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A Study on MBA & KMP for implementing Safeguards by Design (SBD) in SNF interim storage facility

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1. Introduction

In Korea, Spent Nuclear Fuel (SNF) is temporarily managed in dry or wet storage facilities on the nuclear power plant (NPP) site. As the saturation period of temporary storage facilities approaches, the need for interim storage facility to safely manage SNF without shutting down NPPs is becoming apparent. Since the selection of a disposal facility site and operation is time-consuming nature, there is an urgent need to construct an interim storage facility to address this process.

Interim storage facility is subject to safeguards in accordance with the Additional Protocol to the IAEA Safeguards Agreement [1]. Recently, the “Safeguards by Design (SBD)” approach, which considers safeguards from the design stage of nuclear facilities, has been emphasized. SBD is a method that integrates international safeguards considerations necessary for the entire cycle of nuclear facility planning, design, construction, operation, and decommissioning in the design stage [2].

The interim storage facility site and storage method must be selected by comprehensively considering engineering safety and residents' opinions. However, in Korea, no decisions have been made yet. In these uncertain situations, it is necessary to clearly identify safeguards considerations at each stage of the project and develop an implementation plan accordingly to ensure timely construction of interim storage facility when needed.

This study aims to implement SBD in the early stages of the interim storage project, categorized the project stages, and derived safeguards considerations from the operator's perspective. In addition, conceptual designs of Material Balance Area (MBA) and Key Measurement Point (KMP) were proposed as part of the safeguards application plan.

2. Safeguards considerations for interim storage

2.1 Requirements for safeguards

The main stages of the interim storage facility project are divided into planning, design, construction, and operation. When applying safeguards to new nuclear facilities, the facility manager must prepare Design Information Questionnaires (DIQ), which include the types and flows of nuclear and non-nuclear materials, specifications of equipment, and drawings of the facility. Initial Design Information (DI) must be submitted at the preliminary concept design stage, which is the initial stage of the design process. After submission, consultations and information updates must be continuously made in accordance with the requirements of the International Atomic Energy Agency (IAEA). When the construction of a facility is confirmed, the DI is required to be submitted, and after construction is completed, the final DIQ must be submitted. The IAEA may initiate site visits before construction begins and may conduct various activities for Design Information Verification (DIV) [3].

2.2 Safeguards considerations

The three major activities of safeguards are nuclear material accountancy, Containment/Surveillance (C/S), and inspection. Interim storage facilities have the following characteristics.

- There is difficulty in direct measurement through sampling unless the container is unsealed.
- Direct access to the SNF during storage is limited.
- Facilities handle identifiable containers containing nuclear materials (Item facilities).

Considering these characteristics, it is crucial to seal and verify storage containers and install monitoring devices for proper initial verification and implementation of C/S. There is a need to maintain the Continuity of Knowledge (CoK) through these measures. CoK is a concept that ensures safeguards by maintaining the integrity of the information flow of nuclear materials without missing or damaging any data.

MBA and KMP are significant components for nuclear material measurement and management. Pre-setting and simulation are essential for safe management and effective monitoring of nuclear materials.

3. Safeguards applications for interim storage

3.1 Conceptual design of interim storage facility

To propose the MBA and KMP setup methods, interim storage facility was initially conceptualized. It was assumed that SNF would be unloaded from the transport container and stored in a storage container. Storage facility was largely divided into Acceptance/Handling building, Storage building, Building for taking out SNF, and other High-Level radioactive Waste (HLW) storage building. Major areas within the buildings were subdivided as follows:

- Acceptance/Handling Building
  - Acceptance & Standby, Unloading, Inspection, Empty container decontamination & Storage, Temporary storage
- Storage Building
  - SNF Storage
- Building for taking out SNF
  - Repackaging & Container Loading
- Other HLW storage Building
  - Other HLW storage

3.2 Conceptual design of MBA

The MBA is responsible for determining the inventory of nuclear material within the facility and ensuring the accuracy of nuclear material flow measurements. By subdividing the MBA, it can be assigned to each building. When transferring inventory between two MBAs, however, individuals handling the same specific nuclear material are required to prepare two inventory change reports simultaneously for both taking in and out. This process results in an unnecessary increase in workload for operators, regulatory agencies, and the IAEA.

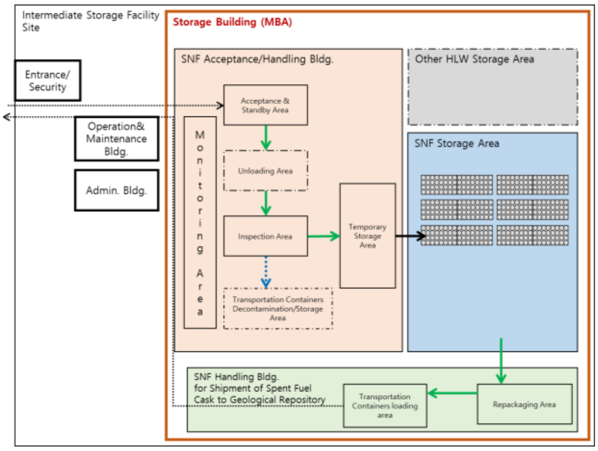

Fig. 1. Conceptual design of MBA for the SNF interim storage facility.

If the verification requirements of several MBAs are found to be consistent, they can be consolidated into a single MBA for conducting material accountancy. The interim storage facility is an item facility, which makes material accountancy easier than a bulk handling facility. If it is demonstrated that C/S is maintained, it can be constructed with a single MBA. Reflecting this, the interim storage facility MBA flow is shown in Fig. 1.

3.3 Conceptual design of KMP

The KMP refers to "a point designated to measure the inventory and movement of nuclear materials within one MBA or between MBAs" [4]. To maintain CoK without inspector presence, measurement efforts must be focused on setting up appropriate KMPs. KMP is divided into Flow KMP and Inventory KMP. For the entire process, inventory KMP can be specified by subdivided area. Table I shows how inventory KMPs were set accordingly. Figure 2 illustrates the relationship between flow KMPs and Inventory KMPs in relation to the SNF acceptance process. Flow KMP refers to the location where material appears in such a form that it can be measured to determine flow. In Fig. 2, flow KMP can only be set at KMP-1, 6, 7, and 9, which are the building boundaries, without any other flow KMPs. Inventory KMP-A to E belong to the same building, but the layout of buildings and processes may change as the design progresses. Since the design of the interim storage facility is not yet finalized, the flow KMPs were divided as much as possible, considering all aspects.

Table I: Inventory KMP classification

Classification	***Area***
KMP-A	Acceptance & Standby Area
KMP-B	Unloading Area
KMP-C	Inspection Area
KMP-D	Transportation Containers Decontamination & Storage Area
KMP-E	Temporary Storage Area
KMP-F	SNF Storage Area
KMP-G	Repacking Area
KMP-H	Container Loading Area
KMP-I	Other HLW Storage Area

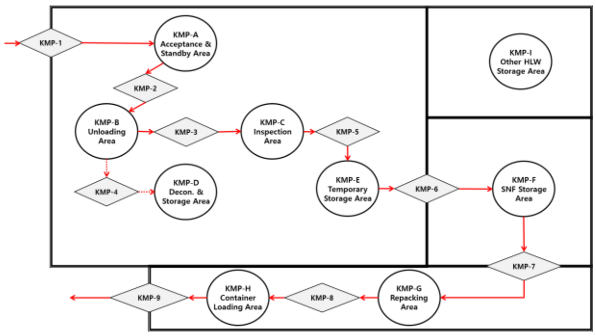

Fig. 2. Conceptual design of KMP for the SNF interim storage facility.

4. Conclusions

In this study, we investigated the safeguards considerations that facility operators should prepare for the timely construction of interim storage facility. As a result of the investigation, it was confirmed that DI and DIQ must be submitted to the IAEA. It is also necessary to prepare related documents in advance to respond to inspections and regulatory agencies.

MBA and KMP setup methods were proposed as part of the safeguards application plan. The entire facility was designated as an MBA, and major areas within the facility were designated as Inventory KMP to ensure the integrity of nuclear material flow. The flow KMPs were set between each area with as much detail as possible considering all aspects, because the design of the facility is not finalized yet. This decision may be changed as the design progresses in the future.

Future studies should differentiate the flow of nuclear materials based on storage and transportation methods and establish KMP accordingly.

The results of this study can be used as a strategy for safeguards when constructing interim storage facility in the future. It is regarded that this will save response time during IAEA inspections and DIV.

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