The construction and commissioning of ADS Injector I cryogenic system

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Accelerator driven sub-critical system (ADS) in China is a kind of transmutation machine to minimize the nuclear wastes. As one of the important parts in ADS, Injector I is built in IHEP/CAS with two superconducting cryomodules. Each cryomodule includes seven spoke cavities and seven superconducting magnets. To achieve the 10MeV Proton beam energy, the cryomodules will be cooled in a liquid-helium bath at a temperature of 2K. A 100W@2K cryogenic system have been designed and built to provide cooling capacity for the 2 cryomodules, vertical test station and horizontal test station. This paper will give a brief introduction about the construction and commissioning of this new 2K cryogenic system.

Objective

- Three stages cryomodule: 2 cavities, 2 solenoids, 2 BPM
  - Φ1400 L=2115
  - 5MeV
- 7 cavities, 7 solenoids, 7 BPM
  - Φ1400 L=485
  - 10MeV
- 14 cavities, 14 solenoids, 14 BPM
  - Φ1400 L=773

Flow diagram

<table>
<thead>
<tr>
<th>Heat load</th>
<th>Quantity</th>
<th>Heat loads @400K(W)</th>
<th>Heat loads @5K(W)</th>
<th>Heat loads @2K(W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000L Dewar</td>
<td>1</td>
<td>8.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-channel Liquid Helium transfer lines</td>
<td>54m</td>
<td>27.10</td>
<td></td>
<td></td>
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<tr>
<td>Single-channel Liquid Nitrogen transfer lines</td>
<td>62m</td>
<td>28.02</td>
<td>1.00</td>
<td></td>
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<tr>
<td>Multi-channel Cryogenic transfer lines</td>
<td>72m</td>
<td>36.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4K Main Distribution Valve Box</td>
<td>1</td>
<td>25.03</td>
<td></td>
<td></td>
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<tr>
<td>Cryomodules</td>
<td>2</td>
<td>15.42</td>
<td>9.42</td>
<td>51.40</td>
</tr>
<tr>
<td>Total for system operation</td>
<td></td>
<td>271.42</td>
<td></td>
<td>51.40</td>
</tr>
</tbody>
</table>

Test results of refrigerator performance

- Refrigeration With UQ2: >1000W@4.5K
- Refrigeration With UQ1: >1000W@4.5K
- Refrigeration & Liquefaction With UQ2: >1500W@4.5K & 621.11L

Pumping system recovery & purification system

- Leybold pumping station
- 20MPa compressors
- Helium storage

Pumping system:
- Working pressure: 3130 ± 30Pa
- Design flow: 48L/s, 100L/s
- Pumping speed: 1600m3/h/bc *5

Recovery and purification system:
- Helium recovery capacity: 410m3/h.
- Purify capacity: 105Nm3/h.
- Outlet purity: ≤5ppm.
- Storge capacity: 10000Nm3 impure helium +10000Nm3 pure helium

Commissioning

- 2014-7-30, refrigerator acceptance test
- 2015-1-19, helium recovery & purify system acceptance test
- 2015-1-26, first cooling down to 4.5K
- 2015-2-4, first cooling down to 2.0K

Milestone and conclusion

MILESTONE

2014-7-30, refrigerator acceptance test
2015-1-19, helium recovery & purify system acceptance test
2015-1-26, first cooling down to 4.5K
2015-2-4, first cooling down to 2.0K

CONCLUSION

ADS Injector I cryogenic system is the first self design and construct 2K system in China. The system has been tested on the Test Cryomodule (TCM) which contains 2 superconducting spoke cavities and two superconducting magnets. In the next month, the first 7 cavities and 7 magnets cryomodule(CM01) will be installed in the tunnel and tested and the second cryomodule(CM02) is following. The whole ADS injector I will commissioning at the beginning of next year.