PIP2IT Cryogenics Distribution System

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PIP-II Meeting
22\textsuperscript{nd}, November, 2016
Outline

- Overview of CMTF Cryogenics System and PIP2IT Cryogenics Distribution System (CDS)
- PIP2IT CDS Function Requirements and Interfaces
- PIP2IT CDS Design Features
- Tentative Schedule
- Summary
- References
The Cryogenics System within CMTF consists of

- Superfluid Cryogenics Plant (SCP)
- Distribution Box
- Cryomodule Test Stand (CMTS) and distribution system
- Future: PIP2IT, including SSR1 + HWR cryomodule and Cryogenics Distribution System (CDS)
Layout of PIP2IT Cryogenics Distribution System [1]
Function Requirements [2]

• Scope: As shown in the layout. Also there are three other smaller lines into the cave alongside the main transfer line (following roughly the same path)
  – Compressor suction header
  – Main relief header
  – High pressure helium supply header

• Main Interfaces
  – HWR and SSR1 will be connected to CDS via U-tubes [3][4][5][6]
  – Distribution Box and SCP
### PIP2IT CDS Function Requirements and Interfaces

**Function Requirements (continued)**

- **Operation Modes**
  - SSR1 and HWR should be independent from each other during steady state operation (i.e., one can be at 2 K while the other is warm at 300 K).
  - One Cryomodule should be <5 K during transition of the other Cryomodule (from 300 K to 5 K or 5 K to 2 K).

To satisfy the operation modes, independent cool-down/warm-up for SSR1 and HWR is required.

- **System Capabilities**
  - 150 W @ 2 K
  - 240 W @ 5 K
  - 750 W @ 70 K
Function Requirements (continued)

• Relationship with CMTS1
  – During CMTS1 transition (cool-down or warm-up), SSR1 and HWR shall be maintained at 5 K or lower.
  – Mode transition (i.e. 300 K to 5 K) is not required during CMTS1 transition

Comment:
  – From CMTS1 point of view, any mode transition or steady state operation at PIP2IT shall have no effect on CMTS1 operation.
PIP2IT CDS Design Features

External Transfer Line
PIP2IT CDS Design Features

Internal Transfer Line

![Diagram showing PIP2IT CDS Design Features with labels for CMTS 1, SSR1, HWR, PIP2IT (PXIE) Cave, Distribution Box, and Internal Transfer Line.](image)
PIP2IT CDS Design Features

- To satisfy operation mode requirements and minimize effects on CMTS1\(^7\)
  - Independent cool-down lines and valves for SSR1 and HWR, as well as isolation valves
  - Coaxial construction to cool down 2 K return line without having to send warm flow back to cold compressor suction, avoiding affecting CMTS1 2 K operation during CDS cool-down
  - To further avoid conflict between CMTS1 and PIP2IT, a flange and bellows construction are built into the transfer line for easier modification to use Kinney Vacuum Pump to reach 2 K
  - To ensure adequate capacities at all temperature levels: Engineering analysis on overall pressure drop and heat load, proper pipe sizes and thermal shield are selected with redundancy\(^8\)
PIP2IT CDS Design Features

Layout of CDS External Transfer Line
## Tentative Schedule

- **Internal Transfer Line procurement and delivery**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start Date</th>
<th>End Date</th>
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<tbody>
<tr>
<td>Receive and evaluate proposals</td>
<td>Dec, 2016</td>
<td>Jan, 2017</td>
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<tr>
<td>Prep for Kick-off meeting</td>
<td>Jan, 2017</td>
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<tr>
<td>Prep for PDR</td>
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<td>Prep for FDR</td>
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<td>Prep for PRR</td>
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<td>Jun, 2017</td>
</tr>
<tr>
<td>Fabrication of ITL</td>
<td>Jun, 2017</td>
<td>Sep, 2017</td>
</tr>
<tr>
<td>Test/Package/Transport</td>
<td>Sep, 2017</td>
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Tentative Schedule – Installation Estimate

• There is no installation plan yet at this moment.
• Rule of thumb: 1 - 2 weeks for each interface based on experience at CMTS
• External Transfer Line:
  – there are 5 - 6 interfaces for External Transfer Line, and it takes about. Therefore roughly 10-12 weeks (~3 months) are needed for external transfer line.
  – The interface with Distribution Box has to be done when CMTS1 is not operating. The interface is slightly more complicated since it will be the closure weld for each circuit. So we will need to pressure test the system after the installation, and before CMTS1 is back to operation.
  – Total 3 months or more depending on CMTS1 operation schedule.
Tentative Schedule – Installation Estimate 2

• Internal Transfer Line
  – 3-5 interfaces (6 – 10 weeks) on the main transfer line depending on vendor design and proposal.
  – There may be 6 valves to be installed as well depending on vendor’s proposal (2 weeks or so?).
  – 3 other header, including compressor suction, high pressure helium supply and main relief header. This is relatively straightforward piping and shouldn’t take long.
  – Total 8-12 weeks (2-3 months).
Tentative Schedule – Installation Estimate 3

- Cave has to be open during
  - Internal Transfer Line installation (8-12 weeks)
  - Final segments of External Transfer Line (circled below)
CDS External Transfer Line design is near completion and will be sent to fabrication.

CDS Internal Transfer Line specification is completed and approved, and is currently in the procurement process (got all approvals and waiting for buyer to be assigned...)

Next steps:
- Complete External Transfer Line and start fabrication
- Procurement management of Internal Transfer Line
- Detailed installation plan and schedule, based on Internal Transfer Line design and CMTS1 operation schedule

Thanks for help from Tejas Rane and Dave Richardson!
References

1. Drawing 5520.000-LE-494021, CMTF PXIE Layout Proposal. F00494021
3. PXIE HWR Cryomodule Functional Requirements Specification. ED0001313
4. PXIE HWR Interface Control Document
5. PXIE SSR1 Cryomodule Functional Requirements Specification. ED0001316
6. PXIE SSR1 Interface Control Document. ED0004129
7. Assembly, PXIE Transfer Line, complete, F10060150
8. PXIE transfer line pressure drop and heat load analysis report, ED0004408
# Back up-Cryomodule Heat Load vs SCP capacity

<table>
<thead>
<tr>
<th>CM</th>
<th>Heat load 2K (static) (W)</th>
<th>Heat load 2K Dynamic (W)</th>
<th>Safety Margin (%)</th>
<th>Total 2K loads (W)</th>
<th>Heat load 5K (static) (W)</th>
<th>Safety Margin (%)</th>
<th>Total 5K loads (W)</th>
<th>Heat load 70K static (W)</th>
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Back-up CDS P&ID