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§3. Shielding Effect on Tritium Water Monitoring System Based on CaF_2 Flow-Cell Detector

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A water monitoring system was developed for measuring the tritium concentration in water. Differ from a liquid scintillation counting system this monitoring system was able to continuously measure tritium concentration in water flowing through a flow-cell detector fabricated from solid scintillation materials. Moreover the system was free from problems related to the use of liquid scintillation cocktails and the generation of radioactive organic liquid waste containing tritium. The monitoring system consists of a flow-cell detector, a pair of photomultiplier tubes, a high-voltage power supply, a coincidence counting module, a water flow pump, and a multichannel pulse height analyzer.

In the previous study, the performance of the water monitoring system installed a flow-cell detector fabricated using 50 μ m CaF_2(Eu) was examined with 10000 sec measurement and linearity between count rates and tritium concentrations was confirmed. The detection limit of tritium in water might be as low as 10 Bq/ml. The result suggested that the system reasonably works as a tritium water monitoring system. However, the measurement time of 10000 sec was too long from the viewpoint of radiation management for on-site measuring.

In the present study, lead shielding effect was investigated for purpose of improvement of the system performance including lowering of detection limit and shortening of measuring time. For estimating shielding effect, two measurements of tritium water and blank water (= background) were practiced.

In the measurement of tritium water, radiation counts detected in the cell were accumulated for 600 sec. For this measurement, seven tritium water samples with deferent concentrations of about 1, 5, 10, 30, 50, 70 and 100 Bq/ml were prepared and relation between tritium concentration and count rate (cpm) was examined. After each measurement, the used cell was cleaned by no tritium water, and no tritium contamination was certified by the background measurement with the same accumulated time.

The result is shown In Fig.1 a skew line (A) derived by linear regression is also drawn. The result suggests that relation between count rates and concentrations was definitely linear because the R^2-value of the fitted line is 0.98 (good fit). Using y=0.1353x (y:count rate, x: tritium concentration), count rates measured can be converted to tritium concentration (Bq).

In the measurement of blank water, shielding effect were examined in five cases; front and back panel shielding, left and right panel shielding, base panel shielding, and top panel shielding, and full panel shielding. The full panels mean six panels, because the water monitoring system was a hexahedron.

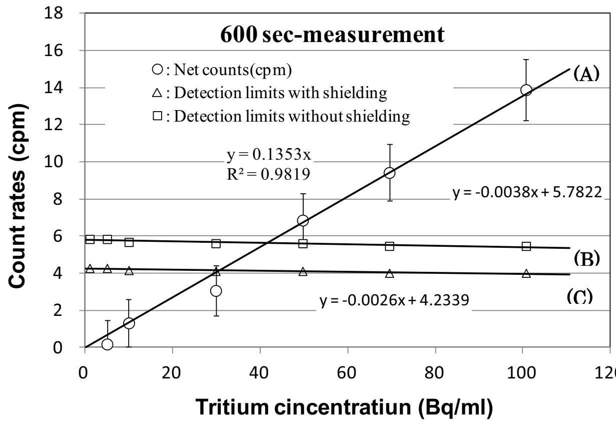

Fig.1 Relationship between tritium concentration and count rate, and detection limits.

Lead blocks with 5cm thick, 20cm long and 10cm wide were used as shielding materials. For respective shielding conditions, 10000 sec-measurements were practiced with and without shielding and decreases of counts by the shielding were calculated using Eq. (1).

$$C_{bdec} = \frac{C_{wos} - C_{ws}}{C_{wos}} \quad 100(\%) \qquad (1)$$

C_{bdec} : Decrease percentage of count,
C_{ws} : Count with shielding and
C_{wos} : Count without shielding.

The calculated results are shown in Table 1. The whole six-panel shielding reduced background counts by 53.8%. Except for the whole panel shielding, the top panel shielding was most effective, the base panel shielding was less effective. As the flow cell detector was installed longitudinally in the measuring device, the projected areas on front, back, light and left panels are larger than that on the top panel. Nevertheless, the top panel shielding was most effective. This result will be useful to design detector shielding in the future study.

Table 1 Decrease rate of BKG counts due to 5cm-Pb shielding

Panels Shielding applied (Pb-5cm)	Decrease rate of BKG counts (%)
Front and Back	9.0
Light and Left	9.6
Base	6.1
Top	12.1
Whole	53.8

In Fig.1, two horizontal lines (B) and (C) are drawn. These lines mean the detection limits calculated without and with the whole panel shielding. It is found that the detection limit in count rate was improved from 6 to 4 cpm, corresponding to from 42.7 to 31.3 Bq/ml. This result means that the 5 cm Pd shielding improved the detection limit of tritium concentration in water lower by about 35%.