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Leak Monitoring of a Fuel Channel Closure Plug Using Tritium Activity Analysis System

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1. Introduction

A Tritium activity analysis system has been used to detect the leakage from the closure plug on the fuel channels of 380[1, 2]. Comparing with DAC(derived air concentration) values of tritium concentration measured from various channels of rows and lines, it could be confirmed that this value measured from the activity analysis system which are composed and developed newly is nearly equivalent to tritium concentration value measured from fixed tritium area monitor(FTAM) which had been operated as the existing system. Therefore, it was suggested that the tritium concentration measuring technique using activity analysis system could be reliable method and a useful method for the detection of leakage of tritium or coolant from closure plug of fuel channel in heavy water reactor.

2. Methods and Results

2.1 Design of Tritium Activity Analysis for Fuel Channel Leakage Detection

Tritium activity analysis system is designed to measure tritium activity in air. Particularly, it detects tritated water vapour, in nuclear power stations, tritium extraction plants, fusing facilities and in various industrial scenarios where tritium is being used. The monitor consists of two separate Modules, a Detection Unit and a Display and Control Unit. The Detection Unit consists of a dual co-axial ion chamber assembly, air filtering system, ion trap, electrometer, sample pump, flow switch, bias power supply, and associated electronics for data output and recording.

The Display and Control Unit consists of the CPU, Controller and I/O board in a card cage and power supply. This unit includes the eight digit LED display, thumb wheel switches for setting the alarm level, connectors for remote communications, audible and visible high tritium concentration alarm and relay contacts for remote alarms, In addition, there are eighteen lights to indicate the status of the monitor and various error conditions. The Detection Unit communicates with the Display and Control Unit via an optical link. An RS-232C link is provided for a local terminal and additional hardware is provided for a second RS-232C.

Sample air drawn into the system is filtered and passed through an electrically polarized ion trap to remove particles and extraneous ions. It is then passed through the outer chamber of the Detection Unit producing ion pairs resulting in an electron current. This ionization current is proportional to the concentration of tritium in sampled air.

2.2 Methodology of Fuel Channel Leakage Detection

The Fig. 1 shows a schematic diagram for site location and diagnostic methodology of tritium activity analysis system. For leak detection, suction horn was located in front of fuelling machine and then to suck in tritium air leaking from fuel channels by force. Sucked tritium air was feed into the tritium activity analysis system located in fuelling machine maintenance room, R103 and R104 room through the catenary and trolley using flexible tube. Previously, tube port should be located so as to penetrate the tritium air sampling tube between the reactor area and fuelling machine maintenance room. Secondly, another tube port should be located between the fuelling machine maintenance room and remote monitoring room to make the tritium air flow from the fuelling machine maintenance room to remote monitoring room, and then finally tritium concentration analysis from tritium air flow fed through these two ports could be accomplished so that leak conditions are evaluated and displayed.

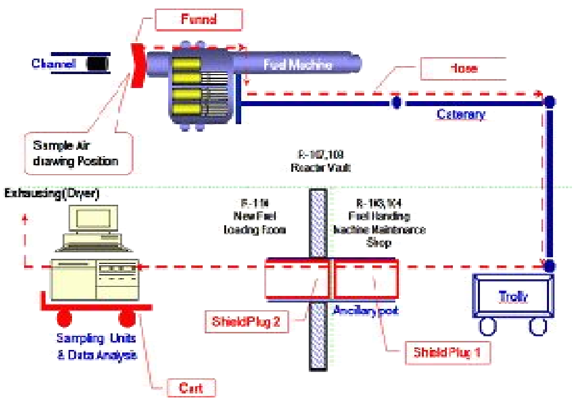

Fig. 1. Schematic diagram for site location and diagnostic methodology of tritium activity analysis system

2.3 Test Procedure

In order to measure the tritium concentration precisely, leakage detection test was performed for a relative long sampling time needed in stabilizing on the subject channels which leakage is suspicious. The concentration data obtained from the tritium activity analysis system for no leakage channel and somewhat leakage channel respectively confirmed during exchanging fuel using the fuelling machine compared with data obtained from the existing tritium concentration analyzer, fixed tritium area monitor(FTAM). Fig. 2 illustrates each location and channel division of subject channels for leakage detection. Each channel are divided total channels into quarters vertically and horizontally, upper two areas are called 1/4 section and 2/4 section from the left to the right direction, and also called lower two areas are called 3/4 section and 4/4 section from the left to the right direction. For the exact leakage detection in the future, these areas should be managed to be fixed. Leakage detection tests were performed for K-7 channel on 2/4 section and V-7 channel on 4/4 section. Table 1 shows the detection procedure to measure the tritium concentration for subject channels.

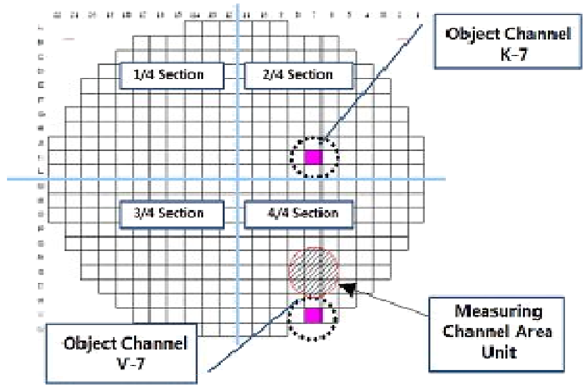

Fig. 2. Location and channel division of subject channels for leakage detection

Table I: Detection procedure to measure the tritium concentration for subject channels.

Measuring method of subject channels	Test time
The mean time for moving to channel	2 minutes
Stabilizing time for concentration measuring	30 seconds
Non-contact measuring	30 seconds
Contact measuring	30 seconds
Moving backward and stand by	1 minute

2.4 Field Test Results

In order to measure precisely, the tritium concentration measuring test was performed for 3 minutes of a relative long measuring time on the subject channels which leakage is suspicious. Fig. 3 presents a representative result measured tritium concentration during 6 minutes from 19:06 to 19:12 for V row and 7 line channel of 4/4 section on the reactor. Tritium concentration of Y axis on the record of tritium detection system indicated about 0.035 V on the average and 0.035 V is equivalent to about 2.6 DAC in DAC(1DAC=3×10^5 Bq/m^3). Comparing with tritium concentration measured from the FTAM during the same measuring time, it could be confirmed that this value(2.6 DAC) measured from the tritium detection system is nearly equivalent to tritium concentration value(2.5~2.8 DAC) measured from the FTAM as shown in Fig. 7-8. Therefore it could be concluded that there was no leakage on the subject channel, and it is expected that the upper values than these values show in case of leakage existence. Hereafter, these data could be applied to evaluate for leakage existence or not reference on the V row and 7 line channels.

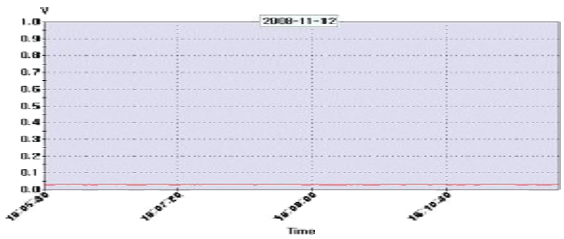

Fig. 3. A representative result measured tritium concentration

3. Conclusions

Through the acquisition of DAC values of tritium concentration measured from various channels of rows and lines using the tritium activity analysis system, it could be confirmed that this value measured from the activity analysis system which are composed and developed newly is nearly equivalent to tritium concentration value measured from the FTAM which had been operated as the existing system. Therefore, it was suggested that the tritium concentration measuring technique using activity analysis system could be reliable method and a useful method for the detection of leakage of tritium or coolant from closure plug of fuel channel in heavy water reactor.

REFERENCES

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