DE-IONIZED COOLING WATER SYSTEM STUDY AND IMPROVEMENT AT TLS

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Abstract

In order to promote the stability and quality of the de-ionized cooling water (DIW) system, a series of studies and improvements on the DIW system are accomplished at the Taiwan Light Source (TLS). The total DIW system capacity is increased 400 GPM, where a special subsystem of 150 GPM is for a new superconducting-rf (SRF) system only. The DIW temperature is globally controlled within ± 0.1 °C. A high precision temperature control system of ± 0.01 °C for local DIW supply is also established to meet the critical stability requirements. The water quality has also been improved by upgrading local filters, reverse osmosis, conductivity meters, pH monitors, flow meters and various resins. The conductivity of the water has been maintained above 10 M ohm/cm and the pH at 7± 0.3. Additionally, the dissolution of oxygen, which is another essential water quality factor, has also been much reduced from 5000ppb to 6ppb by new deoxygenating equipment.

INTRODUCTION

Taiwan Light Source (TLS) had started a series of experiments to established the mathematical model [1] and find out the relationships among the beam orbit position and the utility status [2]. The supplied air temperature and cooling water temperature are the main factors. Once the cooling water and the air exceed 1°C and 0.2°C, respectively, the results show the strong correlation between the beam orbit stability and the utility status. Based on the study, TLS has made more efforts to improve the utility system [3] and conduct more precision thermal and mechanical stability studies meet the latest strict requirement of beam intensity variation within 0.1% [4]. The original specification for the temperature fluctuation <±1°C is far from the requirement.

A SRF cavity will be installed into TLS storage ring in 2004. TLS has devoted many efforts in studying the corresponding issues for the SRF system [5]. In order to serve for the oncoming SRF system, the DIW system has been added a new subsystem at TLS. The 2nd Utility Building was constructed and the total DIW system capacity was increased 400 GPM last year. The piping system is also rearranged to meet requirements for each subsystem.

Moreover, a high precision water temperature control experiment is conducted to meet the critical stability requirement. The experimental apparatus has been set up. The test results will be valuable to establish any real local high temperature precision control DIW subsystem.

DIW quality is another crucial but apt to be neglected issue. Although not like the DIW temperature and pressure directly affecting the subsystem operation, the factors of DIW quality, such as conductivity, pH value and dissolution of oxygen deeply influence the DIW system itself, especially for the piping system. For long-term smooth operation, the DIW quality is also studied and improved.

DIW SYSTEM

The DIW system, composed of three subsystems, i.e., the copper (Cu) subsystem, the aluminum (AL) subsystem and the beam line subsystem, has been operated for years at TLS. The Cu DIW subsystem supplies to magnets, power supplies, RF transmitters and cavities. The Al and the beam line DIW subsystems serve for vacuum chambers and beam line devices, respectively. This DIW system had been upgraded by means of two major projects in 2002.

First, the second utility building was constructed. Two sets of chillers of 450 ton were new installed for the DIW and air conditioning systems. The DIW capacity is increased 400 GMP consequently. The forth DIW subsystem, SRF subsystem, of 150 GPM was new established for the oncoming SRF cavity. The capacity of the beam line DIW subsystem was increased from 150GPM to 300 GPM.

Second, redundant frequency inverter systems for each DIW subsystem were established. Originally, there is only one frequency inverter system for each DIW subsystem. It exists the risk of beam trip through the interlock system once the frequency inverter system trips. The redundant frequency inverter system thus is necessary in case of trip of the running inverter system. Two sets of the redundant frequency inverter systems for each Cu and beam line DIW subsystems are ready currently. Other two sets of the redundant frequency inverter system for the Al and SRF DIW subsystems will be installed in Aug. 2003.

There are two phases of heat exchange in each DIW subsystem. The DIW temperature variation is controlled within +/-0.1 °C for the Cu and Al subsystems and +/-0.15 °C for other two subsystems by means of adjusting the flow rate of the chilled water and cooling water. The DIW pressure is control within +/-0.1kg/cm2 by regulating the pumping frequency. The specifications of each DIW subsystems are list in the Tab. 1. The first and second phased Cu and Al DIW temperature is shown in the Fig. 1

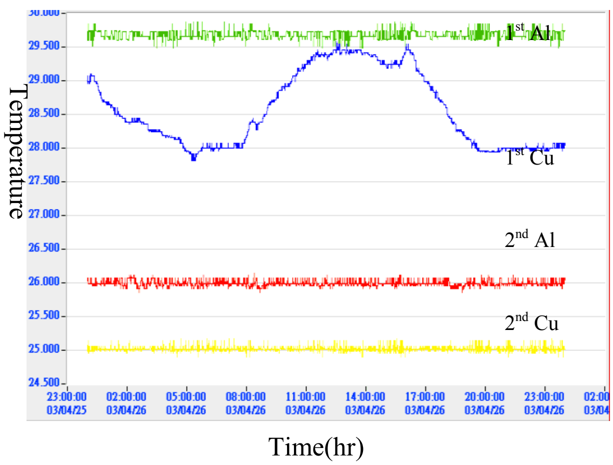

Fig. 1: First and second phased Cu and Al DIW temperature

Table 1: Specifications of each DIW subsystem

	Temperature	Pressure	Flow rate
Cu	25+/-0.1 °C	7.5+/-0.1kg/cm^2	500GPM
Al	25+/-0.1 °C	7.0+/-0.1kg/cm^2	100GPM
SRF	25+/-0.2 °C	7.0+/-0.1kg/cm^2	160GPM
BL	25+/-0.2 °C	7.0+/-0.1kg/cm^2	300GPM

HIGH PRECISION TEMPERATURE CONTROL EXPERIMENT

Beside the primary DIW system upgrading projects abovementioned, the high precision temperature control is a smaller project for local temperature-sensitive equipments. The high precision temperature control experiment has been set up in a laboratory.

Fig. 2 shows of the high precision temperature control experiment. In the experiment, water flows through a 0.5inch stainless pipe. A set of embedded heaters with total 10KW capacity is installed on the upstream of the pipe to control the inlet water temperature. A NI FieldPoint modular distributed I/O system with 16-bit resolution in the range from 4 to 20 Ma serves as the real time controller. A SCR is employed to drive the heater. A heating tape of 220W is coiled on the middle section of the pipe to simulate the heat load.

Two adjustable valves are respectively installed on the upstream and downstream of the embedded heater set to control the flow rate. A flow rate meter with +/- 0.5% accuracy is installed on the downstream.

Three pressure probes with transducers with +/- 0.1kg/cm^2 are installed inlet and the upstream and downstream of the heating tape respectively. The most crucial sensor in this experiment is the thermometer. Three Thermometrics TS8504 thermometers are installed on the upstream and downstream of the embedded heating set and the outlet of the pipe, respectively. The thermometer is accurately calibrated and its accuracy is +/-0.001 °C. The test results show that the water temperature control within +/- 0.01 °C is achievable. The experiment is helpful to set up a real local high precision DIW temperature control system.

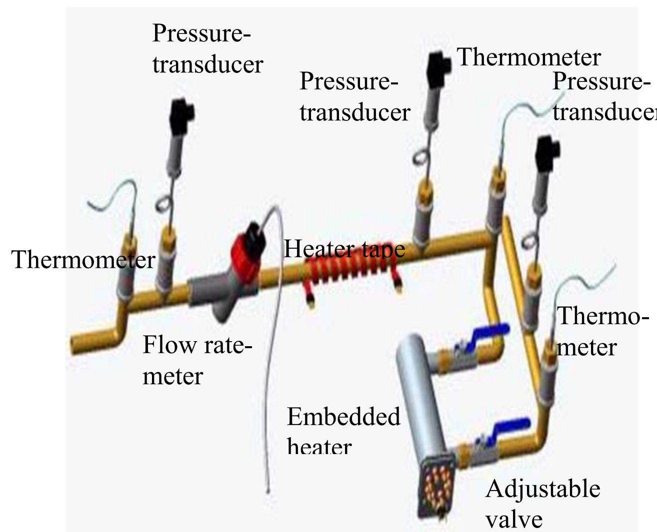

Figure 2: High precision temperature control experiment

DIW QUALITY IMPROVEMENT

Water quality is anther significant issue for the DIW system. There are usually some general impurities in the DIW system after long-term operation, such as suspension, electrolyte, corpuscles, mirco-pranisms, organic substance and gas. There is 5% water entering the recycling loop in the DIW system at TLS. It will flow through 5um filter, resin mixing bed, 1um filter, and ultraviolet sterilizer respectively, as shown in Fig. 3. Once city water is supplied for the DIW system, it will flow through the reverse osmosis (RO) system then into the DIW system. The RO system includes a 10um filter, a set of RO diaphragm, a pressure pump, a medicine tank, a mixing pump, a 8-ton reservoir and a control system.

The water quality has been improved by means of upgrading local filters, reverse osmosis, conductivity meters, PH monitors, accumulated flow meters and various resins. The resistance is kept above 5 Mohm,as shown in Fig.4. The pH value is controlled at 7±0.3, as shown in Fig5. In addition, the dissolve oxygen effect, another important issue of water quality, has also much reduced from 5000ppb to 6ppb through new added deoxygenating equipments.

CONCLUSION

Some major DIW system upgrade projects were implemented in 2002. The DIW capacity was increased 400 GPM. The SRF DIW subsystem of 150 GPM was set up for the oncoming SRF cavity. The capacity of the beam line DIW system was also increased from 150GPM to 400GPM. Redundant frequency inverter systems for each DIW subsystem were established.

The high precision temperature control experiment was conducted. The critical goal of controlling the water temperature variation within +/- 0.01 °C is achievable. This result will be valuable set up a real local high precision DIW temperature control system.

The DIW quality was improved by means of upgrading some crucial components of the DIW system. The resistance is kept above 5 Mohm, while the pH value is controlled at 7+/-0.3 currently. The dissolve oxygen was reduced from 5000ppb to 6ppb.

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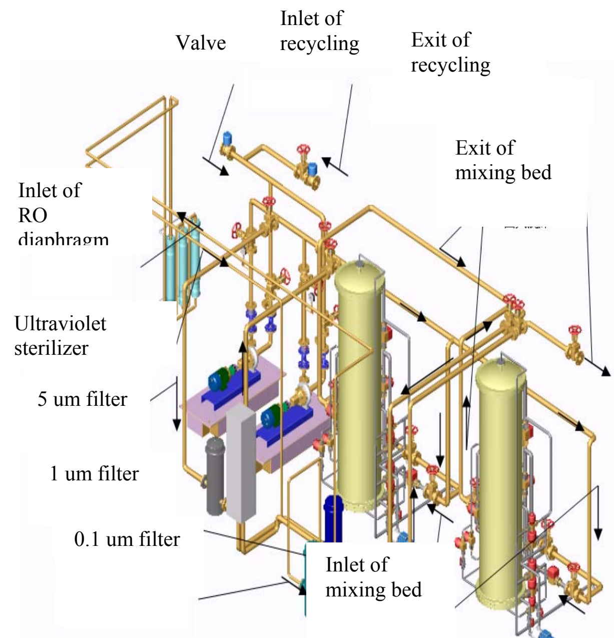

Fig. 3: DIW recycling loop

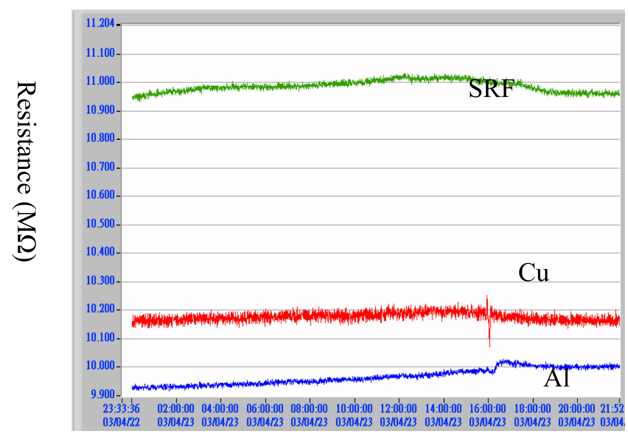

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Fig. 4: DIW resistance.

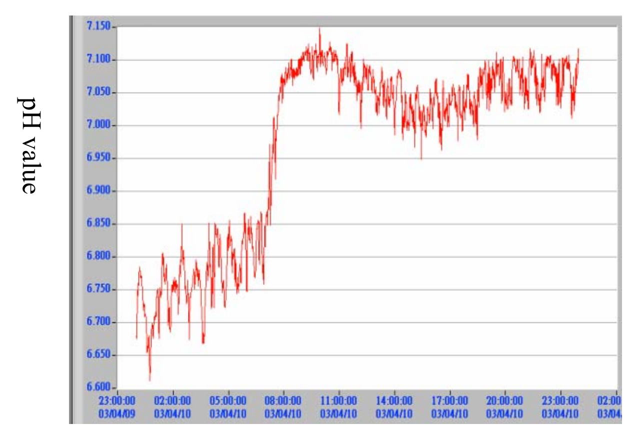

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Fig. 5: pH value of Cu DIW.