Comparison of Tritium Sampling Methods in a Gaseous Ventilation Release Pathway at Vermont Yankee Nuclear Power Station

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Abstract

Tritium release rate at Vermont Yankee Nuclear Power Station has been performed on a monthly basis since startup in 1972. This analytical method utilizes a cold-trap collection apparatus and concurrent measurement of ventilation moisture content. Possible errors in this method for estimating tritium releases from the plant were hypothesized by both inspectors and plant staff. A more representative method for collection of tritium samples was needed. Efforts were focused to develop a continuous sampling method that could be set up and utilized in the instrument room at the main plant ventilation stack base.

A method and apparatus utilizing color-changing silica gel was developed and installed approximately three years ago. For the last two years, data has been collected both via the old, grab-sample cold trap method and from the new, continuously-operating silica gel method.

The old and new methodologies have been compared and contrasted. The results are presented in the following sections. A general description of the equipment utilized and the concurrent results of tritium sampling methods from the ventilation flow at the Vermont Yankee main plant vent stack is also described in the following sections.

The Old Method – Cold Trap Condensation of Moisture in the Process Stream

General Description

The cold trap method for collection of tritium samples has been in use at Vermont Yankee since plant startup in 1972. This method utilizes a flow-through collection flask immersed in a dry ice/methanol bath. The flask is outfitted with an inlet and outlet tube as well as a wet bulb and dry bulb thermometer. The inlet air temperature (wet and dry

bulb) is measured and moisture content is calculated from this information. The collection system is set up for a finite period, usually one or two hours. At the end of the collection period, the apparatus is secured, the collection flask is isolated and the entire apparatus transported to the chemistry lab where the moisture collected in the flask is analyzed for tritium concentration. Utilizing average water vapor in ventilation gases during the collection process, a calculation is performed to determine tritium release rate and total curies released during the period of interest. Initially, one "grab" sample was collected each month and the release rate assumed to be approximated for the entire month. Several years ago, the frequency of collection was changed to weekly to provide improved quantification of tritium releases.

Benefits

Advantages of this method are ease of sample collection and no requirement for permanently-installed apparatus.

Shortcomings

Grab sample collection frequency leads to greater error in the measurement process. Hazardous materials (dry ice and methanol) are utilized, requiring additional training and protective equipment during use.

The New Method – Silica Gel Adsorption of Moisture in the Process Stream

General Description

Columns of silica gel are installed in a continuous side stream flow path in the Plant Stack equipment room at the stack base.

Benefits

Continuous sampling captures daily fluctuations in moisture content and postulated tritium concentrations in ventilation exhaust gas streams. The analytical procedure has fewer steps and no measurements ventilation parameters such as humidity and temperatures. Quantification of tritium releases is significantly improved.

Shortcomings

The apparatus required a design modification entailing significant engineering design effort. The apparatus must be maintained periodically. The system requires more physical space than the cold trap collection method. Care must be exercised during the retrieval of the saturated silica gel.

Comparisons & Contrasts

Equipment Purchase and Setup

- The cold trap method requires the use of a dewar and various glassware, tubing and thermometers as well as the ability to manufacture dry ice cakes.
- All of the equipment utilized in the silica gel method is readily available and required only minimal installation skills

Complexity of the sampling process

- The use of dry ice and methanol for the cold trap method increases the hazard risk to the technician. Protective equipment is required. Good ventilation is necessary.
- The silica gel method is relatively simpler to perform. There are no significant personnel injury hazards with the method.

Collection efficiency

- On the whole, the silica gel method has yielded lower tritium release estimates. This is in large part due to the continuous collection process which captures tritium under all conditions, not just a grab sample taken during the daytime when moisture content can be significantly higher.
- Data from our test runs indicated a significant drop in correlation coefficient when the silica gel collection period was extended beyond one month. Our requirement for tritium sample collection at the stack is monthly and therefore will not be impacted by this situation.

Analytical Method

- The cold trap method only requires warming of the frozen water vapor to obtain water for tritium concentration analysis.
- Additional steps in the laboratory are required to obtain water for analysis via the silica gel method. First, the silica gel is weighed and the total amount of water collected is calculated from this weight. Next, the silica gel is mixed thoroughly and then a portion is processed to remove the entrained water. The water is collected in a condenser apparatus and analyzed for tritium concentration using liquid scintillation methods.

Conclusions

- The silica gel method has been demonstrated to correlate well with the cold trap method in parallel studies at Vermont Yankee.
- The silica gel method more closely approximates the actual releases of tritium from the plant stack.
- The method will be utilized to assess tritium releases at Vermont Yankee.

Acknowledgements

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References

Vermont Yankee Procedures:

- VYOP 2611, Rev. 35, "Stack Effluent Sampling and Analysis"
- VYOP 0631, Rev. 15, "Radiochemistry"

Vendor Info:

- W.A. Hammond Drierite Company, Bulletin #68, "Drying Column for Air and Gases"

Figures & Tables

Power Point Presentation:

- "Collection of Water Vapor for Tritium Analysis from Plant Ventilation"
- Chart comparing "Tritium Sample Collection Methods" (last page of the presentation)