# Design Requirements of a Large-Area Radiation Measuring Instrument for Decommissioning of Nuclear Power Plants

Kidoo Kang*, Yuho Won, Moonhyung Cho, and Jaeeun Lee
Central Research Institute, Korea Hydro & Nuclear Power Co., Ltd, 70, Yuseong-daero 1312beon-gil, Yuseong-gu, Daejeon, Republic of Korea
*kidookang@gmail.com

## 1. Introduction

There are many kinds of radiation measuring instruments in nuclear power plant for the purpose of radiation protection of workers, radioactivity analysis of radwaste and radiation monitoring of the environment. Korea's first commercial nuclear power plant Kori-1 shut down permanently in June 2017. The actual decommissioning will begin in 2022, and then various measuring instrument are needed. Particularly, in order to inspect the contamination of wide area such as the floor of the radiation zone or the site of the power plant, the customized equipment is required to overcome the limited application of current floor contamination monitor system. [1]

## 2. Design requirements of the radiation measuring instrument

### *2.1 Background*

KHNP-CRI established centralized radiation calibration laboratory in 2010 to enhance the management of radiation instrument. It includes the procurement, maintenance and management of portable radiation instruments, calibration and related research. The calibration laboratory was accredited by KOLAS authorized by ILAC. The total number of the accredited items is 11, so far.

Recently, KHNP has developed a new clearance monitor to determine whether the metal scraps meet the regulatory criteria or not. The special features of the clearance monitor are; 1) 12 plastic scintillators and 2 NaI scintillators enable nuclide identification 2) The MDA was lowered to around 1/100 of the allowed clearance level 3) the chamber volume was increased by two times. Integrated operation and performance tests of the clearance monitor were performed. The results of the measurement of metal scraps in which standard sources were placed (approximately 1/100 of the clearance level) showed a good agreement with the source activity within error of -16 % ~ -12 %. [2]

Based on the infrastructure of the radiation lab and experiences with development of radiation measuring instrument, KHNP-CRI is developing 'Large-Area Radiation Measuring Instrument for Decommissioning of Nuclear Power plants' as a part of the mid- to long-term research plan.

At the decommissioning stage of nuclear power plants, it is required to measure various types of buildings, structures, and systems. The measuring results are widely used for a decommissioning plan and other work process.

The radiation survey is done by confirming contamination of material, its quantitative evaluation, and analyzing the radionuclide and its concentration. The method consists of scanning method, static method, and sampling method which are summarized in Table 1.

Table 1. Comparison of radiation survey for decommissioning

| Category | Scanning method | Static method | Sampling method |
|---|---|---|---|
| Usage | contamination distribution analysis | quantitative evaluation | radionuclide analysis |
| Sample represent-ative | very high | high | low |
| Accuracy | low | high | very high |
| Equipment | surface contamination monitor | - surface contamination monitor<br>- in-situ gamma spectrometer | - alpha spectrometer<br>- liquid scintillation counter<br>- gamma spectrometer |
| Measuring target | floor, site | system, structure, wall | concrete, soil, groundwater |

*2.2 Objectives of CRI's prototype instrument*

The target of the development of 'Large-Area Radiation Measuring Instrument for Decommissioning for Nuclear Power Plants' is to develop prototype instrument and method for measuring radioactivity of flat surface such as floor of the radiation zone or the site of the power plant. To get the satisfactory result, several sub-targets were considered as shown in Table 2.

Table 2. Sub-targets of large-area radiation measuring instrument

| Classification | Unit | Performance goal |
|---|---|---|
| 1. size of detector | cm | over 120(W) × 15(D) |
| 2. MDA | $Bq/cm^2$ | 10%~50% of derived concentration guideline level |
| 3. detecting efficiency | % | 30% ≥ $^{90}Sr/^{90}Y$ |
| 4. measuring time | min. | 2min./$m^2$ ~ 5min./$m^2$ |

The size of the detector will be determined so as to overcome the limitations of existing surface contamination monitors including MDA, economic efficiency, and maintainability.

The minimum detectable activity (MDA) should be determined at the level of 10% to 50% of the derived concentration guideline level, based on the Scan MDC calculation formula presented in MARSSIM.[3]

The channel interference between alpha and beta is designed within less than 10% .

Measuring time is defined as the time taken to measure the MDA at 1 $m^2$ area. It takes 222 minutes for a pancake type(detector size 15 $cm^2$) and 33 minutes for a flat type(detector size 100 $cm^2$ The prototype instrument with measuring time of 5 minutes will save time by 85 ~ 95%.

*2.3 Additional Required Features*

Some additional features are; 1) mapping of measured value based on position-sensitive detector 2) implementation of real time MDA 3) implementation of statistical algorithms based on sign test/WRS test. [3]

Moreover, it must have a function to select the automatic and manual modes to prevent human error.

## 3. Conclusion

As a part of the company's mid- to long-term research and development plan, KHNP is carrying out a R&D 'development of large-area radiation measuring instrument for decommissioning of nuclear power plants'. Its purpose is to develop position sensitive radiation measuring device.

The MDA of the new device will be at the level of 10 to 50% of the residual radioactivity concentration, while the detection efficiency is over 30%, and measuring time is about 2~5 minutes for 1 square meter. The measuring time can be drastically shortened(over 85%) comparing to the existing surface contamination monitor.

In addition, the minimum detectable concentration (MDC) will be displayed in real time with statistical verification algorithm, which will greatly enhance reliability of measurement for decommissioning survey.

## REFERENCES


[1] M.H Cho, "A Feasibility Study on Radioactivity Evaluation Technologies for Structures and Materials having Various Shapes and Sizes", KHNP Technical Report, 31-45 (2016).

[2] K.D Kang, "Development of Clearance Monitor for NPP's EM Wastes and its Performance Test", Proc. of the 2017 Waste Management Conference, March 5-9, 2017, Phoenix.

[3] NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (2000).