A Study on Current Status and Challenge of the Application of Safeguards by Design

Jin Young Lee
Korea Institute of Nuclear Nonproliferation and Control, 1534 Yuseong-daero, Yuseong-gu, Daejeon, 34054, Korea
Corresponding author: jylee86@kinac.re.kr

1. Introduction

The International Atomic Energy Agency defines Nuclear Safeguards as follows: "Safeguard are a set of technical measures applied by the IAEA on nuclear material and activities, through which the Agency seeks to independently verify that nuclear facilities are not misused and nuclear material is not diverted from peaceful uses. States accept these measures through the conclusion of safeguards agreements."

In the process of applying the safeguards to each country's nuclear facilities, it was reported that safeguards considerations had often been introduced after a facility's design had been frozen or after construction had reached an advanced stage. In some cases, this had resulted in costly redesign and project delays and had reduced the efficiency and effectiveness of safeguards implementation. For solving this fundamentally, the concept of Safeguard by Design (SBD) was introduced.

SBD is an approach that international safeguards are fully integrated into the design process of a new nuclear facility from the initial planning through design, construction, operation, and decommissioning. SBD has two main purposes. Firstly, it is for avoiding costly and time-consuming redesign work or retrofits of new nuclear fuel cycle facilities. Secondly, it is for making the implementation of international safeguards more effective and efficient at facilities. In terms of SBD, the requirements of IAEA are that a facility or process could be designed to minimize the time that inspectors would need to be present in the facility. This would benefit the IAEA by allowing it to redirect its resources to other activities. It would also benefit the operator by minimizing safeguards intrusiveness at the facility. The State would also benefit by reducing the resources necessary to support the activity. Like this, although SBD is not mandatory internationally and is not currently mandated by domestic law, SBD is highly essential for all stakeholders when considering the above.

2. Current status of the application of Safeguards by Design

2.1 IAEA

In 2013, the IAEA recommended that each country's nuclear regulatory framework include the concept of SBD. As the IAEA issued its recommendations for SBD, it published a guide named "International Safeguards in Nuclear Facility Design and Construction" to establishing relevant regulatory procedures and requirements in 2013. The guidelines introduce SBD and the basic principles and identify stakeholder roles in implementing them. The details are as follows.

- Analysis of the typical use/misuse scenarios by facility type
- General guidelines for the design of safeguards
- Safeguards to be considered when designing specific points and key points
- Required information when preparing a design information document
- Practice and implications through the analysis of similar cases

2.2 U.S.

Also, U.S. national research institutes have been carrying out research projects on SBD since the mid-2000s. The Idaho National Laboratory presented elements and methods of assessment to institutionalize SBD in 2010. The U.S. guideline set the IAEA SBD guidance previously introduced as an international safeguards requirement and defined it by each design stage. In other words, a similarity between the U.S. guidelines and IAEA guidance is that the principle and outline procedures of SBD are almost same, but the difference is that the U.S. guidelines contain more detailed procedures and also consider compliance with local regulatory requirements. The details are as follows.

- Define safeguards requirements
- Deriving actions by each design stage
- Development of safeguards technology and evaluation method
- Facility Safeguardability Assessment (FSA)

2.3 Europe

In Europe's case, EC/JRC proposed a stepwise evaluation method. However, detailed evaluation factors reflecting facility characteristics are still not included.

2.4 Canada

In Canada, SBD was applied to Advanced CANDU Reactor for Spent Fuel Verification. There were some

issue for applying SBD. Firstly, there was difficulty to verify spent fuel in piled spent fuel baskets. For solving this, verification point moved to an earlier part of the flow; Provision made to install radiation monitoring, surveillance at different location of the facility, which resulted in that prevented the need to retrofit equipment after facility construction; reduced cost for Safeguards instrumentation installation and burden on the operator. Secondly, verification of the loading of modular air cooled storage (MACSTOR) cylinders was once a human-inspection-intensive activity for the IAEA. For solving this, especially for the larger MACSTOR-400, additional dedicated monitoring tubes installed next to each of the 16 inner cylinders. Like this, as they introduced SBD concept in the early stage, the design was easily implemented, and which did not impact the structural integrity, the safety basis or the security constraints. These are good example of introducing SBD to real site and being beneficial to not only regulatory authorities but also operator.

2.5 ROK

In 2016, ROK established "The 2nd Strategic Plan for Nuclear Safety and Security in 2017 - 2021" which includes the preparation of standardized safeguards implementation guide and requirements for SBD for high-level radioactive waste management facilities.

3. Conclusions

IAEA already published 3 SBD guidance documents with respect to nuclear facility design and construction, nuclear reactor, and long term spent fuel management in 2013, 2014, and 2018 respectively. U.S. DOE/NNSA also prepared their own SBD guidance documents for research reactor and critical assemblies, independent spent fuel dry storage installations, Facility Safeguardability Analysis (FSA) Process in 2012. Compared to these, ROK is still in its early stages for preparing guidance documents for regulatory organizations and operators.

By 2030, starting from Kori Unit 1, 12 Nuclear Power Plants are planned to be decommissioned in ROK. In order to apply SBD during the design phase for interim storage, transportation and permanent disposal facilities of the nuclear spent fuel following the decommissioning of nuclear power plants, it is urgent to prepare standardized safeguards regulatory implementation guidelines and SBD requirements, taking into account the domestic environment. Also, considering future inspections by IAEA on Gijang Research Reactor which construction license is under review, close cooperation and communication with IAEA are necessary for preparing safeguards regulatory implementation guidelines and SBD requirements for efficient and effective safeguards implementation.

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