A Comparative Analysis of Significance Determination Process between the United States and Japan: Implications for Implementation of Reactor Oversight Process in Korea

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1. Introduction

Recently, the international nuclear regulatory community has increasingly adopted and expanded the use of the Risk-Informed, Performance-Based (RIPB) approach as a means to enhance the effectiveness, efficiency, and transparency of nuclear safety and security oversight. In response to this global trend, Korea has been studying the adaptation of the Reactor Oversight Process (ROP) for conventional reactor to facilitate differentiated regulatory measures. The ROP, implemented by the U.S. Nuclear Regulatory Commission (NRC) since April, 2000, is a process to inspect, measure, and assess the safety and security performance of operating commercial nuclear power plants and to respond to any decline in their performance [1]. Within the ROP, inspection findings (IFs) identified by inspectors are evaluated through the Significance Determination Process (SDP), which determines their risk significance level. The SDP employs a systematic flowchart to categorize findings and assigns one of four risk significance color codes - green, white, yellow, or red - based on the risk level. By benchmarking the U.S. NRC, Japan has adopted the ROP and adapted it to its national characteristics. A comparative analysis of the two processes could help identify key considerations for the adaptation of the ROP in Korea. In this study, a comparative analysis of the U.S. and Japanese SDPs for nuclear security is conducted and key considerations are derived to inform the development of a Korean SDP that addresses the domestic regulatory and operational context.

2. Case Study – United States

The U.S. NRC's security SDP consists of four parts; Baseline Security SDP (BSSDP), Force-on-Force SDP (FOFSDP), Construction Fitness-for-Duty SDP (CFFDSDP), Cyber Security SDP (CSSDP). The risk significance of IFs is evaluated through the SDP, which assigns a corresponding color code (e.g. green, white, yellow, red) [1].

- BSSDP is composed of six flowcharts: Material Control and Accounting (MC&A), Unsecured Safeguards Information (SGI), Significance Screen, Unattended Opening (UAO), Target Sets, BSSDP Worksheet, the flowchart for assessing the IFs is determined by the process depicted in Fig 1.
- FOFSDP is the process by which a licensee's training performance and inspection results related to training failures are evaluated.
- CFFDSDP is the process by which NRC inspectors and management evaluate inspection results at facilities subject to 10 CFR 26, "Fitness for Duty".
- CSSDP is the process by which inspection results related to cybersecurity requirements for nuclear power reactors are evaluated.

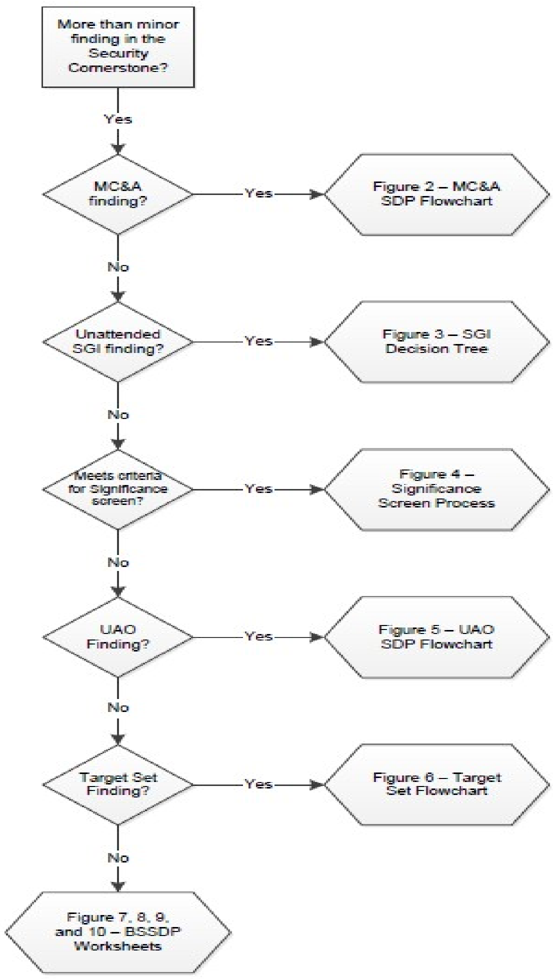

Fig. 1. BSSDP flowchart [2]

The six SDP flowcharts that make up BSSDP are designed to address different aspects of physical protection. The “MC&A SDP” is used to assess the significance of findings related to preventing theft or loss of special nuclear material. "Unsecured SGI SDP” focuses on factors affecting the likelihood of a breach by assessing the nature of the information and the circumstances under which it was neglected or inadequately protected. "Significance Screen SDP" evaluates a series of events that share common characteristics among physical protection-related findings, thereby assessing their impact on the physical protection program and time analysis tools. Selected events with common characteristics serve as entry criteria for this review. "UAO SDP" is an opening (e.g., a culvert or pipe) that allows entry, allows passage through the physical protection zone boundary, and has no substantial internal physical barrier. This process is used to assess whether such openings represent significant security vulnerabilities, focusing on whether the licensee's physical protection program has adequate "defense in depth" attributes. "Target Sets SDP” focuses on areas applicable to target sets, including the target set process itself, cyberattack considerations, and oversight mechanisms. Where appropriate, this SDP could also be linked to the "BSSDP Worksheet" or the “Cybersecurity SDP”.

The "BSSDP Worksheet" is a tool for assessing access authorization, access control, physical protection, and emergency response. Each worksheet identifies the physical protection area affected by the inspection finding (Owner Controlled Area (OCA), Protected Area (PA), Vital Area (VA)) and further categorizes sub-inspection items into Tiers I, II, and III, according to the significance of the IF's impact under the NRC's inspection procedures. The determination of significance is based on both the physical protection area affected and the number of inspection items implicated by the finding.

3. Case Study – Japan

In Japan, the Nuclear Regulation Authority (NRA) SDP for security comprises five annexes; Specific Nuclear Fuel Materials, Safeguards Information, Physical Protection, Unattended Openings (UAO), and Protection Measures. [3]

The appropriate SDP tool for assessing IFs is selected according to the following procedures.

1) When the IF relates to the management of specific nuclear fuel materials, it is assessed using “Specific Nuclear Fuel Materials SDP” flowchart.
2) If the IF relates to the management of nuclear material protection information, it is assessed using “Safeguards Information SDP” flowchart.
3) If the IF relates to physical protection and meets the criticality screen criteria, it is assessed using “Physical Protection SDP” flowchart.
4) If the IF relates to unattended openings, it is assessed using “Unattended Openings SDP” flowchart;
5) Finally, any remaining IFs are assessed using Protective Measures worksheet.

4. Comparative Analysis and Implications for Korea

Both SDPs developed in the United States (Chapter 2) and Japan (Chapter 3) employ structured flowcharts and decision criteria to assess IFs, and to assign a risk significance level. However, they differ in the following aspects.

- While Japanese regulations include requirements for the protection vital equipment, the concept of a “target set” is not explicitly defined within the regulatory framework.
- Japan does not legally mandate FOF exercises, and contract guards are prohibited from carrying weapons. Training is conducted voluntarily by licensees [4].
- The CSSDP is not an independent framework; rather, the Atomic Energy Association (ATENA) issues guidance to strengthen cybersecurity, and licensees are required to submit implementation plans for verification.

Although Japan benchmarked the U.S. SDP, it incorporated domestic conditions to establish distinct framework specific to its own regulatory and operational context.

In order to implement the SDP in Kora, it is necessary to take into account the domestic regulatory and operational context. Korea has several distinctive characteristics.

- Similar to Japan, Korea does not regulate at the “target set” level. Instead, regulations are applied only to designated vital areas.
- Unlike the United States or Japan, Korea treats nuclear security information as classified documents managed under separate legislation.
- In contrast to the United States, where MC&A inspections are conducted primarily from a security perspective, Korea carries out such inspections from a nuclear nonproliferation perspective. These inspections are performed to prepare for and support International Atomic Energy Agency (IAEA) safeguards.
- While Korea conducts physical protection exercises, their scope and intensity reflect national regulatory requirements rather than mirroring the level mandated in the United States.

Since this study focuses on the development of an SDP for conventional operating reactors, the construction fitness-for-duty SDP (CFFDSDP) is excluded from the scope of the proposed Korean SDP. Reflecting these conditions, the preliminary Korean SDP for nuclear security protection can be derived, which is presented in Table I.

A representative example of preliminary SDPs in Korea is presented in Fig. 2. In Korea, physical protection areas are classified as Sabotage PA and VA in terms of sabotage protection, and as Class III PA, Class II PA, and Class I PA based on the grade of nuclear materials, as specified in Ref.[6]. This classification differs from that of the United States, where areas are defined as the **OCA, PA,** and **VA**. Furthermore, in the United States, three types of UAOs – those connecting OCA to PA, OCA to VA, and PA to VA – are assessed according to decision criteria for each case. In contrast, according to the experts in regulatory institution, there are no openings in Korea that directly connect Class III PA and VA. Therefore, to reflect these distinct characteristics of Korea, the preliminary UAO SDP in Korea is structured as shown in Fig. 2: (1) adopting Korea's classification of physical protection areas and (2) establishing decision criteria for the two UAO types.

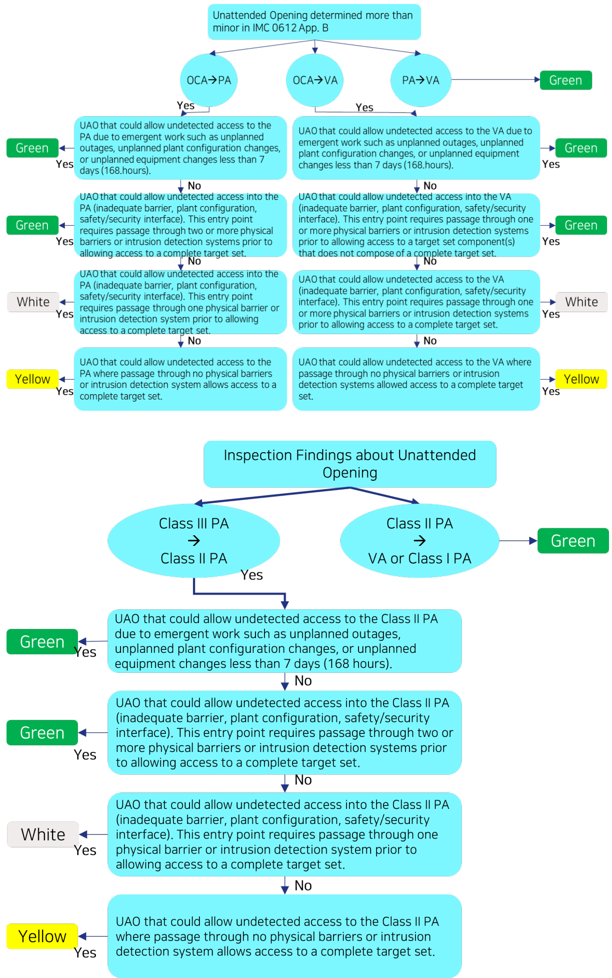

Fig. 2. U.S. NRC UAO SDP (Top) and Preliminary UAO SDP in Korea (Bottom)

Table I: Comparison of SDP

U.S. NRC	**Japan NRA**	**Korea-Preliminary SDP**
BSSDP	**Significance Assessment Guide for the Physical Protection**	**Nuclear Security SDP**
- MC&A	-Significance assessment guide for the management of specific nuclear fuel materials	-
-Unsecured SGI	-Significance assessment guide for the management of safeguards information	-
-Significance Screen	-Significance assessment guide for the physical protection	-Physical Protection (Effects Over Time)
-Unattended Openings	-Significance assessment guide for the unattended openings	-Unattended Openings
-Target Set	-	-
-BSSDP Worksheet (Access Authorization, Access Control, Physical Protection, Contingency Response)	-Significance assessment guide for protective measures (Access Authorization, Access Control, Physical Protection, Information Protection System, Nuclear Material Protection)	-Protection Measures (Access Authorization, Access Control, Physical Protection, Contingency Response)
FOFSDP	-	-
CFFDSDP	-	-
CSSDP	-	-Cybersecurity

5. Conclusion

This study examined and compared the SDP of the United States and Japan, with a particular focus on how Japan benchmarked the U.S. framework and adapted it to its domestic context. Based on these insights, a preliminary UAO SDP in Korea has been developed as a representative example to reflect Korea's unique characteristics.

Both the United States and Japan rely on structured flowcharts and decision criteria to evaluate IFs and assign levels of risk significance. However, the scope and implementation of the two systems differ in important respects. The US SDP incorporates elements such as MC&A, SGI protection, FOF exercises, cybersecurity evaluations, and target set assessment, whereas Japan has developed a simplified SDP that reflects national circumstances, including the prohibition on armed private security and the absence of mandatory FOF drills.

For Korea, this review underscores two critical points, First, in line with global trends toward risk-informed, performance-based regulation, it is important to adopt a structured process – similar to that of the United States – that can enhance both regulatory efficiency and credibility. Second, as the Japanese case demonstrates, overall adoption of the U.S. process may not be practical. Instead, a selective benchmarking approach that adapt the framework to Korea's legal, institutional, operational environment is likely to yield the most effective outcome.

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