Cryogenic upgrade of the low heat load liquid helium cryostat used to house the Cryogenic Current Comparator in the Antiproton Decelerator at CERN

Andrew Lees, Torsten Koettig, Miguel Fernandes, Jocelyn Tan
CERN, Accelerator Technology & Physics Departments, Geneva, Switzerland

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Introduction

Installed in the antiproton decelerator at CERN in 2015 to house cryogenic current comparator (CCC). The CCC uses a superconducting quantum interference device (SQUID) to calculate the AD beam intensity by measuring the distribution of its magnetic field.

The SQUID is highly sensitive to mechanical vibrations, so the cryostat uses a titanium support system to reduce the transmission of vibration. During first operation heat load of 1.04 W on the helium vessel, 0.47 W higher than design, caused a reducing LHe level. To improve the cryogenic performance of the cryostat was upgraded during the shutdown of the AD in 2016.

Modifications to MLI

- Reduced cross section of support rods
- Removal of strain gauge cables reduces heat load on the TS from 5.60 W to 4.20 W
- Cross-section of the HV and TS support rods reduced from 20 mm³ to 16 mm² and 13 mm² respectively. Reducing the first modes of vibration of the HV and TS from 60.9 Hz to 59.8 Hz and 62.5 Hz to 60.1 Hz respectively.

Cryostat design

- The HV and TS are supported using titanium support rods, optimised to limit resonance while limiting heat load due to conduction.
- Sources of harmonic vibration: Re-liquefier at 1-2 Hz and 50 Hz. Ground borne at 50 Hz. AD beam tube.
- Belleville washers account for thermal shrinkage. It is ensured that they are fully flattened when cold.

Mechanical

- The VV is isolated from external vibrations using its mass and the inclusion of flexible elements.
- The HV and TS are supported using titanium support rods, optimised to limit resonance while limiting heat load due to conduction.
- Sources of harmonic vibration: Re-liquefier at 1-2 Hz and 50 Hz. Ground borne at 50 Hz. AD beam tube.
- Belleville washers account for thermal shrinkage. It is ensured that they are fully flattened when cold.

Modifications to support rods

- Removal of strain gauge cables
- Support rod section

Support rod section

Cross-section of the HV and TS support rods reduced from 20 mm³ to 16 mm² and 13 mm² respectively. Reducing the first modes of vibration of the HV and TS from 60.9 Hz to 59.8 Hz and 62.5 Hz to 60.1 Hz respectively.

Reduced calculated heat loads

<table>
<thead>
<tr>
<th>Thermal path</th>
<th>Heat Load (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>2.91</td>
</tr>
<tr>
<td>HV</td>
<td>0.12</td>
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<tr>
<td>Thermal Radiation</td>
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<tr>
<td>Bayonet Connect.</td>
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</tr>
<tr>
<td>HV</td>
<td>0.05</td>
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<tr>
<td>SQUID Feedthrough</td>
<td>0.53</td>
</tr>
<tr>
<td>Instrumentation</td>
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<tr>
<td>Heater Line</td>
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<tr>
<td>Total</td>
<td>8.22</td>
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<tr>
<td></td>
<td>0.52</td>
</tr>
</tbody>
</table>

Conclusions

- Heat loads are now acceptable, allowing operation with a stable level of LHe.
- No indication of a reduction in mechanical performance.
- Diffusion of helium through the ceramic insulators discovered, procedure adapted to manage problem, incorporate monthly vacuum pumping.
- Study is required to eliminate the thermo-acoustic oscillations when filling.