Performance Mapping of the CLS SRF Cryoplant

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Introduction

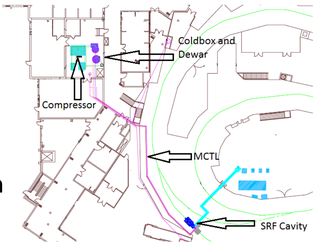
The Canadian Light Source (CLS) is a third-generation synchrotron facility located in Saskatoon, Canada. CLS uses a CESR-B type SRF cavity to replenish energy lost by the electron beam in the storage ring.

Frequent partial warm-ups to expel SRF cavity contaminants require re-adjustment of compressor circuit settings. Exploration of plant capacity under various conditions is useful for establishing operating setpoints, reducing the time taken for operators to re-adjust the compressor settings.

This information is also being used to examine system efficiency and select a more efficient operating point.

CLS SRF Cryo System

The SRF system contains: one CESR-B type 500 MHz cavity, a Linde TCF-50 liquid helium cryoplant, consisting of a coldbox, a 200 kW Kaeser compressor, oil removal system (ORS), gas management panel (GMP), and 2000 L dewar.



Layout of CLS SRF cryogenic system.

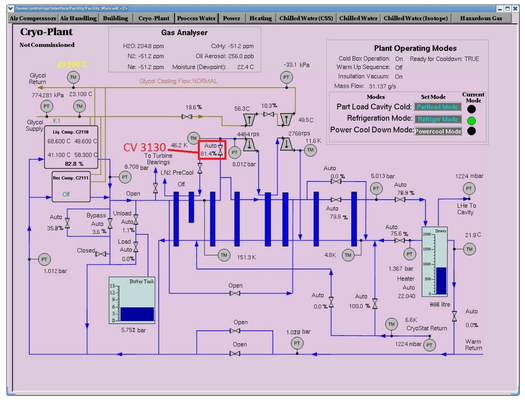
Original load specification: 284 W at 4.4 K. Plant tested to 313 W during commissioning. This test met spec, but did not find the maximum plant capacity.

Compressor Operation

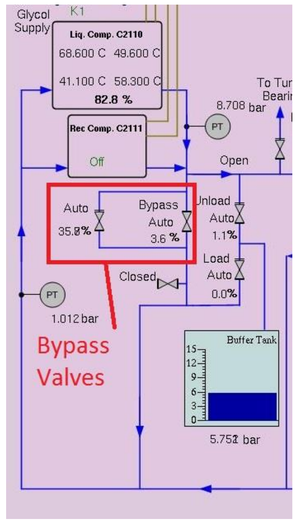
The CLS cryoplant operates with 3 compressor setpoints: part-load, refrigeration, and power-cool. Normal operation is in refrigeration mode. Rather than using a continuous VFD adjustment to match load, the compressor runs at constant speed and discharge pressure and the dewar heater is used with a +/- 25 litre deadband to provide extra load to the system when required.

Adjustments must be such that the compressor bypass valves, which manage the compressor suction pressure, remain within their operating ranges.

Production Variations



CLS SRF cryoplant operating screen



Compressor circuit

The plant turbine inlet pressure control valve (CV3130) is set via a proprietary Linde algorithm. In CLS experience, this valve does not always return to the same setting when the plant mode is switched to refrigeration, and liquid production rate varies significantly with the position of this valve.

While this valve cannot be manually adjusted, it can be forced to open or close slowly by decreasing or increasing compressor suction pressure. However, varying compressor discharge pressure to compensate works well, and is much easier.

Testing

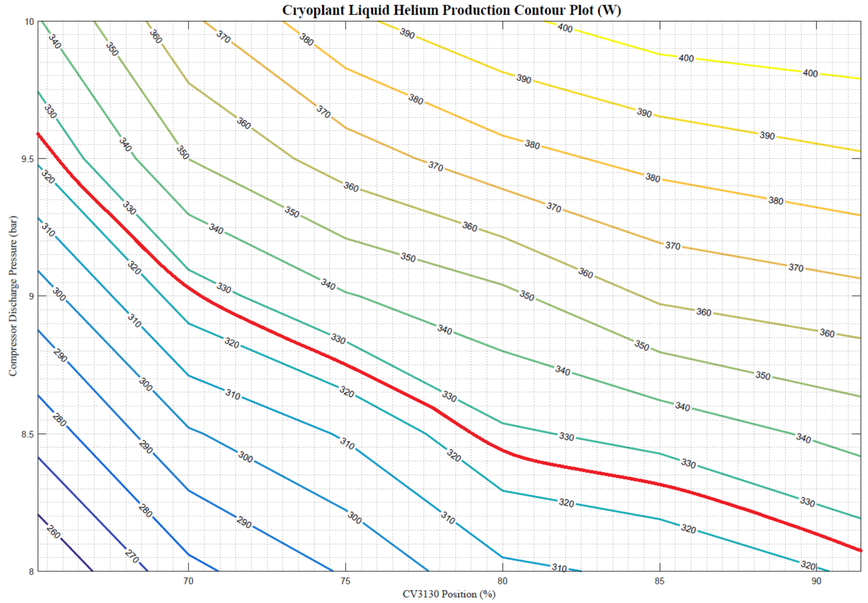
Objective: Create production rate grid for various turbine inlet pressure control valve settings and compressor discharge pressure settings.

Experimental Procedure:

1. Isolate plant from SRF cavity/MCTL
2. Set dewar heater to balance load/unload valves
   - establish production rate
3. Manipulate compressor suction via bypass valves to set turbine inlet valve to desired value
4. Stabilize system – adjust dewar heater to match production
5. Adjust compressor discharge pressure to various settings from 8 & 10 bar a
   - Adjust dewar heater to match production and take reading
6. Repeat steps 3 through 5 for range of turbine inlet valve settings from 65% to over 90%

Results

A convenient cryogenic load map was created. Typical system operation with one cavity and a balancing dewar heater load is roughly 325 Watts. When re-adjusting the compressor, an operator can observe the position of the turbine inlet pressure control valve (cv3130) and adjust the compressor high pressure setpoint to match 325 Watts according to the chart below.



The dewar heater averages 17%, or 128 W

- SRF module and downstream system loads account for 197 W
- Reducing dewar heat would save energy, but need a small amount of heat – very difficult to set compressor exactly.

Dewar Heater	Dewar Heat (W)	Total System Load (W)	$ Saved/yr (estimated)
17%	130	325	$0
15%	105	300	$1713
12%	82	277	$4174
10%	68	263	$5738
8%	54	251	$7244
6%	40	237	$8695
4%	26	223	$10,099
2%	13	210	$11,466
0%	0	197	$12,811

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