Maintenance and Reliability Design Aspects SNS 2K Refrigeration System

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Performance Overview

Main Refrigeration System

A Helium Refrigerator System

With a 2400 Watt Capacity Operating @ 2.1 Kelvin
and a 8300 Watt Shield Load @ 38/50 Kelvin

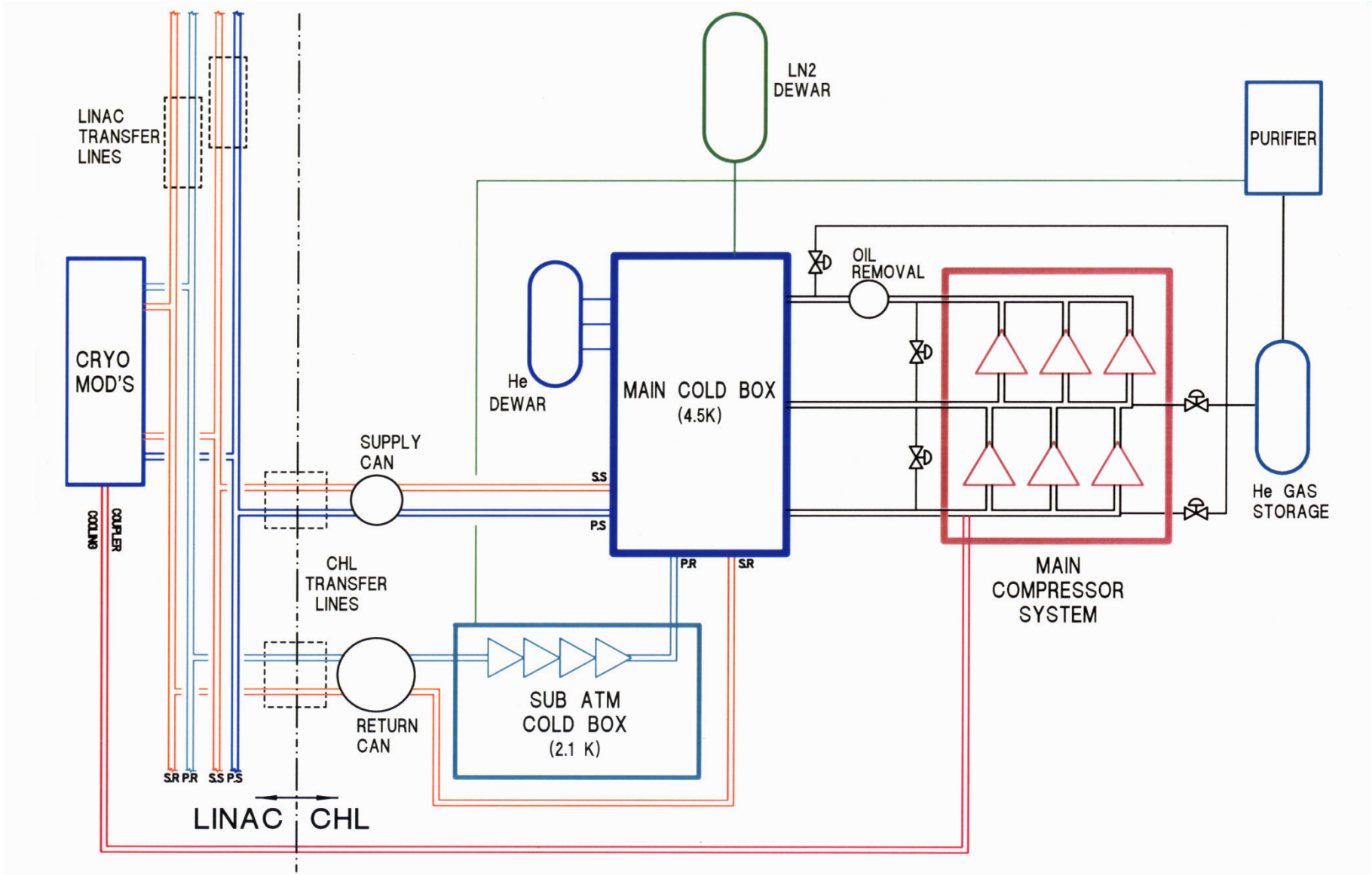
15 g/s Liquefaction (coupler cooling)

Cryogenic Transfer Line System with
4.5 K & 38K Helium Supply and
4.0K & 50K Helium Return

Helium Refrigerator Major Components

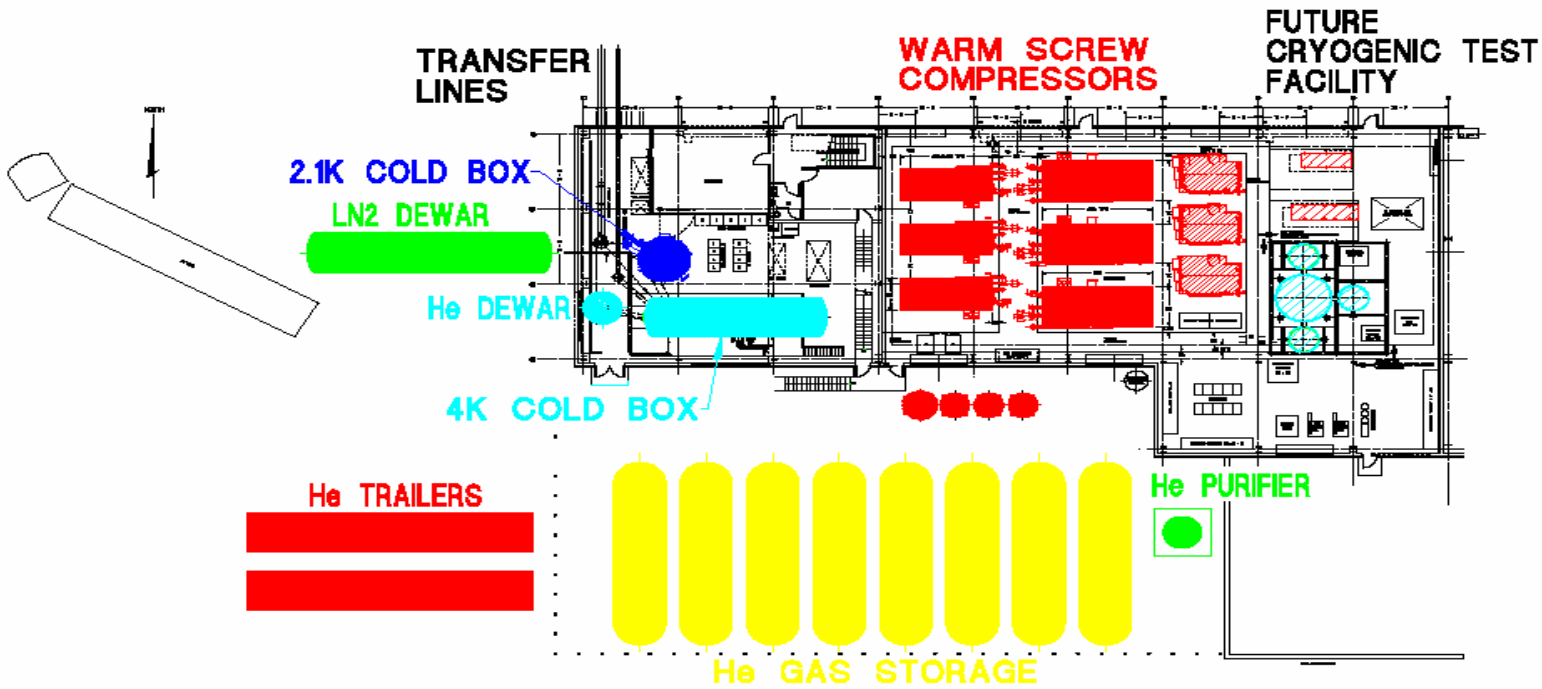
- 8 Gas Storage Tanks (contamination control and storage)
- 6 Warm Helium Gas Compressors, Four needed to run
- 4.5 K Cold Box
- 2. 1K Cold Box with Four Helium Cold Gas Compressors
- Helium Gas Process Piping
- Utilities
  - Power, Water, Instrument Air, Insulating Vacuum Systems
  - Ln2 / Gn2 System
  - Helium Purifier (contamination prevention)
  - Guard Vacuum System (contamination prevention)
- Cryogenic Helium Transfer Lines
- Warm Helium Gas Lines in the Tunnel
- Control system (Allen-Bradley PLC, SNS Standard)

System Overview



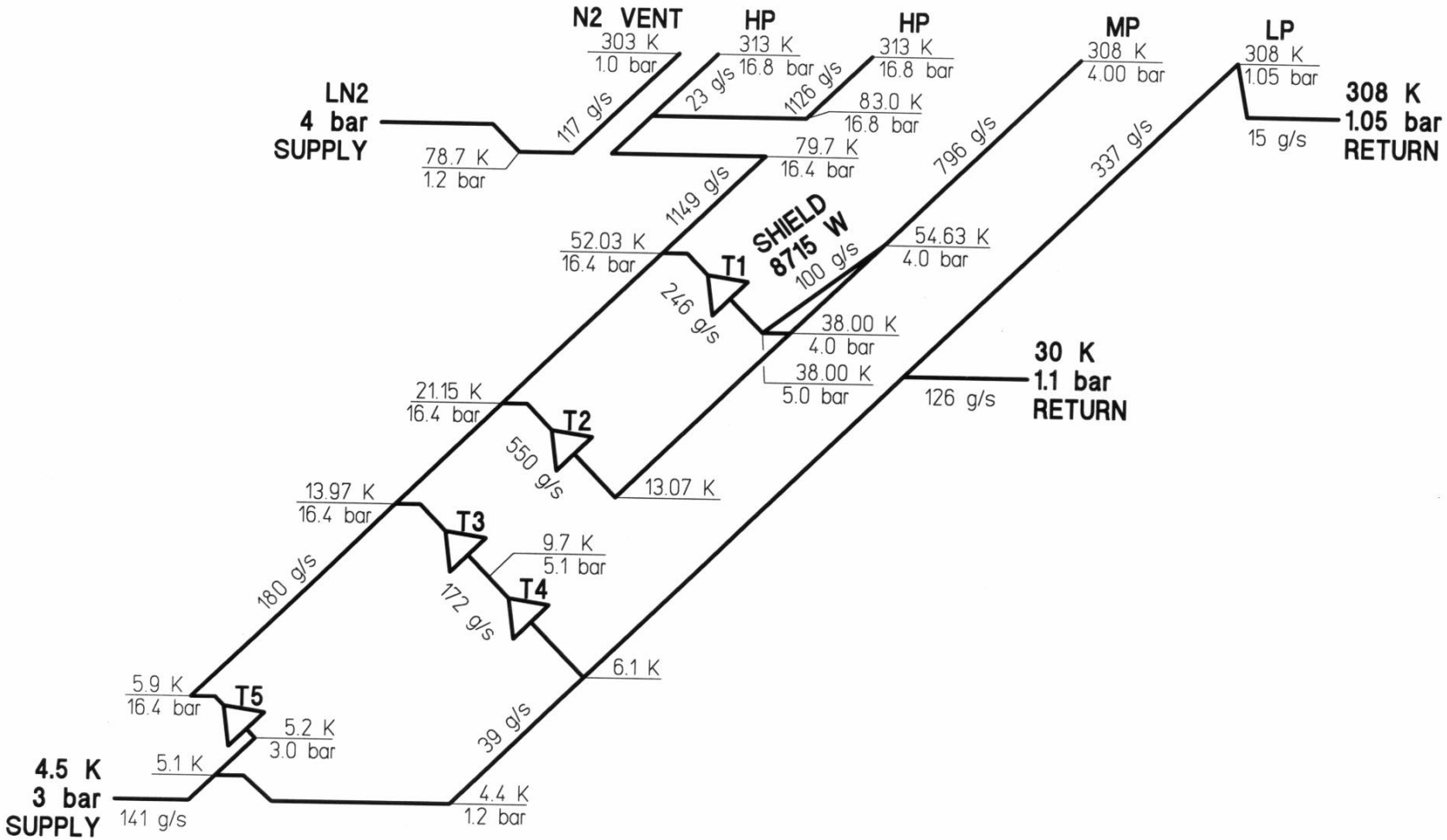
SNS Cryo System

Building Equipment Layout



SNS HELIUM REFRIGERATION SYSTEM
EQUIPMENT ARRANGMENT

T-S Diagram for the Refrigeration Mode
(For User..Only a Starting Point Reference)



JLAB Reliability/Maintenance Design Goal Basis and Scope

- Reliability
  - 99%+++ Plant On-Line Availability
  - 24/365 Operation (Cryo/Non-Cryo Maintenance and Beam OPS)
- Maintenance
  - Cryo Plant ongoing maintenance and repairs with minimal impact to OPS
  - Cryo Plant OPS support of Cryomodule maintenance and repair requirements with minimal impact on the Cryo System.
  - Utilities to Cryo Plant Maintenance/Repair Co-ordination

Mechanisms Used to Achieve Design Goals of Reliability and Running Cost

- **Architectural Engineering Input: Early Project Requirement, Control the Work Environment, First Chance to achieve the goals, No "final" equipment designs" yet……have to depend on past experience. Big Step.**
  - **Equipment Layouts, Installation/Maintenance/Repair/Ops access requirements, building ventilation, piping trench details, indoor/outdoor lighting levels, floor loading/vibration, underground electrical conduits, crane and hoist requirements, control room design, equipment utility lists, noise levels/abatement, ODH design requirements, UPS/Emergency generator, maintenance/repair equipment utilities (ex: welding/vacuum pump receptacles, etc.), spare parts storage allocation, repair/maintenance work areas, communications.**

Mechanisms Used to Achieve Design Goals of Reliability and Running Cost

- **Process Cycle Design:** **FIRST Design Activity….Original T-S is the starting point guideline…but it is ONLY a representation of a maximum capacity design goal. But what about reduced capacity with cost optimization?**
  - **Running cost and increased reliability can be realized by incorporating capabilities such as automatic load capacity tracking with system pressure reduction control as a means to turn down the system capacity AND maintain plant plant efficiency and while reducing "wear and tear" on the system major components. It has impact on some system component designs which must then be specified. Does not mean extra expense.**

Mechanisms Used to Achieve Design Goals of Reliability and Running Cost

- **Major Equipment List and Design/Purchase Specifications:** **Master list and detailed specification of systems which support ops, maintenance, repair, and reliability goals….more than a set of process conditions in the specifications.**

  - **Subsystem requirements were specified in individual equipment specifications to the vendor, each specification requiring specific overall equipment AND component performance/features, design standards, documentation, analysis, testing, and engineering/QA reviews, etc. Example…Component requirements included what type of control system (SNS Standard PLC) and control devices along with manufacturer. Formal preliminary and final very detailed technical design reviews were successfully conducted for each major piece of equipment. SNS QA department tracking by use of "ACLs", Acceptance Criteria Listings.**

Mechanisms Used to Achieve Design Goals of Reliability and Running Cost

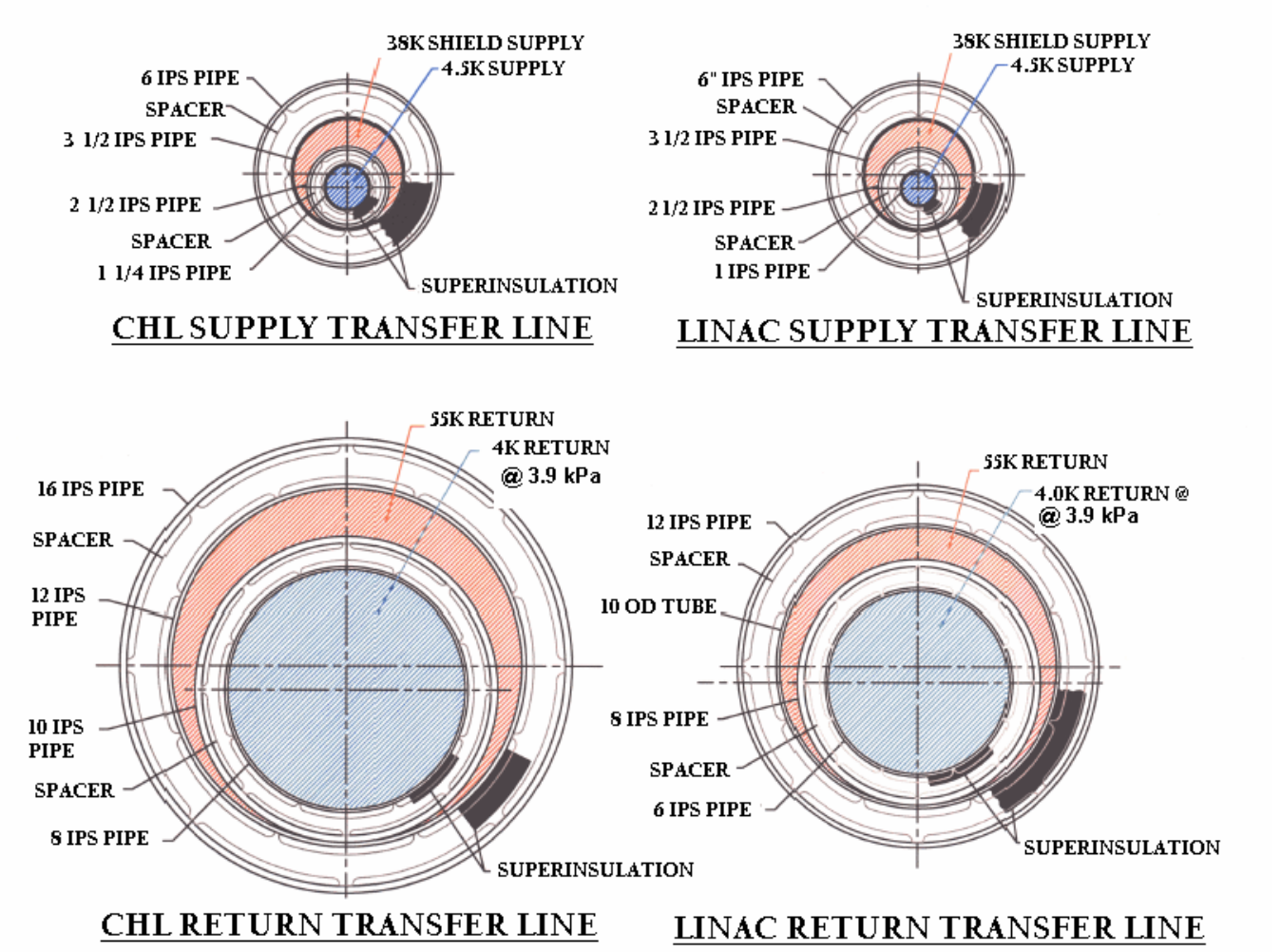
- **Installation Design and Construction:** **Designed not only for minimal space requirement ($) but also for the operation, maintenance and repair activities ($$$).**
  - **Examples include placing piping within trenches, underground electrical distribution to compressor skids, removable cold box shell head clearance, access to compressor final charcoal filter, overhead crane, SS warm helium process piping, compressor bypass piping configuration, distribution system of pure GHe/Guard vacuum/purification systems through the plant and load locations (cryomodules), the ability to disconnect/repair/and put back into service major components with warming system (u-tubes). (Remember U-Tubes/bayonets=Transfer Line/System Loss)**

JLAB Installation Design Packages

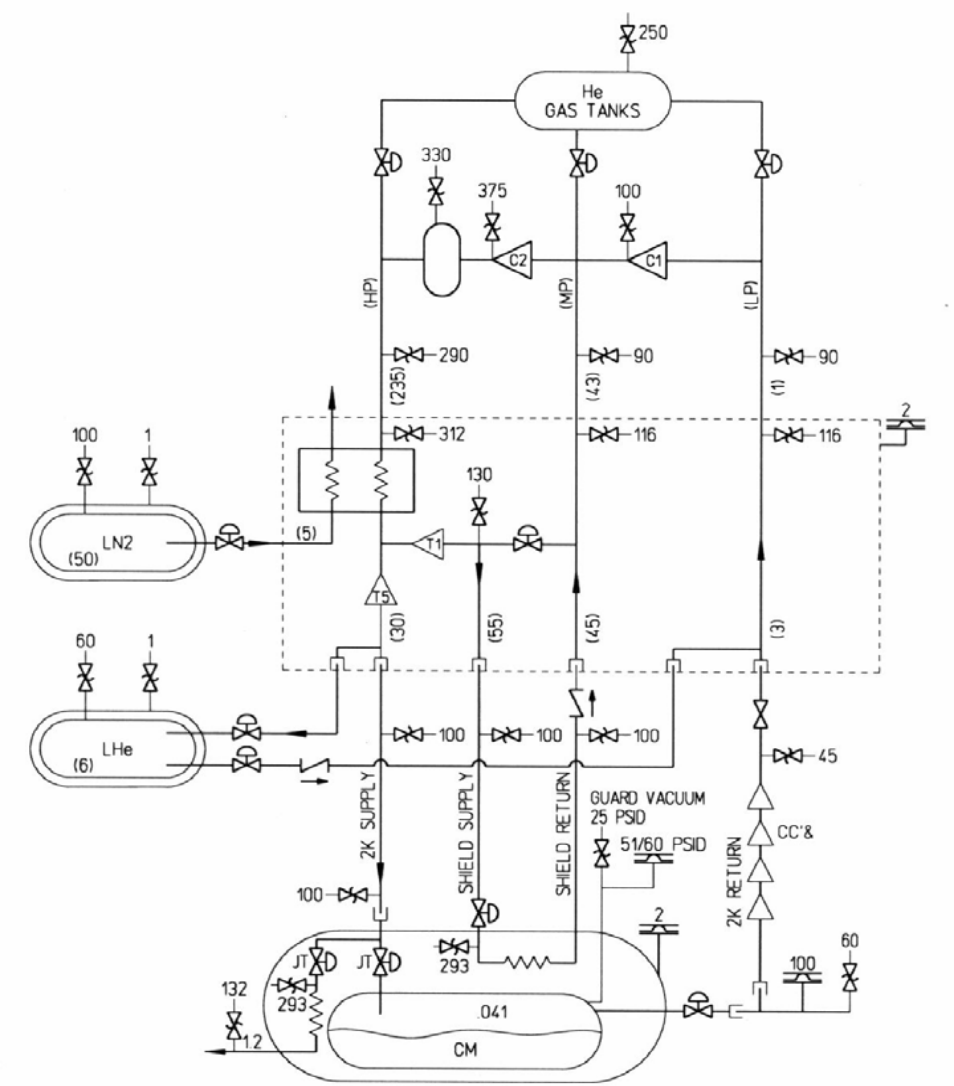
The system is divided in to the following Installation Packages

- Helium Gas Storage Piping
- Compressor Room Piping
- South Wall Piping
- Tunnel Transfer Line Piping (Cold Piping)
- Tunnel warm Piping
- Cold box room Piping
- Utilities
- Control System

Transfer Line Cross sections



Integrated Safety Relief System, PSIG



SNS Cryo System

LN2 System

Helium Gas Storage

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South Wall Piping

SNS Cryo System

Helium Purifier

SNS Cryo System

Compressor Coalescers & Charcoal Filter

SNS Cryo System

Warm He Compressors

SNS Cryo System

Compressor Gas Management Skid

4K Cold Box

SNS Cryo System

2K Cold Box

SNS Cryo System

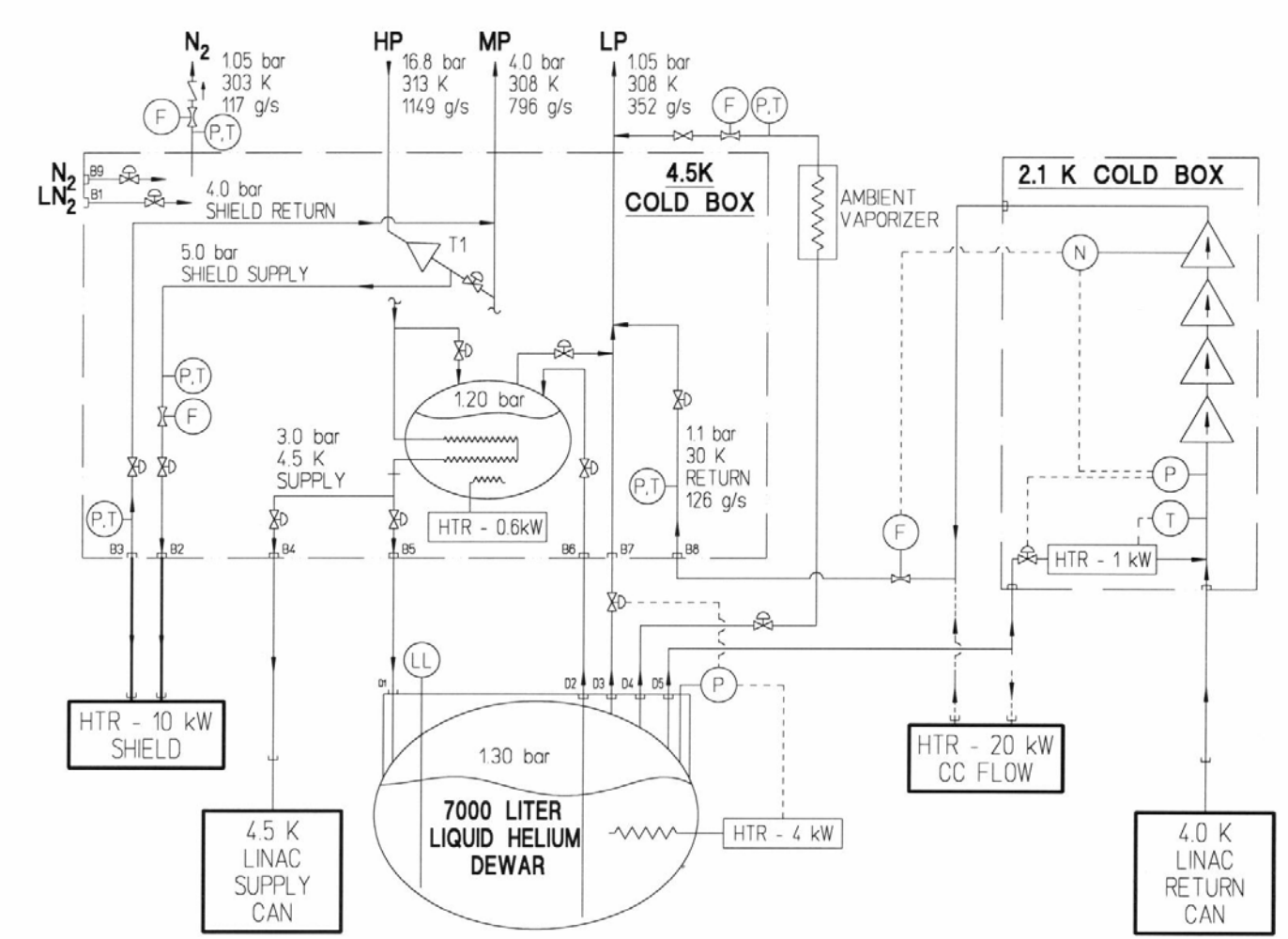
Supply and Return Cans & LHe Dewar

SNS Cryo System

Vacuum Skid

SNS Cryo System

Overall Test Configuration



SNS Cryo System

Conclusions

- JLab and SNS staff put on our collective Design, Installation and Operations “hats”. Focus was on our goals (99+++ operations)
- Design aspects which influence the goals start right away (A&E). Can’t always wait for vendor final information for A&E info. Have to rely on experience.
- Identified key practical main and subsystems which support reliability and maintenance/repair.
- This was incorporated in the Building design, plant and load maintenance hardware requirements, detailed vendor equipment specifications, and installation design… focused on reliability, maintenance and repair.