Measurements of Two Dimensional Gamma Ray Distributions of Low and Intermediate Level of Radioactive Wastes Using Fiber-Optic Radiation Sensors

Si Won Song[1)], Sang Hun Shin[1)], Hyun Young Shin[1)], Hyungi Byun[1)], Cheol Ho Pyeon[2)], Bongsoo Lee[1), *]

[1)] Chung-Ang University, 84, Heukseok-ro, Dongjak-gu, Seoul, Republic of Korea

[2)] Kyoto University, 606-8501, Yoshida-honmachi, Sakyo-ku, Kyoto, JAPAN

[*]bslee@cau.ac.kr

1. Introduction

Large amounts of low and intermediate level waste (LILW) are generated when nuclear power plants operate. In order to transfer such LILW to the radioactive waste disposal site, it is essential to analyze the radioactivity of radionuclides in the radioactive wastes according to the Nuclear Safety Act (Article 70, Enforcement rule 98) and the Nuclear Safety And Security Commission Notice (No. 201760) [1]. Therefore, the nuclear waste disposal facility should operate the radwaste drum assay system for permanent disposal of LILW drums, and it is important to develop technology and evaluation method to maintain the radwaste drum assay system. In this case, it is very important to monitor possible leaks of radioactive material from the radwaste drum and to reduce the risks of contamination for the operators and for the environment [2].

In this study, we fabricated nine fiber-optic radiation sensors to monitor LILW remotely and in real-time with measuring its dose distribution. The LILW are generated during the operation of the research reactor at Kyoto University Research Reactor Institute.

2. Materials and Methods

The sensing probe consists of inorganic scintillators and plastic optical fibers. Nine LYSO:Ce (cerium-doped lutetium yttrium silicate) inorganic scintillators are arranged in a 3 x 3 array on the square plastic plate with a shape of a rectangular parallelepiped. The size of an inorganic scintillator is $3 \times 3 \times 15$ mm^3 and the diameter of a plastic optical fiber is 1.5 mm. The LYSO:Ce inorganic scintillator has a peak wavelength emission of 420 nm, the output is well matched to the peak sensitivity wavelength of multi-pixel photon counter (MPPC) module.

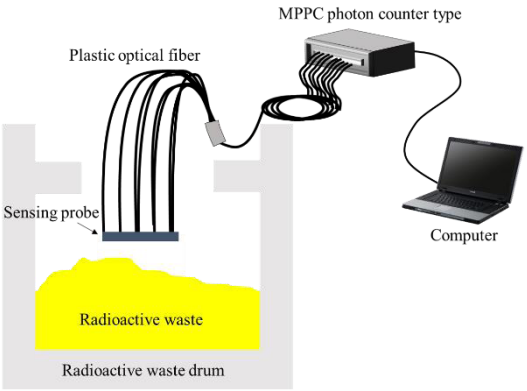

Fig. 1. Experimental setup.

Figure 1 shows an overall experimental setup for measuring dose distribution of LILW with nine fiber-optic radiation sensors. The scintillation light signals generated from the sensing probe are transmitted to the light-measuring device through the 5 m long step-index plastic optical fibers. The light-measuring device used in this experiment is the MPPC module

(C13368-5381, Hamamatsu Photonics). MPPC module has a total of 16 channels, the peak sensitivity wavelength is about 450 nm and measurable wavelengths is from 320 nm to 900 nm.

3. Results

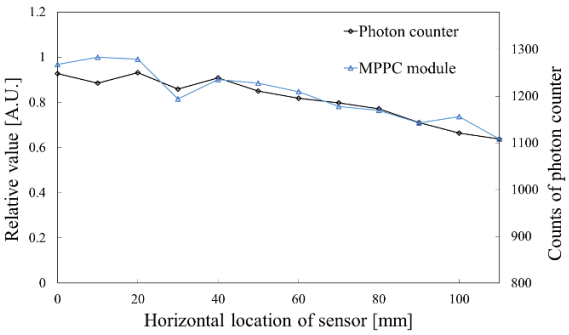

Fig. 2. Gamma ray distributions of LILW using nine fiber-optic radiation sensors.

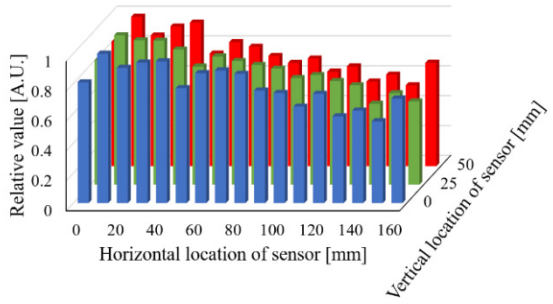

Fig. 3. Tow dimensional gamma ray distribution of LILW using nine fiber-optic radiation sensors.

Figure 2 shows Gamma ray distributions of LILW using nine fiber-optic radiation sensors. The sensing probe was horizontally moved by 1 cm to the left and right from the center of the upper entrance of LILW drum. In this experiment, we used two kinds of light measuring devices such as a MPPC and a photon counter (H11890-210, Hamamatsu Photonics). The measured values using a MPPC are averaged and compared with those of a photon counter.

As shown in Fig. 3, two dimensional gamma ray distribution of LILW was obtained by using nine fiber-optic radiation sensors. It is possible to monitor the leaks of radioactive material from the radwaste drum using an array of fiber-optic radiation sensors remotely and in real-time.

4. Conclusion

In this study, nine fiber-optic radiation sensors were fabricated using LYSO:Ce scintillators, plastic optical fibers and a MPPC module for remote and real-time monitoring of LILW. We measured two dimensional gamma ray dose distribution of LILW in a real radwaste drum. It is expected that the developed fiber-optic radiation sensors can be used to monitor the leaks of radioactive material in the radioactive waste disposal site.

ACKNOWLEDGEMENT

This research has supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2017R1A2B2009480, 2016M2B2B1945255) and this research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. 2018R1D1A1B0704115).

REFERENCES

[1] K.M. Lee, et al., “Radioactive Wastes Assay Technique & Equipment”, Journal of Nuclear Fuel Cycle and Waste Technology, KAERI/TR-2879/2004 (2004).

[2] C. Cali, et al., “On-line remote monitoring of radioactive waste repositories”, EPJ Web of Conference 79, 03007 (2014).