Refurbishment of HANARO Pool Radiation Monitoring System

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1. Introduction

HANARO is an open-tank-pool-type research reactor, and the RPS (Reactor Protection System) of HANARO includes three radiation monitoring systems composed of NMS (Neutron flux Monitoring System), FFDS (Failed Fuel Detection System), and PRMS (Pool Radiation Monitoring System) for a safety operation. Each system has a reactor shutdown function for when the measured radiation levels exceed the preset limits.

As for PRMS, it has been operating for more than 20 years since it was first installed to monitor radiation in the reactor pool surface area. Meanwhile, the manufacturer could not support the technical services of the system because detector spare parts of the PRMS were obsolete. Consequently, the system should be replaced with a brand-new model.

This paper describes the required regulation for replacing old equipment and explains the configuration, functions, and measurement results of the new system.

2. Codes and Standards

Due to the change in codes and standards in the nuclear industry, the approval from the regulatory agency was necessary before installing the new system. The codes and standards are listed in Table I, and these standards are major requisite items of the regulatory agency, although many other standards were applied to the replaced system [1]. The PRMS was installed in compliance with the listed standards according to nuclear industry qualifications of Class 1E digital equipment and Seismic Category-I.

Table I: Applied Codes and Standards

IEEE-323 *	Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations
IEEE-344 *	Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations
IEEE-383	IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations
IEEE-7.4.3.2	IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Station
IEEE-1012	IEEE Standard for Software Verification and Validation Plans
Reg. Guide 1.180	Guide Line for Evaluation Electromagnetic and Radio-Frequency Interference In Safety Related Instrumentation and Control System
MIL STD 461	Requirement for Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
IEC 61000-4	Electromagnetic Compatibility, Part 4
ASME NQA-1	Quality Assurance Requirements for Nuclear Facility Applications
10CFR50-B	Quality assurance criteria for nuclear power plants and fuel reprocessing plants

* : Required standards with respect to Safety Analysis Report.

3. Configuration and Functions

The configuration of the newly installed PRMS is much simplified compared with the previous one for easier maintenance. Fig. 1 shows the configuration of the installed PRMS. The ionization chamber is used to monitor the gamma radiations of the pool surface. The detectors are installed at the same positions of the previous system, and relays and a 2-wire analog signal of the new system operate identically as well. Fig. 2 shows the installed detector location. All functions of the new PRMS are designed to cover those of the previous one.

4. Measurements during Operation

It was proven that the HWLS (Hot Water Layer System) suppresses the gamma radiation level owing to radioactive materials in the pool, [2, 3] and several technical issues on the suppression of radiation had been resolved to minimize radiation from pool. [4] Eventually, HANARO is maintained with the lowest radiation level to protect humans from unnecessary radiation exposure.

The PRMSs were replaced in March 31st. 2018, and Fig. 3 shows a comparative analysis of the measured gamma radiation levels of the three independent channels (A/B/C) during operation, and these data are based on the record of operation log under the condition that the shielding layer is stably maintained. The radiation levels of the A & B channels are between 5 and 7.5 [μGy/h] during full power operation (30MWth), and these levels are slightly higher than that of C channel, because they are positioned near the SOR (Shutoff Rod) driving system, which is a hydraulic system using reactor pool water of higher radiation. [4] The levels of the old were slightly higher, but the measured levels between the old and refurbished PRMS have shown similar trend.

5. Conclusions

The PRMSs of HANARO have been replaced due to the aging problem of the system. The refurbished system is designed to meet the current nuclear-qualifications and functions of the old PRMS. The measurement results have shown that the function of the new system is consistent with the previous system, and

stably operates and monitors the pool surface area radiation. Hopefully, the codes and standards listed in Table I will be useful for a plant manager to refurbish outdated equipment in other nuclear facilities.

REFERENCE

[1] Jung Hwan-Sung, KAERI/TR-2856/2004, *Design Requirement for Electrical System of an Advanced Research Reactor*, 2004, KAERI

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[3] Sayedeh Leila Mirmohammadi, etl., "*Design and Installation of a Hot Water Layer System at the TEHRAN Research Reactor*," Nuclear Technology & Radiation Protection, Vol. 28, No. 1, pp. 18-24, 2013.

[4] Ahn Guk-Hoon, KAERI/TR-1432/99, Analysis of the Radiation Level Variation at the HANARO Pool Top. 1999, KAERI.

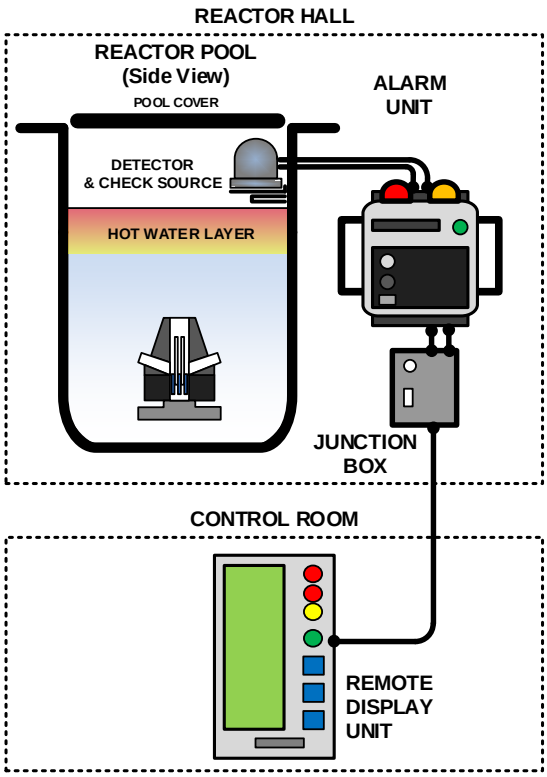

Fig. 1. Configuration of the installed PRMS.

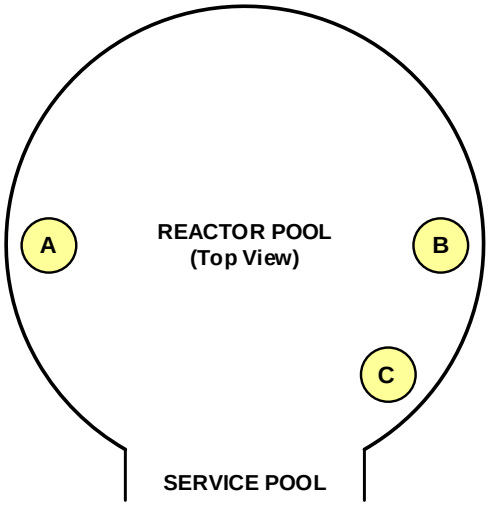

Fig. 2. Detector locations in the reactor pool (Top view).

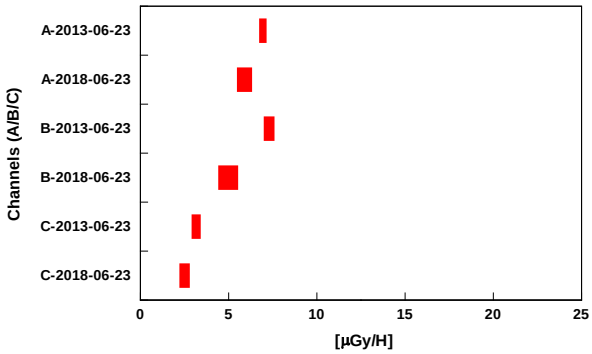

Fig. 3. Radiation measurements during full power operation (30MWth). The measurement dates are 2013-06-23 (Obsolete PRMS) and 2018-06-23 (Refurbished PRMS).