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LABORATORY EXHAUST GAS TREATMENT SYSTEMS AT TPS

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Abstract

There are three main laboratory exhaust gas treatment systems equipped at Taiwan Photon Source (TPS): 1. Acid/Alkaline system for corrosive acids and alkalis, volatile solvents and other hazardous chemicals; 2. Organic system for biological experiments and 3.General system for other gas. Gas is collected in hoods installed near the sources of contamination in laboratories. The contaminated gas then is transported through duct to the gas treatment equipment installed outside of the TPS experimental hall.

INTRODUCTION

There are two synchrotron accelerators i.e., Taiwan Light Source (TLS) and Taiwan Photon Source (TPS) in NSRRC, Taiwan. Based on the operation experience of TLS utility system and utility system design of other international advanced accelerators, the utility system of TPS had been designed and constructed [1].

Both TLS and TPS accelerators are equipped with laboratory exhaust gas treatment systems. There is only one General laboratory exhaust gas treatment system installed in the TLS, the first third-generation synchrotron light source facility built in Asia more than three decades ago. The laboratory exhaust gas treatment system of TLS is equipped with active carbon filter.

To meet increasing demand for more state-of-the-art academic researches, the TPS, one of the world's current brightest synchrotrons, had been completed and the first synchrotron light was delivered on the last day of 2014. Four of seven beamlines of phase-I were opened to users in September 2016, and nine phase-II beamlines are in planning or under construction at this time.

In recent years, due to the rise of environmental awareness and the people's increasing requirements for quality of life, the environmental protection law of air pollution has been gradually transferred from early air pollutants such as particulate pollutants, SOX and NOX to volatile organic compounds, VOCs. Accordingly, only one laboratory exhaust gas treatment system could not satisfy users' requirements in TPS. The laboratory exhaust gas treatment systems in TPS include Acid/Alkaline, Organic and General system.

This paper is aimed to introduce the laboratory exhaust gas treatment systems in TPS.

DESIGN AND CONSTRUCTION

According to the construction schedule of beamlines and laboratories, all the construction of laboratory exhaust gas treatment systems of the TPS have been completed. The General system was accomplished in 2016; the Acid/Alkaline and Organic systems were completed in 2018.

The main ducts of three laboratory exhaust gas treatment systems had been installed in the TPS ring building along the outer area ring.

Apparatus

All three laboratory exhaust gas treatment systems are equipped with two fans for redundancy. All six fans are installed on the roof of the TPS ring building. To keep from gas exhausted from fans re-entering the building and impacting the maintenance staff or pedestrians, taller stacks, higher volume flows and/or optimum were installed on the roof [2].

Four fans of the Acid/Alkaline and Organic systems were selected Green-heck company model: Vektor-MD-22-9-70-LV-HPW. This kind of fan for high plume dilution is designed to entrain ambient air to assist in the dilution of contaminated laboratory exhaust. The capacity of a single fan is 4,719 L/s. The effective plume high is 9.85m, which is calculated based on ASHRAE 2015 Applications Handbook [3]. Other specifications of the fan are listed in Table 1.

Table 1: Specifications of Fans of Acid/Alkaline and Organic Systems

SP (Pa)	RPM	Discharge	Dilution	Power
2287.4	2557	15.2 m/s	170%	17.03kW

Figure 1 shows four fans of the Acid/Alkaline and Organic systems. The high velocity nozzle installed on top of each fan, as shown in the figure, is the key component to entrain ambient air to dilute laboratory exhaust.

Figure 1: Four fans of the Acid/Alkaline and Organic systems.

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The Organic laboratory exhaust gas treatment system is also equipped with an active carbon filter system. There are two phases of filters in the system. The average efficiency of the first one is at least 30%. The second one is mainly for filtering VOCs, SOX, NOX, H2S, HCL and CL2.

Scrubber

In addition to high plume dilution fans, the Acid/Alkaline laboratory exhaust gas treatment system is equipped with a horizontal scrubber.

Figure 2: Picture of the scrubber.

Figure 2 shows the picture of the scrubber. The scrubber comprises a mist eliminator layer, spiral nozzles for liquid distributor, a packed bed layer, contaminated gas inlet, water reservoir, a dosing and control system and two recirculation pumps. The capacity of the customized scrubber is 4,719 L/s. In the mist eliminator layer, the specific surface area and mist elimination efficiency is at least 600 m2/m3 and 99%, respectively. Other specifications of the scrubber are listed in Table 2.

Table 2: Specifications of the Scrubber

Pressure Loss	Gas velocity	Pump power
<500 Pa	< 2.5 m/s	10 HP

Ducting System

The air ducts of the Acid/Alkaline, Organic and General systems are made of, polypropylene (PP), stainless 304 and galvanized steel, respectively.

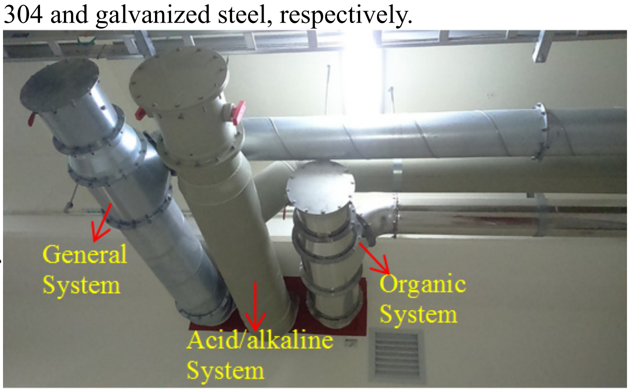

Figure 3: Typical ducts layout of three laboratory exhaust gas treatment systems in a laboratory in the TPS.

Figure 3 shows the typical ducts layout of three laboratory exhaust gas treatment systems in a laboratory in the TPS. They are ducts of General, Acid/Alkaline and Organic systems respectively from left to right in the figure. Duct exits are reserved by blind flanges. The ducts of three systems are 300 mm in diameter. The main ducts of Acid/Alkaline and Organic systems connected to the fans are 800 mm in diameter.

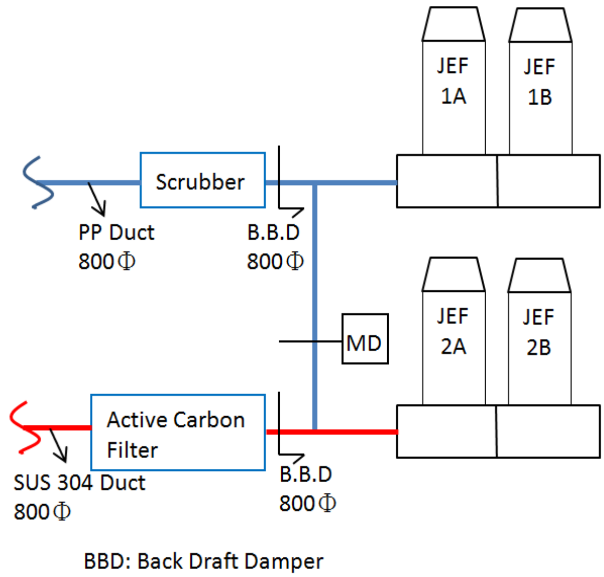

Figure 4: Gas ducts of Acid/Alkaline and Organic systems.

Figure 4 shows gas ducts of Acid/Alkaline and Organic systems. For redundancy consideration, not only both Acid/Alkaline and Organic systems are equipped with two fans, but two systems are connected to serve as backup system for each other, as shown in Fig. 4. A magnetic damper is installed on the gas duct connected between Acid/Alkaline and Organic systems.

CONTROL SYSTEM

The control system of each laboratory exhaust gas treatment system mainly includes a DDC controller (with BAC net /IP Ethernet, 32-bit CPU) and an inverter control panel. Those apparatuses are installed in a local machine room near the main equipment.

Local Control

The laboratory exhaust gas treatment systems of TPS may be locally and remotely controlled. Figure 5 shows the main page of local graphic control of Acid/Alkaline and Organic systems. In Fig. 5, it illustrates flowrate (L/S), frequency and operation status of each fan, total flowrate (L/S), by-pass flowrate (L/S), by-pass opening (%), flowrate and pressure (Pa) in the duct of Acid/Alkaline and Organic systems. The frequency of each fan and the by-pass opening may be locally controlled to adjust the flowrate and the static pressure.

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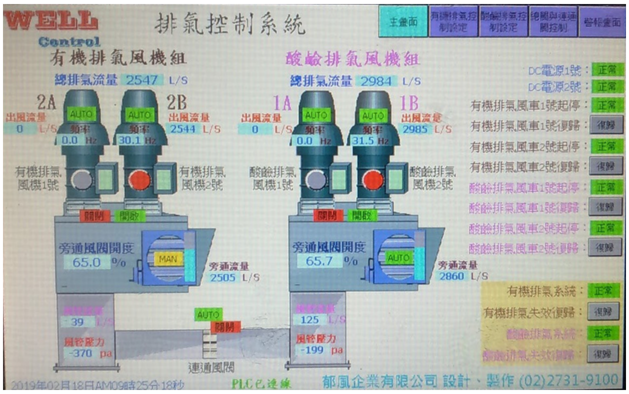

Figure 5: Main page of local graphic control of Acid/Alkaline and Organic systems.

Remote Control and Monitoring

We had also developed a utility archive system to on line monitor and control thousands of utility parameters. The utility archive system is integrated software written by the Lab-View. This archive system consists of a remote viewer level, a data service level, a data processing level, a control level and a device level, as shown in Fig. 6.

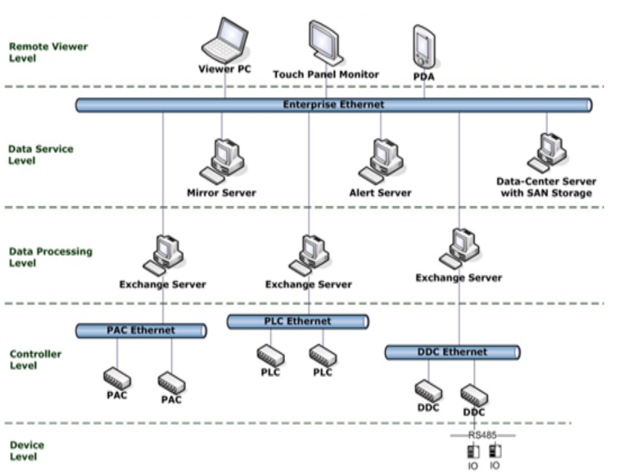

Figure 6: Network of the utility archive system.

The monitoring and control system has adopted the architecture of NI compact-RIO, which meets the requirement for the high precision and fast data acquisition. The remote viewer level is opened for all in house and outside users. The software of the archive viewer in the remote viewer level is used to monitor the whole archive system.

There are total 22, 89 and 100 status or parameters of General, Acid/Alkaline and Organic systems, respectively may be monitored in the archive system. Figure 7 shows seven parameters histories of three laboratory exhaust gas treatment systems as examples. They are respectively from top to bottom the pH value, flowrate of fans 1 and 2 of the Acid/Alkaline system, frequency of fan 2, bypass opening and flowrate of fan 2 of the Organic system and the total flowrate of the General system.

The acceptance tests of three laboratory exhaust gas treatment systems were also completed through the archive system. In Fig. 7, we can observe that the pH value of the Acid/Alkaline system was controlled within 7.6-7.8. The histories of flowrate of fans 1 and 2 of the Acid/Alkaline system show the redundancy and switch of these two fans so that the flowrate of the Acid/Alkaline system may be kept at 3,000 L/s. The frequency of fan 2 and the bypass opening of the Organic system were respectively controlled within 28.1-28.2 and 58.5-59.5% in one week in Fig. 7. This is also the normal control precision.

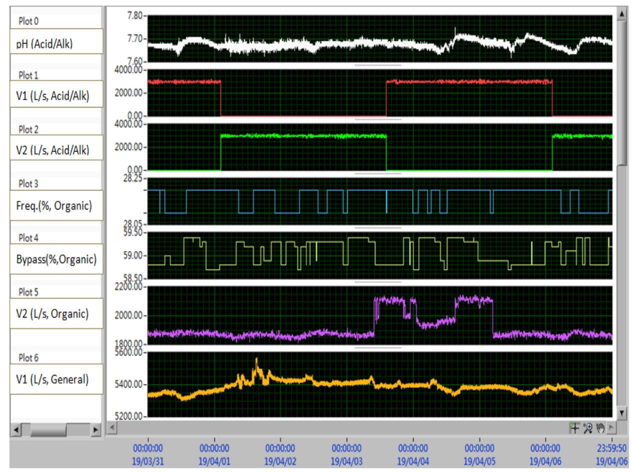

Figure 7: Some parameters histories of three laboratory exhaust gas treatment systems.

In addition to the frequency of fans and bypass opening, the main factor affecting the flowrate is load from users. The flowrates of the Organic and General systems show variation from users' loading.

CONCLUSION

Three laboratory exhaust gas treatment systems at TPS, i.e., Acid/Alkaline, Organic and General systems had been constructed. Four high plume dilution fans were selected for the Acid/Alkaline and Organic systems. Local and remote control systems were also implemented.

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REFERENCES

[1] J.-C. Chang, J.-R. Chen, Y.-C. Lin, Z.-D. Tsai and T.-S. Ueng, "Utility System Design and Construction Status of the 3GeV TPS Storage Ring", in *Proc. 1st Int. Particle Accelerator Conf. (IPAC'10)*, Kyoto Japan, May 2010, paper THPEB074, pp. 4038-4040.

[2] Ronald L. Petersen, Bard C. Cochran, John J. Carter, "Specifying Exhaust and Intake Systems", ASHRAE Journal, pp.30-37, 2002.

[3] ASHRAE 2015 Applications Handbook (Chapter 45).