TECHNICAL SPECIFICATIONS

FOR AN MRBR 9.4 TESLA / 160mm ACTIVELY SHIELDED ROOM TEMPERATURE BORE MAGNET SYSTEM

Prepared by:-
Magnex Scientific Limited
The Magnet Technology Centre
6 Mead Road
Oxford Industrial Park
Yarnton
Oxford OX5 1QU, UK

Tel	***:***	***44 (0)1865 853800***
Fax	***:***	***44 (0)1865 842466***
E-mail	***:***	***sales@magnex.com***
www	***:***	***magnex.com***

Document Ref: TS1276C

Date: April 2004

CONTENTS

1. DESCRIPTION OF THE SYSTEM

The system essentially consists of a highly homogeneous superconducting magnet (9.4 Tesla) housed in a horizontal room temperature bore (160mm), low-loss helium cryostat. Field shimming is accomplished using a combination of superconducting shim coils and passive shim pieces.

The passive shims are mounted on a tube in the bore of the magnet leaving an overall system bore size of 155mm diameter.

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

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 windings are placed on precision machined aluminium alloy and GRP formers, then fully vacuum impregnated for robustness and long-term reliability.

The field homogeneity is defined over a spherical volume and 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 placed 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 the event of the need to activate an emergency discharge of the magnet a quench heater circuit is incorporated within the 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 super- conducting 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	:	9.4 Tesla
Field stability measured a minimum of of 72 hours after energisation	:	Less than 0.05 ppm/hour
Operating current	:	282 Amps (nominal)
Field homogeneity values		
S/C and passively shimmed only	:	10ppm p-p over 8.5cm dsv*

Residual Gradients over 8.5 cm dsv*

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

: 5ppm p-p over 8.0cm dsv‡
10ppm p-p over cylinder 60mm diameter of 60mm long†, and
: 4 ppm p-p over cylinder 30mm diameter by 60mm long†

Fully shimmed using RT shims : 0.1ppm FWHH over 4cm dsv**

† Defined as the peak to peak variation of points plotted over a five plane plot on the surface of the stated cylinder
* Defined as the peak to peak variations of points plotted over a seven plane plot on the surface of the stated spherical volume
‡ Projected over a seven place plot
** If using Magnex standard RT shim set

Time to energise magnet to full field	:	Less than 260 minutes
Estimate of helium consumption during ramping to full field	:	15-20 litres

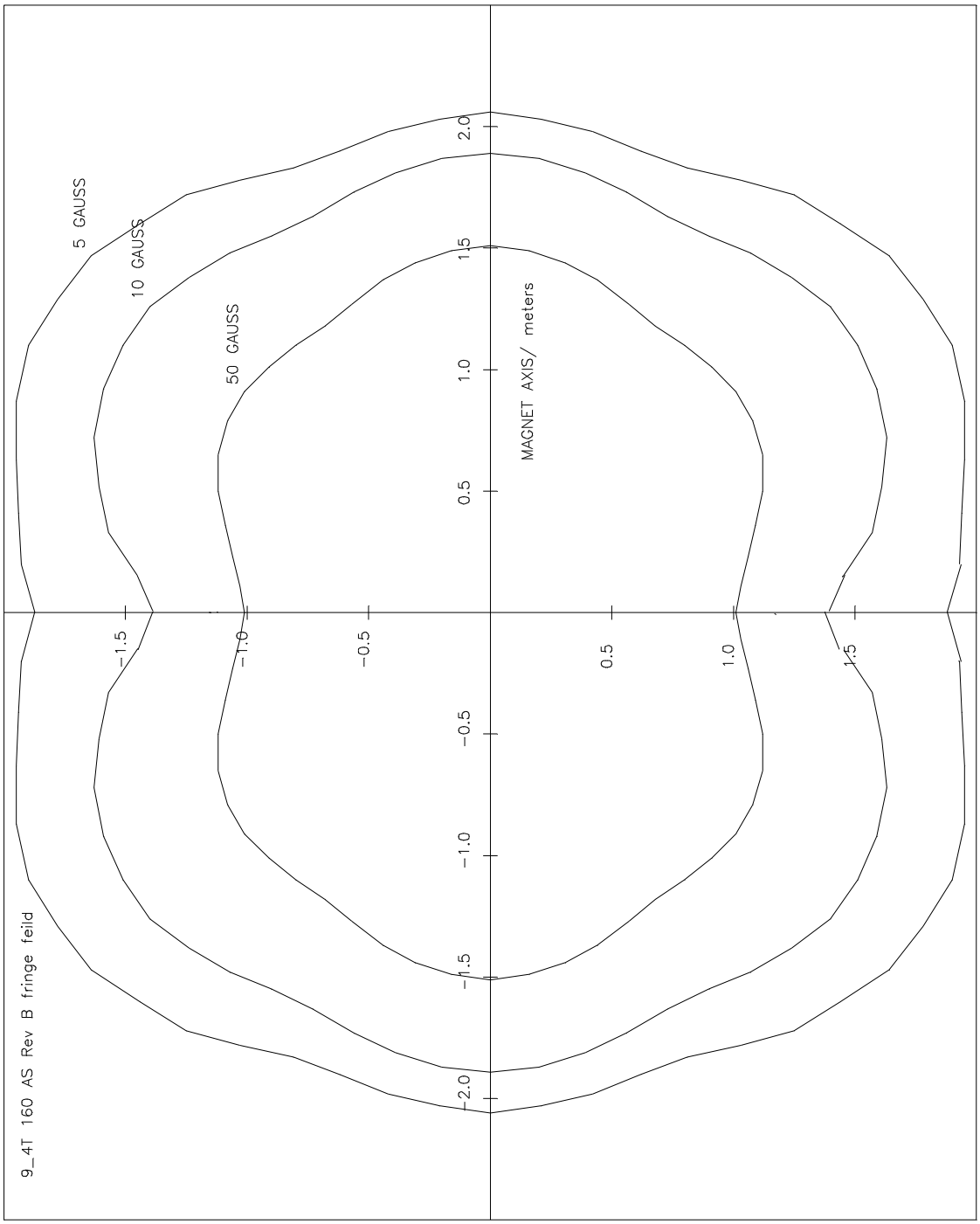
Fringe field

Position of 5 gauss contour (see figure 1)

Axially from magnet centre line	:	2.4 metres
Radially from magnet centre line	:	2.0 metres

*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 1 Fringe field plot of 9.4T 160 mm actively shielded magnet



iii) Superconducting Shim Coils

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

Coil details:-

Shims provided	:	Z1, Z2, X, Y, ZX, ZY, XY, X2-Y2
Maximum recommended current	:	25 Amps
Coupling	:	All shims are de-coupled from main coil

Typical shim strength over 60mm diameter.

Shim	**Strength (ppm/amp of main field)**
Z1	4.5
Z2	1.8
X(Y)	3.4
ZX(ZY)	0.20
XY(X2-Y2)	0.18

3. THE CRYOSTAT

i) General Description

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

The cryostat is supplied with an adjustable height support stand. The helium reservoir contains in total approximately 700 litres of liquid helium of which approximately 250 litres volume is above the minimum operating level. Details of refill intervals are given below.

Cryogen level monitors are incorporated into both the liquid helium and liquid nitrogen vessels and the associated electronics provide liquid level display and low level alarms. A back-up liquid helium level probe is included for use in the event of failure of the primary probe. The probes will monitor helium levels continuously from empty to full conditions.

ii) Specifications

The cryostat is shown in drawing no. AHZ323340.

Dimensions:-

Length of cryostat	:	1224±5 mm
Room temperature clear bore (with passive shims)	:	155±1 mm
Room temperature bore-tube material	:	Stainless steel
Centre of field to base of stand	:	1075 – 1145 mm
Cryostat end-flange to centre of field	:	612±2 mm
Minimum ceiling height for siphon	:	3300 mm
Weight of cryostat (excluding cryogens)	:	2800kg (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)	:	2400 litres
Recommended refill volume during normal operation	:	200 litres
Maximum volume of reservoir	:	700 litres
Hold-time during normal operation (static magnetic field, leads withdrawn)	:	More than 100 days

Liquid nitrogen cryogen details:-

Volume for initial installation (includes pre-cool of magnet to 77K and volume required to completely fill LN2 reservoir)	:	2400 litres
Volume of reservoir	:	200 litres
Refill volume	:	190 litres
Hold-time in static condition	:	More than 14 days

4. ELECTRONICS

i) Combined Helium and Nitrogen Cryomonitors : Magnex Model E5000

Magnex Model E5011 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 Model E5031 Continuous Reading Liquid Nitrogen Level Monitor

Features:-

- Direct display of liquid nitrogen level via analogue meter.
- Adjustable low-level alarm facilities with visual display.
- Modular design.

Designed for EMC approval. Specification data sheet available.

ii) Magnet Emergency Quench Unit : Magnex Model E7000

If the need arises to rapidly de-energise the magnet an emergency discharge unit is provided with the system. This unit is battery operated 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% - 100% of maximum field

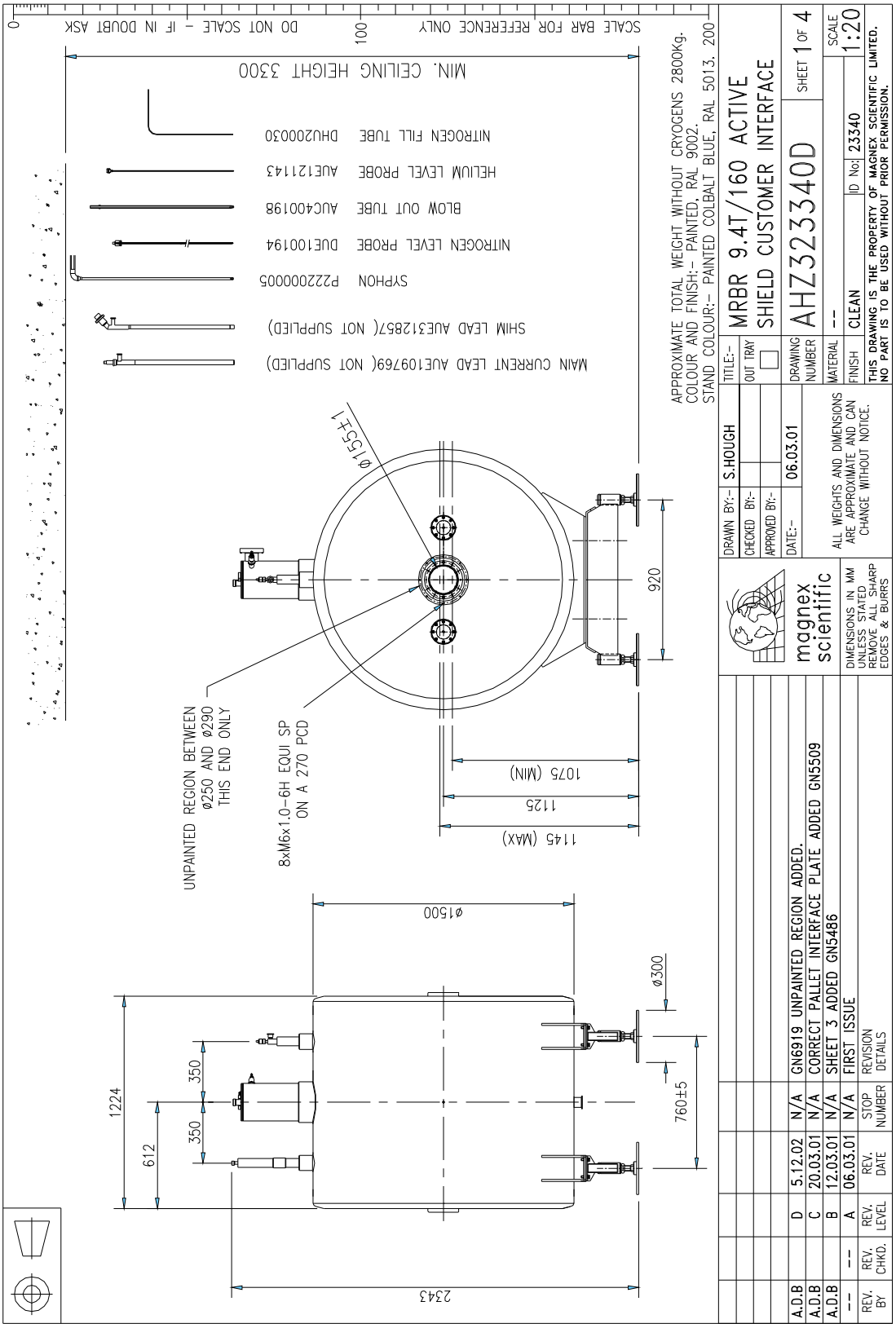
5. SYSTEM COMPONENTS

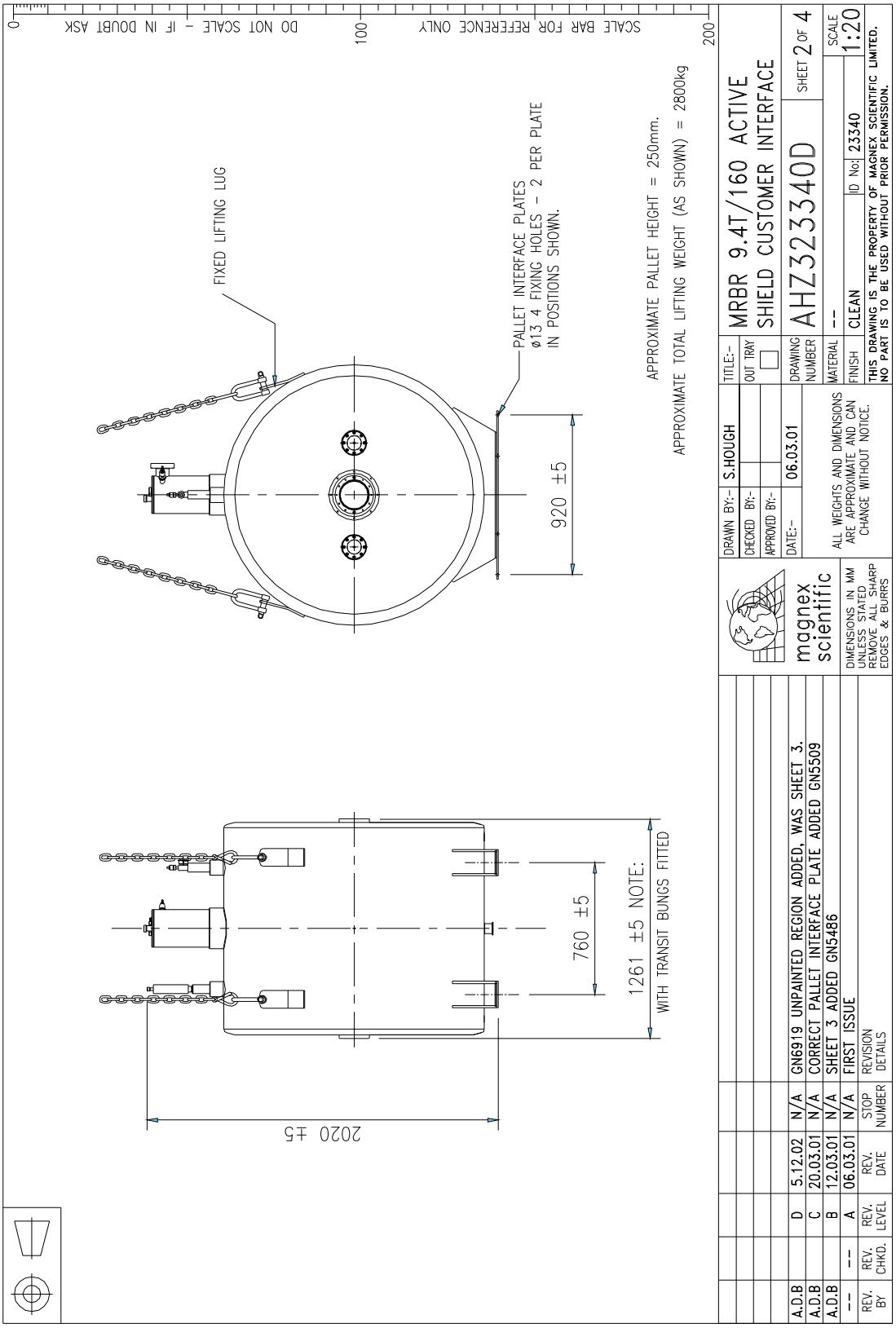
i) Superconducting Magnet System Components

1 off	9.4T 160 mm actively shielded MRBR magnet system with integral s/c shims and lock coils housed in a low loss cryostat.	
1 off	Stand (cobalt blue)	

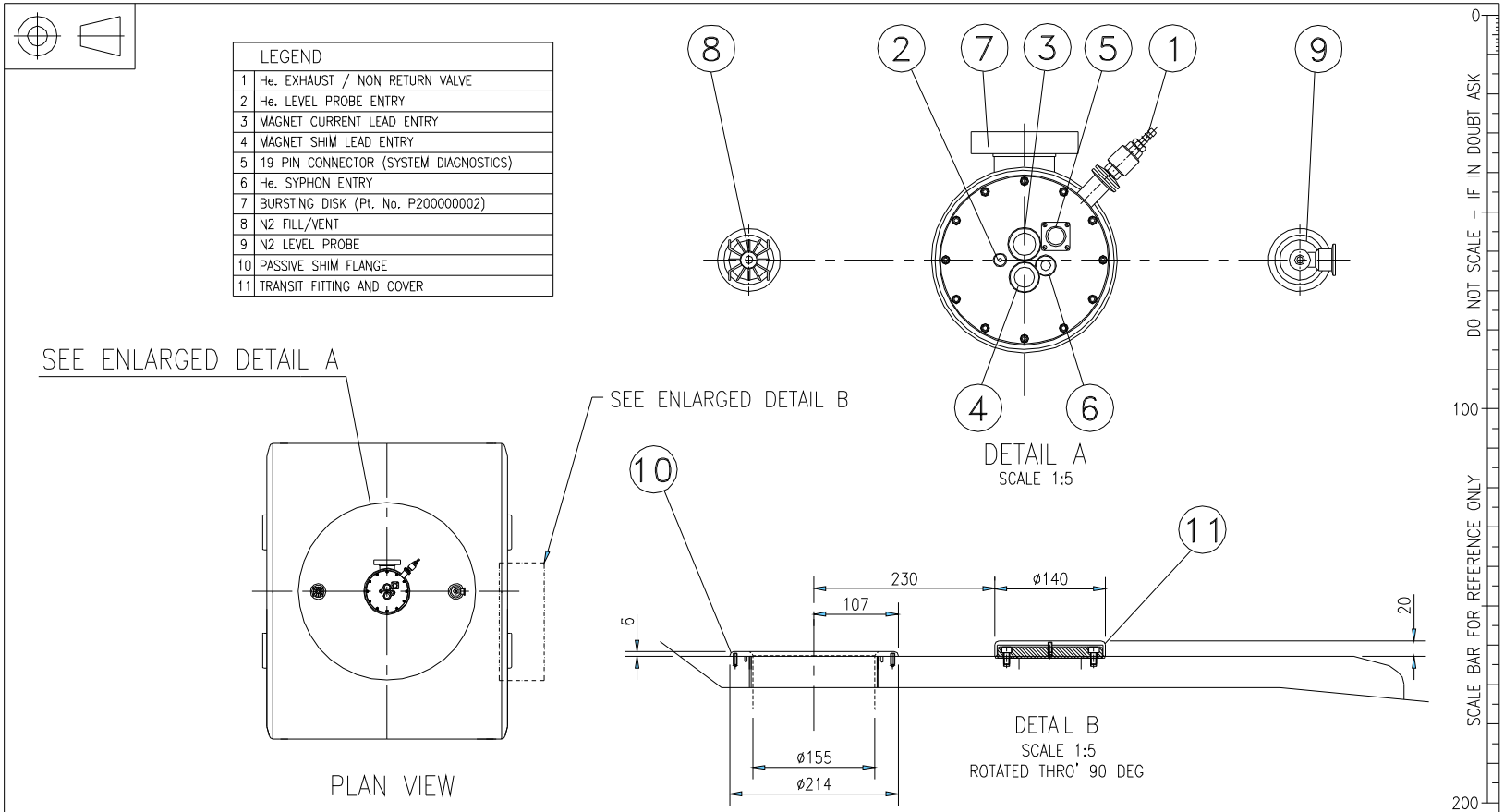
ii) Standard Ancillary Parts

1 off	Helium level monitor	E5011
1 off	Nitrogen level monitor	E5031
1 off	Head oscillator	E5030
1 off	Emergency discharge unit	E7007
1 off	Service cable	C009185
1 off	Helium monitor cable	C009003
1 off	Nitrogen monitor cable	C011385
1 off	Flexible siphon (2.0m)	P222000005
1 off	Nitrogen blow out tube	AUC400198
1 off	Nitrogen fill tube	AHU327799
1 off	Spares kit	AKZ509324
1 off	System manual	MHI1276
1 off	De-mountable Helium Level Probe	AUE121143
1 off	De-mountable Nitrogen Level Probe	DUE100194
1 off	Quench elbow	


SCALE BAR FOR REFERENCE ONLY
DO NOT SCALE – IF IN DOUBT ASK
MIN. CEILING HEIGHT 3300
NITROGEN FILL TUBE DHU200030
HELIUM LEVEL PROBE AUE121143
BLOW OUT TUBE AUC400198
NITROGEN LEVEL PROBE DUE100194
SYPHON P222000005
SHIM LEAD AUE312857(NOT SUPPLIED)
MAIN CURRENT LEAD AUE109769(NOT SUPPLIED)
APPROXIMATE TOTAL WEIGHT WITHOUT CRYOGENS 2800Kg.
COLOUR AND FINISH:- PAINTED, RAL 9002.
STAND COLOUR:- PAINTED COLBALT BLUE, RAL 5013. 200
UNPAINTED REGION BETWEEN
ø250 AND ø290
THIS END ONLY
8×M6x1.0–6H EQUI SP
ON A 270 PCD
ø1653±1
920
1075 (MIN)
1125
1145 (MAX)
ø1500
ø300
1224
612
350
350
760±5
2343
REV. BY
REV. CHKD.
REV. LEVEL
REV. DATE
STOP NUMBER
REVISION DETAILS
A.D.B
A.D.B
A.D.B
--
REV. BY
D
C
B
A
--
5.12.02
20.03.01
12.03.01
06.03.01
REV. DATE
N/A
N/A
N/A
N/A
STOP NUMBER
GN6919 UNPAINTED REGION ADDED.
CORRECT PALLET INTERFACE PLATE ADDED GN5509
SHEET 3 ADDED GN5486
FIRST ISSUE
REVISION DETAILS
magnex scientific
DIMENSIONS IN MM UNLESS STATED
REMOVE ALL SHARP EDGES & BURRS
DRAWN BY:- S.HOUGH
CHECKED BY:-
APPROVED BY:-
DATE:- 06.03.01
ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE AND CAN CHANGE WITHOUT NOTICE.
TITLE:- MRBR 9.4T/160 ACTIVE SHIELD CUSTOMER INTERFACE
OUT TRAY
DRAWING NUMBER AHZ323340D
SHEET 1 OF 4
MATERIAL --
SCALE 1:20
FINISH CLEAN
ID No: 23340
THIS DRAWING IS THE PROPERTY OF MAGNEX SCIENTIFIC LIMITED. NO PART IS TO BE USED WITHOUT PRIOR PERMISSION.


SCALE BAR FOR REFERENCE ONLY
DO NOT SCALE - IF IN DOUBT ASK
0
100
200
FIXED LIFTING LUG
PALLET INTERFACE PLATES
ø13 4 FIXING HOLES - 2 PER PLATE
IN POSITIONS SHOWN.
APPROXIMATE PALLET HEIGHT = 250mm.
APPROXIMATE TOTAL LIFTING WEIGHT (AS SHOWN) = 2800kg
920 ±5
760 ±5
1261 ±5 NOTE:
WITH TRANSIT BUNGS FITTED
2020 ±5
DRAWN BY:- S.HOUGH
CHECKED BY:-
APPROVED BY:-
DATE:- 06.03.01
TITLE:- MRBR 9.4T/160 ACTIVE SHIELD CUSTOMER INTERFACE
OUT TRAY
DRAWING NUMBER AHZ323340D
SHEET 2 OF 4
MATERIAL --
FINISH CLEAN
ID No: 23340
SCALE 1:20
magnex scientific
ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE AND CAN CHANGE WITHOUT NOTICE.
DIMENSIONS IN MM UNLESS STATED
REMOVE ALL SHARP EDGES & BURRS
THIS DRAWING IS THE PROPERTY OF MAGNEX SCIENTIFIC LIMITED. NO PART IS TO BE USED WITHOUT PRIOR PERMISSION.
REV. BY
REV. CHKD.
REV. LEVEL
REV. DATE
STOP NUMBER
REVISION DETAILS
A.D.B D 5.12.02 N/A GN6919 UNPAINTED REGION ADDED, WAS SHEET 3.
A.D.B C 20.03.01 N/A CORRECT PALLET INTERFACE PLATE ADDED GN5509
A.D.B B 12.03.01 N/A SHEET 3 ADDED GN5486
-- -- A 06.03.01 N/A FIRST ISSUE

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	PASSIVE SHIM FLANGE
11	TRANSIT FITTING AND COVER



REV. BY	REV. CHKD.	REV. LEVEL	REV. DATE	STOP NUMBER	REVISION DETAILS
A.D.B		D	5.12.02	N/A	GN6919 DETAIL 'B' ADDED, SHEET No. WAS 2
A.D.B		C	20.03.01	N/A	CORRECT PALLET INTERFACE PLATE ADDED GN5509
A.D.B		B	12.03.01	N/A	SHEET 3 ADDED GN5486
--	--	A	06.03.01	N/A	FIRST ISSUE

magnex scientific

DIMENSIONS IN MM UNLESS STATED REMOVE ALL SHARP EDGES & BURRS

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

DRAWN BY:-	S.HOUGH
CHECKED BY:-	
APPROVED BY:-	
DATE:-	06.03.01

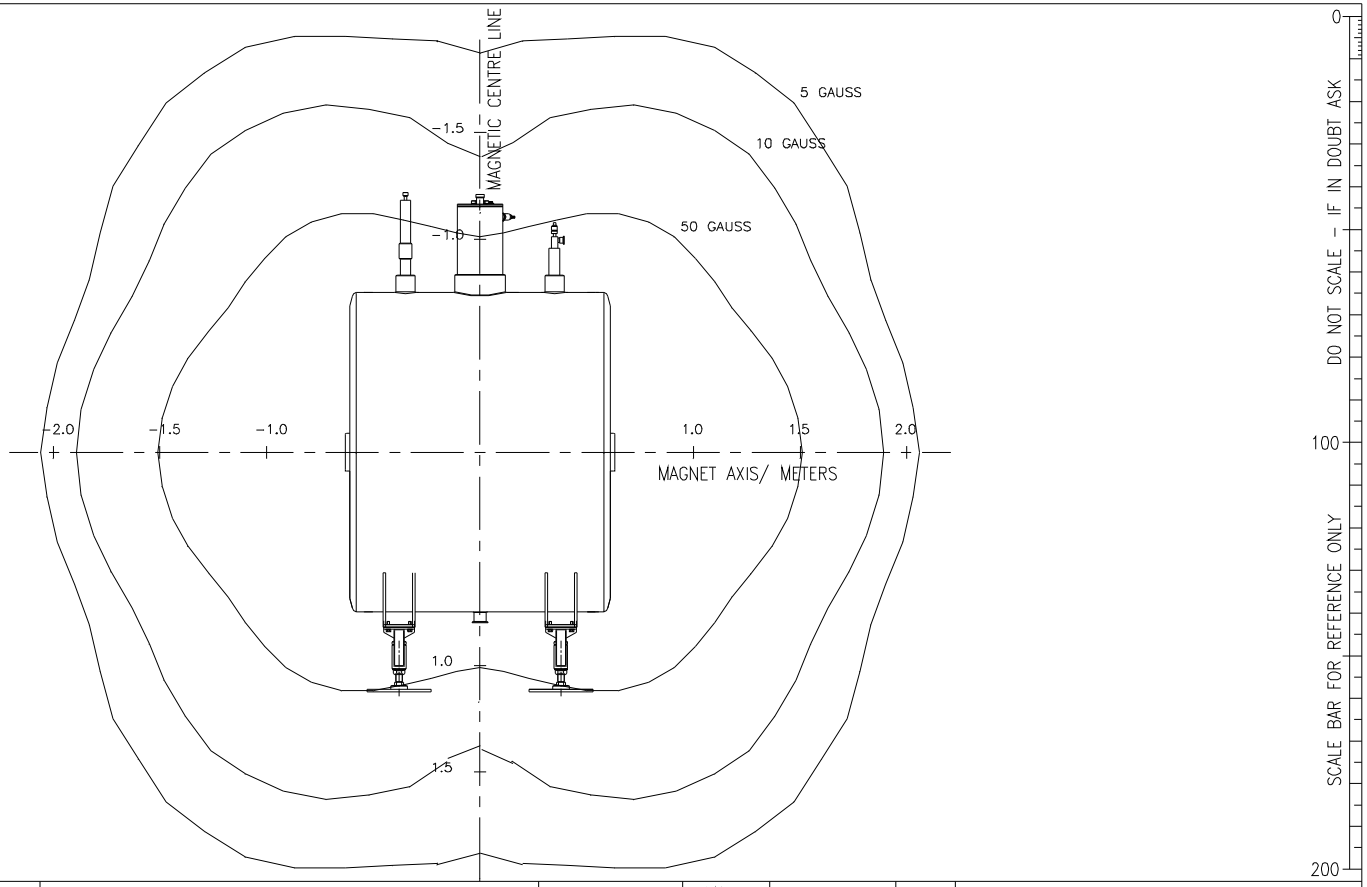
TITLE:- MRBR 9.4T/160 ACTIVE SHIELD CUSTOMER INTERFACE

OUT TRAY

DRAWING NUMBER: AHZ323340D — SHEET 3 OF 4

MATERIAL: -- — SCALE: 1:20

FINISH: CLEAN — ID No: 23340



REV. BY	REV. CHKD.	REV. LEVEL	REV. DATE	STOP NUMBER	REVISION DETAILS
A.D.B		D	5.12.02	N/A	GN6919 THIS SHEET ADDED.
A.D.B		C	20.03.01	N/A	CORRECT PALLET INTERFACE PLATE ADDED GN5509
A.D.B		B	12.03.01	N/A	SHEET 3 ADDED GN5486
--	--	A	06.03.01	N/A	FIRST ISSUE

magnex scientific

DIMENSIONS IN MM UNLESS STATED REMOVE ALL SHARP EDGES & BURRS

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

DRAWN BY:-	S.HOUGH
CHECKED BY:-	
APPROVED BY:-	
DATE:-	06.03.01

TITLE:- MRBR 9.4T/160 ACTIVE SHIELD CUSTOMER INTERFACE

OUT TRAY

DRAWING NUMBER: AHZ323340D — SHEET 4 OF 4

MATERIAL: --

FINISH: CLEAN — ID No: 23340

SCALE: 1:20