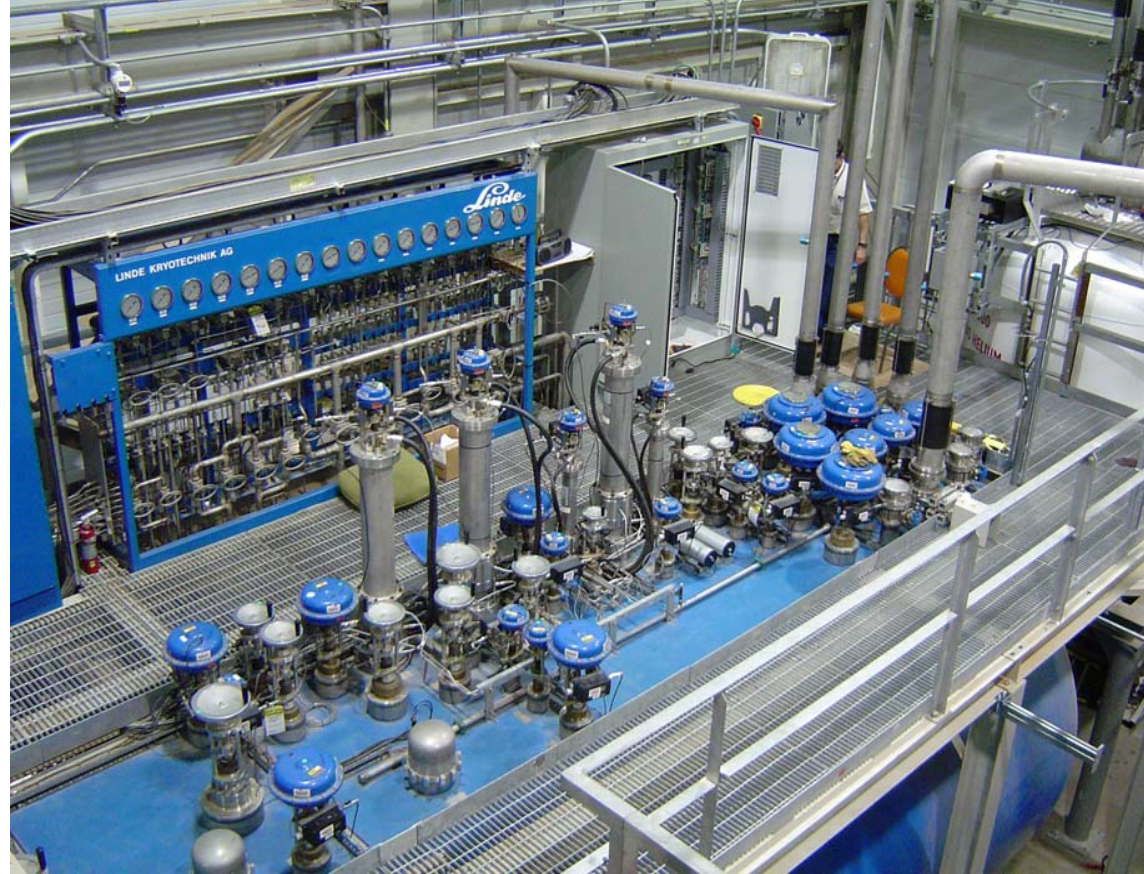


Cryogenics

SNS Cryogenic System Capabilities Overview



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Introduction

The cryogenic refrigeration system has been designed to provide refrigeration capacities of 2400W at 2.1K, 8300W at 35 to 50K and with a 15g/s liquefaction capacity for coupler cooling and filling the modules as and when required.

The SNS cryogenic system is successfully supporting the linac beam commissioning at both 4.4K and 2.1K and has been fully operational since June 2005. This cryogenic system is designed to support the cold section of the linac that consists of 81 super conducting radio frequency cavities at 2.1K.

The 2.1K cold box consists of four stages of centrifugal compressors with LN₂ cooled variable speed electric motors and magnetic bearings. The following presents the cryogenic system capabilities. In particular the test results obtained for maximum capacity and the minimum capacity cold compressor operations.

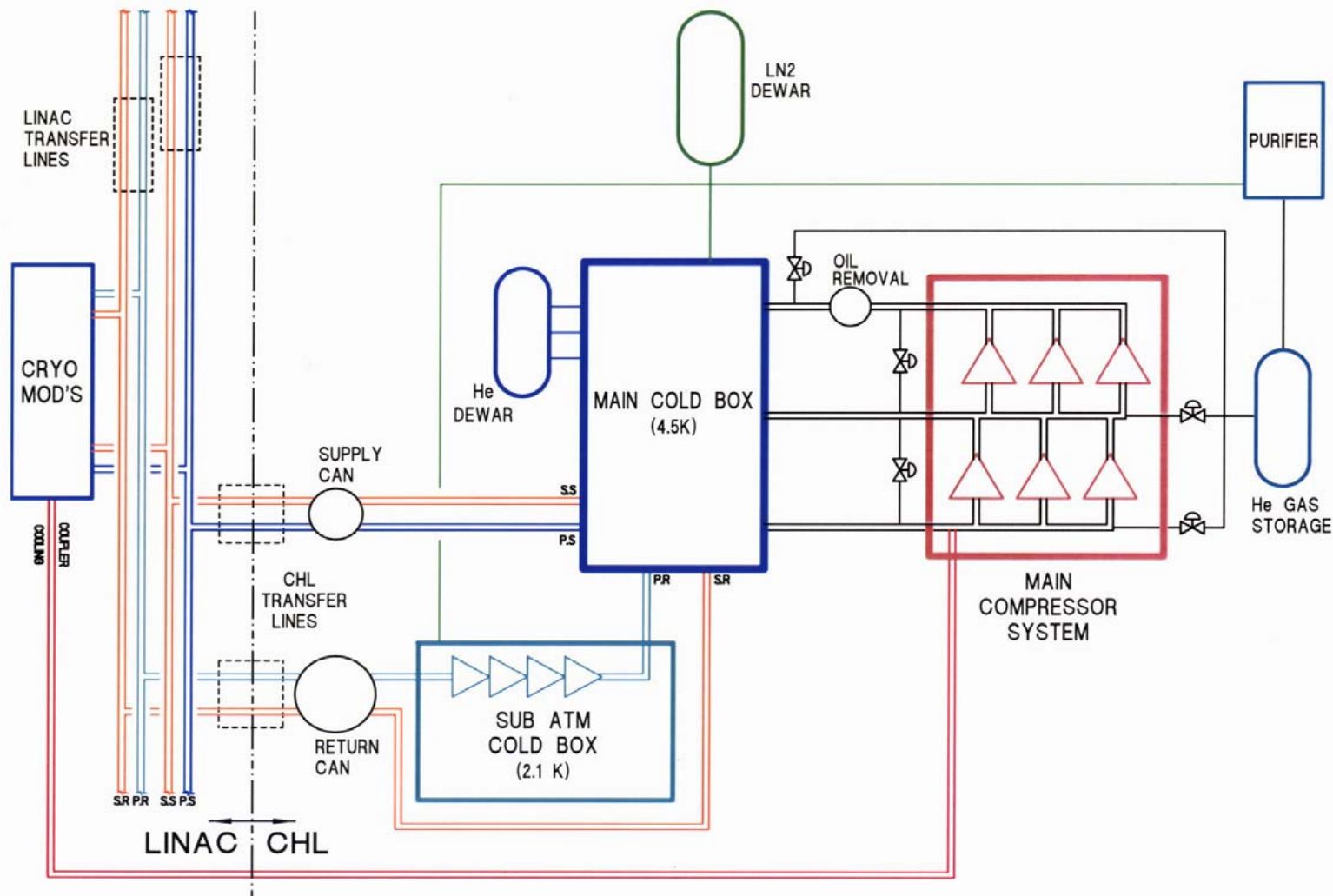
Fully Tested Results at Design Loads

- 2400W at 2.1K Refrigeration
 - 15 g/s 4.5K liquefaction
- 8300W at 35K Shield Refrigeration



Cryomodule during Installation

SNS System Overview



Maximum 2.1K + Liquefaction Test Results

TEST-A: The test was conducted on Dec/1/05 from 3pm to 9pm

1. The CC_Flow = 125 g/s
2. Shield load* = 5.3 kW (60 g/s @37K-53K)
3. Excess liquefaction = 16.0 g/s
4. Max system pressure = 17.0 atm

The above capacity limit is first reached by the 4.5K CBX

*** Actual imposed Shield load onto the refrigerator**

Maximum 2.1K with Liquefaction Test Results

TEST-B: The test was conducted on Mar/11/06 from 3pm to 5:00pm

1. The CC_Flow = 140 g/s
2. Shield load* = 5.3 kW (60 g/s @37K-53K)
3. Excess liquefaction = 4.0 g/s
4. Max system pressure = 17.0 atm

Above 140 g/s the 4.5K cold box became the limiting factor

*** Actual imposed shield load onto the refrigerator**

TEST-C:

Although capacities above 2.1K capacities above 140 g/s became limited by the 4.5K cold box, the 2.1K cold box flow capacity appeared to be able to support up 150 g/s should more 4.5K refrigeration become available.

Minimum 2.1K Refrigeration with Liquefaction Test

TEST-A: The test was conducted on 3/11/2006 from
5:30 pm to 8pm

1. The CC_Flow = 90 g/s
2. Shield load = 5.3 kW (60 g/s @37K-53K)
3. Liquefaction = 4.0 g/s
4. Max system pressure = 12.9 atm

Maximum/Minimum 2.1K Additional Process Data

		Design Basis	Max Capacity 3/11/2006 3:30PM	Nominal Capacity	Minimum Capacity 3/11/2006 5:35PM
I st Stage compressors		608			
C1	Kw		300	250	244
C3	Kw		300	300	203
II nd Stage compressors		2074			
C4	Kw		1456	1355	762
C5	Kw		1456	1355	1154
Ln2 Usage	g/s	120	200	180	150
Total Electric Input Power to Compressors	Kw	2682	3512	3260	2363
Ln2 Equivalent Power (@35% Carnot)	Kw	216	360	324	270
Total Input Power Equivalent	Kw	2898	3872	3584	2633
HP to cold Box	Atm	16.8	17	16.5	12.9
MP cold Box out	Atm	4	2.8	2.8	2.5
Cold box HP Flow	g/s	1150	1077	1030	829
CC Flow	g/s	125	140	125	90
Liquefaction Load	g/s	15	4	4	4
Shield Load	Kw	8300	5300	5300	5300

Carnot Work Summary

		Design Basis	Max Capacity 3/11/2006 3:30PM	Nominal Capacity	Minimum Capacity 3/11/2006 5:35PM
Carnot Work based on 2.1K Operations:					
Primary Load	Kw	400	448	400	288
Liquefaction Load	Kw	102	27	27	27
Shield load	Kw	61	39	39	39
Total Load Carnot Work	Kw	563	514	466	354
Carnot Eff based on 2.1K Operations		0.194	0.133	0.130	0.134
Carnot Work based on 4.5K Operations:					
Primary Load	Kw	542	607	542	390
Liquefaction Load	Kw	102	27	27	27
Shield load	Kw	61	39	39	39
Total Load Carnot Work	Kw	705	673	608	456
Carnot Eff based on 4.5K Operations		0.243	0.174	0.170	0.173

Test Summary

The SNS CHL refrigerator had completed its full capacity testing of 2400W @ 2.1K plus 15 g/s of liquefaction and 8300W at 35K. Having completed the design requirements, the refrigerator was tested for maximum and minimal 2.1K production to develop data of its operating range domain. These tests indicate a 2.1K refrigeration flow range of 90 to 140 g/s with a nominal 4 g/s for cryomodule lead flow. The actual nominal shield load is 5300W and used for all tests. All tests exhibited stable operating conditions.

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