Spent Fuel Transfer to Dry Storage Using Unattended Monitoring System

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1. Introduction

There are 4 CANDU reactors at Wolsung site together with a spent fuel dry storage associated with unit 1. These CANDU reactors, classified as On-Load Reactor (OLR) for Safeguards application, change 16-24 fuel bundles with fresh fuel in everyday. Especially, the spent fuel bundles are transferred from spent fuel bays to dry storage throughout a year because of the insufficient capacity of spent fuel pond. Safeguards inspectors verify the spent fuel transfer to meet safeguards purposes according to the safeguards criteria by means of inspector's presence during the transfer campaign. For the verification, 60-80 person-days of inspection (PDIs) are needed during approximately 3 months for each unit.

In order to reduce the inspection effort and operators' burden, an Unattended Monitoring System (UMS) was designed and developed by the IAEA for the verification of spent fuel bundles transfers from wet storage to dry storage. Based on the enhanced cooperation of CANDU reactors between the ROK and the IAEA, the IAEA installed the UMS at Wolsung unit 2 in January 2005 at first. After some field trials during the transfer campaign, this system is being replaced the traditional human inspection since September 1, 2006 combined with a Short Notice Inspection (SNI) and a near-real time Mailbox Declaration.

2. Spent Fuel Transfer with UMS

In this section, spent fuel transfer process and components of the UMS are described. The UMS is a combination of Non-Destructive Analysis (NDA) and surveillance equipment. Its main objective is to replace human surveillance and still maintain the Continuity of Knowledge (COK) of nuclear material being transferred from the spent fuel pond in CANDU reactors to the dry storage.

2.1 Spent Fuel Transfer Process

The spent fuel bundles cooled over 6 years in the spent fuel pond are applied to the transfer campaign. The basket for spent fuel transfer is filled with 60 bundles and covered under water. Bundles are verified by item counting, serial number identification, and gross defects test before loaded into the basket. The dried basket are then welded and transferred to the dry storage in a shielded flask mounted on a truck. The baskets are loaded by layers in a concrete silo that can contain 9 baskets. Fully loaded silo is welded and kept under dual containment and surveillance (C/S). Fingerprint is taken for each silo for re-verification after the planned transfers are completed. Figure 1 provides an overview of the transfer process and the location of the different instruments.

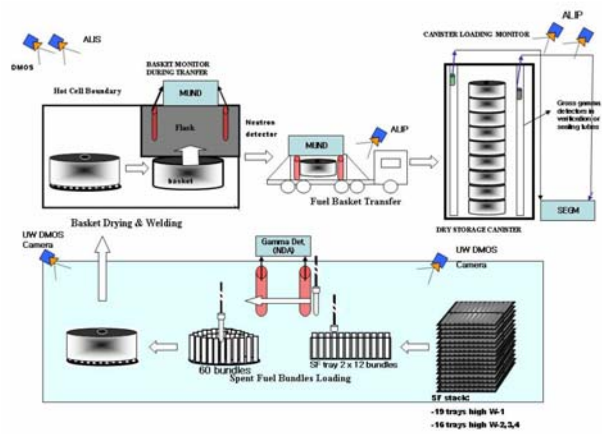

Fig. 1. Diagram of the UMS.

2.2 Unattended Monitoring System (UMS)

The UMS at Wolsung is composed of surveillance and NDA systems. The installed equipments are Digital Multiple Optical Surveillance (DMOS), All In One System (ALIS), and All In One Portable (ALIP) for surveillance system and VIFM, Mobile Unit Neutron Detector (MUND), and Silo Entry Gamma Monitor detectors (SEGM) for NDA system.

Underwater cameras monitor the underwater transfer activity from two different sides in the spent fuel pond. These cameras are used to enable 100% item counting of the spent fuel bundles loaded into the baskets. As each bundle is moved from its tray to the basket, it passes in front of a pair of gross gamma detectors. The signal collected detects the direction of motion and performs attribute verification. Figure 2 shows a sample of the signature collected during the loading of 12 bundles.

MUND installed on the transfer flask detects the loading and unloading of a full basket into/from the transport flask. This NDA radiation monitoring system is in a sealed waterproof enclosure with a battery pack mounted on the upper part of the transport flask. ALIP mounted on the truck carrying the transport flask provides redundancy for the MUND.

While being get into the concrete silo, the basket is further monitored by a pair of SEGM inserted in the silo re-verification tubes. The detectors are secured in their position until the silo end-plug is installed and welded, and the IAEA's seals are attached. ALIS installed in the dry storage area provides also backup measure in case of SEGM failure.

The transmission of NDA data and state of health information from UMS, except ALIS and ALIP cameras, should be performed from the data collection server in the facility CCTV room and remote server at the dry storage area to the IAEA headquarters in Vienna and the IAEA office in Gyeongju.

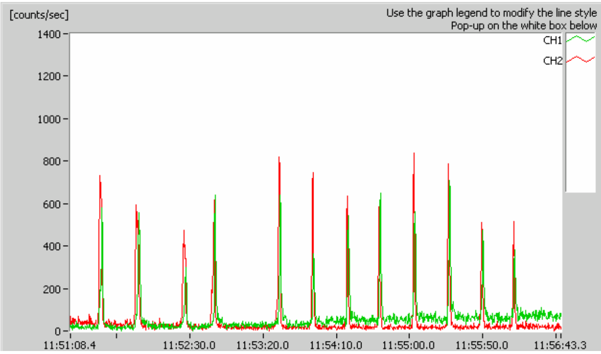

Fig. 2. Loading of half a tray (12 bundles) in the spent fuel bay.

3. Considerations

As spent fuel capacity of dry storage is decreased, the new concept of dry storage, called the MACSTOR/KN-400, is under construction. It is developed based on the MACSTOR-200, which was developed and constructed in Canada and designed to consist of 40 canisters. In addition, KHNP is preparing new type of transport flask possible to transfer two baskets at the same time due to permission expiration of current transport flask. The IAEA and the ROK discuss how to apply safeguards to MACSTOR/KN-400 and new type transport flask and exchange opinions for developing an appropriate inspection method.

All UMS data except MUND are transmitted to the IAEA headquarters at present, so the method of MUND data transmission should be also discussed. Moreover, the current installed NDA equipment is required adjustments.

4. Conclusions

UMS at unit 1 was lastly installed in the early 2008 and the transfer campaigns with UMS were successfully finished at all units of Wolsung site in 2008. The implementation of enhanced cooperation based on UMS to the spent fuel transfer campaign is a major achievement in the process of verification of spent fuel transfer to dry storage at CANDU reactors. It is proving to be an effective and efficient substitution to the continuous presence of inspectors during the spent fuel transfer processes, and reduce the IAEA's inspection effort. However, the present issues to enhance safeguards efficiency and effectiveness should be resolved with sufficiently discussion between the IAEA and the ROK.

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