z3, X, Y, ZX, ZY, XY, X2-Y2
Nominal maximum recommended current:	20 Amps (25 Amps for Z1 & Z2)
Coupling:	All shims (apart from B0) are designed to be de-coupled from main coil
Orthogonality:	All shims are designed to be fully orthogonal
'X' axis alignment:	Nominally coincident with line through the two main service turrets

3.6 Switch Currents

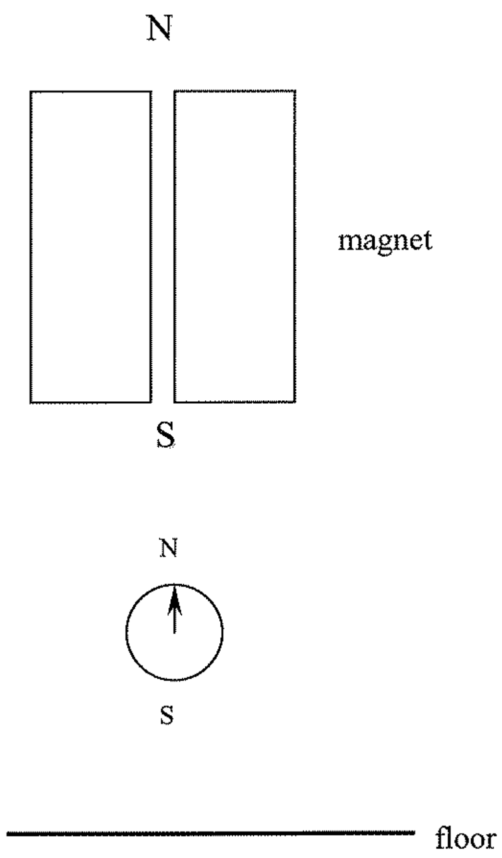
All magnet and shim switches require 60 to 100mA to operate (90mA suggested nominal value to use), e.g. using 30V supply.

3.7 Energisation direction

The magnet is energised such that the North is at the top of the magnet, and the South is at the bottom. This is defined by the procedure below:

- Align the compass to geographic north outside the building, well away from all magnetisable structures: Note which end of the needle points to geographic north. (Geographic north pole coincides with magnetic south pole). In the following, this end of the needle will be referred to as the “N end of the needle”.

- Approach the ends of the magnet with the compass, continuously observing the needle. Keep the compass away from the magnetised elements, since they could demagnetise the compass needle.
- Proceed as described above. The "N end of the needle" must point to the bottom of the magnet (i.e. pointing up the bore tube from the floor). This is the S end of the magnet. The reverse can be checked at the top of the magnet, i.e. the "S end of the needle" must point down towards the bore tube from the top of the magnet, indicating that this is the N end of the magnet.
- Repeat by again aligning the compass to geographic north outside the building, well away from all magnetisable structures:- Ensure that the same end, the "N end of the needle" points to the geographic north as before. This confirms that the compass was not demagnetised and the measurement was successful.



SECTION 4

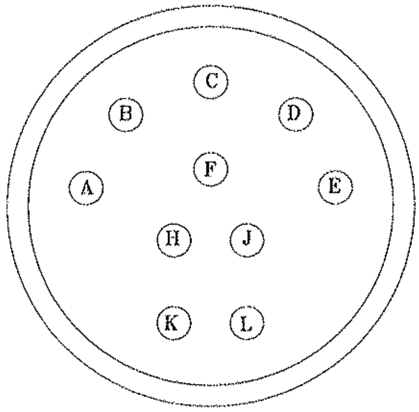
WIRING DIAGRAMS

4 WIRING DIAGRAMS

4.1 10-Pin Seal Pin Designations

OVC 10-Pin Seal

Pin	Function	
A	GCS AB270	I+
B	GCS AB270	I-
C	-	
D	GCS AB270	V+
E	GCS AB270	V-
F	-	
H	Nitrogen Can PT100	I+
J	Nitrogen Can PT100	I-
K	Nitrogen Can PT100	V+
L	Nitrogen Can PT100	V-



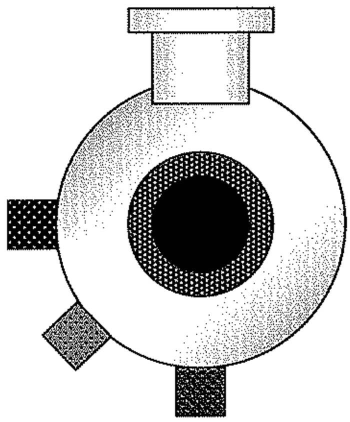
Pin Arrangement in the 10-pin connectors on the magnet.

Blue 10-Pin Seal Nut on Helium Turret ***(red wire)***

Pin	Function	
A		
B	Main Switch Heater	
C		
D		
E	Baseplate PT100	V+
F	Baseplate PT100	I+
H	Baseplate PT100	V-
J	Baseplate PT100	I-
K	B0 Shim Switch Heater	
L	B0 Shim Switch Heater	

Black 10-Pin Seal Nut on Helium Turret ***(black wire)***

Pin	Function	
A	Fixed Helium Probe	V+
B	Fixed Helium Probe	I+
C	Fixed Helium Probe	V-
D	Fixed Helium Probe	I-
E	Spare Helium Probe	V+
F	Spare Helium Probe	I+
H	Spare Helium Probe	V-
J	Spare Helium Probe	I-
K		
L		

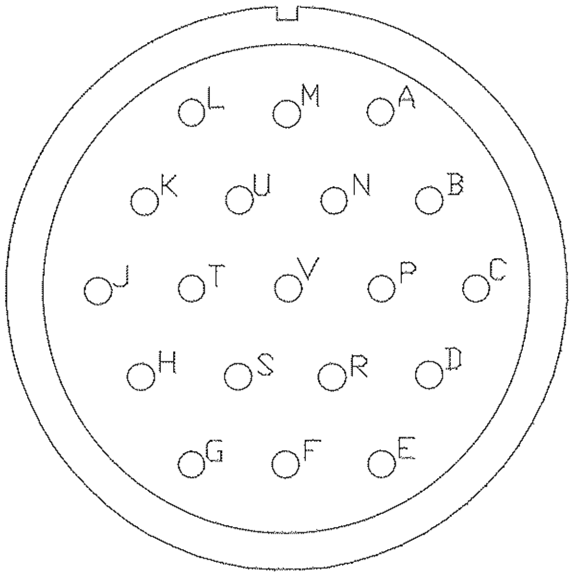


View directly down onto the current lead turret showing positions of the three 10-pin connectors.

Purple 10-Pin Seal Nut on Helium Turret ***(white wire)***

Pin	Function
A	Diagnostics
B	Diagnostics
C	Diagnostics
D	Diagnostics
E	Diagnostics
F	Diagnostics
H	Diagnostics
J	Diagnostics
K	Diagnostics
L	-

4.2 19-Way Shim Socket Pin Designations



Pin Arrangement in the 19-way connector on the shim lead

Pin	Function	
A	Z1 Switch Heater	
B	Z2 Switch Heater	
C	X Switch Heater	
D	Y Switch Heater	
E	ZX Switch Heater	
F	ZY Switch Heater	
G	XY Switch Heater	
H	X^2-Y^2 Switch Heater	
J	Switch Heater Common	
K	B0 Series Switch Heater	
L	Z3 Switch Heater	
M	Main Switch Heater	
N	B0 Switch Heater	
P	Magnet Volts	+
R	Magnet Volts	-
S	Shim Current Circuit	-
T	Shim Current Circuit	-
U	Shim Current Circuit	+
V	Shim Current Circuit	+

SECTION 5

TEMPERATURE SENSORS

5 TEMPERATURE SENSORS

Temperature sensors have been fitted to this system for use on installation and for diagnostic purposes. Two sorts of temperature sensors are fitted, Platinum resistor thermometers and Allen Bradley temperature sensors. Platinum resistor thermometers (PT100) are useful for measuring temperatures between room temperature and 77K. Allen-Bradley temperature sensors are more accurate at lower temperatures (below 77K) to liquid helium temperatures.

5.1 Platinum resistor thermometers (PT100)

These sensors have a nominal resistance of 100 Ohms at 0°C which falls linearly to a typical resistance of 20 Ohms at 77K. A typical calibration is shown on the following page.

5.2 Allen-Bradley temperature sensors

Allen-Bradley temperature sensors are individually calibrated. The calibration charts for the temperature sensors fitted to this system are included in the System Data section of the manual.

5.3 Location of temperature sensors

The temperature sensors fitted to this system are outlined below. Further details on electrical wiring for these can be found in Section 4.1.

Sensor type	Location	Access
Allen Bradley	Gas-cooled shield	ABDE 10-pin seal on side of cryostat
PT100	Nitrogen can	HJKL 10-pin seal on side of cryostat
PT100	Magnet baseplate	EFHJ 10-pin seal 1 on helium turret (blue nut)

PT 100 Platinum Resistor Data

Temperature (K)	Resistance (Ohm)	Temperature (K)	Resistance (Ohm)
77	20.00	79	20.82
81	21.63	83	22.45
85	23.26	87	24.08
89	24.90	91	25.71
93	26.53	95	27.34
97	28.16	99	28.98
101	29.79	103	30.61
105	31.42	107	32.24
109	33.06	111	33.87
113	34.69	115	35.50
117	36.32	119	37.14
121	37.95	123	38.77
125	39.58	127	40.40
129	41.22	131	42.03
133	42.85	135	43.66
137	44.48	139	45.30
141	46.11	143	46.93
145	47.74	147	48.56
149	49.38	151	50.19
153	51.01	155	51.82
157	52.64	159	53.46
161	54.27	163	55.09
165	55.90	167	56.72
169	57.54	171	58.35
173	59.17	175	59.98
177	60.80	179	61.62
181	62.43	183	63.25
185	64.06	187	64.88
189	65.70	191	66.51
193	67.33	195	68.14
197	68.96	199	69.78
201	70.59	203	71.41
205	72.22	207	73.04
209	73.86	211	74.67
213	75.49	215	76.30
217	77.12	219	77.94
221	78.75	223	79.57
225	80.38	227	81.20
229	82.02	231	82.83
233	83.65	235	84.46
237	85.28	239	86.10
241	86.91	243	87.73
245	88.54	247	89.36
249	90.18	251	90.99
253	91.81	255	92.62
257	93.44	259	94.26
261	95.07	263	95.89
265	96.70	267	97.52
269	98.34	271	99.15
273	99.97	275	100.78
277	101.60	279	102.42
281	103.23	283	104.05
285	104.86	287	105.68
289	106.50	291	107.31
293	108.13	295	108.94
297	109.76	299	110.58

OPERATING INSTRUCTIONS AND SPECIFICATIONS

for

Magnex Model E5035 Digital Nitrogen Monitor

Prepared : September 2005

Issue : C

Document : E5035MAN

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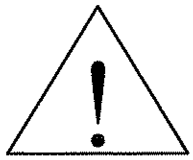
CONTENTS

1. SAFETY



Caution, refer to accompanying documents

1. WARNING – This equipment must be connected to an earthed mains supply. For continued protection against risk of fire or electric shock, replace any fuses with the same type, rating and UL listing.

2. This equipment is not suitable, and must not be used in areas with flammable mixtures.

2. IMPORTANT NOTICE

Please inspect goods immediately on arrival for possible transit damage and notify Magnex Scientific Limited within 3 days of receipt of goods.

Failure to do this will invalidate any possible claim.

DISCLAIMER

Every precaution has been taken in the preparation of this publication. Magnex Scientific Limited assumes no responsibility for errors or omissions. Neither is any liability assumed for damages resulting from the use of the information contained herein.

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CE NOTICE

Marking by the symbol CE indicates compliance of this device to the EMC (electromagnetic compatibility) and LV (low voltage) directives of the European Community. This unit is to be installed and operated as detailed. Any modification or maintenance procedure undertaken which is not approved by Magnex Scientific Ltd could nullify the CE marking of this product and lead to prosecution. A 'declaration of conformity' in accordance with the above directives has been made and is located at Magnex Scientific, Yarnton, Oxfordshire, UK.

3. DESCRIPTION AND OPERATING PRINCIPLE

Within the magnet nitrogen container a capacitive probe controls the frequency of an oscillator built into the unit. Frequency is measured by hardware and results are communicated to the user by means of a single 7 segment display fitted within the unit. When in use, the probe connector, upon which the unit mounts, must remain dry and free from any contamination or corrosion. This also applies to the connector mounted directly upon the unit itself.

When in use the display will show one of :- E,1,2,3,4,5,6,7,8,9, F
where :-

'E' represents a level below 5%.
'1' represents a level between 5% and 15%
'2' represents a level between 15% and 25%
'3' represents a level between 25% and 35%
'4' represents a level between 35% and 45%
'5' represents a level between 45% and 55%
'6' represents a level between 55% and 65%
'7' represents a level between 65% and 75%
'8' represents a level between 75% and 85%
'9' represents a level between 85% and 95%
'F' represents a level above 95%

Calibration is accomplished by the pressing of the calibrate button in the unit which will set the liquid level at this point as full. The calibrate button is visible through the small round hole in the red display filter. Use a slim, non sharp, insulated plastic object.

The calibration procedure will take about 5 seconds :-

Press and hold the calibrate button. The display will change to "C" which will dissappear. Continue holding the button until "C" reappears.
Release the calibrate button at this time. The display of "C" will change to "F" shortly after the button is released. There is no ill effect if the calibrate button is held pressed for longer than the above cycle, the end result is the same.

4. SPECIFICATION

Unit Dimensions :-	
Length	98mm.
Width	56mm.
Height	44mm inc of connector.
Mass	145 grams.
Display	14mm (0.6 inch) 7 segment red LED.

Environmental conditions

The equipment is designed to be safe under the following conditions:

Ambient temperature range	:	10°C to 40°C
Relative humidity range	:	30% to 95% non-condensing
Atmospheric pressure	:	700 hPA to 1060hPA

This unit should only be used in conjunction with the following cables

C0443120	Cable, E5035 Data/Power
C0444010	Cable, PSU E5035

The C0444010 cable contains a PSU unit which has an IEC320 inlet. The power requirements are 100-240V AC 47-63Hz 0.4A

SYSTEM DATA

for

400/54 Actively Shielded Premium NMR Magnet System

Serial no. : 016970

Prepared : Sept 2006

Document : TS1468sysV01.doc

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SYSTEM DATA

Serial Number: **016970**
System Type: **400/54 Active Shielded Premium**

Base to Centre Height

Base to centreline height: 319.99 mm

Magnet Operating Current

Operating current for 400 MHz 1H: 94.7 A
Overfield (increment above operating current): +0.1A for 15 mins above the main field

Recommended Ramping Rates for Main Magnet

Current range (A)		Rate (A min-1)	Induced Voltage (V)
0 to	60	3.9	2.5
60 to	68	0.8	0.5
68 to	82	0.6	0.4
82 to	90	0.3	0.2
90 to	94.7	0.2	0.15

Operating Currents for Superconducting Shims

Shim	Factory Current (Amps)	Installation Current (Amps)
B0	0	0
Z1	-6.39	-6.31
Z2	2.34	+2.02
Z3	19	+19
X	3.26	+2.65
Y	-0.95	+0.34
ZX	2.8	+2.76
ZY	-1.5	-0.81
X2-Y2 (C2)	-2.3	-2.28
XY (S2)	-2.32	-2.75

Location of Temperature Sensors

Sensor No.	Location
2257	Gas Cooled Shield
2287	Magnet baseplate

Allen Bradley Calibrations

Allen Bradley (Gas-cooled shield): 2257

Temperature (K)	Resistance (ohm)	Temperature (K)	Resistance (ohm)
5	3216.24	6	2361.24
7	1879.73	8	1575.51
9	1368.14	10	1219.11
11	1106.54	12	1018.85
13	948.69	14	891.22
15	843.27	16	802.62
17	767.73	18	737.44
19	710.91	20	687.4
21	666.46	22	648.07
23	631.2	24	615.67
25	601.33	26	588.06
27	576.08	28	565.14
29	554.9	30	545.3
31	536.28	32	527.8
33	520	34	512.66
35	505.71	36	499.12
37	492.86	38	486.92
39	481.33	40	476.01
41	470.93	42	466.08
43	461.44	44	457
45	452.77	46	448.71
47	444.82	48	441.08
49	437.48	50	434.02
51	430.68	52	427.47
53	424.37	54	421.38
55	418.49	56	415.71
57	413	58	410.39
59	407.85	60	405.4
61	403.03	62	400.73
63	398.49	64	396.32
65	394.21	66	392.16
67	390.17	68	388.24
69	386.35	70	384.5
71	382.71	72	380.97
73	379.28	74	377.63
75	376.01	76	374.44
77	372.9	78	371.4
79	369.94	80	368.52
81	367.12	82	365.75
83	364.42	84	363.11
85	361.84	86	360.6
87	359.38	88	358.18
89	357.02	90	355.88
91	354.76	92	353.67
93	352.59	94	351.54
95	350.51	96	349.5
97	348.52	98	347.37
99	346.19	100	345.04

Allen Bradley Calibrations

Allen Bradley (Magnet baseplate): 2287

Temperature (K)	Resistance (ohm)	Temperature (K)	Resistance (ohm)
5	3285	6	2397.71
7	1900.56	8	1587.68
9	1375.04	10	1222.59
11	1107.68	12	1018.3
13	946.91	14	888.49
15	839.82	16	798.59
17	763.23	18	732.57
19	705.72	20	681.95
21	660.79	22	642.22
23	625.19	24	609.52
25	595.06	26	581.68
27	569.62	28	558.59
29	548.28	30	538.62
31	529.55	32	521.01
33	513.17	34	505.79
35	498.8	36	492.18
37	485.9	38	479.92
39	474.31	40	468.97
41	463.88	42	459.01
43	454.35	44	449.9
45	445.65	46	441.59
47	437.68	48	433.93
49	430.33	50	426.86
51	423.52	52	420.3
53	417.19	54	414.2
55	411.31	56	408.52
57	405.81	58	403.19
59	400.66	60	398.2
61	395.83	62	393.53
63	391.29	64	389.11
65	387	66	384.95
67	382.96	68	381.03
69	379.14	70	377.3
71	375.51	72	373.77
73	372.08	74	370.43
75	368.81	76	367.24
77	365.7	78	364.2
79	362.75	80	361.33
81	359.93	82	358.56
83	357.23	84	355.92
85	354.65	86	353.41
87	352.19	88	351
89	349.84	90	348.7
91	347.59	92	346.49
93	345.42	94	344.37
95	343.34	96	342.34
97	341.35	98	340.21
99	339.03	100	337.88

Helium Level Probe Resistance Calibration

Helium Probe Serial No: M06/452
Spare Helium Probe Serial No: M06/453

System Serial No: 016970

Probe current: 115mA

Probe resistance (Ω)	Meter Reading (mm)
0	450
6.05	450
60.5	0

The spare helium probe (P2) has the same operational current and calibration as above.