Quantum Design

Applications Newsletter
Spring 2015

ATL Medium Pressure Helium Recovery Systems - NMR Installation

The unyielding demand for liquid helium worldwide continues to cause frequent price jumps, supply shortages, and delivery problems. The situation has become exceedingly difficult even in the United States where 90% of the liquid helium is produced. Looming large on the horizon is the Helium Stewardship Act of 2013 (https://www.congress.gov/bill/113th-congress/house-bill/527) passed by the United States Congress, which sets the time table to shut down the biggest helium gas reserve and supply by 2016. Many researchers have made helium management a foremost priority in planning for the future of their laboratories.

For the moment users are faced with three options: continue to buy liquid helium, upgrade to cryogen-free systems, or recover and recycle the helium used in their instruments. The first option is obviously not a good long term solution, especially for those who consume large quantities (e.g., more than US$30K per year). Cryogen-free systems are expensive, so not suitable for many labs where existing wet systems are still in great working condition. Traditional helium recovery systems are an ungainly option, especially for smaller size labs, due to the industrial size of traditional liquefiers. Now, with Quantum Design's Advanced Technology Liquefiers (ATL) and recovery technology, in-lab recovery and liquefaction has become viable for many users.

The ATL liquefier is designed and integrated for general users, with minimum requirements on experience or knowledge in low temperature instrumentation. The physical size of an ATL160 liquefier is comparable to a 100 liter helium storage tank, and the dewar cart on big wheels can be moved for transfers easily (see a video of an ATL helium transfer at https://youtu.be/jQE_soGSA6c). The liquefaction rate (typically defined as liters/day) of the ATL is proportional to the pressure in the ATL dewar. In the high pressure mode, the helium gas is supplied to the ATL at elevated pressure (e.g., 9 psi) which corresponds to liquefaction rate as high as 27 liters/day (although this rate is also affected by the purity of the input helium).

There are three recovery plant configurations available for different lab situations. Direct recovery (DR) is the most basic and the easiest to implement, but it does not capture transfer boil off, with recovery rates ranging from 60% to 80%. To capture all boil off with more than a 90% recovery rate, one should consider Medium Pressure Recovery (MPR) or High Pressure Recovery (HPR) (http://qdusa.com/products/helium-liquefiers.html).

Compared to a HPR plant which requires considerable space to accommodate gas bags, a high pressure compressor (up to 2500 psi), and gas cylinder banks for storage, a MPR system offers distinct advantages such as smaller footprint, lower pressure (up to 80 psi), and being a fully contained system (e.g., no facilities requirements for additional helium gas recovery plumbing). Designed to capture both static and transfer boil off with greater than 90% efficiency, it is an ideal choice for labs which require recovery from 1-3 cryogenic instruments. The MPR system is compact enough to be treated as laboratory equipment, with modular subcomponents preassembled and leak checked, making installation fairly straightforward. It is also easier for users to manage due to total control of all helium paths which virtually eliminates the risk of atmospheric contamination in the ATL liquefier.

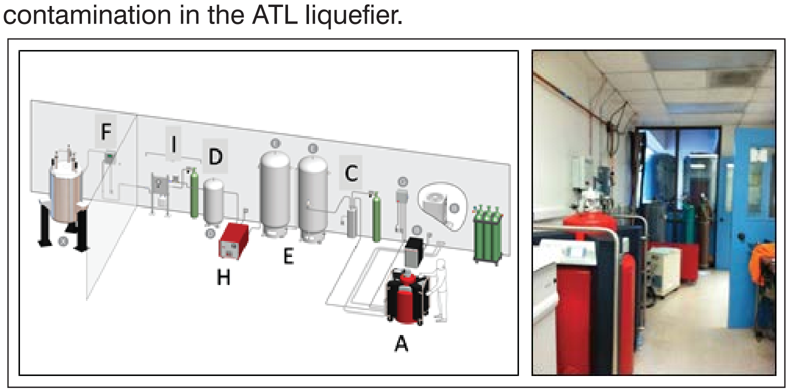

Figure 1 (Left): Schematic drawing of MPR installation with key components including ATL160 liquefier (A), Purifier (C), Surge tank (D), MP storage tanks (E), Electronic back pressure controller (F), MP Booster Console (H), and Gas Manifold (I).

Figure 1 (Right): MPR installation at UC Davis, N.J. Curro NMR Group.

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The left panel of Figure 1 shows the schematic layout of a typical MPR installation. Helium boil off from LHe cryostat(s) is controlled by an electronic back pressure controller (F) and piped through a gas handling manifold (I) into a surge tank (D). The MP booster console (H) monitors the pressure in the surge tank and automatically adjusts its pumping speed to compress helium into the MP storage tanks (E). The booster console seamlessly handles the transitions between low-flow static boil off and high-flow transfer boil off. From the MP tanks, recovered helium is regulated down in pressure (15 psi typical), then purified before being supplied to the ATL for liquefaction. With this setup, both static and transfer boil off are recovered with an expected efficiency of 90% or greater. Any loss can be resupplied by simply connecting a commercial gas cylinder into the helium stream downstream of the MP storage tanks.

The Right panel of Figure 1 shows the actual MPR installation in N.J. Curro NMR Lab at University of California, Davis. This group has a MPMS and a PPMS, plus a 500 MHz NMR system for solid state NMR research. All three cryostats are connected to the MPR recovery system. Combined static boil off is around 12 liters per day. Helium refill takes place two to three times a week. The footprint of the MPR installation is estimated to be about 6.5 m^2.

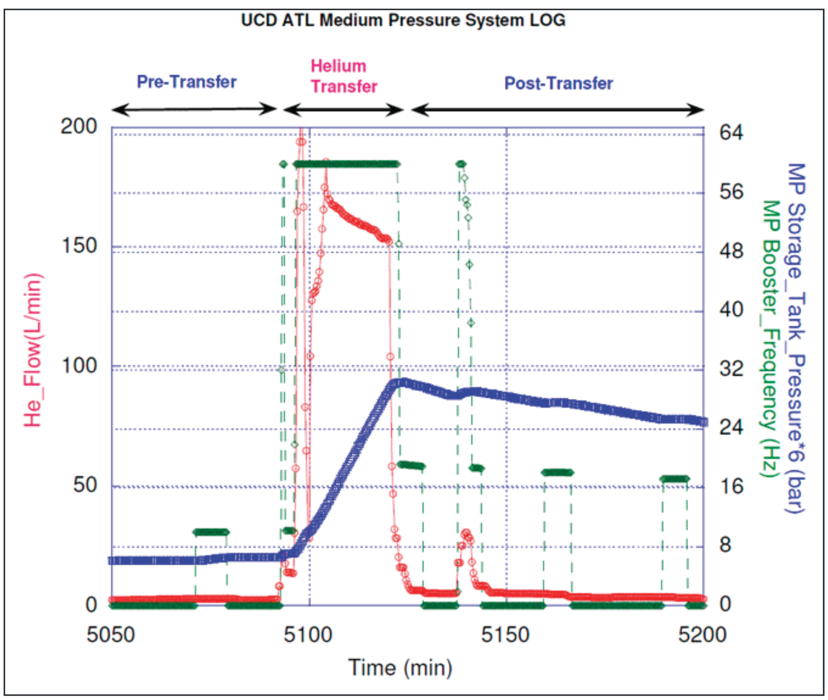

Figure 2: A typical refill transfer log of flow rate, MP tank pressure, and MP booster frequency.

A typical refill transfer log is shown in Figure 2. Notice the Pre-, During-, and Post-Transfer regions marked on top. Flow rate (red) changes from the static rate of 10 L/min, to about 180 L/min during the transfer. Accordingly, the working speed of the MP compressor (green) switches between idle (0 Hz), 10 Hz, and maximum speed of 60 Hz. Storage tank pressure (blue) rises as gas is compressed into them during transfer and then decreases afterward as the gas is drawn into the ATL160 for liquefaction. Also notice that the MP booster is idle about 85% of the time, thus saving electricity and prolonging the lifetime of the booster pump.