§8. Application of the Dehumidifier System by Hollow Fiber Membrane Separation for Tritium Decontamination

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1. Introduction

Since 2008, the tritium decontamination in heavy water system processed for the decommissioning in Fugen Decommissioning Engineering Center (hereinafter referred to as "FUGEN"). In the tritium decontamination, vacuum drying method and through-flow drying method have been applied and these methods were selected and used concomitantly by object condition such as the system structure and size.

However, since the conventional dehumidifier with dehumidification rotor type consists of a lot of components such as heat exchanger, chiller unit, dehumidifier rotor, rotor motor, blower, regeneration heater and regeneration blower, it has gotten large. From this, it affects not only installation position and transfer of the dehumidifier but also applicable area of through-flow drying. Thus, the drying system of the hollow fiber membrane dehumidifier system has been studied in LHD was built and applicability of the built drying system was evaluated by using for the tritium decontamination of FUGEN.

2. Experiment

The dehumidifier was built and that consisted of blower, heat exchanger, chiller unit, membrane module, vacuum pump and recover tank. The dehumidifier was designed to suppress pressure increase of internal of the system for tritium leak measure by securing pressure difference with vacuum of permeation side. The dehumidifier has 50 L min^{-1} of max air flow rate, 5 L min^{-1} of page flow rate, ca. 30 kPa[gage] of membrane module inlet pressure, ca. -70 kPa[gage] of permeation pressure and -80 °C of achieving dew point.

For the object of application test using the dehumidifier, heavy water purification tower was packing ion exchange resin and the resin had been removed in FUGEN was selected. The application test was processed with the condition which was summarized as below.

Object: the system containing the heavy water purification tower (the tower: φ850 mm H3170 mm, pipe: φ15~78 mm L20 m), atmosphere in the object: air containing water vapor mixture of light water, heavy water and tritium water (tritium concentration: 1.0 E+03 Bq cm^{-3}-air), air flow rate: 50 L min^{-1} and temperature: room temperature (11~20 °C).

3. Results and Evaluation

Decontamination performance of heavy water containing tritium of the dehumidifier was evaluated by repetitive test of 5 hour of through-flow drying. In this test, dew point of the air returned from the tower showed 20 °C (2300 Pa[abs]) in the early period, decreased to 7.2~7.5 °C(1000 Pa[abs]) after 25 hours and after that became constant. It was shown that the heavy water containing tritium in flow passage was removed gradually.

Dew point of the air delivered from the dehumidifier into the tower achieved under -80 °C after 5 hour of the repetitive tests and repetition of the dew point was good. Since the tritium concentration was 1.0 E+03 Bq cm^{3} in the tower, they were evaluated to be 4.3 E+02 Bq cm^{3} in the returned air and 2.2 E-02 Bq cm^{3} in the delivered air calculated from those dew points, respectively, and then decontamination factor was estimated to be ca. 10000. In this test, the air flow rate was set to 50 L min^{-1} but effective flow rate became ca. 20 L min^{-1}.

Integrated amount of recovered heavy water containing tritium increased continuously, the total amount was 2.4 L after 86 hour of through-flow drying. Thus, it was confirmed that the dehumidifier has applicability for the tritium decontamination from equipment in the heavy water system.

4. Knowledge of Operation

About cause of the effective flow rate decrease, it was conjectured that pressure loss of the object was bigger than the blower performance of the dehumidifier and since pipe in the flow passage was narrowed by residual heavy water, the pressure loss increased additionally. It was needed to blower upgrade for increase of the recover rate while much heavy water was remained in the early period.

The membrane module shows same dehumidification performance regardless of value of air supply pressure when the pressure ratio between air supply side and permeation side are same. But process rate increases according to the air supply pressure. Thus, it was needed to build high supply pressure for high process rate.

From the above, it was needed that followings were considered when design of the dehumidifier was optimized for the tritium decontamination.

●For the tritium leak measure, the hollow fiber membrane dehumidifier system is designed considering with balance of setup pressure value of the dehumidifier system, air flow rate and achievable dew point.

●For more effective the tritium decontamination, the dehumidifier system is designed to be able to control the air flow rate and dew point. In early period, air flow rate is controlled to be high. As the drying progressed, the air flow rate and the dew point are controlled to be low.