KINNEY®

CASE STUDY

HELIUM PUMPING VACUUM SYSTEM SOLUTIONS

PUMPING & RECOVERY OF HELIUM

Vacuum pump systems are frequently used for the pumping and recovery of Helium (He). The vacuum packages are used in a cryogenic cooling system for superconducting magnets used in the Relativistic Heavy Ion Collider (RHIC) particle accelerator-collider. The RHIC is the only machine in the world capable of colliding beams of polarized protons and is the first machine in the world capable of colliding heavy ions, normally gold ions because of the densely packed nucleus producing head-on collisions of two beams of gold ions traveling close to the speed of light. The resulting collision liberates quarks and gluons (the building blocks of protons and neutrons within the nuclei) that are studied for the advancement of nuclear physics, particle physics, astrophysics, condensed matter physics, and cosmology.

OIL SEALED BENEFITS

Oil sealed systems provide enhanced sealing and cooling when handling lighter molecular weight gases such as He or H2 which results in less gas slippage, higher pumping capacity, and lower temperature operation compared to dry pumping systems. If an oil sealed compressor will be used to recover the pumped gases then the oil contamination from the oil sealed vacuum system is not an issue provided they both use similar type oils. A dry system would minimize oil contamination and reduce the cost of associated oil removal equipment but has a lower volumetric efficiency and runs hotter.

Kinney has many years of experience producing oil sealed vacuum systems consisting of both booster/rotary piston and booster/liquid ring combinations for pumping He in the past to universities, specialty gas companies, governmental labs, and various operators of acceleratorcolliders.

SYSTEM DESIGN & CONTROL

The vacuum boosters and liquid ring vacuum pumps used are all manufactured by Kinney in Springfield, MO and the vacuum systems are fully assembled and tested by Kinney at the same location. Each of the He pumping vacuum systems is composed of:

- Rotary lobe booster, equipped with oil injection for superior sealing and cooling and with a variable frequency drive (VFD) for capacity variation.
- Oil sealed liquid ring vacuum pump, equipped with a full oil sealant recovery system including separator tank with oil mist eliminator, oil circulation pump, heat exchanger, and various valves, fittings, and connecting piping.
- Pressure and temperature transmitters provided with the systems allow monitoring of operational data.

Oil-Filled Liquid Ring Vacuum Pump System

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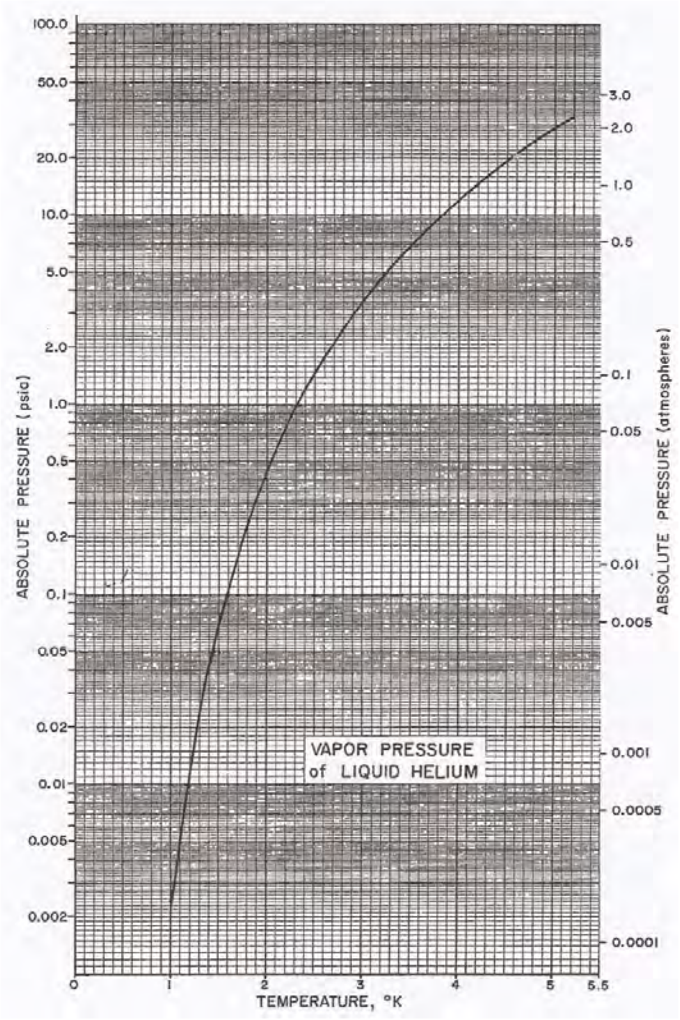
The Triplex MB2002/KLRC525 system is designed to pump up to 4 grams/sec of He at 18 mbar with three pumps running but designed with the flexibility to pump 0 to 6 grams/sec of He at pressures varying from 13 to 30 mbar. For larger or smaller applications Kinney can offer booster/LR pump combinations ranging from 400 to 10,000 acfm. For widely varying flow requirements, Kinney equips the system with a number of control features including:

- VFD or frequency inverters controlling the booster motor rpm
- Inlet pressure control valve
- Discharge pressure control valve that can recirculate thedischarged gas back to suction of the booster



Helium Vapor Pressure vs. Temperature

The common control panels housing the VFD's and programmable logic controller (PLC) for the vacuum systems and supplied by Kinney are designed to interface with the user's Supervisory Control And Data Acquisition (SCADA) computer control system to maintain a set point operating pressure within the 13 to 30 mbar pressure range using a signal from a pressure transducer located at the process. A key pad on the common control panel is used as part of the Human-Machine Interface (HMI) system to enter the set point pressure to be maintained. To maintain the set point pressure the three vacuum systems have the flexibility of shutting down one or more systems if not required, or varying the booster rpm's from a max to min setting, or using the inlet control valve to restrict gas flow if necessary, or bleeding discharge gas back to suction depending upon the control logic used.

HELIUM PROPERTIES

Although the vacuum requirements for most of the accelerator-collider components are in the high and ultrahigh vacuum levels that require special pumping systems and getter materials, the cryogenic cooling system only requires rough vacuum levels as indicated above. The normal boiling point of liquid He at atmospheric pressure is 4.2 K and it drops to 1.8 K if the pressure is reduced to 18 mbar (See Fig. 2). If liquid He is maintained below its lambda point of 2.17 K a quantum mechanical state of liquid He occurs that is referred to as He II where quantum mechanical effects can occur on the macroscale such as superfluidity, where the fluid viscosity becomes almost immeasurable, and the thermal conductivity of the He becomes very high (greater than any known substance) for rapid cooling of surfaces. The cryogenic cooling systems provide cooling for the superconducting radio frequency magnets and cavities in the particle accelerators and the vacuum systems provide the low pressure required for attaining the required temperatures below 4 K as well as collecting the boiled off He gas from the liquid coolant and recycling it through the system where it is compressed, cooled, and purified for reuse as liquid He. The demand and price for He is high which necessitates the need for efficient recovery systems.

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