

§9. Design Consideration of the Gaseous Tritium Sampling System in the Exhaust Detritiation System

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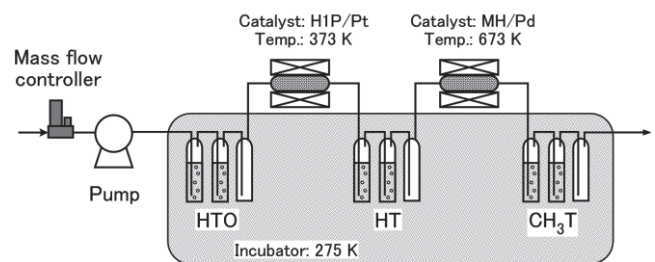
The tritium monitoring in the exhaust gas from a large fusion test device is important to understand the tritium behavior under the deuterium plasma experiments. The tritium concentration in the exhaust gas will be low because the production rate of tritium in the deuterium plasma by a large fusion test device is estimated to be low. Also, the gas species and the chemical components of hydrogen isotopes will vary by the operational conditions of fusion test device and auxiliary system. The typical tritium gas monitor systems are an ionization chamber and a proportional chamber. The ionization chamber is well used for the tritium monitoring in the tritium handling facility. However, it needs the W value which is defined as the average energy loss by the incident particle per ion pair formed. The W value depends on the gas species and chemical components. Thus, it is difficult to apply the ionization chamber with the tritium monitoring in the exhaust gas, when the gas components in the exhaust gas are varied by the operational condition of fusion device. The proportional counter is applied to the stack monitor and in-line monitor, etc. It has lower tritium detection limit than the ionization chamber. However, it is needed the proportional gas, i.e. P-10 gas, routinely. The running cost of the proportional gas will be expensive for a long operation. As is the case with the ionization chamber, the change of gas components makes an impact on the operational condition of the proportional counter. Therefore, the conventional tritium monitor systems are not a suitable for the tritium monitoring in the exhaust gas.

From the view points of the radiation protection and PWI study, the discriminating tritium monitoring of HTO, HT and CH₃T should be also required. In this case, the measurement interval can be longer. So, we propose the accumulated tritium sampling using the water bubbler system combined with two catalysts for the discriminating the chemical forms. The two types of system are shown in Fig. 1. Figure 1 (a) is the discrimination type sampler. It consists of a mass flow controller, a metal bellows pump, water bubbler systems, oxidation catalyst systems and an incubator. The incubator keeps the low temperature around the bubbler system to lessen evaporation of water. The bubbler system consists of the three series-connected bubblers. When the sample gas is introduced in the tritium sampling system, the tritiated water vapor [HTO] can be trapped and removed by first water bubbler system. Then the second stage, the tritiated hydrogen [HT] is oxidized by the hydrophobic platinum catalyst, "H1P," at the 373 K and become tritiated water vapor. Thus, the tritiated hydrogen is trapped by the second bubbler system. The hydrophobic catalyst is effective in hydrogen oxidation process under the wet condition. At last stage, the tritiated hydrocarbon [CH₃T] is oxidized by the metal honeycomb type palladium catalyst at 673 K. The tritiated water vapor from CH₃T is trapped by the third water bubbler system. Figure 1 (b) is

the total tritium sampling system without the discrimination of chemical forms. This system is simplified the system shown in Fig. 1(a). All the tritium chemical forms are oxidized by the metal honeycomb type palladium catalyst at 673 K. Then, the tritiated water vapor is trapped by the water bubbler system. The sampling period of both systems will be one week and the flow rate will be 100 cm³/min. As the result, the accumulated sample gas volume is estimated to be ca. 1 m³. The recovered tritiated water samples in the bubbler will be measured for 60 minutes by a low background liquid scintillation counter. Under this sampling condition, the estimated tritium detection limit is ca. 10⁻⁷ Bq/cm³. This detection limit is sufficient to monitor the tritium concentration in the exhaust gas.

The construction of gaseous tritium sampling systems has been done as shown in Fig. 2. This system contains two types of sampling system as shown in Fig. 1. The gaseous tritium sampling system will be installed and connected to the inlet and outlet of exhaust detritiation system to monitor the tritium concentration. The inlet line will be connected the discrimination type sampler. The outlet line will be installed the total tritium sampler. The monitoring will be started after the deuterium plasma experiment.

(a) Tritium sampler system with discrimination of chemical forms



(b) Total tritium sampler system

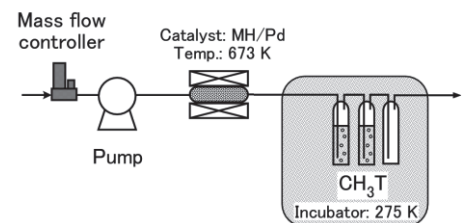


Fig. 1. Schematic diagrams of gaseous tritium sampling system ; (a) tritium sampler with the discrimination of chemical forms, (b) total tritium sampler system without the discrimination of chemical forms.



Fig. 2. Photos of tritium sampling system ; the appearance of tritium sampling system (left) and the water bubbler system in the incubator (right).