TECHNICAL OVERVIEW OF THE SOLARIS LOW-CONDUCTIVITY WATER COOLING SYSTEM

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Abstract

National Synchrotron Radiation Centre SOLARIS started operation in May 2015. In order to receive heat deposited in various synchrotron devices during operation, a low-conductivity water (LCW) cooling system was installed. To fulfil all tasks of cooling system at an acceptable cost of investment and maintenance certain technical and economic conditions, i.e.: installation materials, LCW quality, hydraulic balancing system, automation, control and diagnostics, including the planned service intervals, have to be met. Within this presentation the design, construction and operation of the LCW cooling system will be discussed.

INTRODUCTION

Synchrotron components, usually made from copper, are cooled by deionized (DI) low-conductivity water (LCW) [1] to maintain proper work parameters. Installation ensuring supply of the LCW should satisfy several, fundamental technological assumptions such as efficient depositing of thermal loads generated during normal operation of the synchrotron, its conditioning and tests; resistance to degradation due to physical-chemical properties of LCW and radiation environment in combination with simultaneous availability of materials on the market, as well as enable economic use and utilisation of energy.

MAIN LCW COOLING SYSTEM

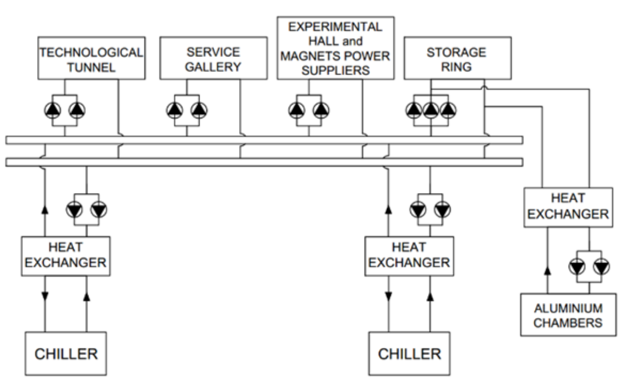

Figure 1: LCW cooling system.

Cooling Chillers

The pumping station cooperates with two cooling chillers situated outside the building (see Fig. 1). Each chiller is provided with:

- Two Freon circuits with the total cooling capacity of 620 kW, which gives the total capacity of 1 240 kW
- Air-cooled condensers
- Six scroll type compressors

Possibility of working in the free-cooling mode

Cold generated by the chillers is transmitted to the main supply manifold through heat exchangers.

Each chiller works independently using a separate circuit.

Pumping Station

The pumping station is situated in the central part of the synchrotron building; from there the LCW supply lines are distributed. The pumping station also includes the following:

- Two plate-type heat exchangers LCW-glycol with circulation pumps receiving hot water from the common return manifold; heat exchangers transfer the heat gains to cooling chillers; the cooled water is supplied to the common supply manifold.
- Four pumping systems for the individual LCW supply lines; each system is provided with two pumps operating in the following mode: one pump is working; the other pump is in standby mode. An exception is the Storage Ring comprising three pumps: two pumps are working; the third pump is in a standby mode.

Each pump is provided with a smooth rotation regulations system enabling automatic adjustment of the system to the current demand for cooling

LCW Backbone

Materials of the installation The Main LCW backbone is made from stainless steel, seamless pipelines marked as EN 1.4541 (AISI 321). This material is used for the diameters exceeding 60 mm. The water flow is turbulent and the [flow] speed exceeds 1.5 m/s.

Pipelines of smaller diameters are made from copper as per EN 1057. The flow speed within them does not exceed 1 m/s.

Dezincification resistant brass connects the stainless steel and copper. This solution enabled a considerable cost reduction.

Direct connections to the LCW backbone are made via flexible, non-conductive (SAE 100R7), EPDM and LLDPE pipes depending on the diameter and presence in the radiation zone.

Cooling circuits Four LCW cooling circuits supply water to the following zones and synchrotron devices (Table 1 and Fig. 2):

- Klystron and Linac Tunnels (K&LT)
- Service Gallery (SG)
- Storage Ring (SR)
- Experimental Hall and Magnets Power Suppliers (EH&MPS)

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Table 1: Parameters of the Main LCW

Zone	Location	Max power	Total flow rate
+25	K&LT	142.28 kW	24.39 m^3/h
+25	SG	105.56 kW	18.10 m^3/h
+25	SR	410.64 kW	70.40 m^3/h
+25	EH&MPS	28.14 kW	4.82 m^3/h
+25	**TOTAL**	**686.61 kW**	**117.71 m^3/h**

The stream of cooling water supplied to the individual devices or device groups can be adjusted with control valves. During normal operation, the demand for cooling in individual circuits is constant and thus the flow of the cooling agents remains constant.

LCW Cooling Circuits

Klystron and Linac Tunnels In this zone, the LCW systems supplies directly the following [system components]: RF modulators together with modulator for thermionic gun, klystrons with solenoids, RF waveguides between klystrons and accelerating structures, RF circulators, magnets: Septum, Dipol and quadrupole on the Transfer Line, connecting the Linac Tunnel with Storage Ring and solenoid magnets behind electron gun. LCW is also used in the Secondary Heating Generators (SHG - swedish name Shuntgrupp) – the devices for water temperature stabilisation supplied MaxIV Synchrotron.

Service Gallery The LCW is also used for direct cooling of RF transmitters, RF circulators and four SHGs dedicated to two RF main cavities and two RF Landau cavities.

Storage Ring This LCW circuit is used to directly cool the following:

1. All components inside the twelve Double Bending Achromats (DBA), namely:
- Magnets DIP, SQFI, SQFO, SXDI and SXDO
- Heat absorbers: crotch, distributed, NEG strips and HAA
2. Front End magnets (FE magnets)
- FE for Beam line
- Diagnostic components
- Vacuum chambers
3. Front End straight sections including similar elements such as FE magnets
4. Secondary closed-loop circuit through plate-type heat exchanger for Aluminium Chambers for Insertion Devices operating on the Municipal Water

Experimental Hall and Magnets Power Suppliers In this zone, the LCW system supplies directly the following:

- All components of each of the two research lines
- Power Suppliers for all DBA magnets

A set of qualitative parameters for the main LCW cooling system is specified in Table 2.

Table 2: Quality Parameters of LCW

Parameter	Value
Temperature	+25±1.5°C
Pressure	6.0 bar
Resistivity	4.0 MΩ·cm
pH	7.50
Dissolved oxygen	25 ppb

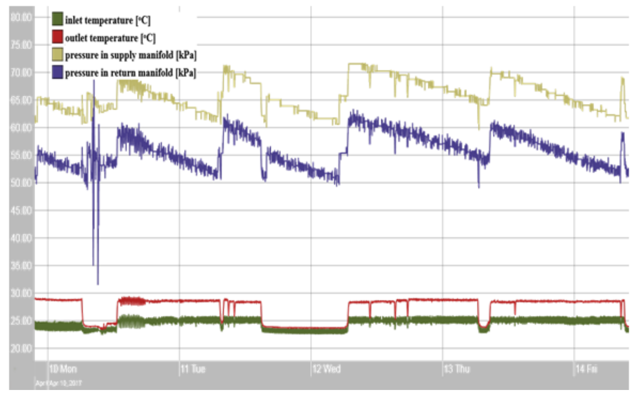

Figure 2: Parameters of cooling water.

Water Treatment

The deionized water (DI), used in the generation of LCW is produced within the demi water plant based on the municipal water (see Figs. 3 and 4). When it is necessary to supplement the LCW system, the DI is directed from the buffer tank, first into the two Mix beds system: with the acid and alkaline bed depending on the current pH value of the LCW and subsequently to the Deoxygen module (vacuum degassing system) to reduce the dissolved oxygen and other gases.

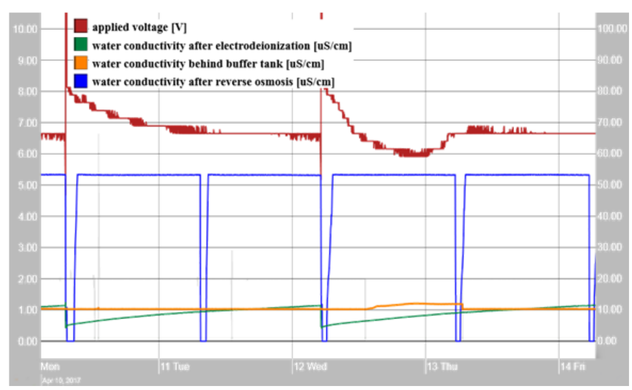

Figure 3: Water treatment – deionization.

During a normal operation of the cooling system where there is no need to supplement fresh DI, LCW in the amount of ca. 100 l/min. is continually filtered on the aforesaid Mix bed, in order to maintain the required resistivity, pH level and degassed. Owing to this solution, the costs of maintaining high quality of the water are insignificant.

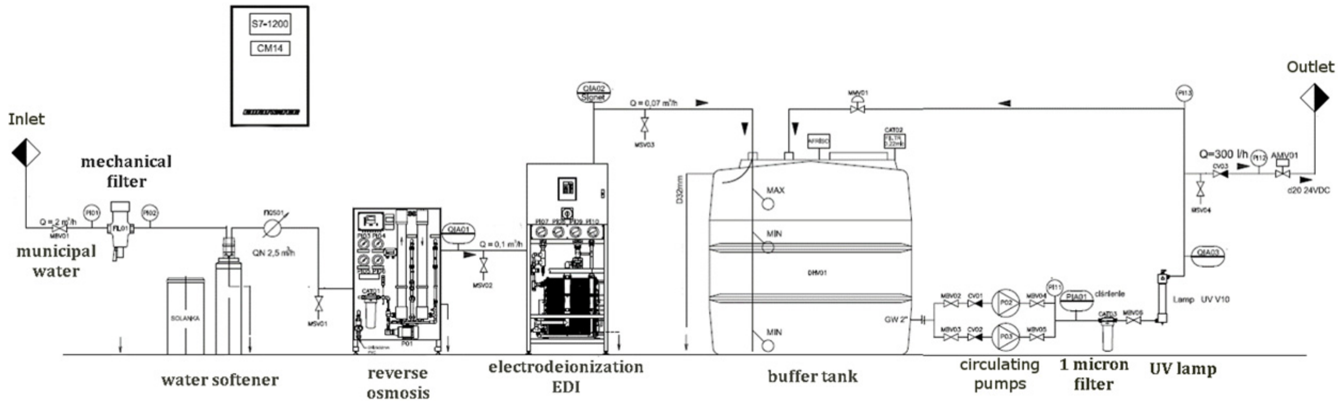

Figure 4: Water treatment plant.

SECONDARY LCW COOLING SYSTEM

In the Linac Tunnel and Storage Ring there are devices requiring the LCW temperature stabilization at the level not exceeding +40±0.025°C; these are accelerating straight sections and SLEDs in the Linac Tunnel and RF cavities in the Storage Ring. For precise LCW temperature control in these components the SHG devices are used (see Fig. 5).

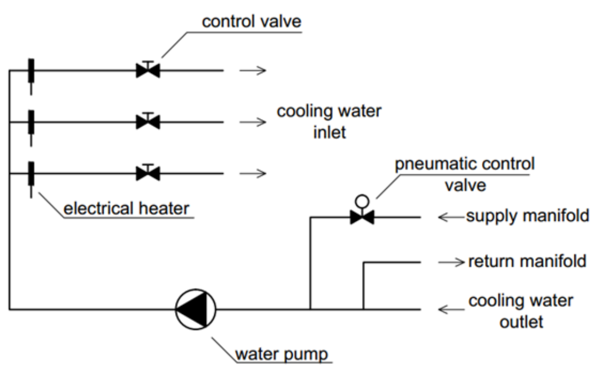

Figure 5: Secondary Heating Generator (SHG) from MaxIV Synchrotron.

The pneumatically controlled valve precisely doses a suitable amount of cooling water from the primary circuit in order to maintain the required parameters in the secondary circuit.

Themionic electron gun has its own independent cooling system based on a Freon chiller also using the LCW – the water in the amount of ca. 10 litres is exchanged every two weeks during the planned Monday shutdowns. The LCW temperature during the electron gun operation is equal to +39±0.01°C.

The cooling water serving the Storage Ring, through the plate-type heat exchanger, is used as a source of chilling in the Aluminium Chambers cooling system for the Insertion Devices. The value of the temperature of the water cooling these chambers is +27±1.5°C. Within the Aluminium Chambers cooling system, the municipal water is used.

OPERATION AND MAINTANANCE

The entire LCW system is managed automatically due to suitable control/monitoring system as shown in Fig. 6.

The operators, using the intuitive GUI, have access to all the equipment using the Ethernet or directly from the engineering panels.

All circulation pumps operate in a redundant mode and the switching (which does not have any effect on the operation of the synchrotron) takes place at weekly intervals.

To increase system reliability regular technical checks of the devices of the diagnosing system have been envisaged and are carried out during the normal operation of the system or during the scheduled shutdowns.

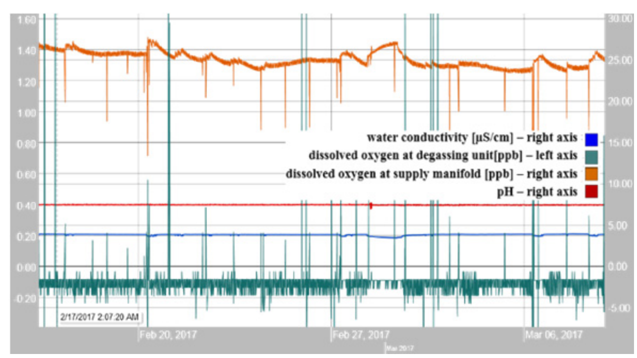

Figure 6: Quality of deionized water.

REFERENCES

[1] R. Dortwegt, "Low-conductivity water systems for accelerators", 2003, Proceedings of the 2003 Particle Accelerator Conference, ROPB008.