# Necessity of Integrated γ Detector Development to Improve National Safeguards System

Ki Hyun Kim
*Korea Institute of Nuclear Nonproliferation and Control, Yusungdae-ro 1534, Yusung-gu, Daejun, Korea, 305-348*
**Corresponding author: khkimb@kinac.re.kr*

## 1. Introduction

The nuclear power plant industry in the Republic of Korea has grown dramatically since it has started the first commercial operation 33 years ago. According to the statistics from Korea Hydro & Nuclear Power (KHNP) in 2010, there are 16 Light Water Reactors (LWRs) in operation and 8 additional LWRs under construction. Furthermore, the number of nuclear power plants will double by 2030. However, increasing amounts of spent fuel assemblies has escalated the IAEA's request for the higher level verification of spent fuel assemblies. In addition, several technical issues have been raised during the Joint Review Meeting on Safeguards Implementation(JRM) between the ROK and the IAEA in order to apply the IAEA equipment, such as SFAT, IRAT, for verifying LWR spent fuel assemblies and non fuel items as well.

In 2009, as Integrated Safeguards(IS) come into effect to all nuclear facilities in ROK, the effectiveness and high performance level of the State System of Accounting for and Control(SSAC) were being required to implement entire safeguards activities. Prior to implementing IS, the SSAC of ROK verified LWR spent fuel assemblies only when they accompanied with IAEA inspectors. Also, the SSAC of ROK should depend on IAEA verification equipment. After coming into effect of IS in ROK, however, the role of SSAC is increasing and the SSAC has been required to acquire its own verification equipment to implement safeguards activities.

For this reason, developing own verification equipment has become indispensable to the SSAC not only to verify LWR spent fuel assemblies and non-fuel items stored in the spent fuel pool but also to enhance its performance level of national safeguards implementation.

This paper analyses the technical problems with the application of existing IAEA equipment through the survey in R&D results regarding nuclear material verification equipment. Furthermore, it will provide validity on the necessity of the verification equipment development for national safeguards implementation and give the direction of development.

## 2. Need for integrated verification equipment

### *2.1 IAEA spent fuel verification equipment*

The SFAT(Spent Fuel Attribute Tester) consists of a MCA(Multichannel Analyzer) and a NaI or CdZnTe detector. It takes measurements from the top of a fuel assembly as it places in the storage rack. The SFAT provides a verification of the presence of spent fuel assemblies through the detection of γ-rays emitted from $^{137}Cs$ (662 keV) of spent fuel assemblies. The detector and its lead shielding are housed in a stainless steel watertight container which is submerged in a spent fuel pool and positioned on the item to be measured. The collimator pipe is attached below the detector housing so that the radiation from the specific fuel assembly rather than from adjacent assemblies reach the detector. The MCA provides for acquisition, recording, analysis of data and supplying power to the detector. The spectral information of the selected γ-rays from a specific fuel assembly is compared with the spectrum from its neighbor to confirm the presence of fission products in the measured assembly.


Fig. 1. IRAT : Irradiated Fuel Attribute Tester

The IRAT(Irradiated Fuel Attribute Tester) is a small, lightweight CdZnTe based detector. It can be used to measure a fission product spectrum from a spent fuel assembly partially raised from a storage rack. The detector is housed in a stainless steel cylinder that includes shielding and a collimator. The MCA collects and analyses spectral information from a spent fuel assembly. The presence of fission product isotopes such as $^{137}Cs$, $^{144}Pr$, $^{154}Eu$ and others is used to confirm the irradiated fuel characteristics.

### *2.2 Problems to apply IAEA verification equipment*

There are two problems with application of IAEA equipment currently being used to verify spent fuel assemblies.

First, the low efficiency of verification work. SFAT and IRAT are being used to identify the genuineness of spent fuel assemblies and non fuel items in the spent fuel pool at the same time. Generally, there is only one crane at the spent fuel pool area. The verification works using SFAT or IRAT which is hanged on the crane would remain the efficiency of work low since verification should be implemented respectively.

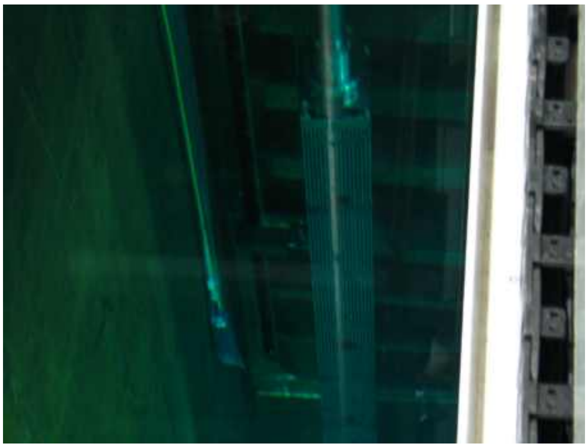

Fig. 2. The Spent fuel verification work using IRAT

Second, the safety problems by handling fuel assemblies. SFAT does not need to handle spent fuel assemblies because the collimator of SFAT takes measurements from the top of a fuel assembly as it places in the storage rack. The collimator of IRAT, however, was designed to take measurements from the side of target items. The items to be verified such as fuel assemblies or other non fuel items should be lifted and moved to the side of IRAT. Due to the above mentioned safety reasons the operators of nuclear facilities in ROK have hesitated the application of IRAT.

*2.3 Environment to develop verification equipment*

In the ROK, R&D results in the field of nuclear material verification equipment have been limited due to the severe conditions of spent fuel pool and heavy dependency on foreign technologies for detectors and MCA. All over the world, not merely in Korea, no nation currently owns verification equipment which can verify spent fuel assemblies and non fuel items at once. Even if there is such equipment, importing the equipment is limited since demands for the equipment remain low. This condition also makes it hard for co-production with commercial companies.

In this regard, the ROK has considered modifying or importing IAEA equipment to implement national safeguards. Considering the ROK's role as a nuclear exporting country, however, the Korean government has recently decided to develop its own verification equipment within the SSAC of the ROK. It would ultimately enhance cooperation between the ROK and the IAEA.

## 3. Conclusions

An increasing number of nuclear power plants has led a number of countries to pursue its own technology in the verification field.

Nuclear Material Control Center(NMCC) in Japan has domestically developed Improved Cerenkov Viewing Device(ICVD). Furthermore, it has consistently invested a large number of resources to develop nuclear material verification equipment. Atomic Energy of Canada Ltd(AECL) also domestically developed ICVD through the Member State Support Program(MSSP). The ROK developed the Optical Fiber radiation Probe System(OFPS) which can verify Canadian Deuterium Uranium Reactor(CANDU) spent fuel assemblies and it has acquired the certification of 'category A' from IAEA.

The ROK has outstanding IT infrastructures and advanced nuclear technologies. The development of integrated verification equipment for LWR spent fuel assemblies will make it possible to solve the problems with application of existing verification equipment and to reduce the length of time for verification. The SSAC of ROK should develop verification equipment and techniques in order to enhance safeguards effectiveness and improve its efficiency. Moreover the developer should consider the operators opinion about the verification equipment.

## REFERENCES

[1] Safeguards Techniques and Equipment 2003 Edition, IAEA Nuclear Verification Series No. 1(Revised), 2003

[2] IAEA Safeguards: Staying Ahead of the Game, IAEA, July 2007

[3] M. S. Kim, J. S. Kim, J. B. Park, Necessity of National Safeguards Evaluation System to Improve National Safeguards System, KNS, May 2009

[4] The 18th ROK-IAEA Joint Review Meeting on Safeguards Implementation, MEST, December 2010