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P2.42: Field Test for Performance Evaluation of a New Spent-Fuel Verification System in Heavy Water Reactor

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There are four CANDU-type reactors under IAEA safeguards at the Wolsung site in South Korea; One of them (Wolsung unit 1) was permanently shut down on the 24th of December, 2019. A new spent-fuel verification system(IOVES) in our previous studies was developed to deal with problems of the existing instrument(OFPS), which has been used to re-verify spent-fuels of the CANDU-type reactors. A field test at Wolsung unit 4 in Korea is carried out to evaluate the performance of the newly developed spent-fuel verification system. This paper aims to discuss the results of the field test in terms of sensitivity, ability to distinguish signals from above and below spent-fuel assemblies, effects of radiation scintillation materials, and the validity of using a reference optical fiber to remove background radiations.

Using the existing and new verification systems, as shown in figure 1, we have measured 19 layered spent-fuel bundles in the spent-fuel storage pool of the Wolsung unit 4. The scan speeds of the existing and new ones are 2 mm/sec and 50 mm/sec, respectively. To evaluate the performance of the new instrument according to the scintillator type, the new instrument examined the multi-layered spent-fuels using three different scintillators (p-terphenyl, BC400, and GS30). The signal generated in the optical fiber itself by the interaction of background radiations and the optical fiber has been obtained using a reference optical fiber to which a radiation scintillator is not bonded.

Although the scan speed of the new instrument was more than 20 times faster than that of the existing one, as shown in figure 2, the former's sensitivity and ability to distinguish the above and below spent-fuel bundles was far superior to the latter. Experimental results also showed that the p-terphenyl organic scintillator performed the best of the three scintillators. Signals that were not visible in results obtained by the Li glass scintillator (GS30) were observed in the signal obtained by the p-terphenyl and BC400 scintillators. The excellent performance of the new verification instrument appears to be mainly due to the high light output and low decay time of the p-terphenyl. It was also confirmed that in the present instrument, the ability to distinguish between the above and below spent-fuel assemblies was improved to some degree by extracting the background radiation signal from the total signal which was produced by both the optical fiber and the scintillation material. On the other hand, for the new instrument, there is little difference in the ability to distinguish the spent-fuel bundle layers. The effects of removing the background radiation would depend on the relative signal amplitude of the scintillation material and the optical fiber. The newly developed verification system is expected to reduce the time and effort required for IAEA safeguards inspection activities and to lower the nuclear operator's burden.

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