

“A Method of Locating Leakage of Heavy Water in CANDU Reactors Using the Ratio of Tritium to Heavy Water in a Water Vapor Sample”

Mr. Jason Shin, KHNP, Republic of Korea

A CANDU reactor is a pressurized heavy water reactor (PHWR). A CANDU reactor consists of two main systems: Primary Heat Transport System (PHT) and Moderator System (MOD). Due to the difference in the residence time of heavy water in the core, the concentration of tritium differs between PHT and MOD. In the case of Wolsong Nuclear Power Plant, the tritium concentration in heavy water is 2 Ci/kg in PHT while it is 40 Ci/kg in MOD. If heavy water leaks, it will evaporate into the reactor building, increasing the tritium concentration in the atmosphere, which may cause serious internal exposure to workers. The majority of leaked tritium will be collected by the heavy water steam collection system; however, about 10% of the tritium will be released in the environment. It is therefore imperative to identify and repair the leak point immediately. However, it is not easy to quickly identify a leak point.

Identification of leak points can become much easier if we know whether the point belongs to PHT or MOD. Making use of the large difference in tritium concentration between these two systems, a steam sample in the air will be collected to estimate the amount of heavy water leak from the two systems.

$$AX + BY = T,$$

$$X + Y = H,$$

A = tritium concentration in the heavy water of PHT (known),

B = tritium concentration in the heavy water of MOD (known),

X = the amount of PHT heavy water in the sample (unknown),

Y = the amount of MOD heavy water in the sample (unknown),

T = the amount of tritium in the sample (measured), and

H = the amount of heavy water in the sample (measured).

With a simple modification, we obtain the following formulae,

$$X = (T - BH) / (A - B)$$

$$Y = (T - AH) / (B - A).$$

Using these formulae, the amounts of PHT heavy water and MOD heavy water in the sample can be determined. Based on these values, the ratio of the heavy water leak from the systems, PHT to MOD, can be obtained. If there is an increase in tritium concentration levels in the air, a sample will be collected to calculate the heavy water leak ratio of PHT/MOD, and also the tritium leak ratio of PHT/MOD, by the method described above.

In actual incidents of rapid increase of tritium concentration in the air of the reactor buildings of Wolsong unit 3 in December 2008 and Wolsong unit 4 in April 2009, this method was successfully used to determine the leak point for repair.