Chemistry - PI 24

# HEAVY WATER LEAKAGE - DETECTION

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Objectives:

1. Name and briefly describe the operation of five of:

   (1) Beetles
   (2) Silica Gel
   (3) Cold Finger
   (4) Tritium Monitor (Dual Chamber)
   (5) Bubblers
   (6) Infra-Red
   (7) Portable Leak Detector

   with respect to detection of heavy water leakage to atmosphere.

2. Name and briefly describe two methods for the detection of heavy water leakage to light water systems.

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Heavy water leakage may occur to:

(a) Atmosphere
(b) Light Water Systems, eg:
- Secondary Heat Transport
- Closed Cooling System
- Open Cooling System

The environmental monitoring of such leakage is covered in Section 5 of this course and the biological effect in the Radiation Protection Training Course.

It is not intended that trainees be able to quote the exact method of detection at any one station (that will be done in station specific courses). This module is to outline the basic principles behind some of the more common tools used for leak detection.

## A. Leakage to Atmosphere

### (1) Beetles

Beetles are merely two electrodes positioned in collection pots below heavy water systems. If the pots fill with heavy water, even though it has a low conductivity, the electrodes will be shorted and the current flow between them may be used to trigger an alarm. More than one beetle may be positioned in a pot to give initial warning followed by high level alarm. Beetles have the advantage of being reliable and easy to maintan.

### (2) Silica Gel

Silica Gel is used mainly to measure stack losses of heavy water. Silica Gel is a material which will readily absorb and retain water, either heavy water or light water. Filters packed with silica gel receive a small sample of stack air. Subsequent weight gain of the filter and gel is a determination of total water going up the stack. Some other method of analysis is used to determine the isotopic concentration of the water vapour in the stack.

### (3) Cold Finger

A Cold Finger is a chamber cooled by liquid air on the outside, through which is passed an air sample. All of the moisture in the air is condensed and may be weighed to determine the moisture content of the air. Once again an isotopic analysis will have to be done to determine the amount of heavy water.

### (4) Tritium Monitor

Heavy water systems will contain Tritium from neutron activation of the Deuterium. Therefore any heavy water leaked will contain Tritium. Tritium decays by emitting a low energy $\beta$ particle and use of this is made in a **dual chamber** instrument which is a set of ionization chambers, one shielded from $\beta$, the other exposed. The exposed chamber measures $\beta + \gamma$, the shielded chamber measures only $\gamma$; the difference between the two; $\beta$; is a measure of the Tritium and hence a measure of the heavy water. Knowing the Tritium concentration in air allows a calculation of heavy water from knowledge of Tritium concentrations in heavy water systems (of course one has to know which system is leaking.)

(5) **Bubblers**

An air sample is passed through a canister of light water and any heavy water in the air will preferentially remain in the liquid phase. It is customary to analyze the liquid in the canister after sampling for Tritium by liquid scintillation.

(6) **Infra-Red**

Detailed operation of infra-red analyzers is covered in Lesson 224.30-3. In short, the different isotopic species of water have different vibrational frequencies. The absorption of infra-red light passed through a sample of water varies quite markedly with isotopic concentration. If an infra-red generator/detector system were then placed across a sample of air containing moisture, the system could, with appropriate calibration tell us (a) how much moisture is in the air and (b) whether the moisture is light water, heavy water or a combination thereof. This method of analysis seems almost too good to be true. Possibly so as recent disenchantment with the reliability of in-line IR meters may precipitate their removal from service.

(7) **Portable Leak Detector**

Recently there has been a major thrust by CNS and Ontario Hydro Research to develop a hand held portable leak detector to find leaks right at the source. Early tests are encouraging.

The detector consists of a small integral fan which draws an air sample from the atmosphere to be tested near a suspect item. The air sample is passed over a hygrometric (water sensitive) circuit element which is part of an ac bridge circuit. Any change in air moisture changes the impedance of the element, and the resulting current is used as a moisture indication. The leak detector will not distinguish between light and heavy water.

"To give some idea of the detector's sensitivity, the perspiration from an individual's palm produces a full scale deflection at a distance of 8 - 10 cm from the detector's inlet". (Research Report E79-72).

## B. Leaks to Light Water Systems

Leak detection to light water systems have two purposes; firstly for environmental and safety reasons and secondly, for economic reasons. The following methods have been, or are presently in use:

### (i) Manual Sampling

In spite of the best efforts to develop viable in-line instrumentation, manual sampling remains the most reliable method. A grab sample of water from, SHTS, recirculated cooling water or open cooling water is analyzed by scintillation techniques for Tritium.

### (ii) In-Line Infra-Red Analysis

The in-line IR leak monitor is commonly referred to as a Barringer (after the manufacturer). The electronics are complex but the method is simply to draw a sample of water and pass it through an IR system. Once again I refer you to Lesson 224.30-3 if you wish to read about the details of IR monitors.

### (iii) Gamma Monitors

At power, N-16 is produced by the (n,p) reaction of O-16. The N-16 is a high energy $\gamma$ emitter and although short lived, use may be made of this to detect leaks at power. By pointing a sensitive $\gamma$ meter at the light water process stream, any indication of $\gamma$ radiation would be an indication of heavy water leakage into the light water.

Practice Exercises

1. List at least five methods for detection of heavy water leakage to atmosphere. For each method give a brief point form outline of principle or basis.

2. List at least two methods for detecting heavy water leakage to light water systems. Briefly describe the basis of operation of each method.

   Check your work against the data supplied in the text.

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