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EUROPEAN XFEL COOLING AND VENTILATION SYSTEMS

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Abstract

The European Xray Free Electron Laser EuXFEL is operating since 2016. The technical systems for cooling and ventilation CV were designed, built and commissioned by the DESY work package WP34. The water cooling systems consists of 3 cooling systems: 30/45°C low conductivity water LCW for klystron, power converter and magnet cooling; 20/30°C LCW for tunnel rack cooling and 8/14°C for air conditioning and for air-drying. The ventilations of the tunnels are connected to a serial ventilation system. The air flow starts from the experimental hall in opposite direction of the beams until to the injector. The series ventilation system of the tunnels saves costs for air treatment like cooling, heating and air-drying. The tunnel walls are a good heat storage that increases the air temperature stability by a factor of ten. The advantages of this concept will be described.

INTRODUCTION

The European XFEL starts on the DESY premises and ends after 3.4 km at the experimental hall in Schenefeld. The beam direction is from east to west. Figure 1 shows the site map of the facility.

XHPSC pump house Schenfefeld

XHM pump house DESY Bahrenfeld

Figure 1: Map of the Eu-XFEL in Hamburg.

WATER COOLING SYSTEM OF XFEL

The water cooling system is divided in 2 sections since the tunnels are about 3.5 km long from the gun to the experimental hall XHEXP1.

- XHM Pump House:

The XHM pump house (Fig. 2) is located on the DESY premises and serves the injector in DESY-Bahrenfeld and the 2 km long XTL tunnel until the first separation shaft XS1 in Osdorfer Born. That is why the main cooling demands are in the linac tunnel XTL for the RF stations, the electronic racks and the normal conducting magnets.

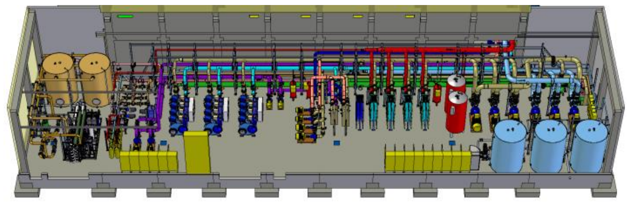

Figure 2: XHM pump house DESY Bahrenfeld, 3D model.

Figure 2 shows the 3D model of the pump house with its piping, pumps, chillers, water storage tanks and control cabinets. Figure 3 is a photo of the final installation.

Figure 3: XHM pump house installation.

Figure 4: XHM cooling towers for dry and wet cooling.

Figure 4 shows the hybrid cooling towers. Each tower has a rated power of 2 MW. The water temperature is controlled by variable speed fans. If the air temperature

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exceeds 25°C, the coolants air sprayed with deionized water to apply the evaporation cooling.

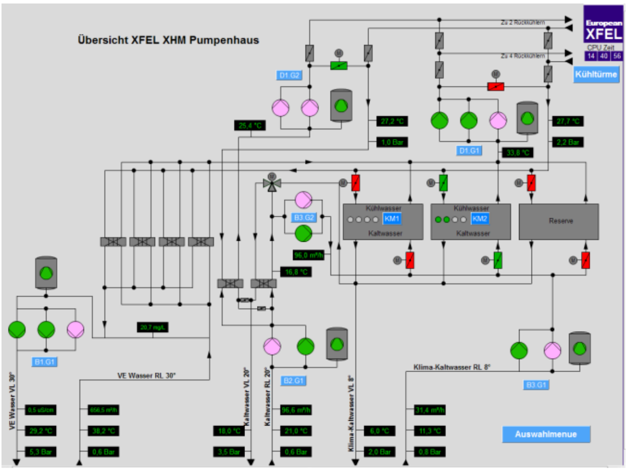

Figure 5: Display of XHM cooling system.

Figure 5 is a screen shot of the cooling system. The control system is EPICS, which supervises the temperatures and pressures of the cooling loops. It stores the data and generates alarms as well. The regulation of the temperatures and the protection of the machines are done by PLCs.

-XHPSC pump house on Schenefeld premises:

It supplies the distribution and photon tunnels, named as XTD1 to XTD10, the experimental hall XHEXP1 and their hutches, the laboratory and the office building XHQ as well.

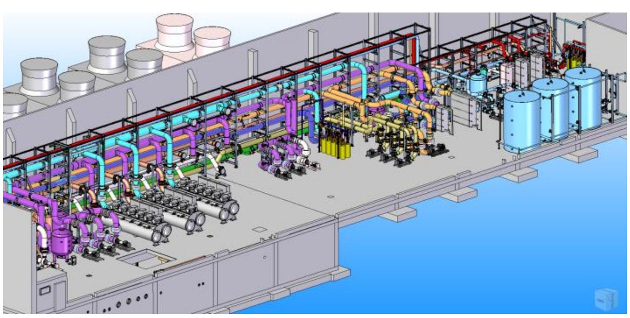

Figure 6: XHPSC pump house Schenefeld, 3D model.

Figure 6 shows the 3D model of the XHPSC pump house for the Schenefeld premises. It is similar to the XHM pump house on the DESY site. There are 3 chillers installed. Each chiller has a nominal power of 2 MW of cold water. For further buildings and laboratories there is a spare place for another chiller. There are 5 cooling tower behind the building with 2 MW each.

Figure 7 is a photo of the final pump house installation.

Figure 7: XHPSC pump house installation.

TUNNEL VENTILATION SYSTEM

The tunnel ventilation system was an important issue for the success of the SASE lasing of the undulator lines. There is only access to the tunnel through the shafts for the tunnel air. This is absolute different to the access of the existing undulator line installations.

In the undulator lines the tunnel air temperature should be constant over the time but may vary along the tunnel. The time variation should not exceed +/- 0.1°C. The dew point of the tunnel air should be above 14°C. This corresponds to 21°C and 65% humidity. This avoids corrosion of the equipment, special of the printed circuit boards. The water temperatures in the tunnels are all above 18°C. This avoids condensation on pipes and coolants as well.

Figure 8 shows the air flow in the tunnels. The air volumes of the tunnels were chosen for the linac tunnel XTL to 60,000m³/h, the XTD tunnels, equipped with undulators and dumps, to 30,000m³/h and the pure XTD photon tunnels to 20,000m³/h. In the first design each tunnel has its own ventilation system. That means one has to condition 270,000m³/h outside air. The most impact has the day and night temperature slope. She slope is typically 10°C. You can find a slope of 0.3°C in the tunnel supply air after cooling and heating the outside air.

The temperature stability is significant better if one uses the tunnel exhaust air instead of the outside air. But recirculation is not feasible because of the length of the return channel. The idea was to use the tunnel walls as a thermal storage. This is for free. The photon installations are less sensitive to temperature drifts. Therefore the treated air flows first over 360 m to 660 m through the photon tunnels XTD6,8,9 before the exhaust air is retreated and send to the XTD7,10 tunnels. See Fig. 8. The photon tunnels XTD6,8,9 have simple plate radiators with heat thermostats to replace the heat losses of the tunnel walls.

The shafts XS2,3,4 are bypassed by the tunnel air. The tunnel exhaust air is retreated before it flows into the next

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tunnel. Therefore the air temperature treatment is minimal. An air-drying is not required.

The undulator line requires tight temperature constancy. Therefore the undulator sections in XTD1,2,4 have their own high precision ventilation compartment. The high precision air conditioning for the undulator line uses the tunnel air as supply air.

The temperature monitoring is ongoing and will be evaluated in the next winter shut down.

The next benefit of the series ventilation is that the air stays long in the tunnel before the air is released to the outside. The dumps produce isotopes, mostly with short decay time. The dump caverns (Fig. 8) are part of a tunnel and the air should stay in the tunnel as long as possible. Therefore the tunnels are put in series from the dump to the entrance shaft XSE.

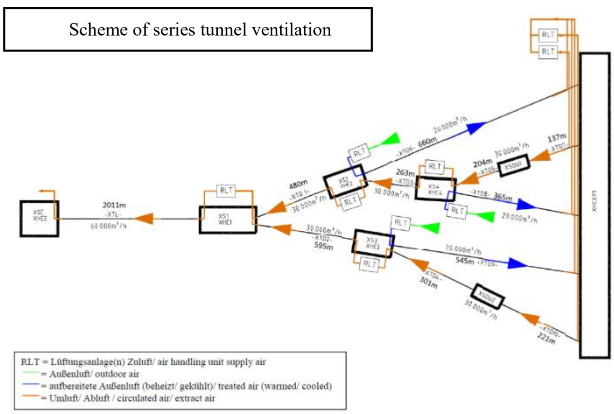

Figure 8: Scheme of the Series Tunnel Ventilation.

Figure 9: Tunnel Air Handling Unit.

Figure 9 shows an air handling unit AHU with air cooler (pipe with black insulation in the back) und air heater (pipe with white insulation in the front). Each tunnel has its own AHU.

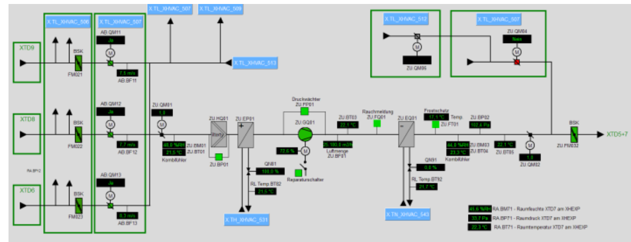

Figure 10: Control Display of tunnel air handling unit AHU.

Figure 10 shows the control display of a tunnel AHU. This figure shows for example that the exhaust airs of the 3 photon tunnels are collected and retreated by the AHU before the supply air flows into the next tunnel with a dump.

SUMMARY

The water cooling systems run since beginning reliable. The temperature levels are 8/14°C for the air conditioning, the 20/30°C for electronic rack cooling and 30/45°C for the high power cooling. The cooling towers are hybrid types. They run most of the year dry without water evaporation. On hot days the coolants are sprayed to apply the evaporation cooling. The temperature regulation is done by variable speed fans.

The ventilation of the tunnels was a challenge because of the requirements from the accelerator installations and the undulator lines in the tunnels. The temperature constancy over long distances depends on the air volume flow and the load balances along the tunnels. The access is only through the tunnel ends possible. In the first design every tunnel has its own ventilation system. This was changed to series tunnel ventilation against the electron beam direction.

The benefits for series ventilation are

- Increased temperature stability below 0.1 °C by using tunnel air as supply air.
- Lower operation costs for air treatment, because only 60,000m³/h outside air instead of 270,000m³/h is heated, cooled and dried.
- Isotopes from the beam dumps stay longer in the tunnels before they are released to the outside.