TECHNICAL SPECIFICATIONS

FOR AN MRBR 7.0 TESLA / 160mm ACTIVELY SHIELDED

ROOM TEMPERATURE BORE MAGNET SYSTEM

Prepared by:-

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1. DESCRIPTION OF THE SYSTEM

The system consists of a highly homogeneous superconducting magnet (7.0 Tesla) housed in a horizontal room temperature bore (160mm) low-loss cryostat. Field shimming is accomplished using a combination of superconducting shim coils and passive shim pieces.

If the magnet is being supplied with a Magnex Scientific gradient the passive shims will be mounted on the outside of this, if not they will be mounted on the outside of a tube placed in the bore of the magnet which will leave an overall clear bore size of 155mm diameter.

Cryomonitors for helium and nitrogen are provided along with an emergency quench heater control unit.

2. THE SUPERCONDUCTING MAGNET

i) General Description

The magnet is wound from multi-filamentary NbTi conductor with a high percentage of copper to superconductor. The coils are wound on precision machined aluminium alloy and GRP formers, they are then fully vacuum impregnated for robustness and long-term reliability.

The field homogeneity is defined over one spherical volume and two cylindrical volumes, all orders of impurity up to 10th order are theoretically cancelled within this volume. Inevitably winding tolerances and small amounts of environmental influence will distort the central field; corrections for these distortions are made in the first instance by superconducting shim coils located on a former surrounding the main coil, final corrections are made by passive shim pieces positioned in the bore of the system.

The magnet coils are fully protected from accidental damage due to a quench by a diode resistor network located within the helium reservoir.

In case the need to activate an emergency discharge of the magnet arises, a quench heater circuit is incorporated within the magnet's windings.

The magnet is designed to conservative levels of stress and mechanical stability to ensure reliable and stable operation. In addition the use of high quality superconducting wire ensures that a highly stable magnet system is achieved. Long term field stability is enhanced by the use of an internal superconducting field lock coil.

ii) Specifications

Magnet type	:	**Multi-coil superconducting**
Central field	:	**7.0 Tesla**
Field stability measured a minimum of 72 hours after energisation	:	**≤ 0.05 ppm/hour**

The above values assume that the room temperature is maintained at +/- 1°C

Operating current	:	**252 Amps (nominal)**
Time to energise magnet to full field	:	**Less than 120 minutes**
Estimate of helium consumption during ramping to full field	:	**10-15 litres**

Field homogeneity values

S/C and passively shimmed only	:	**≤ 8ppm p-p over 8.0cm dsv***
Fully shimmed using RT shims†	:	**≤ 4ppm p-p over 8.0cm dsv***

Resident Gradients over 8.0 cm dsv :

Z^3	**< 1ppm**
ZX	**< 1ppm**
ZY	**< 1ppm**
$X^2 - Y^2$	**< 1ppm**
XY	**< 1ppm**

Fringe field (see also *figure 2.1)*
Position of 5 gauss contour‡:

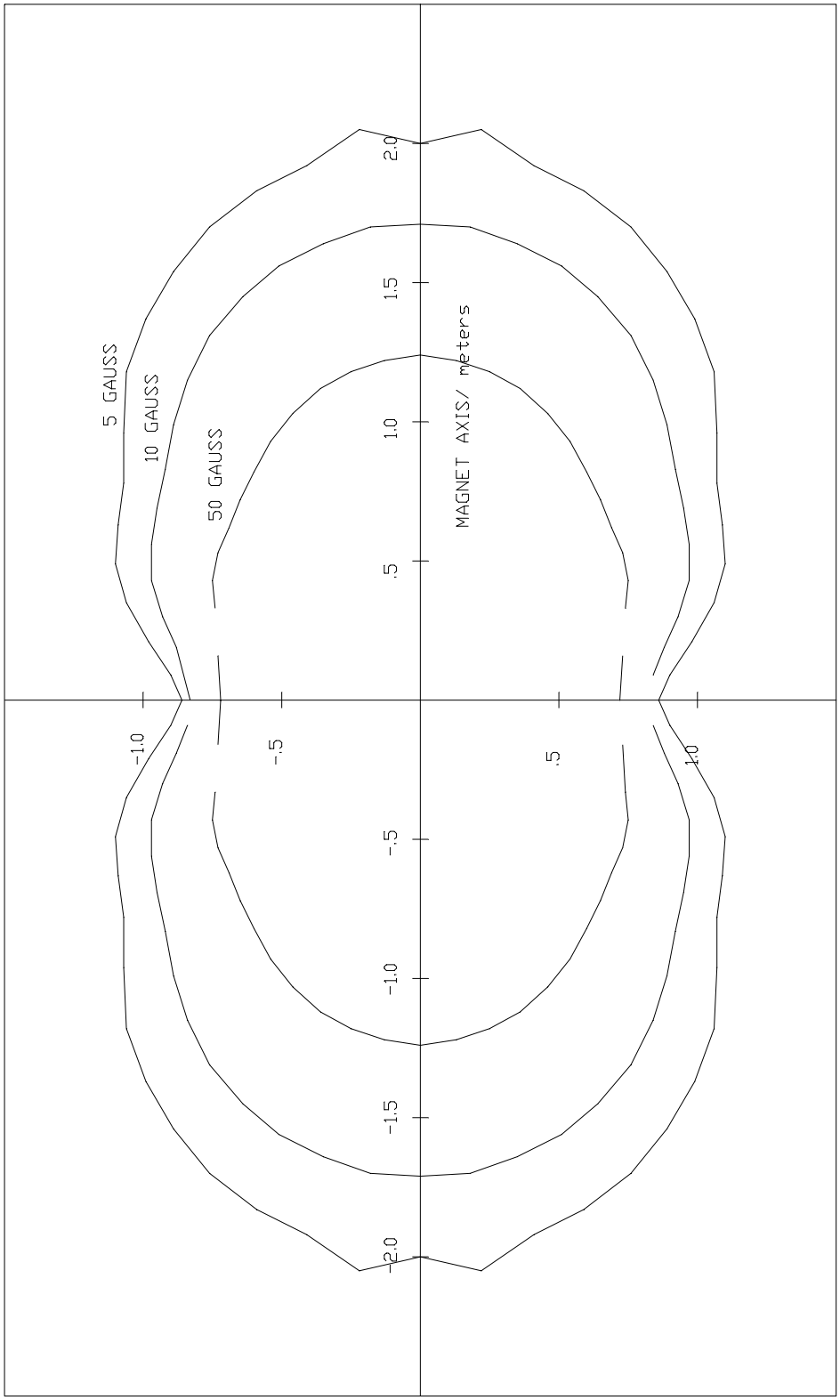
Axially from magnet centre line	:	**2.1 metres**
Radially from magnet centre line	:	**1.1 metres**

* *Defined as the peak to peak variations of points plotted over a seven plane plot on the surface of the stated spherical volume*

† Projected specification i*f using Magnex standard RT shim set*

‡ *Safety Note: In the event of a quench it is possible for the magnetic field to momentarily bloom beyond this limit. For further details please consult the Magnex site planning guide for this magnet.*

Figure 2.1 Fringe field plot of 7.0T 160 mm actively shielded magnet



iii) Superconducting Shim Coils

Coils are positioned on a former in the helium reservoir. Each coil set is fitted with a superconducting switch for persistent mode operation.

Parameters

Maximum recommended current	:	**25 Amps**
Coupling	:	**All shims are de-coupled from main coil**

3. THE CRYOSTAT

i) General Description

The cryostat is of conventional layout consisting of a central all-welded stainless steel helium vessel surrounded by an aluminium gas-cooled radiation shield and a liquid nitrogen reservoir. The complete assembly is contained within an outer vacuum chamber, this is of an all welded stainless steel construction with a room-temperature bore-tube also constructed from stainless steel. The outer vacuum vessel is fitted with a vertical service turret located centrally on the top of the cryostat. The turret provides access to the helium reservoir for the magnet service wiring, the demountable magnet leads, the demountable helium level probe, and the helium transfer siphon.

The cryostat is supplied with a height adjustable support stand. When full, the helium reservoir contains around 400 litres of liquid helium, approximately half of which is above the minimum operating level. Details of refill intervals and volumes are given below.

Cryogen level monitoring is incorporated into both the liquid helium and liquid nitrogen vessels; the associated electronics provide both liquid level display and low level alarms. A back-up level probe is included in the liquid helium vessel for use in the event of failure of the primary probe.

ii) Specifications

The cryostat is shown in drawing no. **ANZ335430**

Dimensions:-

Length of cryostat	:	**1012mm**
Room temperature clear bore (with passive shim tube but without gradient)	:	**155mm**
Room temperature bore-tube material	:	**Stainless steel**
Centre of field to base of stand	:	**1075 – 1145mm**
Cryostat end-flange to centre of field	:	**506mm**
Minimum ceiling height for siphon	:	**3130mm**
Weight of cryostat (excluding cryogens)	:	**1550kg (approx.)**

Liquid helium cryogen details:-

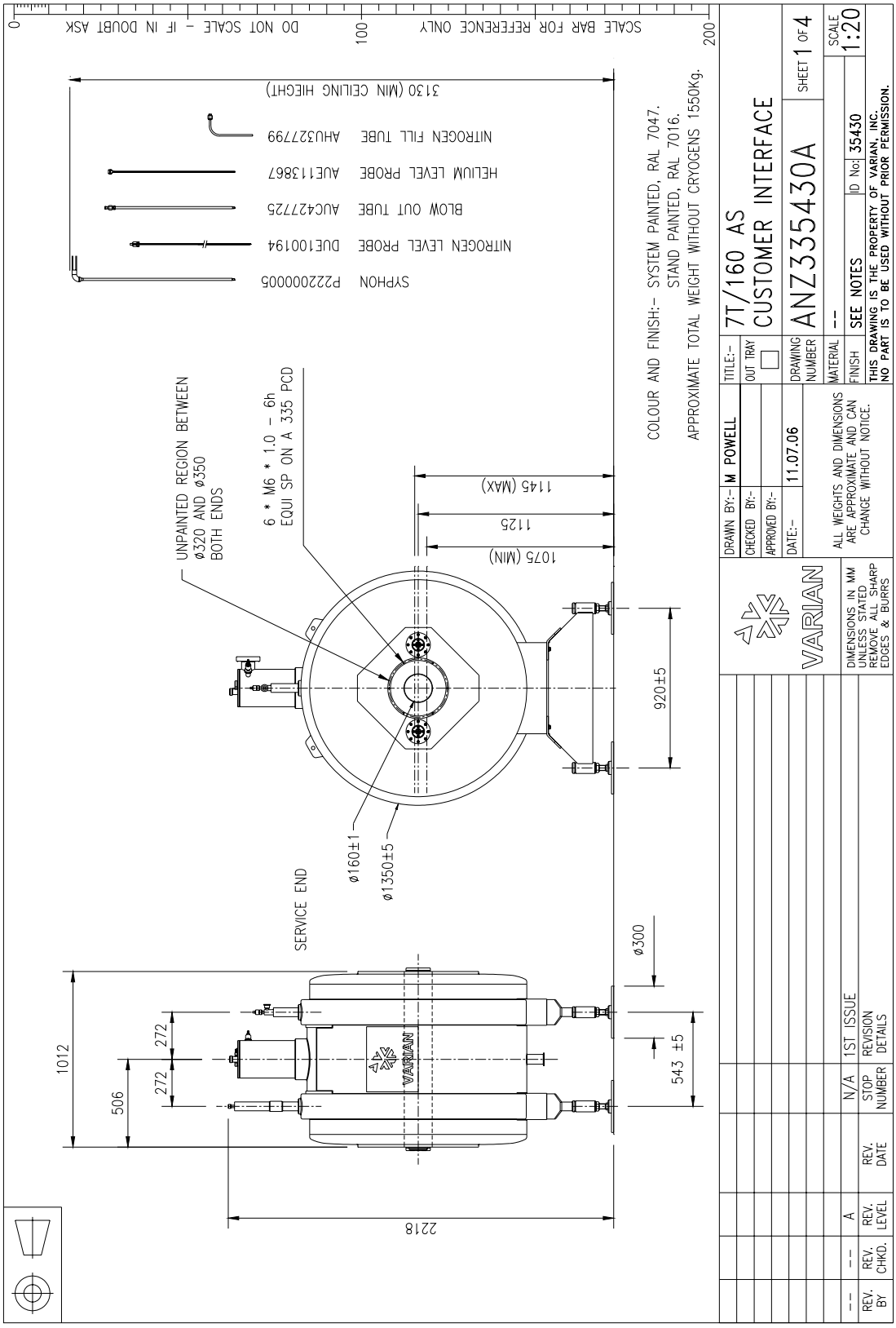
Volume for initial installation (includes cooling the magnet from 77K to 4.2K volume required to completely fill helium reservoir and to top-up helium reservoir after magnet energisation)	:	**800 litres**
Recommended refill volume during normal operation	:	**200 litres**
Maximum volume of reservoir	:	**400 litres**
Hold-time during normal operation (static magnetic field, leads withdrawn)	:	**More than 150 days**
Maximum allowable pressure drop along quench ducting in order to comply with the Pressure Equipment Directive	:	**5.0psi for a quench rate of 0.3375kg of helium per second, where the temperature of the helium exiting from the burst disc port is approx. 10K**‡

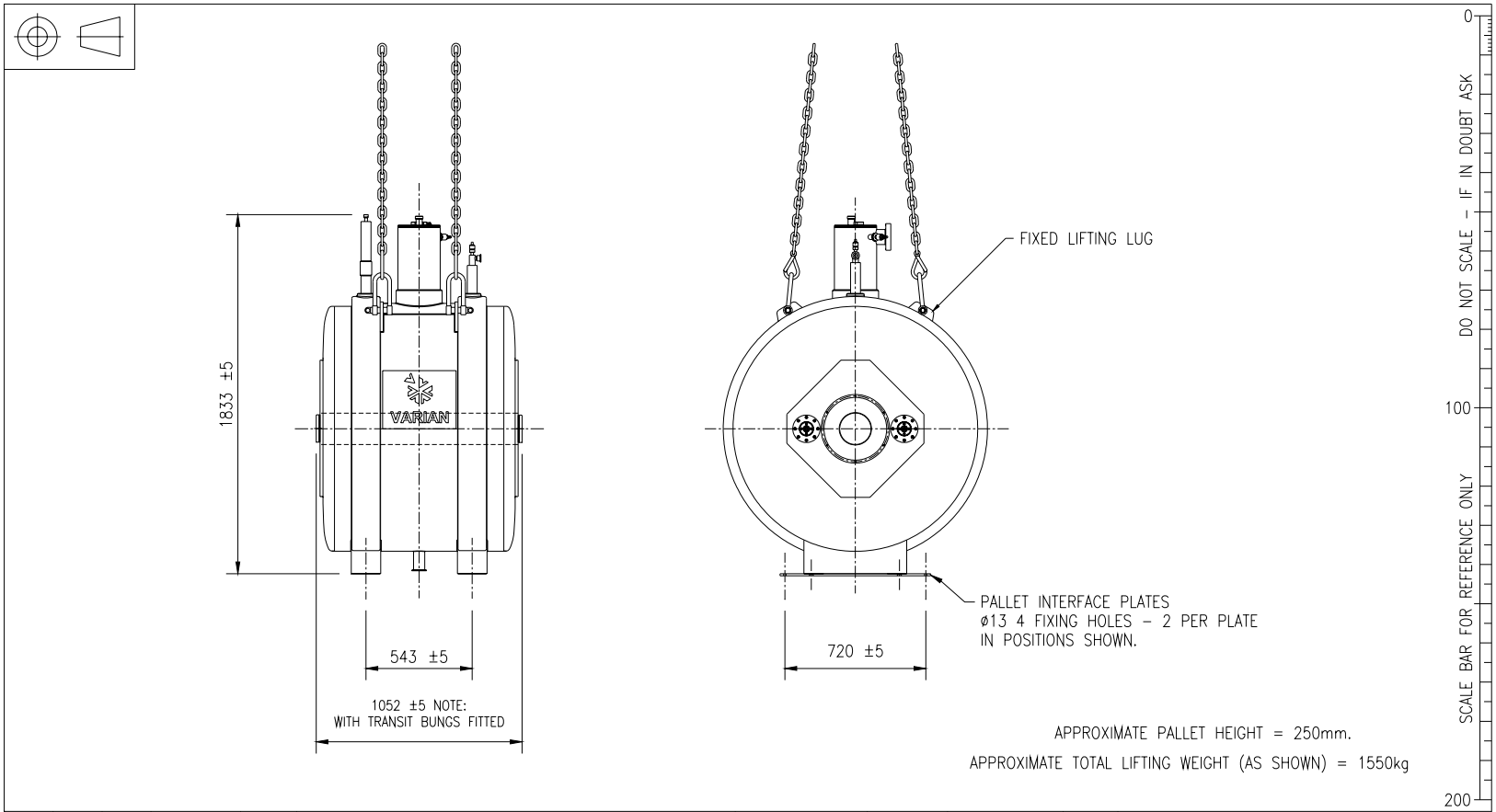
Liquid nitrogen cryogen details:-

Volume for initial installation (includes pre-cool of magnet to 77K and volume required to completely fill LN2 reservoir)	:	**800 litres**
Volume of reservoir	:	**200 litres**
Refill volume	:	**190 litres**
Hold-time in static condition	:	**More than 19 days**

‡ *For further information, please consult Magnex Scientific Ltd.*

4. CUSTOMER INTERFACE DRAWINGS





REV. BY	REV. CHKD.	REV. LEVEL	REV. DATE	STOP NUMBER	REVISION DETAILS
--	--	A		N/A	1ST ISSUE

VARIAN

DIMENSIONS IN MM UNLESS STATED REMOVE ALL SHARP EDGES & BURRS

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

DRAWN BY:-	M POWELL
CHECKED BY:-	
APPROVED BY:-	
DATE:-	11.07.06

TITLE:- 7T/160 AS CUSTOMER INTERFACE

OUT TRAY

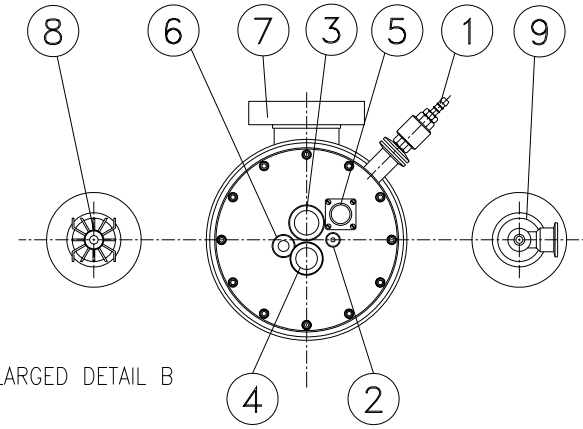
DRAWING NUMBER: ANZ335430A — SHEET 2 OF 4

MATERIAL: --

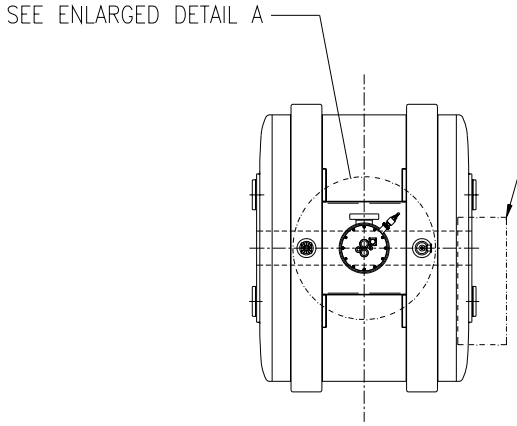
FINISH: SEE NOTES — ID No: 35430

SCALE 1:20

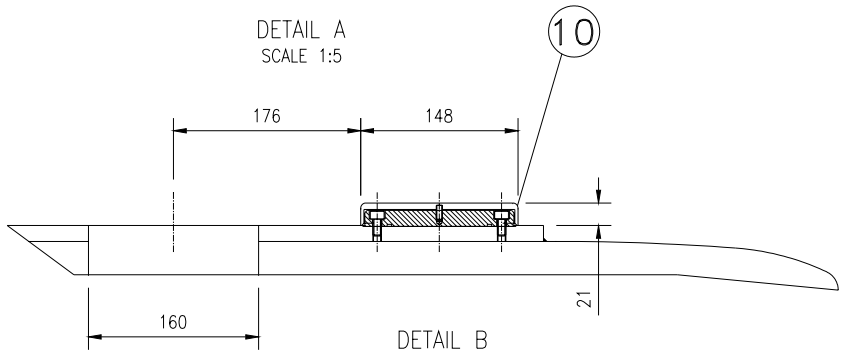
LEGEND	
1	He. EXHAUST / NON RETURN VALVE
2	He. LEVEL PROBE ENTRY
3	MAGNET CURRENT LEAD ENTRY
4	MAGNET SHIM LEAD ENTRY
5	19 PIN CONNECTOR (SYSTEM DIAGNOSTICS)
6	He. SYPHON ENTRY
7	BURSTING DISK (Pt. No. P200000002)
8	N2 FILL/VENT
9	N2 LEVEL PROBE
10	TRANSIT FITTING AND COVER



DETAIL A
SCALE 1:5



PLAN VIEW



DETAIL B
SCALE 1:5
ROTATED THRO' 90 DEG

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

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--	--	A		N/A	1ST ISSUE

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OUT TRAY ☐

DRAWING NUMBER: ANZ335430A

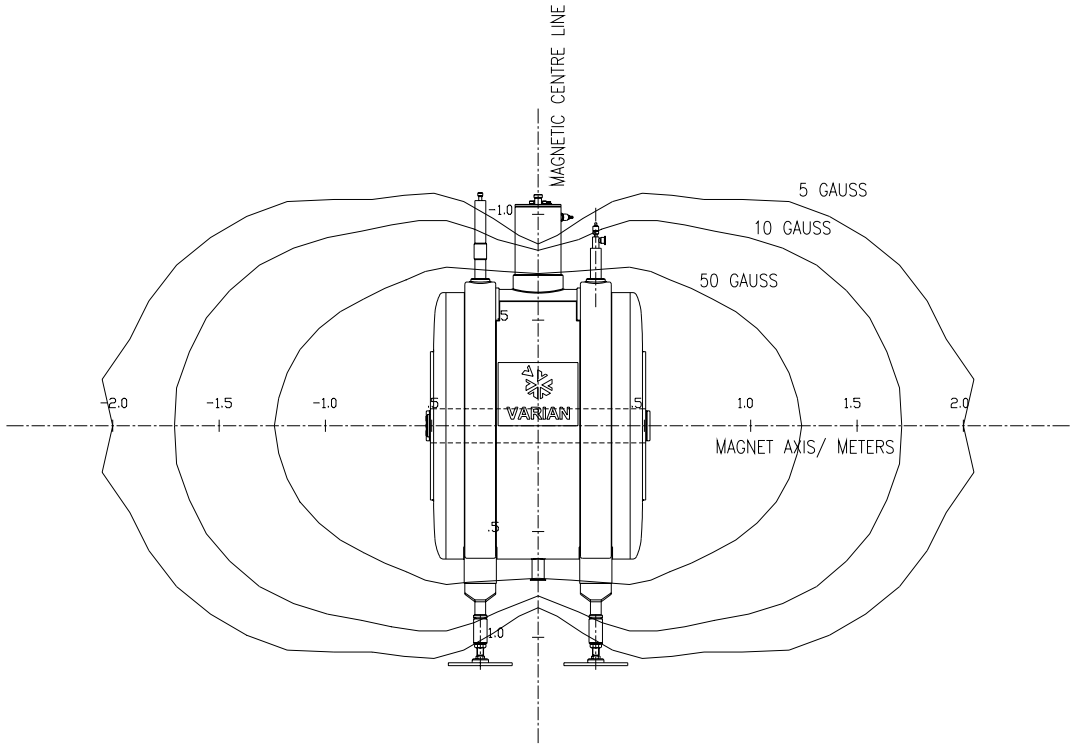
SHEET 3 OF 4

MATERIAL: --

FINISH: SEE NOTES

ID No: 35430

SCALE 1:20



NOT TO SCALE

FRINGE FIELD LINES SHOWN FOR GUIDANCE ONLY

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

REV. BY	REV. CHKD.	REV. LEVEL	REV. DATE	STOP NUMBER	REVISION DETAILS
--	--	A		N/A	1ST ISSUE

VARIAN

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APPROVED BY:-	
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TITLE:- 7T/160 AS CUSTOMER INTERFACE

OUT TRAY

DRAWING NUMBER ANZ335430A SHEET 4 OF 4

MATERIAL --

FINISH SEE NOTES ID No: 35430

SCALE 1:20

5. ELECTRONICS

i) Magnex Model E5000: Helium and Nitrogen Cryo-monitors

Magnex Continuous Reading Helium Level Monitor

Features:-

- Direct digital display of liquid helium level in mm
- Variable interval sample and hold facility
- Adjustable low-level alarm facility with visual and change-over relay output
- Modular design
- Designed for EMC approval (Specification data sheet available)

Magnex Continuous Reading Liquid Nitrogen Level Monitor

Features:-

- Direct display of liquid nitrogen level
- Adjustable low-level alarm facilities with visual display
- Modular design
- Designed for EMC approval (Specification data sheet available)

ii) Magnex Model E7000: Magnet Emergency Discharge Unit

In case the need to rapidly de-energise the magnet arises an Emergency Discharge Unit is provided with the system. This unit has a battery back-up facility and can be activated at the touch of a button.

The unit incorporates the following features:-

Quench/Emergency discharge button	:	**Mechanical switch with guard to protect against accidental usage**
Power Source	:	**Lead Acid rechargeable batteries on continuous recharge. Push button battery check facility**
Heater resistance (located in magnet winding)	:	**12 ohms (nominal)**
Operating current	:	**2 Amps (nominal)**
De-energisation time to 10% of nominal field	:	**30 seconds**
Field range for guaranteed Emergency Quench Activation.	:	**>60% of full field**

6. SYSTEM COMPONENTS

i) Superconducting Magnet System Components

1 off	**7.0T 160 mm actively shielded MRBR magnet system with integral s/c shims and lock coils housed in a low loss cryostat.**	HI1373
1 off	**Stand**	DHC111583

ii) Standard Ancillary Parts

1 off	**Helium level monitor**	E5052
1 off	**Helium monitor cable**	C0090003
1 off	**Demountable helium level probe**	AUE113867
1 off	**Nitrogen level monitor**	E5035
1 off	**Nitrogen monitor cable (Data/Power)**	C0443120
1 off	**Nitrogen monitor cable (PSU)**	C0444010
1 off	**Demountable nitrogen level probe**	DUE100194
1 off	**Emergency discharge unit**	E7007
1 off	**Service cable**	C0091085
1 off	**Flexible siphon (2.0m)**	P222000005
1 off	**Braided nitrogen transfer line**	ATU327865
1 off	**Nitrogen blow-out tube**	AUC427725
1 off	**Nitrogen fill tube**	AHU327799
1 off	**Spares kit**	AKZ509324
1 off	**System manual**	MHI1373

iii) Optional Ancillary Parts

	Quench duct elbow	AHC126439
	4” Quench duct adaptor assembly	AHC327457
	6” Quench duct adaptor assembly	AHC327456
	8” Quench duct adaptor assembly	AHC327455