Design, Manufacture and Testing of a Pair of Superconducting Solenoids for the Upgrade of the NSE Spectrometer J-NSE at the Research Reactor FRM II

E. Theisen, C. Boffo, A. Sendner, J. Steinmann, W. Walter; Babcock Noell GmbH
T. Kozielowski, M. Monckenbusch, S. Pasini; Forschungszentrum Jülich
O. Holderer; Forschungs-Neutronenquelle Heinz Meier-Leibnitz
Outline

Introduction to NSE
Design concepts
Manufacturing
Performance
Conclusion
Introduction

Neutron Science

Typical applications*:

- Thermal fluctuations of surfactant membranes in microemulsions
- Polymer chain dynamics in melts
- Thermally activated domain motion in proteins

### Design Concepts

**Special requirements**

**For a NSE magnets pair**

- **Low vibrations**
  - Use of Pulse tube cryocoolers with weak connection to the coils to minimize the impact of vibrations on field stability thus on the experiments.

- **Low permeability**
  - Minimize the impact of magnetization on the experiment. Use of aluminum formers and low permeability steel for cryostat.

<table>
<thead>
<tr>
<th>Conduction Cooled</th>
<th>Identical twins</th>
<th>Active shield</th>
<th>Quench safe</th>
</tr>
</thead>
<tbody>
<tr>
<td>The use of cryocoolers allows operation in absence of a cryoplant. This is a major feature when operating in a radiation controlled area.</td>
<td>The two magnets must provide the same field integral and profile for the experiments to be successful.</td>
<td>Active shielding is required to magnetically decouple the two magnets.</td>
<td>With 10 coils per system in series, a proper quench concept is required to minimize mechanical stresses.</td>
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C. Boffo, International Conference on Magnet Technology MT25 30.08.17
J-NSE Specs
Main Parameters

<table>
<thead>
<tr>
<th></th>
<th>NC</th>
<th>SC</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm bore diameter</td>
<td>310</td>
<td>320</td>
<td>mm</td>
</tr>
<tr>
<td>Cold mass length</td>
<td>-</td>
<td>2.2</td>
<td>m</td>
</tr>
<tr>
<td>Cold mass diameter</td>
<td>-</td>
<td>1.2</td>
<td>m</td>
</tr>
<tr>
<td>Device length</td>
<td>2.2</td>
<td>2.5</td>
<td>m</td>
</tr>
<tr>
<td>Maximum current</td>
<td>440</td>
<td>220</td>
<td>A</td>
</tr>
<tr>
<td>B Field on axis</td>
<td>0.3</td>
<td>1.2</td>
<td>T</td>
</tr>
<tr>
<td>B Field integral</td>
<td>0.5</td>
<td>1.5</td>
<td>Tm</td>
</tr>
</tbody>
</table>

Sample coil
Access port
Cryocoolers
Current leads
Suspensions
Adjustment rails
5 couples of field and shield coils

0.8 mm diameter SC wire with 6 µm filaments to minimize hysteresis effects

Peak field on conductor 2.87 T at 220 A

Loadline percentage of 54% at 4.2 K

Al formers required accurate eddy current analysis to minimize heat loads during ramps
J-NSE Design

Thermal

2 PT cryocoolers with 1.5 W @ 4.2 K each

HTS leads to minimize heat load at 4.2 K

Al5N used to transport the heat from coils to cold heads while minimizing gradients

25% margin on the heat load at nominal 8.5 A/min ramp rate

The ramp rate is limited by eddy currents in the system
Full aluminum former manufactured with high tolerances

Forces up to 220 kN in case of quench

Cold diodes for quench protection

Coils vacuum pressure impregnated
Manufacturing Process
Performance
Results of the Factory Acceptance Tests

System B; 3. Abkühlen
alle Sensoren

Cooldown
Minimal temperature drift during ramping
B field profile
Performance
Results of the Factory Acceptance Tests

Cooldown
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Performance
Results of the Factory Acceptance Tests

Cooldown
Minimal temperature drift during ramping

B field profile
Conclusions

HIGH PRECISION
Precisely machined aluminum formers design

LOW PERMEABILITY
Low permeability materials successfully implemented

PLUG’n PLAY
No liquid helium inventory required

QUENCH SAFE
Quenches are easily recovered by the system

DELIVERED
The system is now installed at FRM II
Thank you for your attention