§8. Design and Construction of the Exhaust Detritiation System for Large Fusion Test Device

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With the progression of nuclear fusion program, the deuterium plasma experiments will be conducted to realize high temperature plasma physics. Under the deuterium plasma operation, tritium and neutron will be produced by D-D reaction. Although the production rate of tritium in a large fusion test device would be extremely low, tritium itself is radioactive material. Thus, the careful tritium handling is required to reduce tritium release into the environment from the viewpoint of public acceptance, lows and regulations. As one of the detritiation techniques for vacuum exhaust gas from fusion test device, the combination of catalytic oxidation reactors and water vapor absorber is the candidate methods. This system has been utilized as air detritiation system (ADS) in tritium handling facilities all over the world and fully established technique. The features of vacuum exhaust gas from fusion test device are high hydrogen isotopes concentrations, oxygen free, low flow rate and temporary large flow rate from the cryosorption pumps more than 10 Nm^3/h. Therefore, the exhaust detritiation system (EDS) for the fusion test device has to be designed with the large buffer tanks to receive temporary large flow rate. Also the air has to be introduced to dilute of hydrogen concentration less than 1 vol% for safety combustion and to add the oxygen for hydrogen combustion. On the other hands, the large gas flow rate more than 50 Nm^3/h is exhausted from the vacuum vessel and the related facility when the fusion device is maintained after the plasma experimental period. To process the large gas flow by the conventional system, a large amount of molecular sieves will be necessary. The large equipment system is detrimental due to limitations of space. Also, the initial and running costs of molecular sieves will be the enormous sum. Then, we have proposed the application of the advanced technique of polymer permeable membrane instead of the molecular sieves. It has the advantages of continuous separation process, little place to install, low cost and maintenance free, etc.

The required specifications of EDS are shown in Table 1. As was stated previously, the EDS consists of two systems; one is the vacuum gas detritiation system and other is the purge gas detrtitiation system. The maximum process gas flow rate is 20 Nm^3/h and 300 Nm^3/h, respectively. The detritiation factor is more than 20. The vacuum gas detritiation system will be only operated during the plasma experiments. However, the purge gas detritiation system has to operate through the year, because the related facilities will be operated all the year round. Figure 1 shows the 3-D layout drawing according to the process flow diagram [PFD] and the piping and instrumentation drawing [P&ID]. The largest buffer tanks for the vacuum gas detritiation system are designed at the west side of the area because the height at the east side is limited by the air-conditioning equipment and the cable tray for electrical wiring system. Thus, the west side around the buffer tanks is explosion protection area.

All the system components of EDS have been installed at the end of March 2015 as shown in Fig. 2. The EDS will be completed until the end of August 2015. Then the commissioning of EDS will be done until the end of January 2016.

Table 1. The specifications of EDS

Systems	Exhaust Detritiation System [EDS]	
	Vacuum gas detritiation system	Purge gas detrtiation system
Target process gas	Vacuum exhaust gas from all vacuum components	Purge gas from the vacuum vessel and related facilities
Max. process flow rate [Nm^3/h]	20	300
Operating time [h/year]	~3600 [24 h x 150 days]	~8000 [24 h x 330 days]
Detritiation factor	> 20	
Gas composition in process flow	Q_2, Q_2O, CQ_4, He, Ar, N_2, etc (Q=H, D, T)	Room air

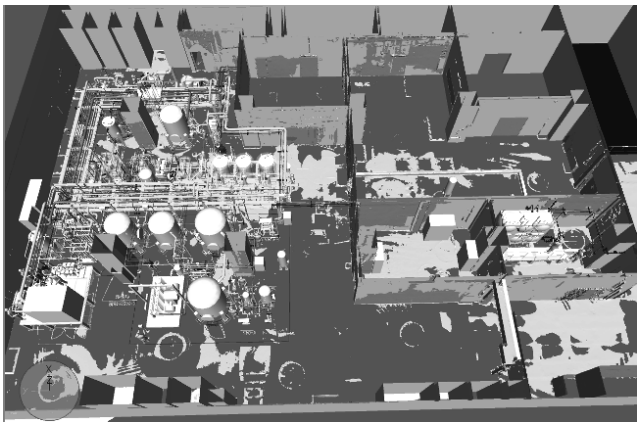

Fig. 1. The 3-D layout drawing and a bird's-eye view of the EDS; [left side] detritiation systems, [right side] the system control room and tritiated water storage tank.

Fig. 2. Photos of the polymer permeable membrane module set for the purge gas detrtiation system (left) and the molecular sieves beds for the vacuum gas detritiation system (right).