Improvement of Measurement Method for Low Level Tritium in Exhaust Air

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1. Introduction

Tritium is a representative low-energy beta emitter, mostly generated by atmospheric radiation by cosmic rays, or distributed in the atmosphere by conventional artificial nuclear experiments, and in modern times, it is also generated during operation of nuclear utilization facilities. Tritium has little effect in terms of external exposure because it emits beta radiation which has a short range that could not penetrate the stratum corneum of the skin. However, in the case of HTO form, which is the chemical molecular structure of water that is easy to be absorbed into the body, it cause internal exposure. Tritium could be homogeneously distributed in body organs and cells when it was inhaled or absorbed in the body, binding to specific molecules or tissues, and cause internal exposure. Therefore, when contamination air is discharged from the facility, we must continuously monitor the exhaust air to manage below the exhaust standard. For the analysis of low level tritium, it is sampled in exhaust air using molecular sieves or silica gel as absorbents. However, depending on the environment, season, and characteristics of the absorbent, the collection efficiency is different or the mechanical strength of the absorbent material is weak, so care should be taken when handling. In this paper, the analysis method that can efficiently measure low-level tritium was improved by supplementing the disadvantages of the absorbent used for the analysis of tritium in the exhaust air of facilities

2. Methods

The existing trap methods for collection of tritium are classified into two types. The first method is to collect tritium using a bubbler, and the second method is using a molecular sieve or silica gel. The trap method using a bubbler simplifies the operation of the air sampler and makes handling of the sample relatively easy. [1], [2] However, the measurement of low-level tritium is inaccurate using this method, so it is a more adoptable method for the nuclear utilization facilities. The collecting method using a molecular sieve or silica gel can measure low level tritium. [3] However, molecular sieves have relatively low absorption rates of about 20% for water. Silica gel has a high water absorption but mechanical strength by impact or friction is very weak.

Figure 1. Air Sampler

Figure 2. Electric furnace (Pyrolyser)

Therefore, by improving the bubbling method, we sought a method to analyze low-level tritium in exhaust air without molecular sieve or silica gel. Electric furnace is mainly used to extract low-level tritium contained in solid samples such as wood, soil, and plants, or viscous oil in the form of high-temperature vapor. Molecular sieve or silica gel also extracts tritium through an electric furnace. However, there is a limitation in the physical properties of the sample to analyze a liquid sample using an electric furnace. Therefore, the bubbling sample is converted into a form suitable for a furnace by using natural pulp as an absorbent. For sampling, the air exhausted from the stack is collected using air collecting sampler. At this time, tritium in the air is trapped into deionized water. When the collection is complete, it quantified the sample water which is absorbed by the natural pulp. Natural pulp is a cellulose-based material made with wood as the raw material, and it is composed of fiber with many small pores, so it has excellent hygroscopic property and strong heat resistance also it can be processed in various forms and is easy to handle. The pulp contained the collected water is put into a container of the furnace, and burn it to extract tritium in 0.1M nitric acid solution. The extracted solution is quantified, mixed with a scintillation material. And then, it measured the level of tritium by LSC. This method can be extracted once more in the form of vapor by burning the bubbling sample before LSC measurement. Therefore, tritium can be concentrated in the sample and lower MDA can be expected when measured by LSC.

3. Conclusions

In order to use this method as a low-level tritium analysis method, it is first necessary to study whether natural pulp is adoptable as an absorbent for the sample water. So, we will be to analyze the molecular structure, chemical properties and the degree of recovery from the natural pulp. It will compare between the methods using a natural pulp absorbent with using a silica gel or molecular sieve. If the effectiveness of this analysis method is proven, it is expected that it can be introduced as a low level tritium analysis method at nuclear facilities and related institutions.

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