TECHNICAL SPECIFICATIONS

FOR AN MRBR 4.7 TESLA/160mm ACTIVELY SHIELDED ROOM TEMPERATURE BORE MAGNET SYSTEM

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CONTENTS

1. DESCRIPTION OF THE SYSTEM

The system essentially consists of a highly homogeneous superconducting magnet (4.7 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.

Passive shims can be mounted on a tube in the bore of the magnet leaving an overall system bore size of 155mm diameter. However, if a gradient coil is fitted then the passive shims are mounted on the gradient.

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 and then fully vacuum impregnated for robustness and long-term reliability.

The field homogeneity is defined over two cylinders and a sphere. All orders of impurity up to 10th order are theoretically cancelled within these volumes. 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. 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 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	:	4.7 Tesla
Field stability measured a minimum of 72 hours after energisation	:	Less than 0.05 ppm/hour

The above values assume that the room temperature is maintained at +/- 1^{o}C

Operating current	:	250 Amps (nominal)

Field homogeneity values

S/C and passively shimmed : 10 ppm p-p over 8.5cm dsv[1]

Residual Gradients over 8.5 cm dsv[1]

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

: 5ppm p-p over 8.0 cm dsv[2]
10ppm p-p over cylinder 60mm diameter by 60mm long[3], and
: 4 ppm p-p over cylinder 30mm diameter by 60mm long[3]

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

Time to energise magnet to full field : Less than 40 minutes

Estimate of helium consumption during ramping to full field : 10-15 litres

Fringe field : See Figure 1

Position of 5 gauss contour[5]

Axially from magnet centre line : 1.9 metres
Radially from magnet centre line : 1.1 metres

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[1] Defined as the peak to peak variations of points plotted over a seven plane plot on the surface of the stated spherical volume.

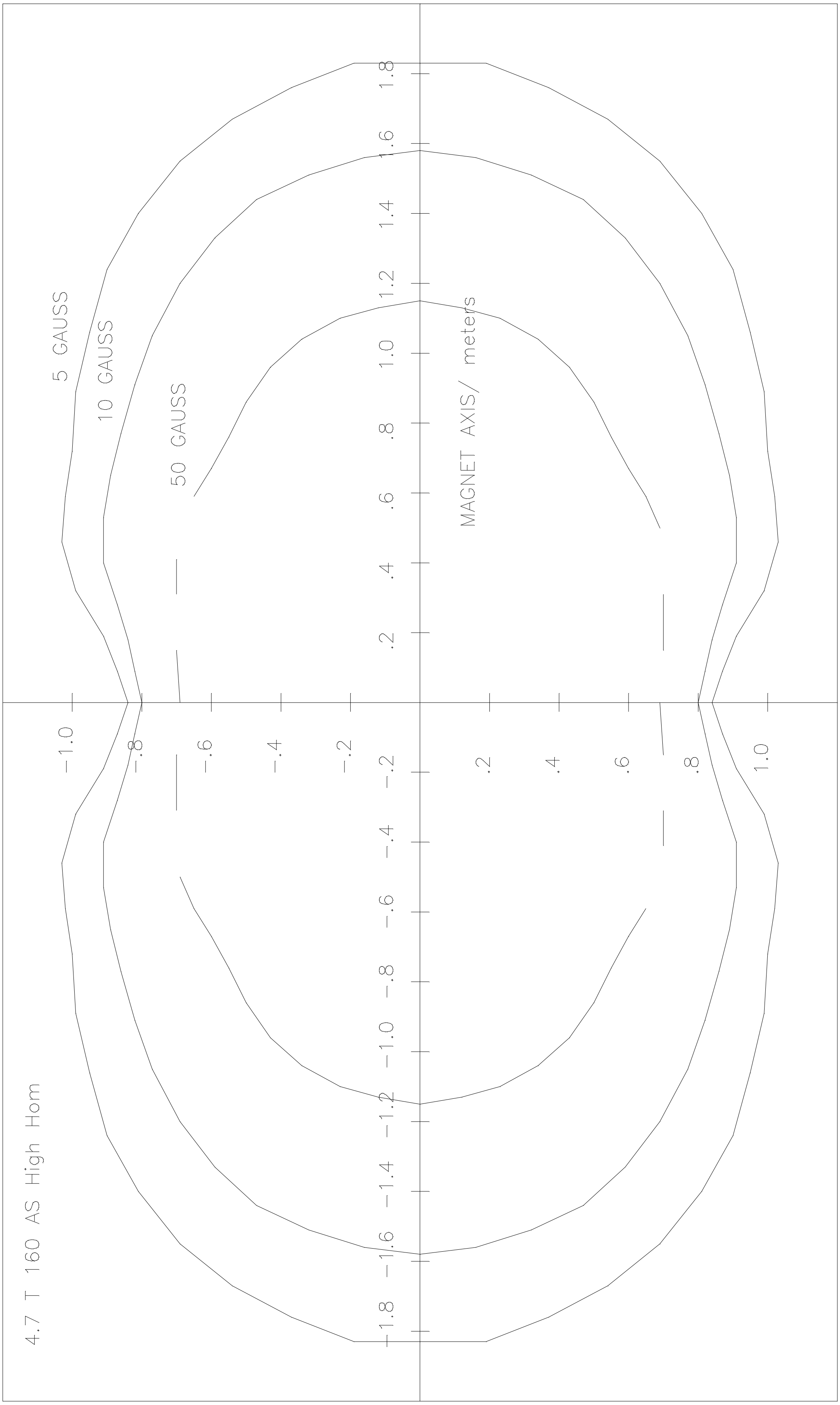
[2] Projected over a seven plane plot.

[3] Defined as the peak to peak variation of points plotted over a five plane plot on the surface of the stated cylinder.

[4] If using Magnex standard RT shim set.

[5] **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 4.7 T 160 mm actively shielded magnet



iii. <u>Superconducting Shim Coils</u>

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 designed to be de-coupled from main coil

Typical shim strength over 60mm diameter

Shim	Strength (ppm/amp of main field)
Z1	15.0
Z2	6.5
X(Y)	5.0
ZX(ZY)	0.42
XY(X2-Y2)	0.40

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 400 litres of liquid helium of which approximately 200 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. AHZ328473

Dimensions:-

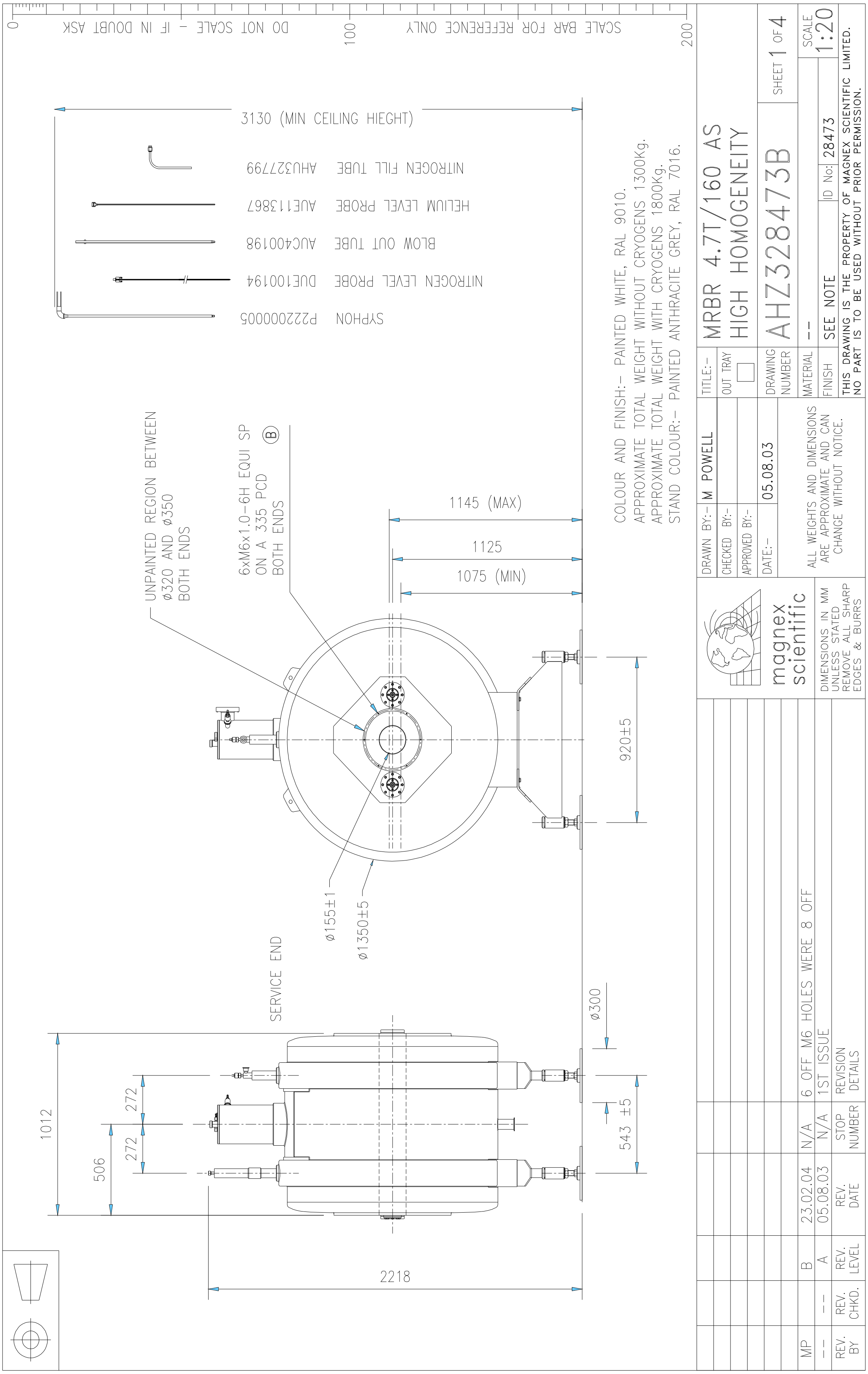
Length of cryostat	:	1012mm
Room temperature clear bore (with passive shims)	:	155mm
Room temperature bore-tube material	:	Stainless steel
Centre of field to base of stand	:	1075-1145mm
Cryostat end-flange to centre of field	:	506mm
Minimum ceiling height for siphon	:	3130mm
Weight of cryostat (excluding cryogens)	:	1300kg (approx.)

<u>Liquid helium cryogen details:-</u>

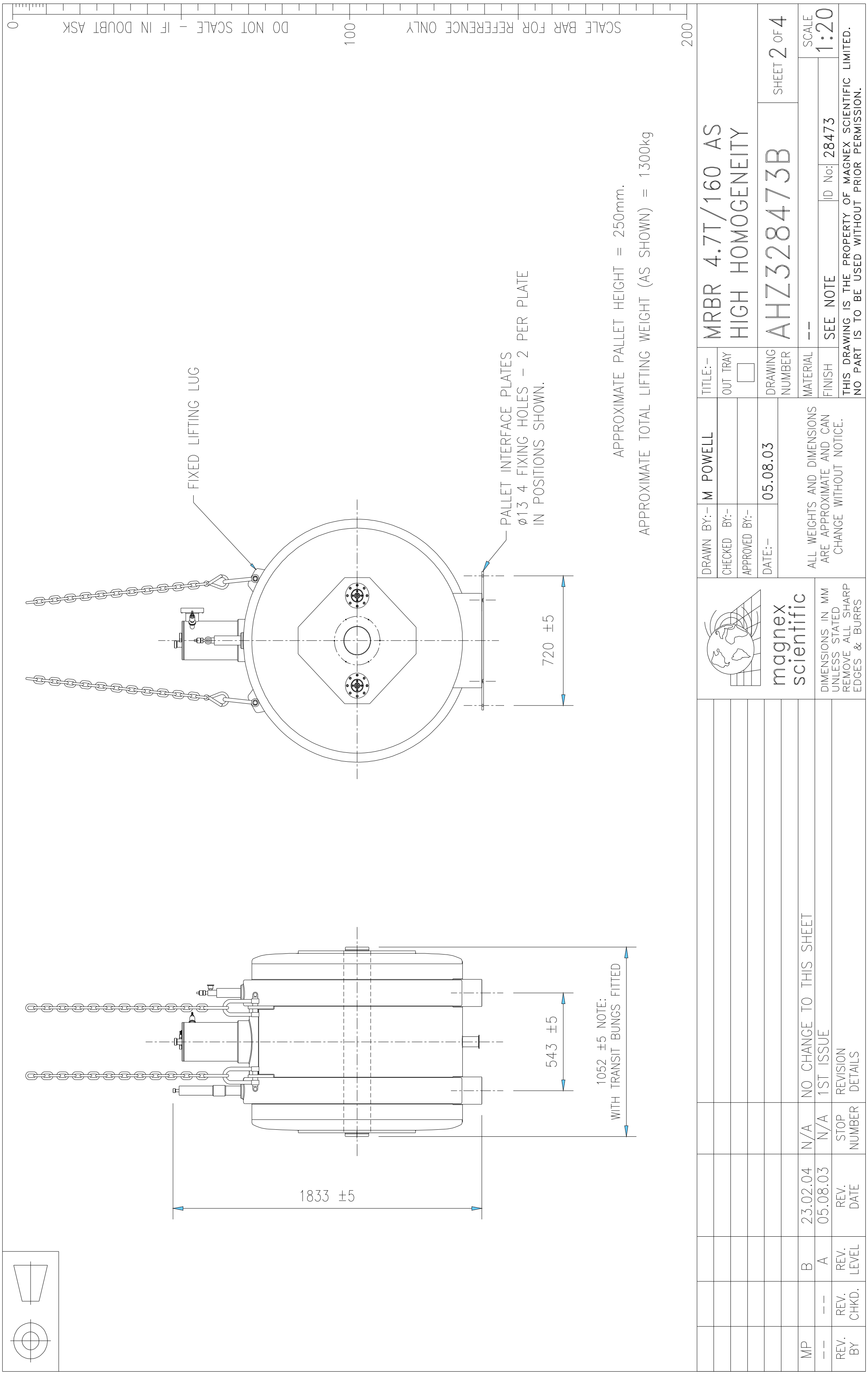
Volume for initial installation (includes cooling the magnet from 77K to 4.2K, volume required to completely fill helium reservoir and to top-up helium reservoir after magnet energisation)	:	800 litres
Recommended refill volume during normal operation	:	200 litres
Maximum volume of reservoir	:	400 litres
Hold-time during normal operation (static magnetic field, leads withdrawn)	:	More than 150 days

<u>Liquid nitrogen cryogen details:-</u>

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 14 days



0
DO NOT SCALE - IF IN DOUBT ASK
100
SCALE BAR FOR REFERENCE ONLY
200
3130 (MIN CEILING HIEGHT)
NITROGEN FILL TUBE AHU327799
HELIUM LEVEL PROBE AUE113867
BLOW OUT TUBE AUC400198
NITROGEN LEVEL PROBE DUE100194
SYPHON P222000005
UNPAINTED REGION BETWEEN
Ø320 AND Ø350
BOTH ENDS
6xM6x1.0-6H EQUI SP
ON A 335 PCD
BOTH ENDS
B
1145 (MAX)
1125
1075 (MIN)
COLOUR AND FINISH:- PAINTED WHITE, RAL 9010.
APPROXIMATE TOTAL WEIGHT WITHOUT CRYOGENS 1300Kg.
APPROXIMATE TOTAL WEIGHT WITH CRYOGENS 1800Kg.
STAND COLOUR:- PAINTED ANTHRACITE GREY, RAL 7016.
920±5
Ø155±1
Ø1350±5
SERVICE END
Ø300
543 ±5
1012
506
272
272
2218
TITLE:- MRBR 4.7T/160 AS
HIGH HOMOGENEITY
OUT TRAY
DRAWING NUMBER AHZ328473B
SHEET 1 OF 4
SCALE 1:20
MATERIAL --
FINISH SEE NOTE
ID No: 28473
THIS DRAWING IS THE PROPERTY OF MAGNEX SCIENTIFIC LIMITED.
NO PART IS TO BE USED WITHOUT PRIOR PERMISSION.
DRAWN BY:- M POWELL
CHECKED BY:-
APPROVED BY:-
DATE:- 05.08.03
ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE AND CAN CHANGE WITHOUT NOTICE.
magnex scientific
DIMENSIONS IN MM UNLESS STATED
REMOVE ALL SHARP EDGES & BURRS
MP B 23.02.04 N/A 6 OFF M6 HOLES WERE 8 OFF
-- -- A 05.08.03 N/A 1ST ISSUE
REV. BY
REV. CHKD.
REV. LEVEL
REV. DATE
STOP NUMBER
REVISION DETAILS


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) = 1300kg
720 ±5
543 ±5
1052 ±5 NOTE:
WITH TRANSIT BUNGS FITTED
1833 ±5
TITLE:- MRBR 4.7T/160 AS
HIGH HOMOGENEITY
OUT TRAY
DRAWN BY:- M POWELL
CHECKED BY:-
APPROVED BY:-
DATE:- 05.08.03
DRAWING NUMBER AHZ328473B
SHEET 2 OF 4
MATERIAL --
FINISH SEE NOTE
ID No: 28473
SCALE 1:20
ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE AND CAN CHANGE WITHOUT NOTICE.
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DIMENSIONS IN MM UNLESS STATED
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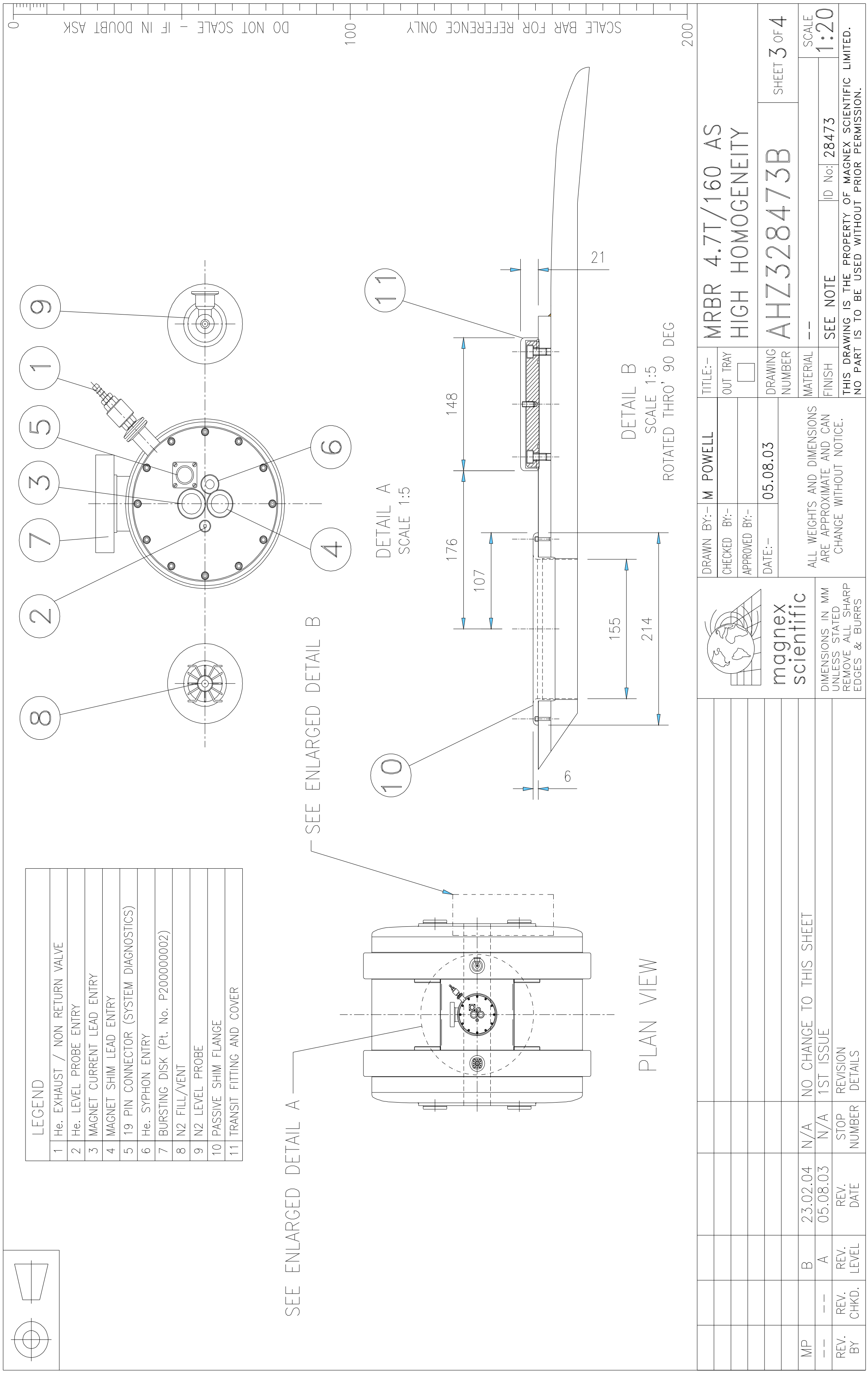
DO NOT SCALE - IF IN DOUBT ASK
SCALE BAR FOR REFERENCE ONLY
0
100
200
LEGEND
1 He. EXHAUST / NON RETURN VALVE
2 He. LEVEL PROBE ENTRY
3 MAGNET CURRENT LEAD ENTRY
4 MAGNET SHIM LEAD ENTRY
5 19 PIN CONNECTOR (SYSTEM DIAGNOSTICS)
6 He. SYPHON ENTRY
7 BURSTING DISK (Pt. No. P200000002)
8 N2 FILL/VENT
9 N2 LEVEL PROBE
10 PASSIVE SHIM FLANGE
11 TRANSIT FITTING AND COVER
SEE ENLARGED DETAIL A
SEE ENLARGED DETAIL B
PLAN VIEW
DETAIL A
SCALE 1:5
DETAIL B
SCALE 1:5
ROTATED THRO' 90 DEG
21
148
176
107
155
214
6
TITLE:- MRBR 4.7T/160 AS HIGH HOMOGENEITY
OUT TRAY
DRAWN BY:- M POWELL
CHECKED BY:-
APPROVED BY:-
DATE:- 05.08.03
DRAWING NUMBER AHZ328473B
SHEET 3 OF 4
SCALE 1:20
MATERIAL --
FINISH SEE NOTE
ID No: 28473
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DIMENSIONS IN MM UNLESS STATED
REMOVE ALL SHARP EDGES & BURRS
MP | B | 23.02.04 | N/A | NO CHANGE TO THIS SHEET
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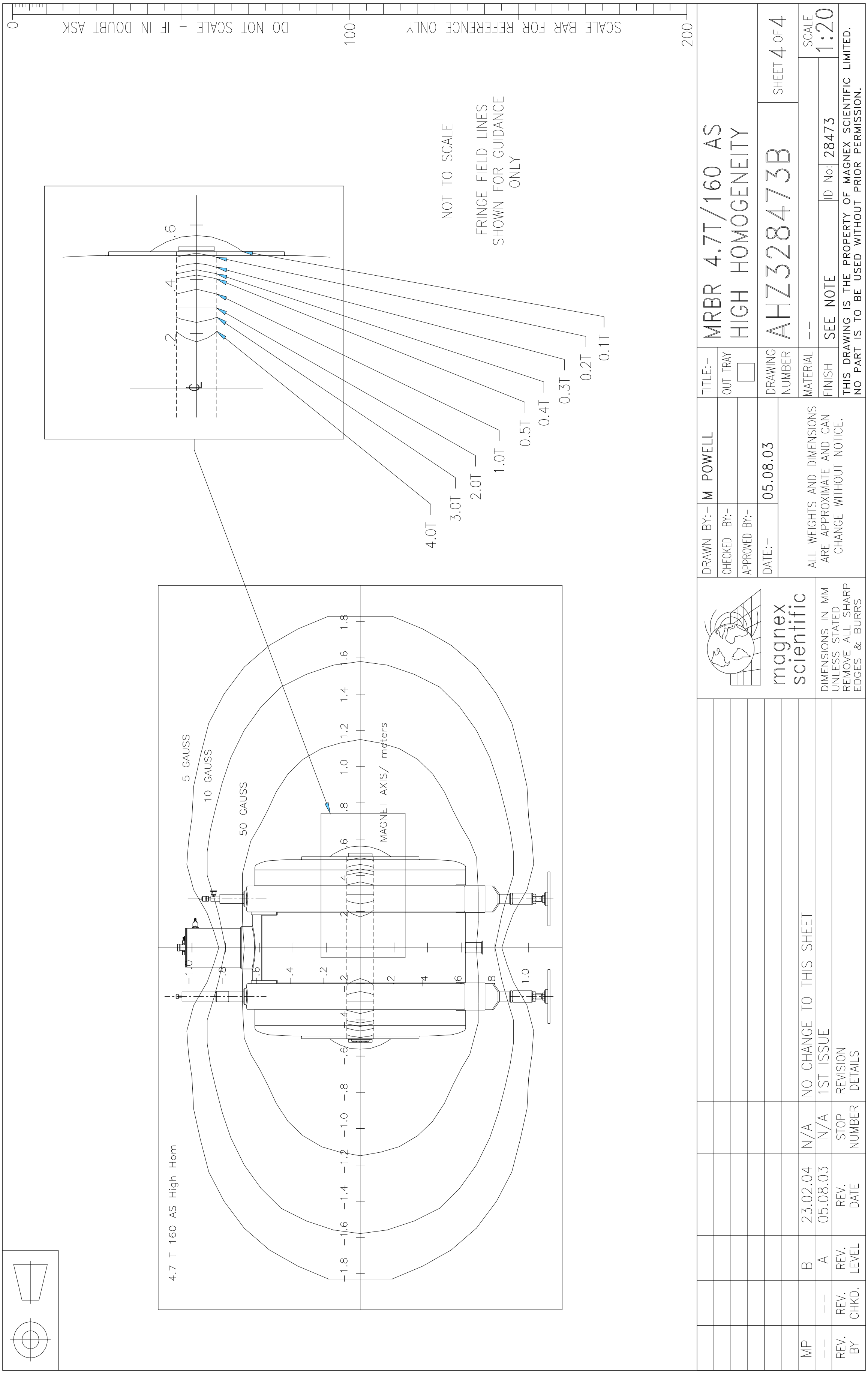
DO NOT SCALE - IF IN DOUBT ASK
SCALE BAR FOR REFERENCE ONLY
0
100
200
NOT TO SCALE
FRINGE FIELD LINES SHOWN FOR GUIDANCE ONLY
4.0T
3.0T
2.0T
1.0T
0.5T
0.4T
0.3T
0.2T
0.1T
5 GAUSS
10 GAUSS
50 GAUSS
MAGNET AXIS/ meters
4.7 T 160 AS High Hom
TITLE:- MRBR 4.7T/160 AS HIGH HOMOGENEITY
OUT TRAY
DRAWING NUMBER AHZ328473B
SHEET 4 OF 4
SCALE 1:20
MATERIAL --
FINISH SEE NOTE
ID No: 28473
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CHECKED BY:-
APPROVED BY:-
DATE:- 05.08.03
ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE AND CAN CHANGE WITHOUT NOTICE.
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DIMENSIONS IN MM UNLESS STATED REMOVE ALL SHARP EDGES & BURRS
MP | B | 23.02.04 | N/A | NO CHANGE TO THIS SHEET
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REV. BY | REV. CHKD. | REV. LEVEL | REV. DATE | STOP NUMBER | REVISION DETAILS

4 SYSTEM COMPONENTS

i. Superconducting Magnet System Components

1 off 4.7T 160 mm actively shielded MRBR magnet system with integral superconducting shims and lock coils housed in a low loss cryostat.

1 off Stand

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	C0091085
1 off	Helium monitor cable	C0090003
1 off	Nitrogen monitor cable	C0113085
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	De-mountable Helium Level Probe	AUE113867
1 off	De-mountable Nitrogen Level Probe	DUE100194
1 off	System manual	
1 off	3m nitrogen transfer line	ATU327865

iii. Optional Ancillary Parts

Quench duct assembly.	4”	AHC327457
	6”	AHC327456
	8”	AHC327455