Safeguards challenges of Fast Breeder Reactor

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1. Introduction

Although the safeguards system of Sodium Fast Reactor (SFR) seems similar to that of Light Water Reactor (LWR), it was raised safeguards challenges of SFR that resulted from the visual opacity of liquid sodium, chemical reactivity of sodium and other characteristics of fast reactor.

As it is the basic concept stage of the safeguards of SFR in Korea, this study tried to analyze the latest similar study of safeguards issues of the Fast Breeder Reactor (FBR) at Joyo and Monju in Japan.

For this reason, this study is to introduce some potential safeguards challenges of Fast Breeder Reactor. With this analysis, future study could be to address the safeguards challenges of SFR in Korea.

2. Safeguards approaches for the FBR

It is common understanding that the international safeguards objective is the timely detection of the possible diversion of the fuel at the interested facility. Therefore the goal quantity for detection on the plutonium-bearing TRU-fuel at Monju is 1 SQ (or 8 kg of Pu) in the form of TRU-fuel, fuel rods, or portions thereof. As the timeliness goal for detecting the possible diversion depends on whether the plutonium is in un-irradiated "fresh" or irradiated "spent" fuel, the timeliness goal of spent fuel is one month and that of fresh material is three months. It indicates the need for monthly field inspections by the IAEA inspectors at Monju site.

It has been also applied similar nuclear materials (NMs) accounting procedures in accordance with the IAEA safeguards agreement such as defining Material Balance Areas (MBA), Key Measurement Points (KMPs) and strategic points for Containment and Surveillance(C/S), nuclear material accountancy etc. Besides thes safeguards measures, more robust safeguarding features were applied at Monju, including hardened secured storage locations for the TRU-fuel assemblies, advanced redundant C/S, continuous, unattended custom-designed Non-Destructive Assay (NDA) .

Under the Additional Protocol to the safeguards agreement between Japan and the IAEA, it is applied additional measures such as provision of annual updated information on nuclear-related equipment and nuclear related research, all nuclear facilities and activities,

In fast breeder reactors, the access of the reactor core is difficult to verify the inventory of fuel in the reactor core. In this case, Japan and the IAEA agreed that dual containment and surveillance measures to monitor the movement of fuel to and from the reactor core to meet inspection goals. The surveillance systems for experimental fast breeder reactor JOYO and the prototype fast breeder reactor MONJU of JAEA consist Modular Integrated Video Surveillance (MIVS) system and radiation monitoring systems.

3. Safeguards challenges for the FBR

Considering the coolant sodium of a SFR is opaque to light, a conventional visual observation is not available for safeguards purpose. Because spent fuel from sodium reactors is placed in a sealed can prior to introduction to the spent fuel pond, there is no opportunity to check the balance between the fresh fuel storage area and the spent fuel pond. It may be possible to use Under-Sodium Viewing (USV) of serial numbers of fuel assemblies in ex-vessel storage combined with CoK between storage and the canning station to generate a verified association between fuel assembly serial numbers and can serial numbers to allow item accountancy. While this USV technology with ultrasonic waves has been widely developed for examining the structures of the reactor core and internal components of SFR in 1972, this ultrasonic viewing technology has been demonstrated under reactor conditions and has sufficient resolution to permit ready confirmation of serial numbers of fuel assemblies under liquid sodium.

A second difficulty associated with canned fuel becomes evident when CoK of the spent fuel pond is lost. Cerenkov viewing of canned spent fuel cannot distinguish fuel from irradiated non-fuel nor can it detect pin diversions. At Monju the surveillance systems are complemented by redundant non-destructive assay systems to detect the presence and distinguish among dummy, DU blanket, fresh TRU fuel and spent TRU fuel. For addressing partial defects such as the removal of spent fuel pins, it was suggested the pin diversion system that proposes insertion of tiny neutron and gamma detectors inside guide tubes to detect partial removal of spent fuel. An alternative may be to use camera to record assembly serial numbers during the canning process. The spent fuel storage pond itself is normally under redundant video surveillance. This surveillance is used to confirm the arrival of spent fuel assemblies and the removal of any spent fuel assemblies from the pond.

4. Remarks

While some reactor types can be safeguarding using traditional item accountancy with the deployment of new technologies, the innovative reactor types may

require more newly innovative safeguards approaches to achieve the measurement goals in a robust and reliable mood.

This study reviews the current safeguards status and issues of FBR. Several safeguards challenges are in progress to address the current loopholes of safeguards systems. Further study is needed to explore the safeguards issues of other reactor type such as Small Modular Reactor (SMR) or Very High Temperature Reactor (VHTR) which are considered the next generation reactors in Korea.

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