Application of National Safeguards Instruments for Spent Fuel Verifications to the IAEA Inspections

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1. Introduction

OLRs are significantly important facilities from Safeguards perspectives. CANDU NPPs require a lot of PDIs for IAEA safeguards inspection due to its unique characteristics. Safeguards efforts for interim inspection and transfer campaign to dry storage at four units exceed half of total IAEA inspection activities last year (Fig.1) [1]. Four OLRs are in operation at the Wolsong site. Wolsong unit 1 started its commercial operation in 1983. At a CANDU 600 MW reactor, 16 to 24 fuel bundles are replaced from two or three channels a day. About 5,000 fuel bundles are discharged and stored for six years in a spent fuel storage bay before its transfer to the dry storage (Fig. 2) annually at one unit. It requires for IAEA to update a safeguards scheme to maintain diversion path and equipment to verify the discharge of spent fuels from the core. Korea has developed safeguards instruments and shares with IAEA for spent fuel verification. This paper explains the instruments that Korea developed in order to optimize national inspection in parallel with IAEA safeguards.

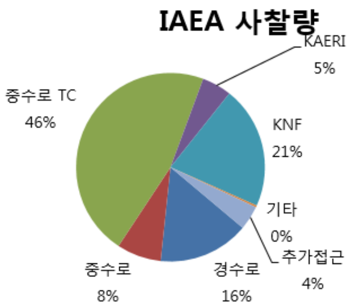

Fig.1. IAEA safeguards inspectional efforts in 2017.

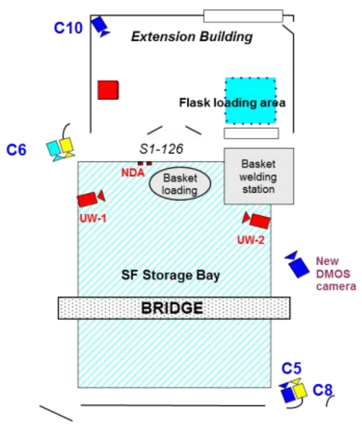

Fig.2. Spent fuel storage bay at the Wolsong NPP.

2. Safeguards Equipment for Spent Fuel Verification KINAC Developed

KINAC (the predecessor of TCNC) developed several Instruments for the safeguards inspections on spent fuels verification. Three of them were especially used at the spent fuel storage bay at the Wolsong NPP. These instruments were mainly developed for use in national inspection in consideration of potentiallly common use with IAEA inspection. Joint use of these equipment was discussed between Korea and IAEA. Those systems were performed well in real safeguards inspections and certified by IAEA. The first one is the Spent CANDU Fuel Verifier (SCAV), the second one is Spent CANDU Fuel Identifier (SCAI), and third one is Optical Fiber Probe Scintillator (OFPS)

2.1 SCAV (Spent CANDU Fuel Verifier)

SCAV was used to measure gamma rays emitted from spent fuel bundles piled up high on trays stored in a spent fuel storage pond. Operators move the underwater gamma scanning device equipped with a supporting tool, a stepping motor and a CdZnTe semiconductor radiation detector to acquire NDA data. The SCAV detection head moves in the spent fuel inventory where fuel bundles are stacked up on the storage rack in a bay. Fig. 3 shows gamma scanning signals on the spent fuel stacks in the storage rack of bay. In this figure, gamma ray intensities acquired at different positions are used for counting the number of spent fuel stacks.

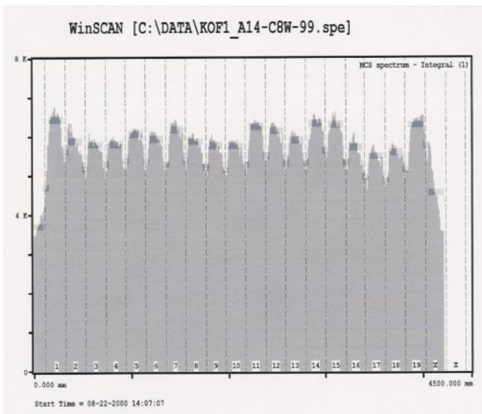

Fig.3. Gamma scanning signals on the spent fuel stacks

SCAV was replaced by Optical Fiber Probe Scintillator (OFPS) system due to its limited inspection coverage in 2007. Thick shield of CdZnTe detector in SCAV is not able to verify some spent fuels at the bottom layers beyond the funnel structure.

2.2 *SCAI (Spent CANDU Fuel Serial Number Identifier)*

SCAI was developed to read the serial number on the spent fuel bundle. Facility operators load 60 bundles from the tray into a basket placed on an underwater working table. Before operators put a cover onto the basket, inspectors confirm the serial numbers on the top surface of spent fuel bundles. Fig.4 shows the process of spent fuels loading inside a basket before its transfer campaign to dry storage. The transfer campaign has been taken place for about five months annually at each Wolsong unit. SCAI consists of three components: an underwater camera, light bulbs, and supporting guiding tools. With SCAI, pictures of serial numbers are taken with high resolution in the deep storage bay. It provides the images on the monitor and records them for storage and review (Fig.5).

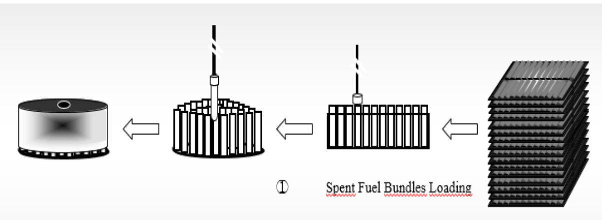

Fig.4. The process of spent fuels loading in a basket

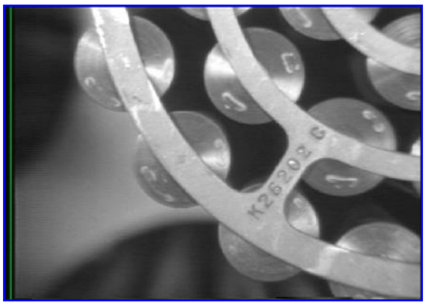

Fig.5 Image of the serial number taken by SCAI.

SCAI played a leading role until IAEA installed MiniGrand based system (MGBS) as an unattended monitoring system (UMS) in 2005. The UMS consists of two underwater cameras, two non-destructive analysis (NDA) detectors in the spent fuel bay (MGBS) and another detector on the transfer flask (Mobile unit neutron detector, MUND), respectively. Two underwater cameras are working on a regular basis in the spent fuel bay. In the dry storage, two NDA detectors (Silo entry gate monitor, SEGM) were installed, as well [2].

2.3 *OFPS (Optical Fiber Radiation Probe System)*

A new verification system based on optical fibers that make gross gamma measurement was developed. A Cerium activated silicate glass scintillator was used as a detector. It assists the re-verification of spent fuel bundles at the bottom layers in the funnel structure which SCAV is not able to measure. Fig.6 shows each of detector's insertion directions which was compared between SCAV and OFPS. The size of OFPS detector is a lot smaller than SCAV so as to pass through 1.5 cm gap between bundles. The OFPS system was certified by IAEA for the safeguards equipment (Category B) in 2007 [3]. The OFPS system stands in for the existing SCAV system.

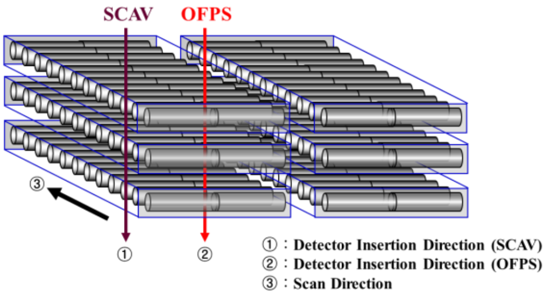

Fig.6. Two detectors are moving downwards or upwards between storage racks and between bundles, respectively.

The OFPS system consists of the scanning actuator, optical scintillator coupled to a flexible optical fiber detector, data acquisition electronics and portable computer. Fig.7 shows 16 counting peaks measured from the in-between bundles of trays. The number of measured bundles layers are compared with the number of the declared one for safeguards verification [4]. The OFPS is still used up to date.

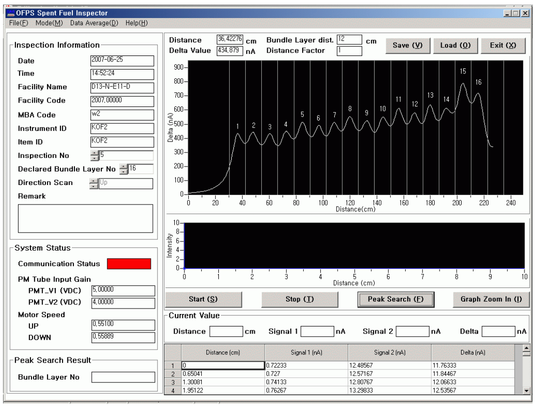

Fig.7. Measured counting peaks on the spent fuel bundles.

Unfortunately, current OFPS system is used once a year during IAEA PIV (Physical Inventory Verification) inspection. Besides, the equipment is stored on site at the plants without constant temperature and humidity control. Circumstances such as the low frequency of use and inadequate storage places stand in the way of maintain the system. Continuous maintenance/upgrade is necessary to increase its application to IAEA member states.

3. Conclusion

Korea has provided enhanced safeguards equipment to IAEA as an active measure to ensure the international transparency and credibility of nuclear activities. KINAC developed several equipment for safeguards inspections for national inspection and IAEA safeguards in mind. Three instrument were used especially for spent fuels verification at the spent fuel storage bay at the Wolsong NPP: SCAV, SCAI, and OFPS system. They were certified by IAEA as the safeguards equipment. These instruments were successfully applied for joint use. Two system are not applicable at this time after the changes of situation. However, the OFPS system is being used for IAEA safeguards inspection at the Wolsong NPP until the present.

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