Development of a 1.5 Tesla whole-body MRI Magnet with a very low helium inventory

Adam Johnstone1, Michael Simpkins3, Simon Chorley1, John Teah3, Jonathan Noys3, Peter Dietz3, Marcel Krup1*, Adrian Bampton1, Simon Calvert1

1: Siemens Magnet Technology, Oxford, UK
2: Siemens Magnetic Resonance, Erlangen, Germany

(*) No longer employed by the company

**RATIONAL**
- Siemens Healthineers aims to reduce the total cost of owning an MRI scanner for our customers and to ensure availability of MRI scanners into the future.
- One challenge is the reduced availability and increasing cost of helium. Conventional MRI systems are cooled by greater than 1000 litres of liquid helium.
- A high risk/reward programme was set-up to realise the next generation of whole-body MRI magnets with a significantly reduced inventory of liquid Helium (< 50 litres). This work is presented.

**PROGRAMME**
- **Magnet Technology**
  - Technologies to cool MRI magnets with small (<50 litre) Helium volumes.
  - Must work within MR imaging system.
- **Logistics**
  - Magnets have less thermal inertia.
  - Cool down at site or in hubs required.
  - See Oral presentation by A Mortensen Thu-Mo-Or29
- **Infrastructure reliability**
  - Customer impact of poor power and water reliability must be minimised.

**MAGNET SPECIFICATION**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Field strength at isocentre</td>
<td>1.494T</td>
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<tr>
<td>Long term temporal field drift</td>
<td>&lt; 0.3 ppm/hour</td>
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<tr>
<td>0.5T Fringe field</td>
<td>Radial (y) = ± 2.5 m, Axial (z) = ± 4.6 m</td>
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<tr>
<td>Magnet Length</td>
<td>1528 mm</td>
</tr>
<tr>
<td>Magnet Bore Diameter</td>
<td>950 mm</td>
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<tr>
<td>Liquid Helium volume</td>
<td>Less than 50 litres</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>500 x 500 x 350 mm Elliptical Volume (138 pk to 98 pk ppm (14.8ppm achieved)</td>
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</tr>
<tr>
<td>Target shim mass</td>
<td>40kg</td>
</tr>
<tr>
<td></td>
<td>(2.7kg achieved)</td>
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**INSTRUMENTATION**
- 107 x calibrated Carbon Ceramic Resistor (CCR) temperature sensors were positioned on all components to obtain temperature maps.
- 34 x optical strain gauges were used to measure strains without magnetic interference, for example on the suspension rods.
- Various heaters and voltage taps were also used for thermal characterisation and measurement of quench voltages.
- A National Instruments PXI chassis including four PXI-4070 DMMs and four PXI-2530B multiplexers were used for acquiring signals.

**REALISATION**

**CRYOGENIC PRINCIPLE**
- Multi-legged gravity driven thermosyphon
- Vapour return to recondensing coldhead

**MAGNET DESIGN**

**TESTING: RAMPING**
- The temperature rise in the superconducting coils during ramping was measured and compared with hysteresis loss predictions.

**ACKNOWLEDGEMENTS**
- Thank-you to the staff at Siemens Magnet Technology, (Oxford), Siemens MR (Erlangen), Siemens Corporate Technology and our suppliers.

**PRESENTATION**
- Presented at 25th Magnet Technology Conference, August 2017, Amsterdam, Mon-Af-Po1, Poster number 872