Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 18-19, 2023

Analysis of Safeguards-by-Design Regulation Approach for Spent Fuel Dry Storage Facility Construction in Site

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1. Introduction

The purpose of the IAEA safeguards system is to provide credible ensure to the international community that nuclear materials and other specified items were not diverted from peaceful nuclear uses. The safeguards system consists of the IAEA's authority to establish safeguards, the safeguards rights and obligations in safeguards agreements and additional protocols, and technical measures implemented pursuant to those agreements. Of foremost importance as a based on IAEA safeguards is the international safeguards agreement between a country and IAEA, concluded pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons(NPT) [1].

In nuclear safeguards, spent fuel pools at nuclear power reactors are reaching their capacity. Since there is no long term Spent Nuclear Fuel(SNF) storage solution currently, dry cask storage is practiced in the interim storage facility. Once the cask is sealed, it is difficult to verify its contents, hence posing a nuclear safeguards concern because of the potential for misuse of plutonium inside the dry cask.

In the absence of a national long term spent fuel repository, spent nuclear fuel would move to dry storage such as Independent Spent Fuel Dry Storage Installations(ISFSIs) designed by Unite State. These are designed to provide safe storage for decades, until the fuel is either reprocessed or entombed in a long term repository.

In this circumstance, especially in the construction stage, safeguards-by-design(SBD) regulation approach is necessary to ensure the integrity of safeguards of spent nuclear fuel dry storage facility.

SBD regulation has two main objectives, first, to avoid cost issues and redesign work or retrofit of new nuclear fuel facilities and second, to make the implementation of international safeguards more effective and efficient at such facilities. The attainment of these goals would relieve industry and the International Atomic Energy Agency(IAEA) burden, economic, and resources.

In this paper, in particular, necessity of Safeguards-By-Design regulation approach was analyzed by safeguard implementation perspective in Republic of Korea.

2. Safeguards-By-Design Regulation Approach

The IAEA Safeguards detection goals: Under Article 28 of INFCIRC153, the technical objective of international safeguards is "the timely detection of diversion of significant quantities of nuclear material from peaceful to non-peaceful uses, and the deterrence of such by the risk of early detection. In addition, the IAEA must detect any potential misuse of the facility for undeclared purposes [2].

One significant quantity(SQ) is the approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be excluded [3]. Table 2.1. shows the SQ values of various nuclear materials.

Table 2.1. IAEA Significant quantities for nuclear material

	Material	SQ
Direct-use	PU(containing <80% ^{238}Pu)	8 kg
	^{233}U	8 kg
	HEU(^{235}U >20%)	25 kg
Indirect-use	LEU(^{235}U <20%)	75 kg
	Th	25 ton

The IAEA is currently in transition, moving towards a state-level safeguards approach, and will rely less on facility-centric safeguards criteria in the future. Relevant safeguards goals are cited from the IAEA Safeguards Criteria for inspecting "Storage Facilities"

o Safeguards Detection Goals relevant to Storage

- Detect the diversion of 8kg of plutonium in the form of spent fuel within three months of possible diversion
- Detect the diversion of 8kg of 233-uranium in the form of spent fuel within three months of possible diversion
- Detect the diversion of 75kg of 235-uranium in the form of spent low-enriched fuel within one year of possible diversion
- Detect the diversion of 20 tons of thorium in the form of spent fuel within one year of possible diversion

In terms of design, the facility must accommodate IAEA safeguards equipment(e.g. seals, surveillance, and radiation detection system). As the dry storage is being designed and constructed, the facility operator, State regulatory authority, and IAEA should also discuss whether the dry storage facility will need to accommodate other measures, such as the remote monitoring of safeguards equipment.

In the implementation of international safeguards, nuclear material accountancy is the safeguards measure of fundamental importance with containment and surveillance as important complementary measures. Simply, nuclear material accountancy is meant to the accounting and control of the nuclear material inventories, and related inventory changes, with independent verification by the IAEA. In order to account for the nuclear material inventories and associated change, the facility operator should define a nuclear Material Balance Areas(MBAs), in consultation with the IAEA.

Typically, each dry storage would be defined as a separate and distinct MBA, although a very large regional dry storage could be sub-divided into multiple MBAs to facilitate accounting. The facility operator and designer propose the MBA layout and structure to the State Regulatory Authority. In this regard, an MBA layout diagram should be prepared by the facility operator at the earliest design stage, because it allows them to visualize the over-arching issues regarding safeguard of the nuclear material, where is the nuclear material stored, inventoried, and where could the transfers be verified. It is advisable to involve the IAEA in these discussion at early stage, since the layout of the MBA and associated Key Measurement Points(KMPs) impact the implementation of nuclear safeguards.

The Fig.1. shows the most basic MBA layout diagram for a dry storage facility and nuclear site. There is on inventory KMP, where the nuclear material would be stored. It does not matter if the spent fuel storage is in dry vertical cask, horizontal cask, or modular vaults. In the simplest case, there would be on nuclear material transfer path into the MBA, flow KMP-1, and the other transfer path out, KMP-2. The MBA layout diagram indicates the spent fuel receipts would be verified, or checked at KMP-1, prior to storage. It also indicated that if the spent fuel were shipped from the dry storage facility, such as to a long-term geologic repository, the spent fuel would be verified during shipment at KMP-2.

Once a dry cask has been sealed, verification of its contents is very challenging. This loss of Continuity of Knowledge(CoK) is risky and must be overcome. Hence, current spent fuel verification methods should be improved to ensure the timely detection of the diversion of a significant quantity of nuclear materials. In this example, the most likely diversion scenarios are; 1. Diversion of spent fuel prior to transfer to the dry storage, 2. Diversion of spent fuel during transfer to the dry storage, 3. Diversion of spent fuel from storage at the dry storage, 4. Diversion of spent fuel during shipment from the dry storage.

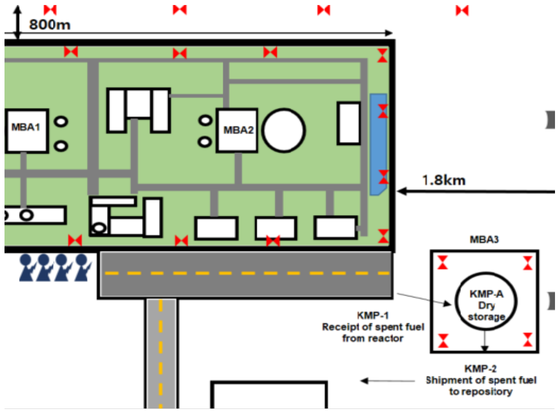

Fig.1. Material Balance Area(MBA) layout and Key Measurement Points(KMPs) for dry storage facility and nuclear site.

From the foregoing discussion, the dry storage facility and associated spent fuel transfer and storage casks or vaults, should be designed to accommodate the following systems

- Use of IAEA dual sealing systems
- Use of IAEA surveillance systems
- Use of IAEA radiation detectors
- Possible remote monitoring and transmission of date from IAEA seal, surveillance, and radiation detection systems
- Safe engineering access to the spent fuel storage casks
- Use of emerging safeguards measures
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4. Conclusion

In this paper, in particular, necessity of Safeguards-By-Design regulation approach was analyzed by safeguard implementation perspective in Rep of Korea.

Firstly, Safeguards Detection Goals relevant to Storage was explained in section 2 by 4 categories. Each steps include detail information which is used to set up target set identification.

Secondly, the procedure of MBA and KMPs identification was explained by MBA layout and KMPs diagram.

Consequently, there are insufficient requirements for the safeguards CoK and inspection procedure of the dry storage facility in Republic of Korea, and therefore regulatory and inspection measures based on IAEA Working Group are needed.

Acknowledgement

This work has been supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety(KOFONS), using the financial resource granted by the Nuclear Safety and Security Commission (NSSC) of the Republic of Korea(No. 2106018)

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