SPECIFICATION FOR A 7.0 TESLA/400MM ROOM TEMPERATURE BORE MAGNET SYSTEM

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1. DESCRIPTION OF SYSTEM

The MRBR 7.0/400 System is a complete superconducting magnet system intended primarily for Research Studies on the Clinical/Biological applications of NMR Imaging (MRI) and NMR Spectroscopy (MRS).

The system essentially consists of a highly homogeneous superconducting magnet (300MHz ^{1}P, 7.05 Tesla) housed in a horizontal room temperature bore (400mm), low-loss helium cryostat. Field shimming is normally accomplished using both superconducting and room temperature shim coils. For Imaging applications X, Y and Z gradient coils can also be provided with the system.

Normally the room temperature shims and gradients are mounted on independent non-conducting formers, and are positioned in the room temperature bore of the system.

The system can be complemented with the supply of electronic consoles housing the superconducting magnet power supply with integral switching unit for energisation of the superconducting shim coils, multi channel room temperature shim coil power supply and cryomonitors for helium and nitrogen. An emergency quench heater control unit is 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 a precision machined aluminium alloy former and then fully vacuum impregnated for robustness and long-term reliability.

The field homogeneity is defined over a 20cm diameter spherical volume and all orders of impurity up to and including 12th 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 loacted on a former surrounding the main coil. Final corrections are made by room-temperature correction coils placed in the bore of the system.

The magnet coils are fully protected from accidental damage due to a quench by a cold diode 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.

ii. Specifications

Magnet type	:	Multi-coil superconducting
Central field	:	7.05 Tesla (300MHz ^{1}P)
Field stability measured a minimum of 72 hours after energisation	:	Less than 0.05 ppm/hour
Operating current	:	178 Amps (nominal)
Field homogeneity values		
Superconducting only shimmed	:	Less than 20ppm over 20cm dsv*
Fully shimmed using RT shims	:	Less than 5ppm over 20cm* 0.1ppm hhlw over 13cm dsv**
Estimate of helium consumption during ramping to full field	:	150 litres
Fringe field (position of 5 gauss contour in unshielded state)	:	See Figure 1
Axially from magnet centre line	:	10.9 metres
Radially from magnet centre line	:	8.6 metres

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

** hhlw measurement

iii. Superconducting Shim Coils

These coils are positioned on a non-conducting 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 : Z1, Z2, Z3, Z4, X, Y, ZX, ZY, XY, X2-Y2, Z2X, Z2Y, ZXY & Z(X2-Y2)

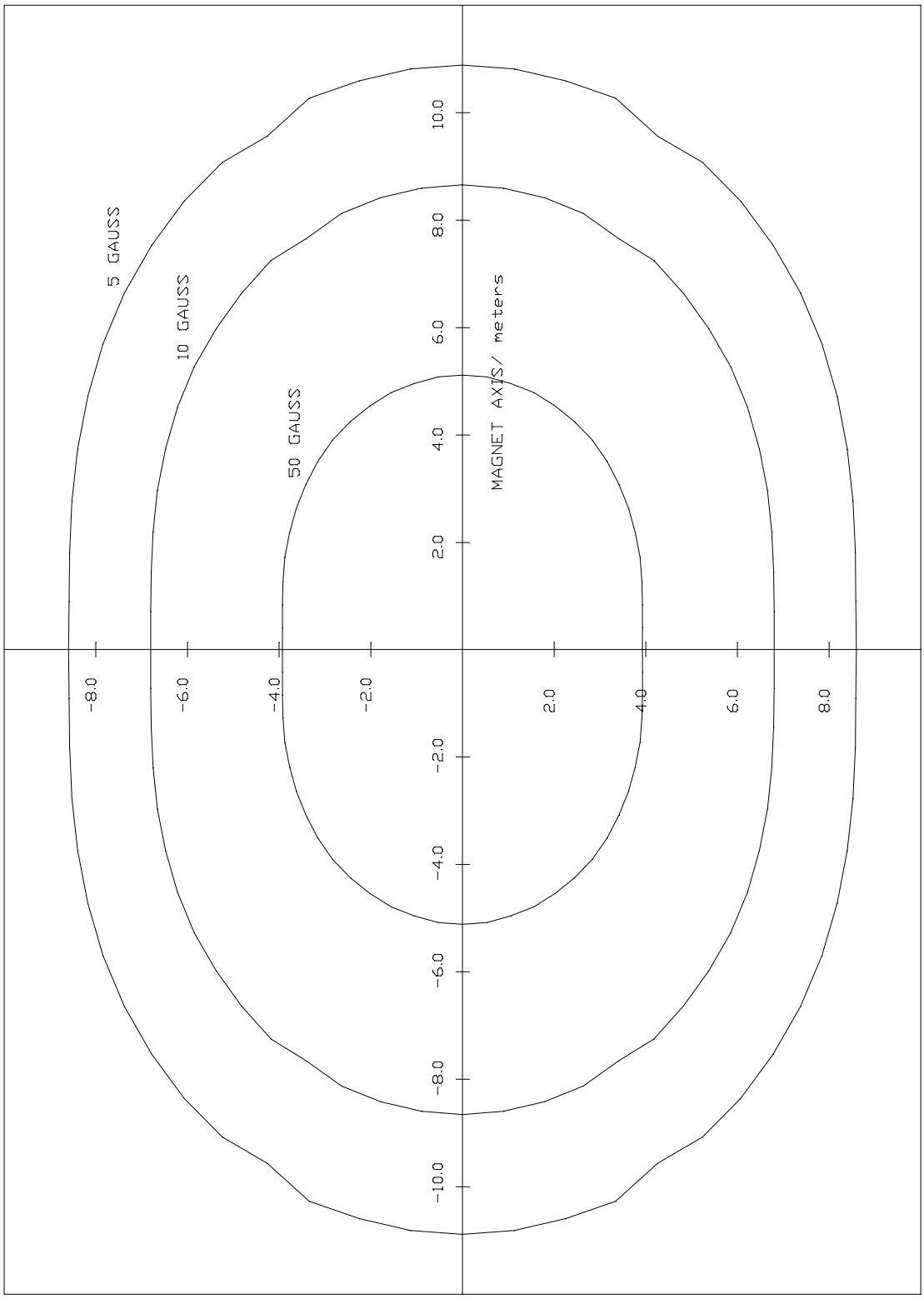
Maximum recommended current : 25 amps

Coupling : All shims are decoupled from main coil except Z1, Z2, Z3 and Z4

Typical shim strengths over 20cm diameter:

Shim	Strength at 10 cm radius (ppm/amp)
Z1	36.6
Z2	16.3
Z3	2.39
Z4	1.20
X	5.90
Y	5.90
ZX	1.21
ZY	1.21
XY	0.47
X2-Y2	0.47
Z2X	0.18
Z2Y	0.18
ZXY	0.032
Z(X2-Y2)	0.032

Figure 1 Stray Field (Unshielded)



3. THE CRYOSTAT

i. General Description

The cryostat is of conventional design, 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 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 has end-flange closures constructed from aluminium which are sealed to the main body and bore-tube by compressed rubber 'O' ring seals. The room-temperature bore-tube is constructed from stainless steel.

The cryostat is supplied with a support stand that consists of load-spreading plates which have provision for fixing to the floor of the installation room. The helium reservoir contains in total approximately 1030 litres of liquid helium of which approximately 190 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 specifications (see figure 2) are as follows:-

Dimensions:-

Length of cryostat	: 1840mm
Height with support frame	: 2210mm
Room temperature clear bore (without shims and gradients)	: 400mm
Room temperature bore-tube material	: Stainless steel
Centre of field to base of stand	: 875mm

Cryostat end flange to centre of field	:	920mm
Outside diameter	:	1720mm
Minimum ceiling height for service tools	:	3033mm
Weight of cryostat (excluding cryogens)	:	5200kg (approx)

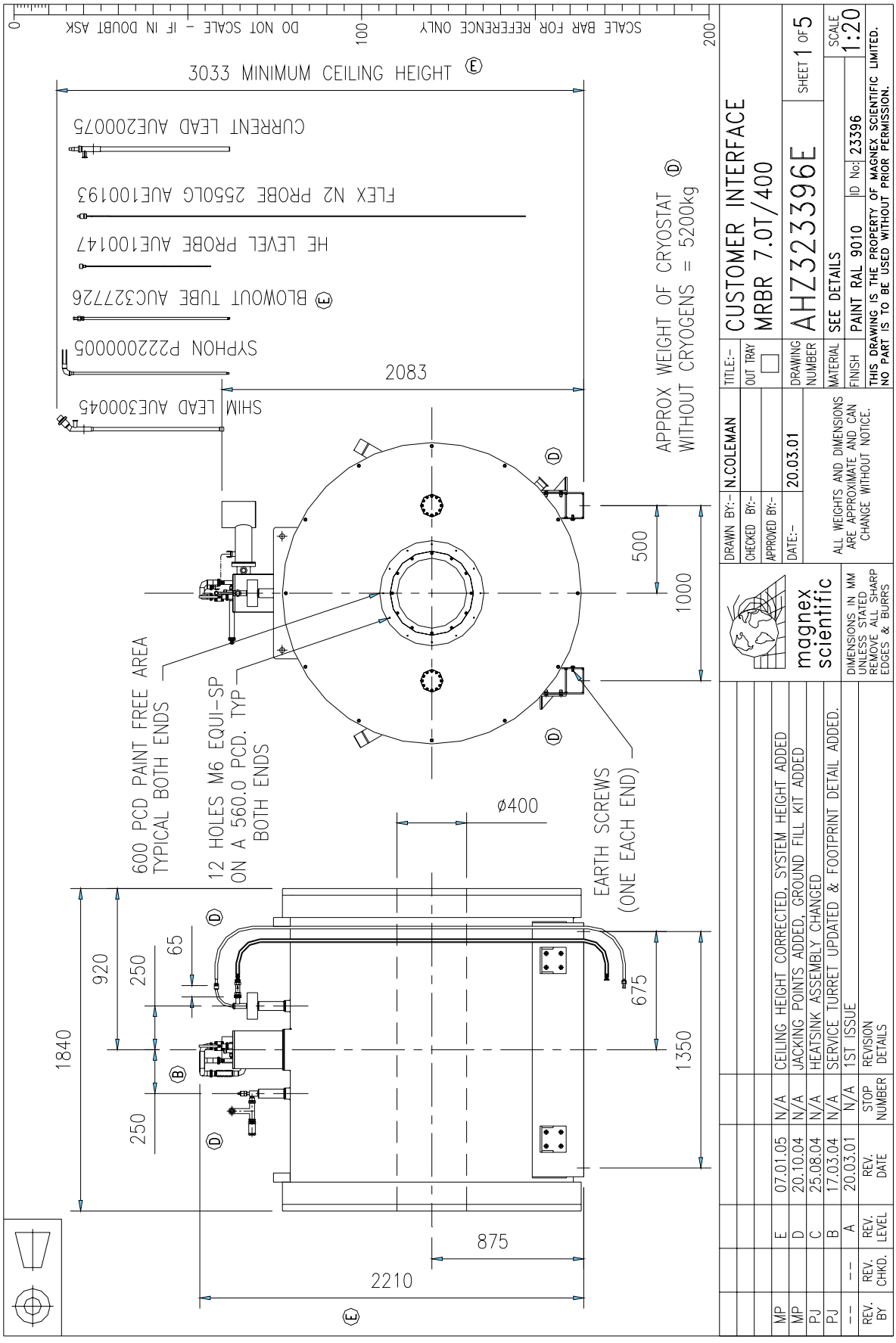
Liquid helium cryogen details :-

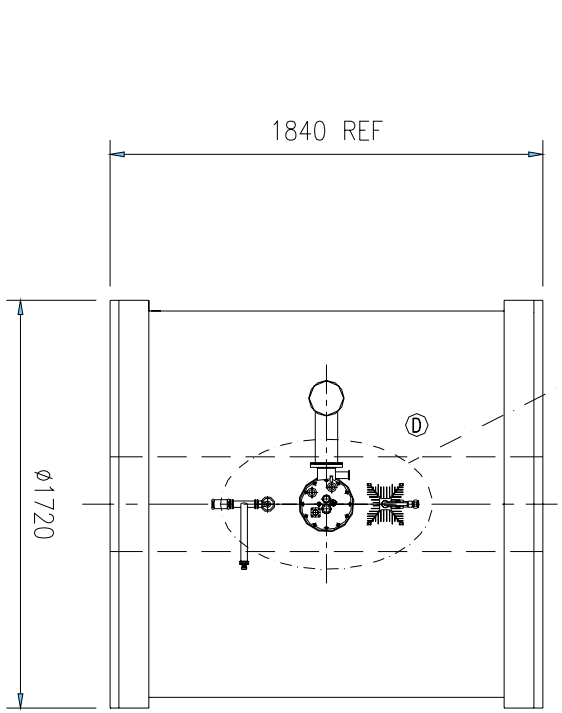
Volume for initial installation (includes cooling the magnet from 77K to 4.2K, volume required to completely fill helium reservoir and top-up after magnet energisation)	:	2500 litres
Recommended refill volume during normal operation	:	190 litres
Maximum volume of reservoir	:	1030 litres
Hold-time during normal operation (static magnetic field, leads withdrawn)	:	More than 45 days

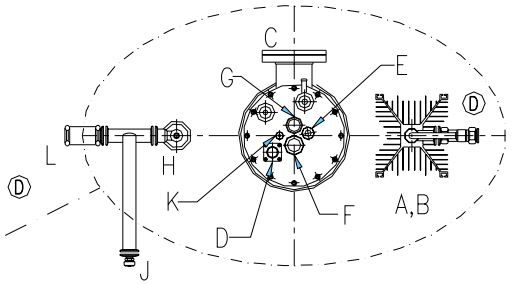
Liquid nitrogen cryogen details :-

Volume for initial installation (includes pre-cool of magnet to 77K and volume required to completely fill LN2 reservoir)	:	4000 litres
Volume of reservoir	:	170 litres nominal
Refill volume	:	170 litres nominal excluding transfer losses
Hold-time in static condition	:	More than 12 days

Figure 2 Drawing of cryostat







PLAN VIEW SCALE 1:10 Ⓑ

A	LN2 FILL/ EXHAUST PORT
B	CHECK VALVE (N2 BOIL OFF)
C	HELIUM CAN BURSTING DISC
D	ELECTRICAL LEAD THROUGH
E	SYPHON ENTRY SEAL
F	MAGNET CURRENT LEAD ENTRY SEAL
G	SHIM CURRENT LEAD ENTRY SEAL
H	LN2 LEVEL PROBE
J	LN2 PRESSURE RELIEF VALVE
K	HELIUM LEVEL PROBE ENTRY SEAL
L	CHECK VALVE (EXHAUST FOR N2 TOP-UPS)

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
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MP		D	20.10.04	N/A	GROUND FILL KIT ADDED
PJ		C	25.08.04	N/A	HEATSINK ASSEMBLY CHANGED
PJ		B	17.03.04	N/A	SERVICE TURRET UPDATED & FOOTPRINT DETAIL ADDED
--	--	A	20.03.01	N/A	1ST ISSUE

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APPROVED BY:–	
DATE:–	20.03.01

TITLE:– CUSTOMER INTERFACE MRBR 7.0T/400

OUT TRAY

DRAWING NUMBER AHZ323396E

SHEET 2 OF 5

MATERIAL SEE DETAILS

FINISH PAINT RAL 9010

ID No: 23396

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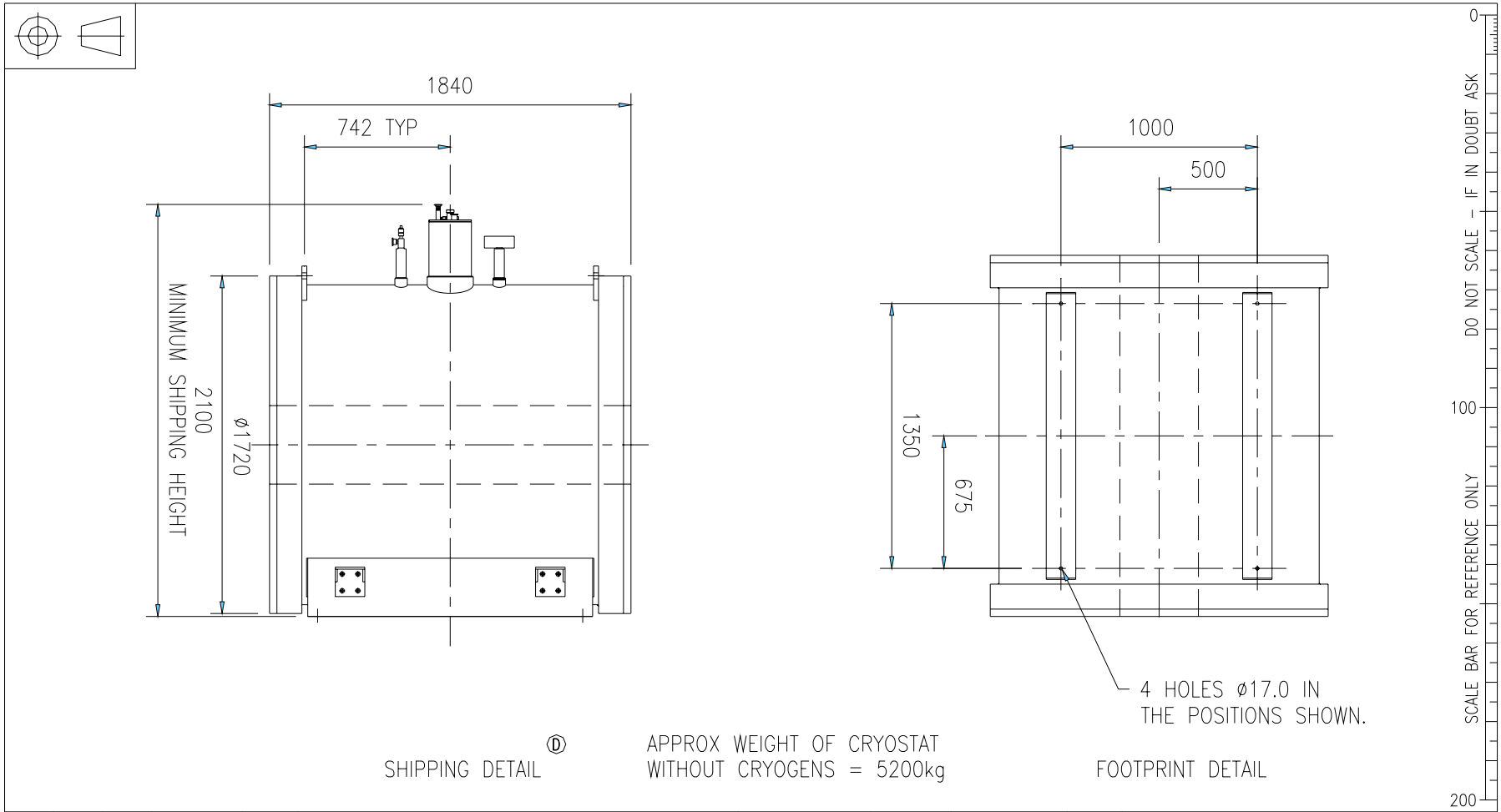

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PJ		B	17.03.04	N/A	SERVICE TURRET UPDATED & FOOTPRINT DETAIL ADDED
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OUT TRAY

DRAWING NUMBER AHZ323396E SHEET 3 OF 5

MATERIAL SEE DETAILS

FINISH PAINT RAL 9010 ID No: 23396

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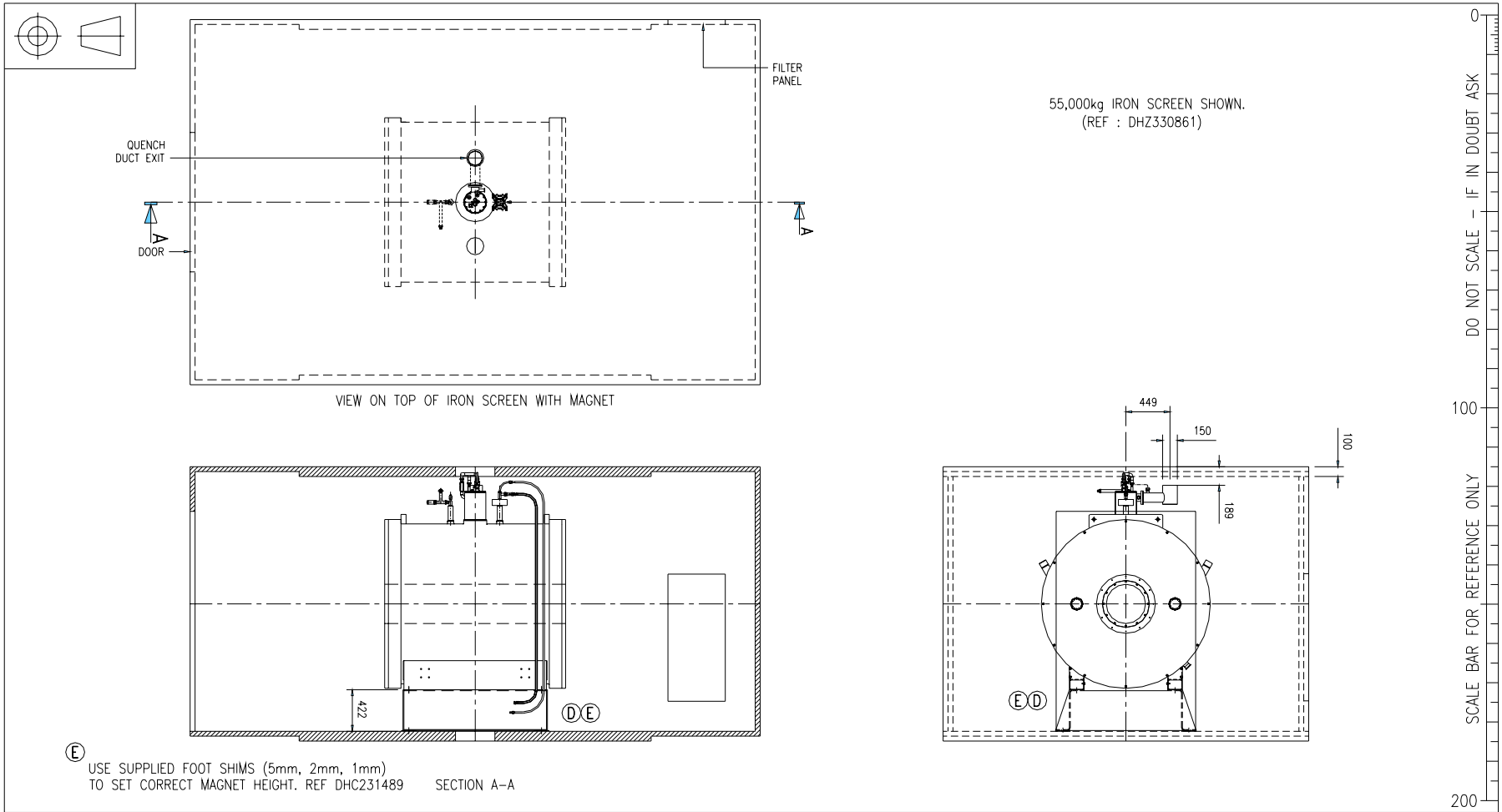

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MP		D	20.10.04	N/A	JACKING POINTS AND STAND ADDED, GROUND FILL KIT ADDED
PJ		C	25.08.04	N/A	SHEET 4 ADDED WITH UPDATED HEATSINK ASSEMBLY
PJ		B	17.03.04	N/A	SERVICE TURRET UPDATED & FOOTPRINT DETAIL ADDED
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OUT TRAY

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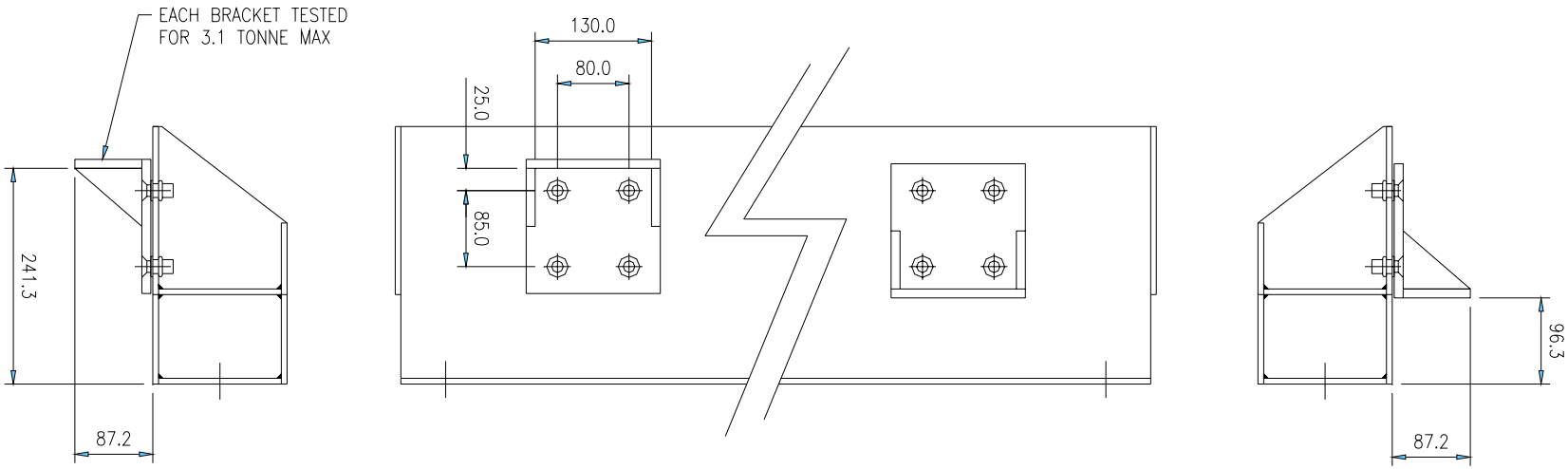
MATERIAL: SEE DETAILS — SCALE 1:40

FINISH: PAINT RAL 9010 — ID No: 23396



1 OFF TOE JACK LIFTING BRACKET
4 OFF M12 HT/STEELx35Lg CSK HD SKT
PER EACH FOOT.
NOTE: BRACKET CAN BE USED EITHER WAY UP.

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
MP		E	07.01.05	N/A	NO CHANGE TO THIS SHEET
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PJ		C	25.08.04	N/A	NO CHANGE TO THIS SHEET (SEE SHEET 4)
PJ		B	17.03.04	N/A	SERVICE TURRET UPDATED & FOOTPRINT DETAIL ADDED
--	--	A	20.03.01	N/A	1ST ISSUE

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OUT TRAY
DRAWING NUMBER AHZ323396E
SHEET 5 OF 5
MATERIAL SEE DETAILS
SCALE 1:5
FINISH PAINT RAL 9010
ID No: 23396

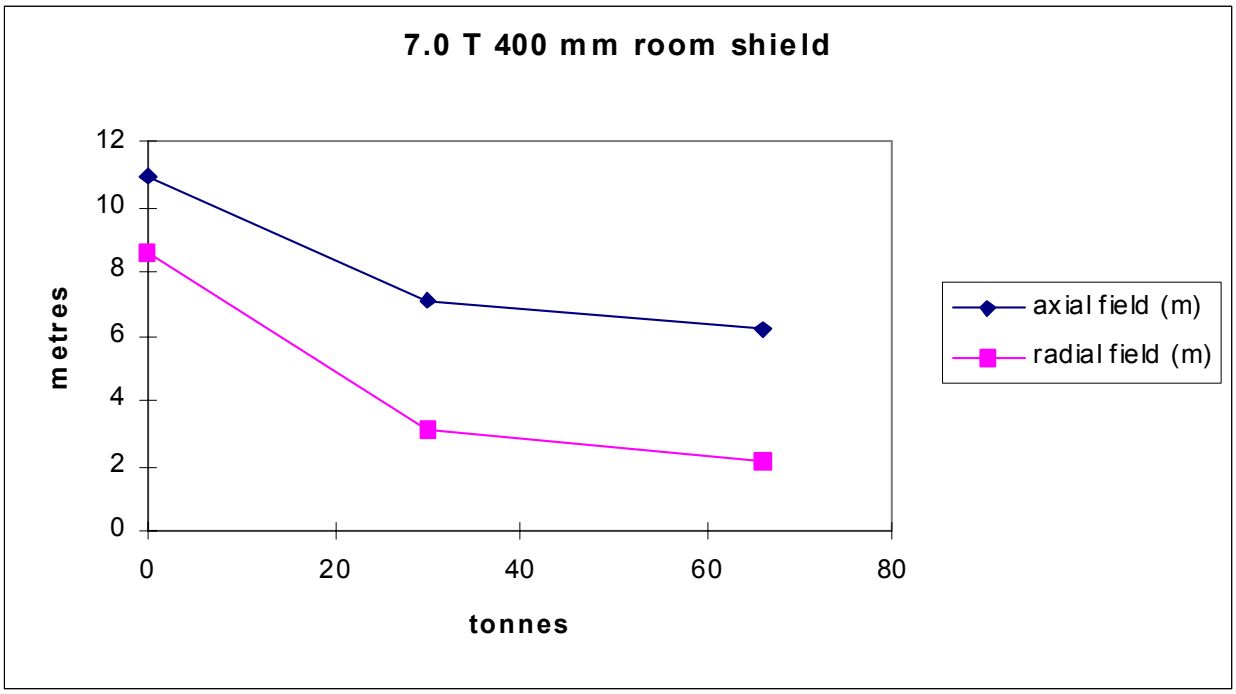
4. SYSTEM COMPONENTS

1 off	7T/400mm magnet system with integral s/c shims, housed in a low loss cryostat.
1 off	Stand
1 off	De-mountable main current lead
1 off	De-mountable s/c shim current lead
1 off	E5011 helium level monitor
1 off	E5031 nitrogen level monitor
1 off	Head oscillator
1 off	E7002 emergency discharge unit
1 off	Set of service cables (8.5m)
1 off	Helium monitor cable
1 off	Nitrogen monitor cable
1 off	Flexible siphon (2.0m)
1 off	Nitrogen blow-out tube
1 off	Nitrogen ground level fill kit
1 off	Spares kit
1 off	De-mountable helium level probe
1 off	De-mountable nitrogen level probe
1 off	System manual

APPENDIX

7T/400 Passive Room Shield Guidelines

Typical shield dimensions 3 m wide x 3 m tall x 5 m long



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