THE PURIFIER SYSTEM FOR HELIUM CRYOGENIC PLANT IN NSRRC

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Abstract

A cryogenic adsorber is a purifier cooled with liquid nitrogen that is used to trap impurities from gaseous helium in the helium cryogenic system. The output purity can be decreased to less than 5 ppm and the dew point to -62 ℃. The maximum rate of flow of each adsorber is 95 Nm^3/h. We installed five cryogenic adsorbers in the cryogenic system and completed its testing in 2011; five additional cryogenic adsorbers will be installed in 2012. The configuration, installation, test results and operation of an cryogenic adsorber system are reported herein.

INTRODUCTION

Two cryogenic plants (power 450 W) were installed in NSRRC to supply liquid helium to the superconducting cavity and the superconducting magnets in years 2002 and 2006 [1]. The configuration of the two cryogenic plants is shown in Fig. 1. The total volume of gaseous helium in the two cryogenic plants is about 4500 m3. Another cryogenic plant (700 W) for the TPS project was commissioned in year 2012 [2]; we have further gaseous helium (3500 m3) for this new cryogenic plant. To remove the contaminants from the helium in the cryogenic plant is important because solid particles might clog the system or damage the expansion turbine. Any contaminant that condenses and solidifies at low temperature must also be removed. We planned that one purifier system comprised five cryogenic adsorbers to eliminate gaseous impurities from gaseous helium in our cryogenic plants during year 2010, and to complete its installation and its test in 2011.

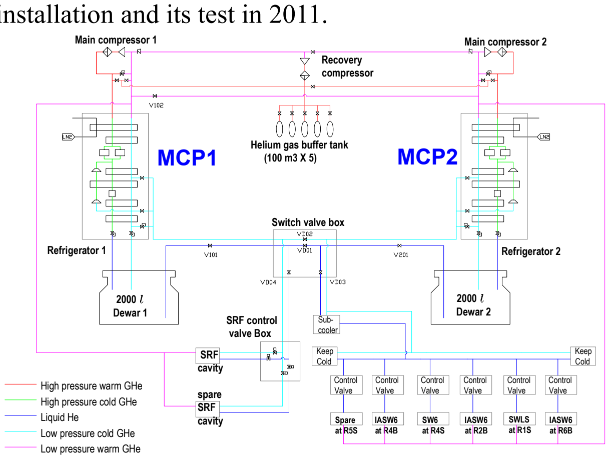

Figure 1: The configuration of the TLS cryogenic plant.

CRYOGENIC ADSORBER

Fig. 2 shows the detailed construction of the cryogenic adsorber used to purify gaseous helium in the cryogenic system. The level of impurity should be less then 5 ppm and the dew point of the adsorber below -62 ℃, with maximum rate 95 Nm^3/h of flow of each adsorber. The principal components of the adsorber include a steel cylindrical container, valves to control the rate of flow of gaseous helium and liquid nitrogen, a heat exchanger, activated charcoal and a liquid nitrogen reservoir [3].

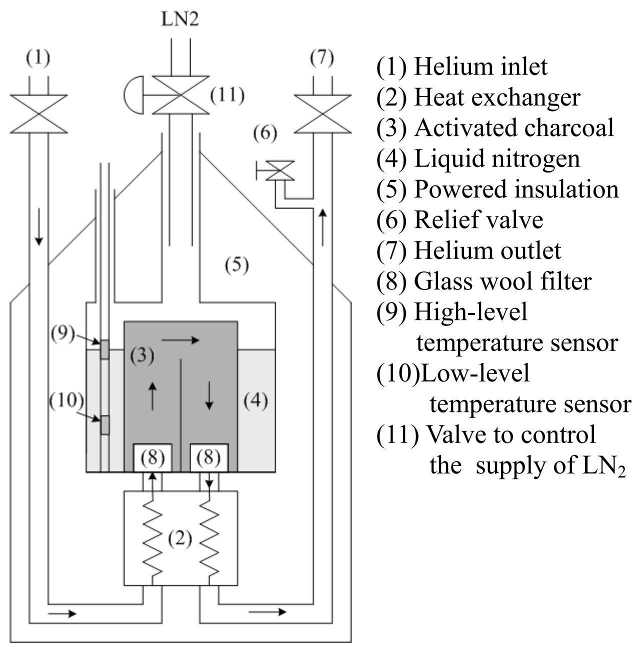

Figure 2: Cryogenic adsorber.

The total flow of gaseous helium in the adsorber is described as follows. 1) Gaseous helium near 23 ℃ flows into the absorber through (1). 2) Gaseous helium is pre-cooled with heat exchanger (2), which is cooled with gaseous helium returning from the other side and with liquid nitrogen. The flowing gaseous helium becomes cooled to around -185 ℃, and water vapour or other condensable gas would be condensed here, drain down to the bottom of the adsorber, and be expelled through the blowdown valve. 3) The cooled gaseous helium flows through the glass wool filter (8) and activated charcoal (3) to eliminate residual contaminants in the helium. 4) Cooled and clean gaseous helium would flow from the adsorber via the helium outlet valve (7), and the entire cleaning of gaseous helium is completed.

The liquid nitrogen would flow in the absorber via the LN2 supply control valve (11). To measure the liquid level of the liquid nitrogen, two temperature sensors are installed in the adsorber at (9) and (10). When the level of liquid nitrogen is below that of the low-level sensor (10), the temperature increases above -196 ℃ and LN2 flows automatically into the adsorber. The same method is applied in the high-level sensor (9): when the temperature

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of sensor (9) attains -196 ℃, the flow of LN2 is terminated. Because of the large heat load of the cryogenic system, powdered insulation (5) serves to decrease the heat leak of the adsorber.

One purifier system consisting of five adsorbers as installed and tested at NSRRC is shown in Fig. 3.

Figure 3: Adsorbers of the purifier system.

THE PURIFIER SYSTEM

Fig. 4 shows the configuration of the purifier system. For various purposes, three manners of operation are performed in our system -- cleaning newly added gaseous helium, cleaning the used helium buffer while the cryogenic system is stopped, and cleaning gaseous helium when the cryogenic system is operating.

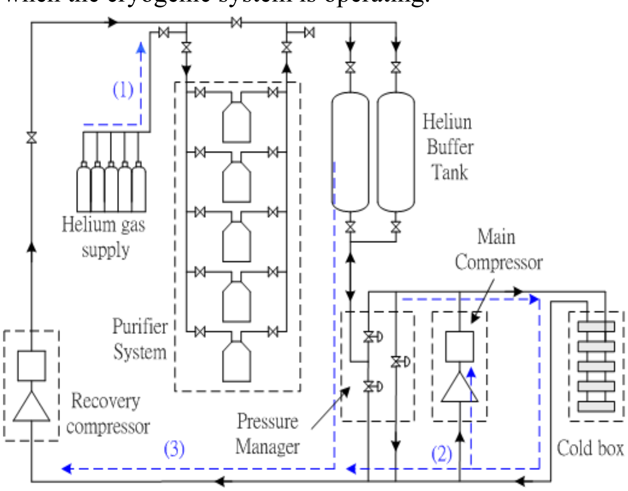

Figure 4: Configuration of the purifier system.

The used gaseous helium slowly decreases because of leaks, maintenance, trip events, purging and pumping, and safety tests each year. On occasion we refill with new gaseous helium into the buffer tank, normally with helium of purity greater than 99.999 %. We connect the cylinders to our purifier system such that in the first way the purifier system traps the moisture and supplies purer helium to the buffer.

During normal operation of the cryogenic plant, moisture becomes trapped in the cold part; its reading value is small and stable. In the second way, we operate the purifier whilst the cryogenic plant is running. Fig. 5 shows the measurement of H2O. Before the purifier system operates, the value is about 2.3 ppm; after operation of the purifier system for 30 h, the value decreases to 1 ppm.

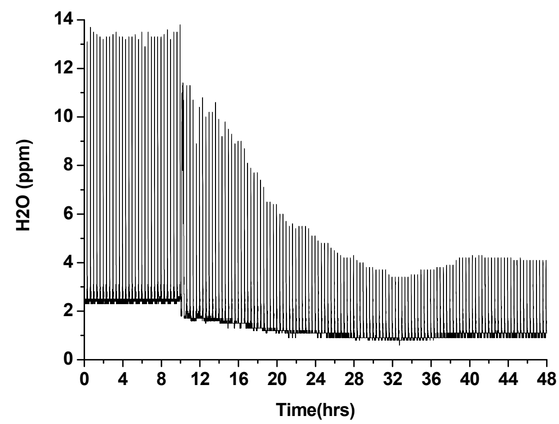

Figure 5: Moisture reading of the analyzer during cryogenic system operation.

When the cryogenic plant or the superconducting devices stop for a few days, some moisture arises because of a temperature increase. In the third way the recovery compressor conveying the helium to the buffer tank passes through the purifier system. Fig. 6 shows the H2O content during warming of the cryogenic plant. During this period, one cryogenic plant and three superconducting magnets become totally warm; the moisture increases from 1 ppm to 13 ppm. When the purifier system is operated again, more than four days are required to decrease the moisture from 13 ppm to 5 ppm.

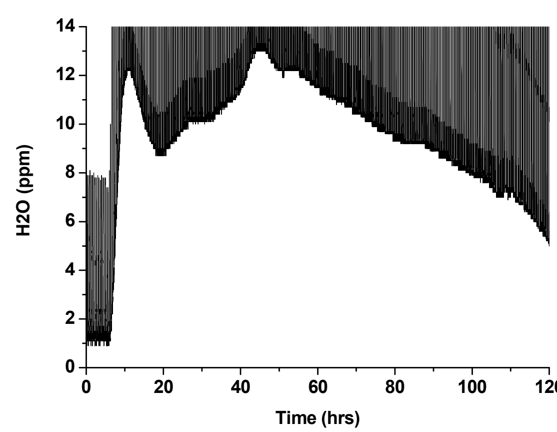

Figure 6: Moisture reading of the analyzer during cryogenic plant and superconducting devices warm up.

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When purification is completed, we isolate the purifier system and warm the cryogenic adsorber with electric heaters. Once the adsorber is warm, we perform purging and pumping with two dry vacuum pumps. In our experience, some water observed during the regeneration, which means that this purifier system really traps moisture from the helium cryogenic plant.

CONCLUSION

This purifier system has been operated to trap gaseous impurities, especially moisture, in the helium cryogenic system. Automatic and continuous operation has been tested for more than five days. Next we shall install a second purifier system in year 2012, which can serve as a support system when the first purifier system must be regenerated.

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