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OVERVIEW OF SESAME WATER COOLING SYSTEM DESIGN & OPERATION*

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Abstract

SESAME started operation in January 2017. In order to receive heat deposited in various synchrotron devices during operation, a low-conductivity water cooling system was installed. Within this paper the design, construction and operation of the water cooling system will be discussed, Both Hydraulic and Thermal Behaviour of the system will be analysed and discussed with numerical simulation means as well as real operation pressure and temperature data for the purpose of a better understanding of the cooling system.

INTRODUCTION

SESAME cooling system basically based on two Air-cooled chillers, with a total capacity of 2314Kw. The cooling water coming from chillers feeds thermally insulated buffer tank, the buffer tank provides the cooled water to the accelerator subsystems (injector, Booster, Storage Ring & Beamlines) through two plate heat exchangers with a total capacity on 1762Kw of thermal exchange.

The air temperature inside the experimental Hall, Booster & Storage Ring tunnels are conditioned through five AHU's, two of them are used for the Experimental Hall with a total capacity of 500Kw, one for the Booster Tunnel with a capacity of 500Kw, and two for the Ring Tunnel with a total capacity of 30kw.

The general scheme of SESAME cooling system is shown in Figures 1 and 2, and the accelerator thermal loads are shown in Table 1 below. for this phase of operation at SESAME the only existing beamlines are (XAFS/XRFS) and IR Beam line including the Front ends. a future plane is foreseen to increase the cooling capacity through the installation of a third chiller of 1157kw cooling capacity and increase the Heat exchange with a third heat exchanger of 880Kw exchange capacity to cope with the future needs at SESAME which includes the Air Conditioning of the Experimental and optical Hutches as required for the current operation the hydraulic system is working in manual mode. The group of pumps is fixed to a constant RPM, through VFD system, the users select manually the percentage of RPM that they need and do a final optimization by controlling the differential pressure sensor available between the inlet and outlet rings. This operational mode is stable if the system is a circuit closed without and modification to the local consumption. For the moment the system meets the criteria but in future operation the scenario will be different: the map of pressure and water flow velocities will be not constant for different reasons

Table 1: Thermal Loads for Subsystems

Component	Power (Kw)
SR	774.8
RF+Dipole PS	640
Booster+Injector	70
AHU'S	600

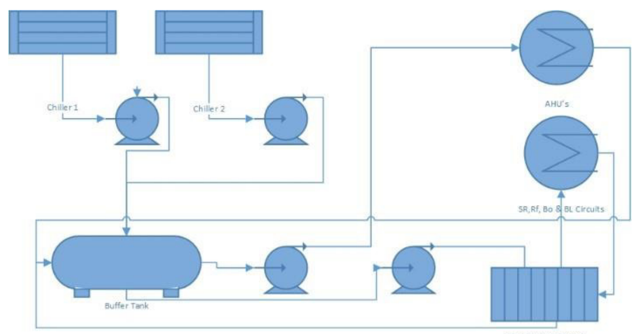

Figure 1: General scheme of the cooling system.

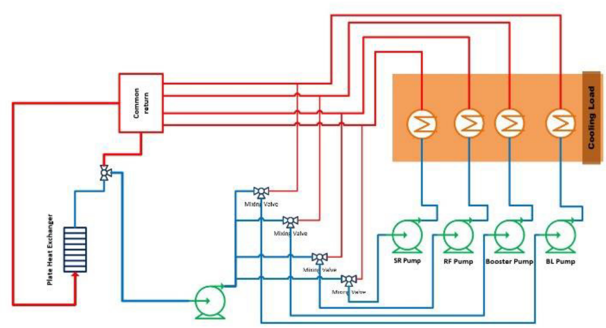

Figure 2: Scheme of the cooling circuits of the accelerator (SR,RF,Bo& Bl).

SR COOLING SYSTEM

For the Storage Ring the main supply cooling pipe line Starts with DN150 Pipe size which is divided by a Tee and reduced gradually from DN100, DN80, DN65 and Ends with DN50 Pipe size, the total Flow in the SR Circuit is 24L/s with a differential pressure of 8bars. The water flow inside the ring is 180° Circulated with Zero Velocity Point at the ends (Figure 3), at each girder the flow is branched with a supply and return cross equipped with a

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main ball valve. the crosses supplies the upstream & downstream Manifolds on the girders and directly supplies the dipole.

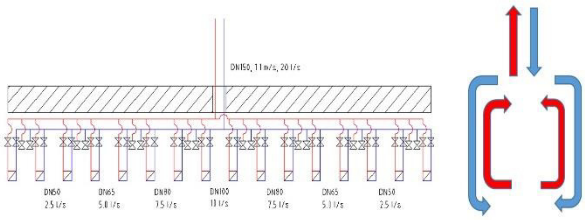

Figure 3: SR Cooling water circulation configuration.

SR Manifolds & Instrumentations

The storage ring consists of 16 girders each is equipped with two supply and two return manifolds which feeds and receive the cooling water of the short and Lunge quads, Focus and defocus sextuples as well as four crotch absorbers, three of the crouches are installed on the Arc chamber and the fourth one is on the straight section of the cell. the supply manifolds receive cooled water from the cross distributer located in the inner side of the ring. there is no pressure regulation installed on the manifolds return flow. instead a flow limiter is installed at each branch of supply manifold as shown in Table 2, this limiter restricts the flow rate to the quantity required by the multipoles and absorbers.

Table 2: Supply Manifold Flow Limiters

Flow Limiter	**Q (l/min)**	**Location**
REG-1212D	11.2	Absorber2
REG-1206D	5.3,5.6	QF&Absorber1
REG-1205D	4.6	Absorber3
REG-1203D	2.4,	SF&SD
REG-1202D	1.2	QD
REG-1201D	0.5	Absorber4

For the return manifolds flow switches are installed as means of protection to make an interlock incase the flow rate required by the magnets and absorbers get below the minimum required flow. In Table 3 the flow switches types & ranges for magnets & absorbers are shown., Figure 4. Also shows a 3D view of the Assembly.

Table 3: Return Manifold Flow Switches / Consumption

Flow Switch	**Q (l/min)**	**Location**
BVO-1235	29	Dipole
SWK2216	11.2	Abs. 2
SWK2290	5.6,4.6,5.3	Abs.1,3 & QF
SWK2240	2.4,2.4	SF&SD
SWK2218	1.2	QD
SWK2208	0.5	Abs.4

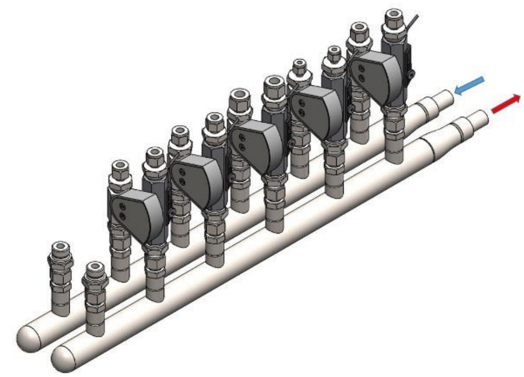

Figure 4: SR girders manifolds.

RF COOLING SYSTEM

The cooling of the RF system consists of three major cooling circuits, the first cooling circuit delivers cooled water for the cooling of the solid-state amplifiers, the second one feeds the cooling racks of the RF cavities, and the third circuit is used for the cooling of the secondary circuit of the RF cavity.

The main supply & Return line sizes are DN150, which delivers and collect cooling water through DN50 pipe size to four SS Amplifiers, four RF cooling Racks and the secondary circuit of the RF cavity as shown in Figure 5.

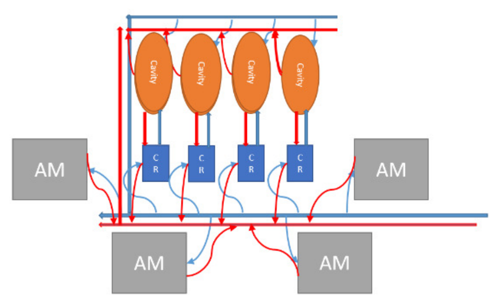

Figure 5: RF system Cooling Circuits Scheme.

The major cooling load is consumed by the Solid State amplifiers and the RF cavity cooling Racks. Table 4 contains the load distribution as well as the flow required by each component.

Table 4: Flow and Power Parameters

Component	**Q (l/min)**	**Power (Kw)**
Cavity Sec. Cir.	29.4	4
SS Amplifiers	200	90*4
Cooling Rack	75	66*4
Dipole P.S.	40	1.44

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COOLING SYSTEM OPERATION

The operation of the cooling system went smoothly with a minor difficult at the early stage operation due to the Air inside the cooling system, to overcome the problem the cooling team performed a manual venting process to ensure that the remaining air inside the cooling circuits is minimum and could be handled by the automatic vents installed on the main piping as well as the distribution manifolds.

The water cooling temperature entering the four cooling circuits (SR, RF,Bo & Bl) is 24±1 ºC, mixing valve is used to control the temperature entering the cooling circuits , the mixing valve opening is automatically actuated based on the set temperature vale feedback . In Table 5 the operation pressure and flow values are shown.

Table 5: Pressure and Flow Operation Parameters

Cooling circuit	Q (l/S)	Pressure (Bar)
SR Circuit	24	8
RF Circuit	22	6.5
Booster Circuit	5.5	6
Beam Lines Circuit	5.5	6

Concerning the thermal regulation currently the three way valves are regulated by using a temperature sensor located at the return, after the rings. the thermal regulation is inside the acceptable levels because the amount of power to be dissipated is far from the nominal value. As the power in the system is going to increase significantly then the regulation mode will be a source of thermal instabilities.

Operational Issues

The operation of machine, SESAME encountered some problems related to the cooling system, one of the important issues we have is the frequent interlock of some sextuples flow switches, SWK (Figure 6) which consists of a small movable orifice cap equipped with a permanent magnet and restrained by a spring, the spring mass system (orifice cap and magnet) responds the flow return and interacts with a coil fixed on the body of the flows witch which sends an interlock signal to the control system based on the location of the magnet.

SESAME exploring the different possibilities for the interlock problem as well as the different possible solutions. But in general since the operation of the machine the sextuple flow interlock problem recorded for 8 times and two times for the long quads.

Figure 6: KOBOLD flow limiter.

Another issue is the difficulty to keep the minimum straight hydraulic length to get a fully developed flow entering the flow switch and leaving the flow limiter in order to get a stable and reliable reading and signal of the flow switch and a stable and fully developed flow entering the magnets and the absorbers after passing the limiter. Figure 7 below is a CFD simulation showing the minimum straight length of tube required to get a stable flow leaving the limiter which is not possible to achieve with the current configuration of connections we have.

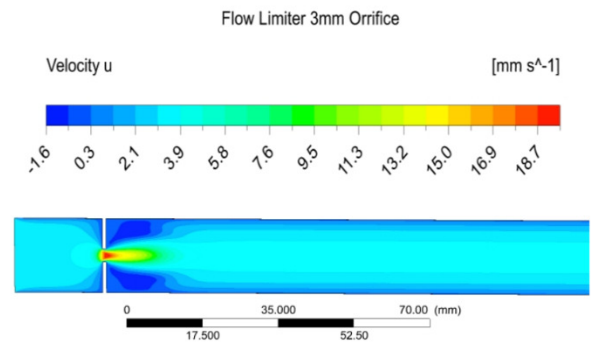

Figure 7: Flow limiter flow simulation.

CONCLUSION

For the future upgrades of the cooling system, replacement of the flexible tubes and rubber hoses for absorbers and magnets to manifolds is foreseen with a stainless steel tubes. for the hydraulic regulation an automatic control of frequency for each group of pumps. and a change of the temperature reference sensor position for the three-way valve regulation should be considered as recommended by system review report [1].

REFERENCES

[1] Marcos Quispe, "Notes on SESAME Cooling System", *OPEN SESAME Project Report No. 001*, 28/04/2017