

§3. Trial Production of Monitor for Tritium in Vapour of Atmospheric Air

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Rapid monitoring of tritium concentration in work place and in exhaust air is one of the most important assignment of radiation safety for facilities for nuclear fusion research. There are mainly three chemical species of tritiated compounds in atmospheric air, i.e.; molecular hydrogen, methane and water vapour. Among the legal limits of tritium concentrations of those compounds, there are differences of over four magnitudes of order (Table 1). When one monitored the tritium concentration without discriminating the chemical species, one should compare it with the least value; one for tritiated organic compounds. However, the minimum detectable concentration (MDC) of ordinary tritium gas monitors is higher than the value. Usually, water vapour is the largest in quantity of the tritiated compounds in atmospheric air. The purpose of this study is to investigate a feasibility of a real-time monitor for tritium in vapour of atmospheric air.

Table 1 legal limits of tritium concentration

Chemical species	Room air Bq cm ⁻³ -air	Exhaust air Bq cm ⁻³ -air
Molecular hydrogen	1×10 ⁴	7×10 ¹
Methane	1×10 ²	7×10 ⁻¹
Water	8×10 ⁻¹	5×10 ⁻³
Organic compounds (exc. methane)	5×10 ⁻¹	3×10 ⁻³
Other	7×10 ⁻¹	3×10 ⁻³

Last year, we performed producing hydrogen gas by reducing water using heated magnesium turnings and measured the hydrogen gas via an ion chamber or a proportional counter¹⁾. However the hydrogen concentration in the measured gas could not be controlled during the experiments. To estimate the tritium concentration in the water vapour in air, the water vapour trappings with both the cold trap method and the solid collecting method were performed and the characteristics of the methods were compared.

Three trapping methods as bellow were performed;

- (1) Cold trap method (CTM),
- (2) Active method with molecular sieve (AMM), and
- (3) Passive method with molecular sieve (PMM).

Whereas the air was sent by air pumps for the CTM and the

AMM, no pump was used for the PMM method for which the molecular sieve was simply contained in a wire gauze case and hanged in a room.

The collection of water vapour was carried out in air with the tritium concentration of about 0.1 mBq cm⁻³ for 24 hours. To recover the water collected in the molecular sieve, the molecular sieve was heated to 400°C with nitrogen purge, and the water vapour was condensed via a cold trap. The condensed water was measured with liquid scintillation counting. In addition, the time variation of the water vapour collection to the molecular sieve was estimated by measuring the change in the weight during the experiments.

In atmospheric air of the temperature of 30°C and humidity of 70%, the weights of the water collected by the CTM, the AMM, and the PMM were 11 g, 15 g, and 19 g, respectively. Hence, the collection ratios for the CTM and the AMM, i.e.; ratio of the water quantity trapped in the trap to that in the whole air passed the trap, were 32% and 47%, respectively. Whereas the simplest method, the PMM trapped the highest quantity.

The change in weight of the molecular sieve by the PMM was experimentally increased with the time, i.e.;

$$w(t) = C(1 - e^{-\lambda t}).$$

One should use the molecular sieve of which the increasing rate is linear portion for monitoring the tritium concentration. The weight was nearly linearly increased up to 80% of the saturated condition. One should use the molecular sieve for tritium monitoring under the condition. When the temperature assumed to be 30°C and the humidity to be 70%, the absolute humidity were 21 g m⁻³(-air). The molecular sieve can keep the water up to 20% of the weight of itself. Hence, the sufficient weight of the molecular sieve will be 200 g for 24 hours collecting under 30°C and 70% of air.

For 30°C and 70% of air, tritium concentration of tenth the legal limit of exhaust air corresponds to the tritium concentration of 24 Bq cm⁻³ in trapped water. When the background count rate of a liquid scintillation counter is 20 cpm and the counting efficiency is 30%, the minimum detectable activity is 13 Bq for 10 minutes measurement. This condition will provide enough sensitivity for 1-g water sample measurement for measuring the tritium concentration in exhaust air.

The most effective trapping method for collecting water vapour in air was the PMM. One can use 200 g of molecular sieve for 24 hours collection. To measure tenth the legal limits of tritium concentration for exhaust air, 1 g of the condensed water should be measured.

- 1) W. W. Bowman and M. B. Hughes, Methods of Low-Level Counting and Spectrometry, IAEA, Vienna, (1981) 353