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Development of Tritium Recovery System using Catalytic Recombiners and Adsorbers

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1. Introduction

AGENCORE is developing and installing various tritium handling facilities to produce the gaseous tritium light sources (GTLS). The tritium handling facilities, including the cutting and sealing device of the GTLS, the tritium adsorption/desorption equipment, and the tritium filling rig, should be installed in a high-integrity glove box in preparation for tritium leakage. If tritium leaks during the operation of the tritium handling facilities, a system to recover tritium from the glove box is required to minimize the release of tritium into the environment. Typical tritium recovery systems include a metal getter or a hydrogen recombiner [1,2]. Therefore, AGENCORE has designed and installed the new tritium recovery system based on catalytic recombiners and MS adsorbers for the tritium handling glove boxes, instead of the metal getter system which is very vulnerable to oxygen and moisture.

2. Design of Tritium Recovery System

2.1 Design Requirements for Tritium Recovery System

One option to recovery tritium is to use a catalytic recombiner to react tritium in the glove box atmosphere with oxygen to convert it into moisture, and the moisture generated by the recombination reaction is removed using a Molecular Sieve (MS) adsorber. Then the concentration of tritium in the glove box atmosphere is lowered below the emission limit. Key design requirements for the tritium recovery system are as follows [3,4].

- It shall be possible to recover the elemental tritium leaked into the glovebox.
- If the glovebox tritium concentration exceeds the set value, the tritium recovery system shall be operated and the tritium concentration shall be reduced to below the set value (5.0×10^{8} Bq/㎥).
- The recirculation shall provide an atmospheric recirculation rate capable of removing at least 99% of the tritium leaked into the glovebox within 8 hours.

2.2 Tritium Recovery System Configuration

The main devices of this system are catalytic recombiners (2 parallels), MS adsorbers (2 parallels), and a tritium monitor. A schematic diagram of this system is shown in Figure 1.

The tritium concentration in the glove box atmosphere over the decontamination factor and the flow rate can be calculated by the following equation.

$$C = C_0 \cdot exp(-\lambda \cdot t \cdot F/V) \qquad (1)$$

where C is the tritium concentration (TBq/㎥) in the glove box, C_0 is the initial tritium concentration (TBq/㎥) in the glove box, λ is the decontamination factor, t is the operating time (min), F is the flow rate (㎥/min), and V is the glove box volume (㎥). The reduction of tritium concentration in the glove box over the operating time and the decontamination factors is shown in Figure 2.

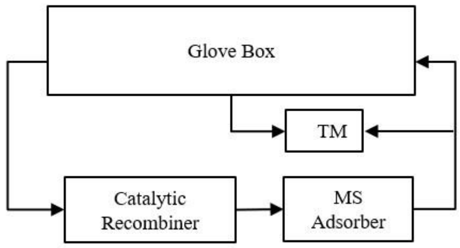

Fig. 1. A schematic diagram of the tritium recovery system using catalytic recombiners and MS adsorbers.

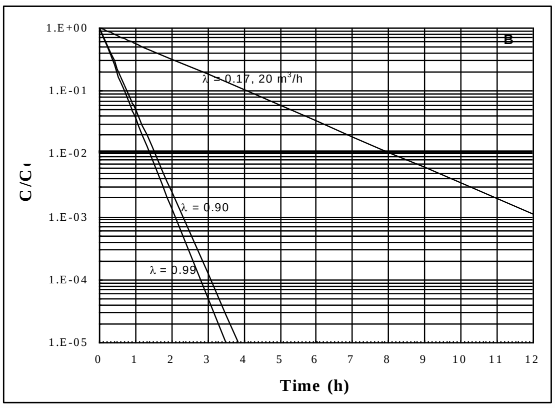

Fig. 2. The rate of reduction of tritium concentration with the tritium decontamination factors (λ).

2.3 Catalytic Recombiner

The catalytic recombiner is a Ni metal catalyst-based reactor. Two nickel beds are installed, each with the Ni metal amount of 2.5 kg, the flow rate of 140 l/min of H_2, and the conversion efficiency of > 99 % @ 5 l/min & 250℃. This Ni bed is designed and manufactured according to ASME Section Ⅷ Div. 1, and the bed leakage rate is $1x10^{-9}$ He-cc/sec [5].

2.4 MS Adsorber

Two MS adsorbers are installed in parallel, one in operation and the other in standby conditions. When the moisture content of the gas from the operating dryer exceeds the set dew point, the standby dryer is operated. The MS in the saturated adsorber is replaced with new one, and the spent MS is treated as radioactive waste.

3. Installation of Tritium Recovery System

Figure 3 shows the tritium recovery system designed and manufactured by AGENCORE. The main equipment of this system is a surge tank, a recirculation pump, a heat exchanger, catalytic recombiners (2 parallels), gas preheaters, MS adsorbers (2 parallels), a hygrometer, and tritium monitors.

The glove box atmospheric gas passes through the gas preheater in advance, the temperature rises to about 250℃, and then enters the catalytic oxidizer. More than of 90% of the tritium introduced into the catalytic oxidizer is converted into moisture by reaction with oxygen. The gas that comes out of the catalytic recombiner is cooled to below 25℃ while passing through the heat exchanger and enters the MS adsorber. In the MS adsorber, moisture is completely removed at a dew point temperature of -20℃ or less, and only clean gas is exhausted. The gas that comes out of the MS dryer passes through the tritium monitor again. If the tritium concentration is below the set value (3.7×10^{6} ㏃/㎥), it is discharged by the exhaust fan, but if it is above the set value, it is recycled to the glove box and processed.

Fig. 3. Picture of Tritium Recovery System for Tritium Handling Facilities.

4. Conclusions

AGENCORE has developed and installed a new high-performance tritium recovery system using catalytic recombiners and MS adsorbers. When the tritium concentration in the glove box exceeds the set level (5.0×10^{8} ㏃ / ㎥), a tritium concentration alarm is generated, all flow paths outside the glove box are blocked, and the tritium recovery system is connected to start the recirculating operation. This facility will be used to recover tritium in the GTLS production facility of AGENCORE. Currently, the license for tritium handling facilities is being reviewed.

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