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OPERATION OF SLRI CRYOGENIC SYSTEM FOR A 6.5 T SUPERCONDUCTING WAVELENGTH SHIFTER

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Abstract

The cryogenic plant at Synchrotron Light Research Institute was designed to be used as the main liquid helium supply for a superconducting wavelength shifter, in order to generate high-energy X-rays from the relatively low-energy 1.2 GeV Siam Photon Source storage ring. The plant was installed and successfully commissioned in the year 2009. During the past three years since commissioning, the cryogenic system had been in operation to perform helium liquefaction without a superconducting magnet. Since the installation of a 6.5 T SWLS in September 2013, the cryogenic system has begun its operation with a full-time load. In this work, the first operation of the cryogenic system with a superconducting insertion device is presented.

INTRODUCTION

The existing superconducting wavelength shifter (SWLS) at SLRI requires a cryogenic system that can provide adequate liquid helium supply in order to operate at 4.5 K. Synchrotron Light Research Institute (SLRI) has set up a helium liquefaction plant with liquefaction capacity of 20 liters/hr for this purpose. The main characteristics of SLRI cryogenic plant are summarized in Table 1.

Table 1: Characteristics of SLRI Cryogenic Plant [1]

Item	Description
Helium Liquefier Model	Air Liquide HELIAL 1000
Liquefaction Mode	Claude Cycle Two expansion turbine in series
Liquefaction Capacity Without LN2 pre-cooling	20 liter/hr
Helium Dewar Storage Capacity	450 liter Storage Pressure 1.30 bar
Compressor Station	Discharge pressure 12 bar Suction pressure 1.05 bar Water cooled
Helium Recovery Compressor Capacity	6 m^3/hr
Helium Gas Buffer	20 m^3
Helium Gas Bag	110 m^3

The cryogenic plant has been in operation since April 2009. During the period from May 2009 to November 2010, we had performed 5 cold tests of the SWLS. The cold test data indicates that the liquid helium consumption rate of the SWLS was rather high (>20 liters/hr). During these cold tests we also encountered a problem related to structural integrity of the cryostat during pressure build-up. This has called for a redesign of the SWLS cryostat that can tolerate higher build-up pressure with lower liquid helium consumption rate (<5 liters/hr). Since the design and construction of a new cryostat requires a considerable amount of time, a 6.5 T SWLS was kindly lent to SLRI from NSRRC, Taiwan. During two years before the installation of a 6.5 T SWLS, the cryogenic system has been in operation without a superconducting device. In order to reduce power consumption, the cryogenic system has been operated by “warm-up and cool-down operation”. This process has been periodically performed every month [2].

FIRST OPERATION WITH SUPERCONDUCTING WAVELENGTH SHIFTER

In July 2013, SLRI successfully installed the 6.5 T SWLS. The magnet is then cooled from ambient temperature down to 4.5 K. The diagram of cryogenic plant including helium circuit for SWLS is shown in Figure 1.

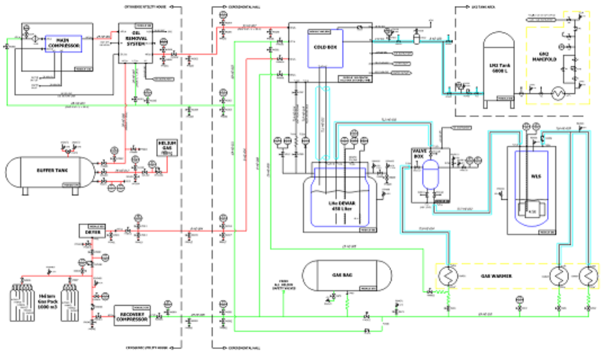

Figure 1: Configuration of Cryogenic System.

For cooling down and filling liquid helium to SWLS cryostat, a bulk of liquid helium is extracted from the 450 liter main storage dewar through a liquid helium transfer line and a cryogenic valve box. The evaporated helium

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will be collected through a gas return line, passing through a gas warmer and then returning to the low pressure side of the cryogenic plant.

To enable continuous operation, the liquid helium consumption rate of the SWLS plus liquid helium transfer line and the valve box must be lower than the liquefaction capacity of the plant. The fully automatic LHe filling for the SWLS cryostat was developed to reduce liquid helium loss. This filling procedure is shown in Figure 2, which begins by opening 5% of cryogenic flow control valve (FCV1110) from the valve box to the SWLS cryostat for 5 minutes to cool down the transfer line. After that, filling command starts ramping FCV1110 to 50% with ramping rate of 0.05% per second. During this time, the valve box pressure (PT1110) is monitored to ensure that it does not exceed 1.35 bars. This pressure is higher than that inside the SWLS cryostat. The liquid helium level is monitored by an AMI136 LHe level meter. The filling stops when the liquid helium level reaches the maximum level set point. The filling is automatically performed again when the LHe level drops down to the minimum level set point. Employing this filling procedure, the total LHe consumption rate is less than 5 liters/hr.

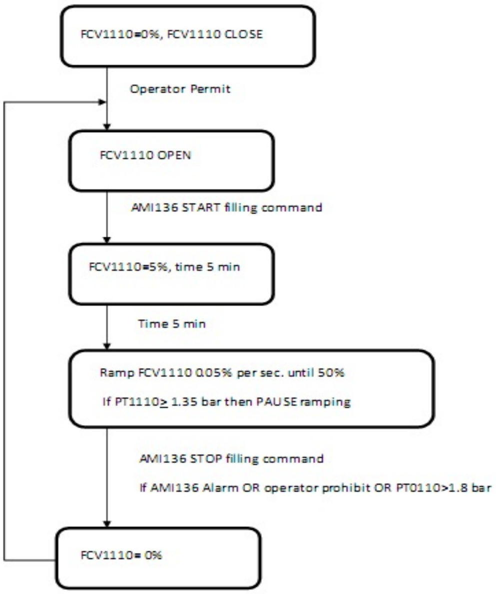

Figure 2: SWLS automatic filling procedure.

Figure 3 shows the trends of liquid helium level in SWLS cryostat and main dewar storage during normal operation. The SWLS minimum level set up 30% start filling and stop filling at 50%. The main dewar keeps 50%-70% of level. The maximum SWLS cryostat pressure is compatible to dewar pressure 1.30 bar and the compressor suction line 1.05 bar. The availability of cryogenic system is achieved via transferring liquid helium from dewar to the cryostat during the period of 1 day.

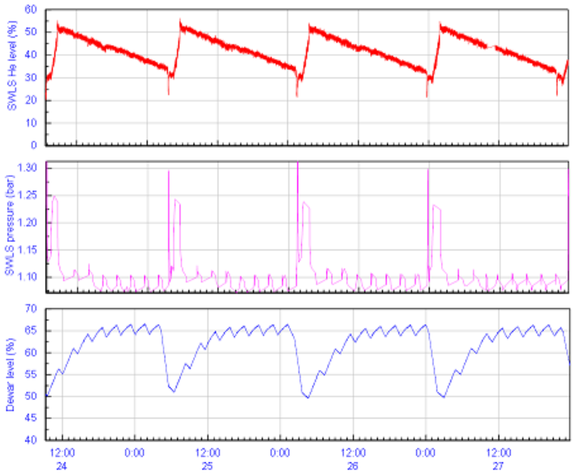

Figure 3: LHe levels and cryostat pressure during normal operation.

RELIABILITY AND STABILITY

Number of interruptions caused by malfunctions in the cryogenic system is presented in Table 2. During the first year of operation, there were 8 such events. However, system recovery has always been swift, and as such the loss of user beamtime due to cryogenic system malfunction had been minimal.

Table 2: Statistics of interruptions for cryogenic plant during September 2013-May2014

Event/Problem	**Event Number**
Power failure	3
Utility fault (Cooling water, compressed air, computer failure)	
Main compressor fault	2
Expansion turbine fault	3

To improve the system stability and shorten the recovery time, a supervision system was developed to constantly monitor the status of the system. Figure 4 shows the configuration of supervision system. The system health can be monitored via the internet. The system will also generate and send an SMS alert to the corresponding staff as soon as an anomaly is found, so that the staff can come and take corrective action in a timely manner.

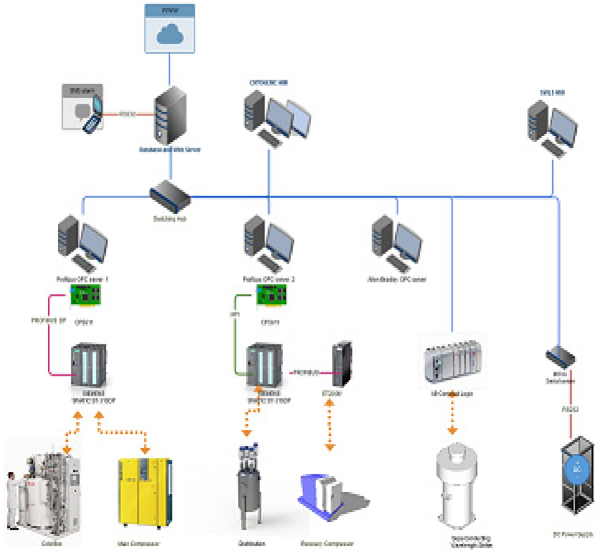

Figure 4: Configuration of supervision system.

CONCLUSION

We succeeded in cooling down and operating the superconducting wavelength shifter as planned. So far the cryogenic system is proved to be both reliable and stable. However, from our experience, a turbine failure can happen without any noticeable minor malfunction in advance. Preventive maintenance is essential in avoiding potentially long shutdown.

REFERENCES

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[2] S. Srichan et al., “Operation Experience and Failure Analysis of SLRI Cryogenic System”, SCC2011, the Hague, Netherland, September, 2011.