

UTILITY SYSTEM DESIGN AND CONSTRUCTION STATUS OF THE 3GeV TPS STORAGE RING

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Abstract

The design of the utility system for the 3.0 GeV Taiwan Photon Source (TPS) has been completed. The construction engineering of the TPS utility system has been contracted out in the end of 2009. This paper presents the design and construction status of the TPS utility system, including the electrical power, grounding, cooling water and air conditioning systems. The TPS construction site is located adjacent to TLS. And parts of areas of TPS and TLS are overlapped. The whole utility system construction will be completed in the end of 2012. Therefore, the construction engineering of the TPS utility system is a challenge to finish on a tight schedule and keep the TLS in operation during the construction. Some management schemes of the construction engineering are also presented in this paper.

INTRODUCTION

Taiwan Light Source (TLS), the first third-generation synchrotron radiation facility in Asia, has been operated for more than 17 years since the first beam stored in the storage ring. Although the reliability and stability of the TLS have been upgraded for years, TLS has gradually lost its advantage of competition due to its limitation of straight sections and available space for new IDs. In order to meet increasing demand for more state-of-the-art researches, the TPS project was proposed and designed to achieve targets of low emittance, high brightness, stability and reliability. Each subsystem of the TPS will apply the most advanced and reliable techniques to achieve this goal.

Utility system is one of the most critical subsystem affecting the beam quality and reliability. We had made many efforts on studying utility effects on beam quality and upgrading utility system since 1998. This study is aimed to present designs of three main utility subsystems, i.e., electrical power and grounding system, the cooling water system and the A/C system. The design and operational experiences of utility systems at TLS are valuable to the design and construction of utility system design of the TPS.

LAYOUT OF THE UTILITY SYSTEM

TPS is designed to be constructed on the same campus of TLS for the purpose of efficient operation of both TPS and TLS in the future. The TPS is optimized located adjacent to TLS and the existing Administration Building is located on the core area of the TPS ring. About two

third of TPS ring is designed underground. It is a challenge to construct TPS with keeping TLS and Administration Building in normal operation. Before excavation of earth of TPS ring, a temporary utility piping and cabling construction engineering for the Administration Building is needed. We have completed this engineering on the first season of 2010.

A new utility building for the TPS, Utility Building III, will be constructed next to the existing utility building, Utility Building II, where main equipment of the cryogenics system was installed. There is one utility trench connecting the TPS ring and the Utility Building III for the piping system and electrical power transmission. The schematic drawing of TPS, TLS and three Utility Buildings is shown in Figure 1.

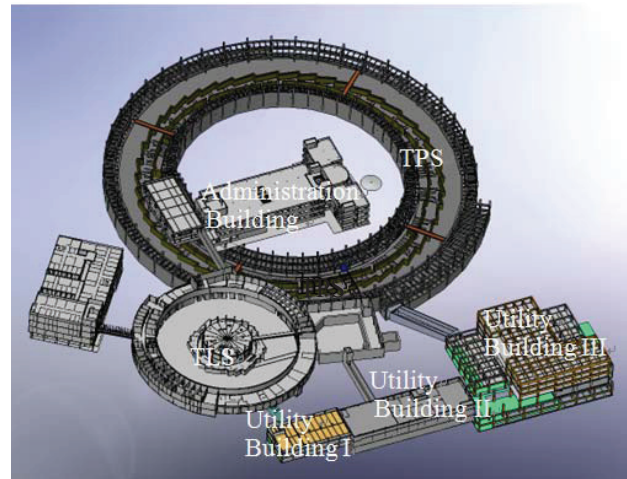


Figure 1: TPS, TLS and three Utility Buildings.

Figure 2 shows layout of the storage ring tunnel and technical trenches of the TPS. As shown in Figure 2, the TPS storage ring building may be basically divided into seven areas from core area to outer area, i.e., A: Utility area, B: Inner corridor, C: Control Instrumentation Area (CIA), D: Storage ring tunnel, E: Experimental hall, F: Outer corridor, and G: Outer area. Equipment and piping system of each area are briefed as follow.

A: Utility area: The width of this area is 4.4 m. There are 8 power substations located in this area to distribute electrical power to the CIA and equipment in the storage ring tunnel. There are also 12 AHUs for 24 CIAs and 12 AHUs for the storage ring tunnel installed in this area.

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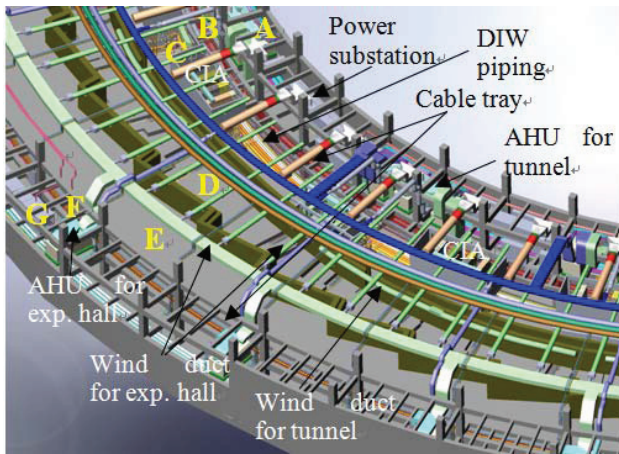


Figure 2: Layout of the storage ring tunnel and technical trenches of the TPS.

B: Inner corridor: The width of the corridor is 2.2 m. DIW piping systems for the storage ring tunnel and CIA around the corridor are buried underground. Cable trays for the storage ring tunnel and CIA are installed overhead around the corridor.

C: CIA: There are total 24 CIAs distributed in this area. This area is designed adjacent to the storage ring tunnel. Panels of subsystems of the accelerator are installed in each CIA room to support operation in the storage ring tunnel.

D: Storage ring tunnel: DIW piping and cable trays from CIA pass underground through the storage ring tunnel to girders. The supply wind ducts are installed on the inner wall of the tunnel above booster magnets. There is no return air duct installed in the tunnel and return air flows out through void of this area. Four-layer cable trays are installed next to girders for power cables and signal wires.

E: Experimental hall: For future beam line use, 48 utility subsystems, which include electrical power panel, pipings of DIW, chilled water, heating water and compressed air will be symmetrically distributed around outer wall of the experimental hall. Supplied wind ducts are radially distributed above the ceiling of the experimental hall.

F: Outer corridor: The width of this corridor is 2.2 m. There is also constructed a corridor of 2.2 m on height of 4.8 m above the floor. There are installed one-layer cable tray and chilled and heating water and cryogenics piping systems on this area for both Experimental hall and Outer area use.

G: Outer area: It is a 2-floor area and the width is 4.9 m. The first floor is extended area of Experimental hall, where beam lines and hunched installed. Eighteen AHUs are installed on the second floor to serve for areas D, E, 1st floor of area F and upper area of area D. The supplied wind ducts are uniformed distributed above the ceiling on areas D, E, and F. Returned wind ducts are installed on the 1st floor of area G.

ELECTRICAL POWER AND GROUNDING SYSTEMS

The electrical power capacity is evaluated according to power demand of each subsystem. The most two power consumption accelerator subsystems are magnet power supply and radio frequency, and the power demands of these two subsystems are 3,540 kW and 1,696 kW, respectively.

The power demand of the main utility equipment installed in the Utility Building III is estimated about 4.0 MW. The total power capacity of the TPS is estimated about 12.5 MW. The power loads of each subsystem are listed in Table 1.

Table 1: Total power demand for the TPS storage ring.

	power demand (kW)
Magnet Power Supply	3,540
RF	1,696
Cryogenics	743
Vacuum	640
Beam lines	600
Instrument Control	492
Injection	329
Insertion Device	213
Front End	163
Radiation Safety	86
Mechanical Positioning	30
Utility	4,000

The grounding resistance of the TPS is simulated about 0.2Ω. We had successful experience of constructing the grounding system of 0.2Ω at TLS. [1] In the case of TPS, there are total 64 electrodes, including 52 copper rods and 12 chemical electrodes of 30 m in depth distributed under the TPS storage ring building. Forty two electrodes of copper rods of 3 m in depth are buried under the Utility Building III. Electrodes are connected by bare copper wire. Figure 3 shows grounding electrodes distribution.

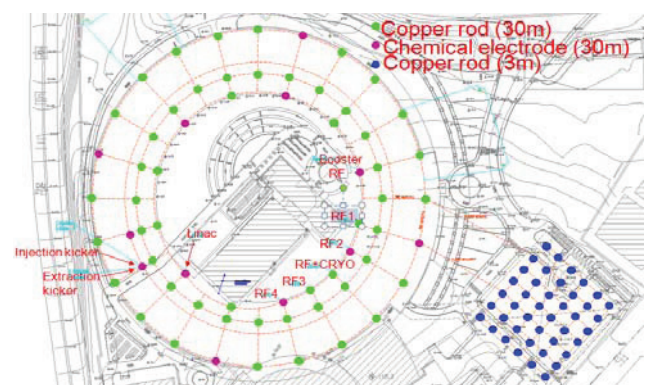


Figure 3: Grounding electrodes distribution of TPS storage ring building and Utility Building III

COOLING WATER AND AIR CONDITIONING SYSTEMS

Like the case of TLS, the cooling water system of TPS includes de-ionized water (DIW), chilled water, cooling-tower water and hot water. All cooling water subsystems are operated in close loops. The DIW system includes four subsystems, i.e., Cu DIW for magnets and power devices, Al DIW for vacuum chambers, RF DIW for RF system, Booster and BL DIW for booster devices and beam line optical instruments. Both cooling tower water and chilled water systems supply for DIW and AHU. The specifications of abovementioned cooling water subsystems are listed in Table 2.

Table 2: Specifications of cooling water of the TPS

	Temperature	Pressure	Capacity
Cu DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	1659 GPM
AL DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	380 GPM
RF DIW	25 ± 0.1 °C	7.5 ± 0.1 kg	1284 GPM
Booster+ BL	25 ± 0.1 °C	7.5 ± 0.1 kg	1238 GPM
Tower (DIW)	32 ± 0.5 °C	2.5 ± 0.2 kg	6000 RT
Tower (AHU)	32 ± 0.5 °C	2.5 ± 0.2 kg	6000 RT
Chilled (DIW)	7 ± 0.2 °C	2.5 ± 0.2 kg	3466 RT
Chilled (AHU)	7 ± 0.2 °C	2.5 ± 0.2 kg	3677 RT
Hot Water	50 ± 0.3 °C	2.5 ± 0.2 kg	1800 kW

Water treatment is another important issue in the cooling water system. The recycle system, RO system and deoxygenating system are main schemes to control DIW quality. The resistivity of DIW will be kept higher than 10MΩ. The dissolve oxygen will be controlled less than 10 ppb and the pH value will be controlled within 7±0.2.

We had applied CFD scheme to simulate the temperature distribution and air flow of the storage ring tunnel and experimental hall. [2] The layout of these areas has been modified as shown in Figure 2. We are constructing a numerical model of the final design of these areas to simulate the effects of the air conditioning system.

POWER SAVING SCHEME

Presently, the contract power capacity of TLS between the NSRRC and the Taiwan Power Company is 5.5MW. The total power capacity of the TPS is estimated about 12.5 MW, as abovementioned. For environmental and economical consideration, power saving is a main issue of the future operation. We have successful power saving experience in TLS. [3] We will apply those power saving schemes, including optimization of operations of chillers, pumps, AHUs and variable frequency devices on TPS. We will also install two heat pumps on TPS. The coefficient of performance (COP) of the heat pump is about 350%, which is about 4 times that of a traditional electrical heater. The heat pump installed for TPS is the type of water to water.

MILESTONES OF TPS UTILITY SYSTEM CONSTRUCTION

The construction of the TPS utility system will be completed in the end of 2012. Some major milestones of the TPS utility construction have been set. The grounding system of TPS will be completed in August 2010. The construction of the main power substation and installation of high voltage equipment in Utility Building III will be finished in March 2011. The electrical power system for the TPS ring will be tested and ready for operation in May 2012. The whole utility system construction will be completed in July 2012, and the acceptance test will be finished in Oct. 2012.

For efficiently control the construction progress, we apply management software to check the schedule and 3D drawing software to check detail layout of construction.

CONCLUSION

We had completed the design of the TPS utility system. The TPS storage ring building may be divided into seven areas from core area to outer area, i.e., Utility area, Inner corridor, Control Instrumentation Area (CIA), Storage ring tunnel, Experimental hall, Outer corridor, and Outer area. All the utility equipment, piping system and cable trays are well designed. The construction engineering of the utility system of TPS has been started. A temporary utility piping and cabling construction engineering for the existing Administration Building and TLS has been completed this year.

The electrical power demand and the cooling capacity of the DIW and A/C systems have been estimated. Some utility techniques and experiences of the TLS, such as the power load and grounding classification, CFD simulation and power saving schemes are applied in the design and construction of the utility system of the TPS.

ACKNOWLEDGEMENT

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