INITIAL PERFORMANCE OF A MULTIPLE-MAGNET HELIUM RECOVERY SYSTEM

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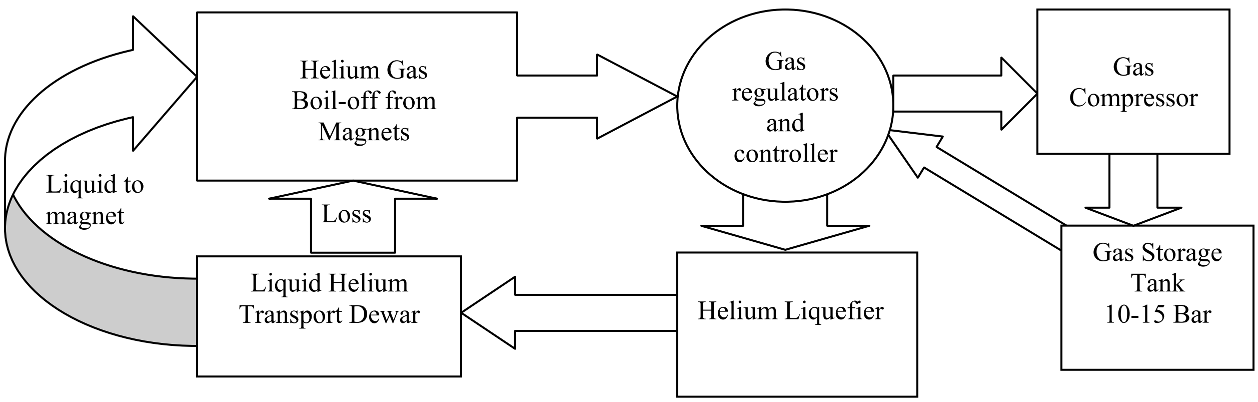
Introduction

Helium is a non-renewable resource. Virtually all modern MRI magnets have some form of helium re-liquefication to make them economic to operate and environmentally responsible however many MRI and NMR magnets still exist that do not use any form of helium recovery. Many magnets can be retrofitted with a cold finger to re-condense the cold helium gas boil-off, however, some magnet designs are not compatible with this type of retrofit. In this case the helium gas must be collected at room temperature and liquefied. For large MRI magnets, the volume of gas becomes enormous without some kind of gas compression system. In this paper, we present our solution for helium regeneration at our imaging centre and its performance over its first year of operation.

Materials and Methods

The helium recovery system services 3 superconducting magnets. One is a Magnex (Abingdon, UK) 3T 800 mm bore whole body MRI magnet. The second is a 4.7T Oxford (Oxford, UK) 330 mm horizontal bore small animal MRI magnet. The third is an 11.7T Oxford 89mm vertical bore NMR magnet. The main components of the recovery system are a Cryomech (Syracuse, NY) model LHeP18 liquid helium plant capable of producing 18 litres of liquid helium per day and a Quantum (Vancouver, BC) model Q09.4-HR3 helium recovery gas compressor system. Other parts of the system are a 2000 USWG gas storage tank, 250 litre helium transport dewar and a programmable logic controller to detect pressure levels and control pressure valves to maintain the proper pressures in the different parts of the system. A block diagram of the regeneration system is given in the figure below.



Results and Discussion

Prior to the startup of the helium recovery system, the 11.7T and 4.7 T magnets had been at field at our site for 7 and 3 years respectively with a helium consumption of 4 l/day. The gas recovery system uses 3 differential pressure regulators to maintain the pressure from a magnet exhaust pressure of 0.75 psi, to the storage tank pressure of 40-215 psi. Without recovery, the normal exhaust pressure is about 0.1 psi regulated through a one-way valve to the atmosphere. There was a concern that the increase in exhaust pressure would change the helium consumption of these magnets. With the 3 T magnet added to the system for the past 4 months, the total helium boil-off has been 12.14 ± 1.15 l/day with the 4.7 and 11.7T magnets virtually unchanged at 3.10 ± 0.15 and 1.05 ± 0.26 l/day respectively. To account for the losses during the transfer from liquefier to transport dewar and transport dewar to magnet, 18.56 l/day must be generated. From the gas collected during all transfers, the transfer efficiency has been 82 ± 2 %. To date, the liquefier production has been 22 l/day resulting in 18 l/day of usable liquid. The system differs from a complete liquefying system in that it does not have a gas purification stage and relies on the clean boiloff gas from the magnets. The liquefier has now operated continuously for one year and collected gas from more than 50 transfers. To date, the measured impurities in the storage tank are less than 0.02% Air in helium. There is some indication of contaminant buildup on the cold head but no noticeable reduction in helium production. The recovery efficiency of the system should be very high with the only losses being during transfer line cool down, insertion, withdrawal and leaks. Data on system losses has only been possible in the last 4 months and is 0.7 ± 1.3 l/day.

Although our design was governed by the age and design of our 3T magnet, the benefit of servicing more than one magnet cannot be overlooked. In our case an 18 l/day liquefier was adequate. Larger capacity liquefiers are available. An additional factor to consider is that our magnet does not have a cold head but instead uses a nitrogen jacket. Servicing of the cold head is required every 18-24 months and on some systems required lowering the field. Our system is outside of the magnet and easily serviced. As well, there is no problems with the low frequency noise of the cold head. One disadvantage is that personnel experienced in helium handling are required and the system is best suited to a research installation. The regeneration system is on target to pay for itself in about 3.5 years of helium operating costs and is a cost effective solution for the operation of an imaging centre.