LCLS-II Cryomodule Isolation Vacuum Pump Cart

A Semi-Automated, Flexible, and Interlocked Pumping System

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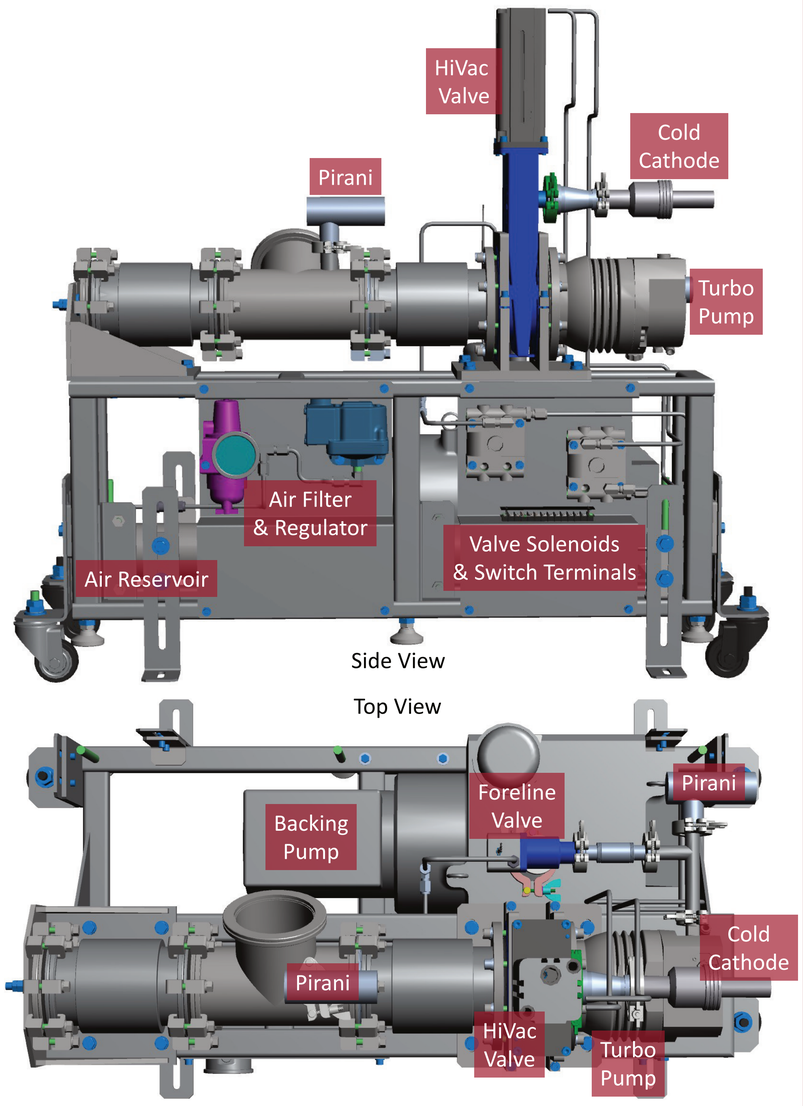
ABSTRACT

The LCLS-II Project at SLAC National Accelerator Lab is a major upgrade to the lab's Free Electron Laser (FEL) facility adding a new injector and superconducting linac. In order to support this new linac a pumping scheme was needed to isolate the liquid helium lines cooling the RF cavities inside the cryomodules from outside ambient heat as well as to exhaust any leaking helium gas.

LCLS-II cryomodule string

Carts were built with support for both roughing and high vacuum pumps and read back diagnostics. Additionally, a Programmable Logic Controller (PLC) was then configured to automate the pump down sequence and provide interlocks in the case of a vacuum burst. The design was made modular such that it can be manually relocated easily to other sections of the linac if needed depending on vacuum conditions.



CAD model of pump cart.

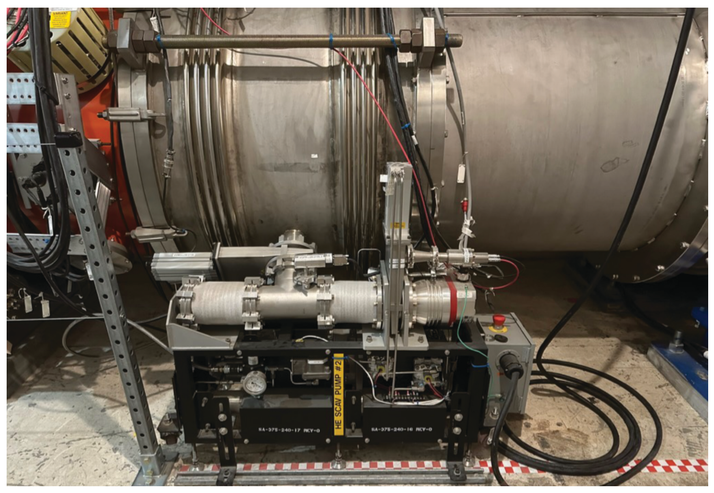
PROBLEMS

The primary concerns for the cryomodule isolation region are buildup of gasses that can transfer heat to the circulating cryogenic lines as well as formation of ice which can build up causing damage.

- It is almost impossible to completely avoid all leakage of helium gas within the cryomodule, so it must be continuously pumped out.
- If the cryogenic lines start warming up due to heat transfer to outside atmosphere, the cryogenic fluids will expand creating more gas leakage into the isolation vacuum.
- If temperatures increase too much, a quench will occur shutting off the machine and leading to downtime.

SOLUTION

To avoid these issues, we designed a pump cart system with automated pump down sequences and interlocks. As much electronics as possible were installed remotely outside of the tunnel to avoid radiation damage and allow access for troubleshooting. Design is intended to be turn-key such that pump down and recovery operations are largely hands-off, handled by the PLC logic. Carts and PLC support are designed to be as portable as possible in case it needs to be relocated to areas with higher leak rates.



Operational pump cart installed on cryomodule.

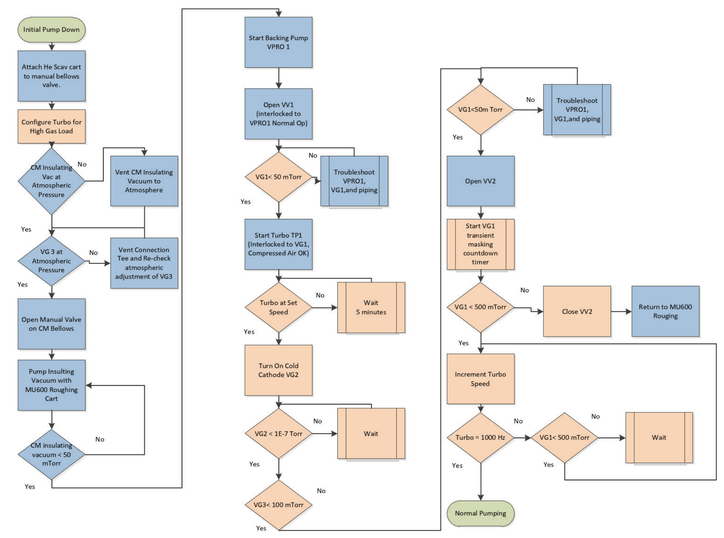
HARDWARE

- Allen-Bradley ControlLogix PLC
  - 1756-L83 Controller
  - 15” PanelView touch panel
- MKS 937B Combination Gauge Controller
- Pfeiffer TCP-350 Turbo Pump Controller
- Kashiyama NeoDry 36-12 Roots Pump
- Digi ConnectPort TS 16 MEI Terminal Server

Shared ControlLogix PLC and gauge/pump controllers.

SOFTWARE

- PLC code developed in Studio5000
  - Mostly ladder logic with some structured text.
  - Single main program template with input parameters for different installations.
  - Leveraged heavy use of Add-on Instructions and UDTs for consistent device-type logic.



Initial pump down procedure.

- Integrated with SLAC’s EPICS based distributed control and data archiving systems.
- Standard EPICS modules:
  - EtherIP to connect to PLC via Ethernet
  - Asyn and StreamDevice for RS232 connection to gauge and pump controllers
- User interfaces both for EPICS (via EDM) as well as locally at the PLC with a touch panel HMI.

EPICS EDM screens.

PLC touchscreen HMI screens.

RESULTS

A total of nine pump carts were successfully deployed across the four different cryomodule strings. Minor issues with the PLC logic, sticky valve solenoids, and a noisy current transducer were observed during the process of commissioning. All these issues have since been corrected and the carts have been running stably for over a year now.

After running at 2 Kelvin, larger than expected helium leaks were discovered in L3B. One cart each was moved from L1B and L2B to add supplemental pumping where the highest pressures were observed. The move was accomplished very smoothly as designed and gas loads have since been well within specifications.

ACKNOWLEDGEMENTS

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