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Review of Reactor Oversight Process for Security in the US and Japan

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1. Introduction

The Reactor Oversight Process (ROP) is the U.S. Nuclear Regulatory Commission (NRC)'s program to inspect, measure and assess the safety and security performance of operating commercial nuclear power plants and respond to any decline in their performance [1]. The ROP was adopted to U.S. NRC in April 2000 and is still in operation today.

Other countries have been developing their own risk-informed performance-based regulatory frameworks to enhance the effectiveness of the regulatory activities. Especially, Japan actively reformed the regulatory framework after Fukushima accident and adopted the ROP framework in April 2020 [2]. In Korea, ROP for safety has been studied extensively; however, ROP for security has not received much attention.

In this study, the ROP for security of the US and Japan have been reviewed and compared. It is intended to lay the foundation for the introduction of the ROP for security in Korea by reviewing cases of security-related application of ROP in the US and Japan.

Considering the two independent regulatory agencies take charge for safety (Korea Institute of Nuclear Safety, KINS) and security (Korea Institute of Nuclear Nonproliferation and Control, KINAC) separately according to the Nuclear Safety Act, integrating ROP procedures and findings for safety and security has been specially noted.

2. Methods and Results

In this section, ROP frameworks and security related application examples of ROP in the US/JAPAN are reviewed.

2.1 ROP Frameworks

The NRC has developed a regulatory framework for systematic reactor oversight. (Figure 1) A step-by-step approach based on risk-informed method is presented to secure public health and safety related to the use of nuclear power plants.

The ROP monitors the plant performance in seven cornerstones (initiating events, mitigating systems, barrier integrity, emergency preparedness, occupational radiation safety, public radiation safety, security) in three strategic performance areas (Reactor Safety, Radiation Safety and Safeguards) as shown in Figure 1. The focus is given on graded regulation based on objective risk and performance measurement. [1]

On the other hand, the Cross-Cutting Areas (CCA) are additionally reviewed to identify key issues that have a common influence on the seven cornerstones. It consists of three items: human performance, problem identification and resolution, and safety-conscious work environment. Within this framework, collection of the information on the performance of licensees (operators), assessment of safety significance, provision of appropriate responses can be performed.

Although the regulatory framework of the Japan- NRA uses slightly different terms from that of the US-NRC, it divides the surveillance area in a similar way.

The security cornerstone in the US was originally the "Physical Protection", and it was evaluated as the cornerstone of "Physical Protection" until the first quarter of 2004 after the introduction of ROP. From the second quarter of 2004 to 2011, the security cornerstone was excluded from the evaluation of inspection items and performance indicators. Since 2012, the "Security" cornerstone has been added back and has been still being evaluated. In Japan, the security is assessed as a cornerstone of "Physical Protection". [1, 2, 3]

2.2. Flowsheet to Perform the ROP

Figure 2 shows an assessment flowsheet to perform the ROP. This applies in common to both the US and Japan.

For each cornerstone, the regulatory agency (NRC or NRA) collects the inspection results and the licensee collects performance indicator data. The significance assessment like SDP (Significance Determination Process) of NRC is used to assess the impact of inspection results on safety/security and the performance indicator is compared with the established risk-based thresholds. Then, by considering both results of the significance assessment and the performance indicator evaluation grade, the reactor performance evaluation is performed. The reactor performance is divided into five columns, from the grade that does not require additional regulatory action to the grade that cannot be operated, and countermeasures are taken accordingly.

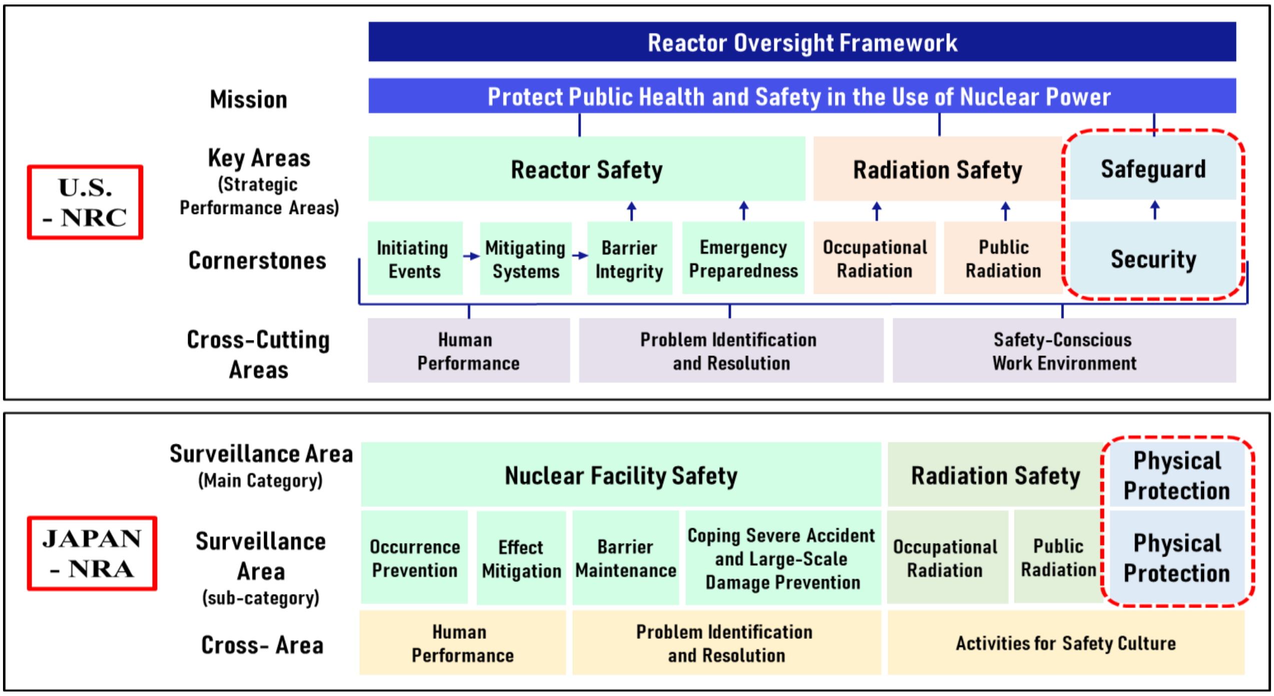

Fig. 1. ROP Regulatory Framework

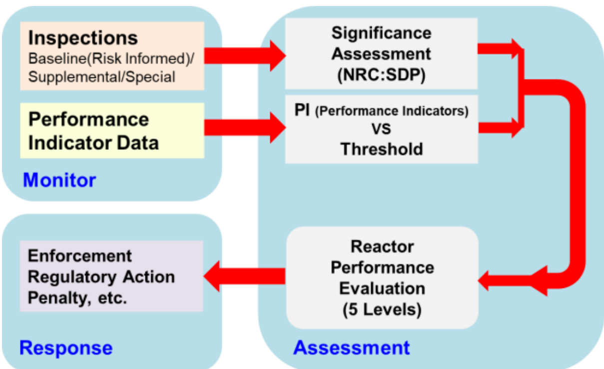

Fig. 2. Flowsheet to Perform the ROP

In the case of US-NRC, the guidelines in the Action Matrix are used to determine the appropriate response. Follow-up actions may include supplemental inspections for unsolved findings or enforcement actions for inspection results. The reactor performance evaluation result and inspection plans are disclosed on the website of the regulatory agency and at a public meeting. However, certain information related to findings and performance indicators pertaining to the security cornerstone is not publicly available. Thus, security-related information is not discussed during public meetings. Especially, in case of the US, security-related information has not been disclosed to the public since the September 11 attacks because the information may be exposed to potential adversaries. [1, 3]

US-NRC discloses the history and safety/security grades of 17 performance indicators for 7 cornerstones, and Japan-NRA is evaluating 14 performance indicators for 7 cornerstones. [3,4]

In nuclear plant, well-trained security personnel and a variety of protective systems to guard vital plant equipment, as well as programs to assure that employees are constantly fit for duty through drug and alcohol testing are required. Thus, the security (physical protection) cornerstone measures the effectiveness of the security and fitness-for-duty programs. [1]

The objective of the security (physical protection) cornerstone is to provide assurance that the licensee's security system and material control and accounting program use a defense-in-depth approach and can protect against: [5]

a. The design basis threat of radiological sabotage from external and internal threats
b. The theft or loss of radiological materials

Performance indicators related the security cornerstone are described in Table 1.

Table 1. Performance Indicators related the Security Cornerstone in the US/JAPAN

	Cornerstone	Performance Indicators
US (NRC)	#7 Security	• Security system equipment availability
JAPAN (NRA)	#7 Physical Protection	• Percentage of unusable time of intrusion detectors and surveillance cameras (limited to those installed in restricted areas and surrounding protected areas.)

2.3 Significance Assessment

The US-NRC introduced the Significance Determination Procedure (SDP) that grades and marks the importance of inspection results according to impacts on safety or security. The purpose of the SDP is to provide a basis for determining appropriate countermeasures for the Inspection Findings (IF) and to accumulate long-term information for the performance evaluation of each reactor. The Japan-NRA also assesses the significance of the performance degradation (same as IF) in order to determine whether additional inspection is necessary when performance degradation is confirmed. [2, 3]

Table 2 shows the four-grade classification according to the significance assessment of the US/Japan. Both in the US and Japan, the significance of the IF is evaluated in 4 grades (green-white-yellow-red) by using the risk-information. [2, 3]

The significance assessment is divided into quantitative and qualitative analysis method. Quantitative analysis method is performed according to changes in CDF (Core Damage Frequency), LERF (Large Early Release Frequency, used in the US), and CFF (Containment Failure Frequency, used in Japan). The significance of reactor safety such as initial event, mitigation system, and barrier integrity is usually assessed by using the quantitative analysis.

Qualitative analysis method should be used when PRA(Probabilistic Risk Assessment) modeling is difficult or risk increase/decrease evaluation is difficult.
The threshold of the security PI of the US-NRC is the same as the one of the "Physical Protection" of Japan-NRA. The range of "Green" grade is 0~0.08, "White" grade is more than 0.08, and both "Yellow" and "Red" grades have no thresholds. (Table 1) [4]

Security significance assessment guides in the US/JAPAN are shown as Table 3. Details of the NRC's security SDP for reactors are described in IMC (Inspection Manual Chapter) 0609 App. E. In case of the Japan-NRA, there is a guide to assess the significance of physical protection, GI0012. The guide presents implementation procedures to assess the significance of the inspection findings related to the security cornerstone. Specific evaluation methods are stipulated in 5 annexes unlike US-NRC. Although the classification and evaluation procedure for the significance assessment are same as for nuclear safety, a meeting for listening to licensee's opinion is held in a private place.

2.4 Historical Performance for Security

In order to check whether the goals for each cornerstone are satisfied, an inspection is performed to check the status of equipment related to cornerstones and performance of operators. The inspection procedures for security of the US/Japan are listed up in Table 4. The original physical protection (i.e., security) cornerstone of US-NRC had four cornerstone-specific inspectable areas such as access control, access authorization, response to contingency events, and security plan changes. the NRC inspection guide for security is described in IP (Inspection Procedure) 71130, and it is subdivided into twelves and provides each inspection guide.

Table 2. Classification Criterion of Significance Assessment

	Quantitative Assessment (Risk-Informed)			**Qualitative Assessment (Deterministic)**
	ΔCDF (/yr)	US: ΔLERF (/yr)	JAPAN: ΔCFF (/yr)	
Red	> 1E-4	> 1E-5		• The grade that has a large impact on the function or performance of securing safety and makes it impossible to use the reactor
Yellow	1E-5 ~ 1E-4	1E-6 ~ 1E-5		• The grade of having an effect on the function or performance of securing safety and a significant decrease in the safety margin
White	1E-6 ~ 1E-5	1E-7 ~ 1E-6		• It has an effect on the function or performance of securing safety and the decrease in safety margin is insignificant, but the grade that needs improvement due to regulatory intervention
Green	< 1E-6	< 1E-7		• Although there is an effect on the function or performance of securing safety, it is limited and extremely small, and the grade to be improved according to the operator's correction program (CAP, Corrective Action Program)
Minor	Little to no impact on safety			

Table 3. Security Significance Assessment Guides in the US/JAPAN

USA	IMC 0609 App. E Security Significance Determination Process For Power Reactors	
	• Baseline Security Significance Determination Process.	
	• Force-on-Force Significance Determination Process	
	• Construction Fitness-for-Duty Significance Determination Process	
	• Cyber Security Significance Determination Process for Power Reactors	
JAPAN	GI0012 Significance Assessment Guide for the physical protection	
	Annex 1	Significance assessment guide for the management of specific nuclear fuel materials
	Annex 2	Significance assessment guide for the management of nuclear material protection information
	Annex 3	Significance assessment guide for the physical protection
	Annex 4	Significance assessment guide for the unmanaged entrance
	Annex 5	Significance assessment guide for protective measures

Some security guides of NRC such as “Access Control”, “Contingency Response – Force-On-Force Testing”, “Equipment Performance, Testing and Maintenance”, “MC&A”, “Review of Power Reactor Target Sets” are not disclosed to avoid exposure to potential adversaries. The inspection should be performed for each reactor according to the frequencies suggested in each inspection guide.

Meanwhile, Japan conducts nuclear regulatory inspections in accordance with the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material, and Reactors. NRA’s inspections that existed before 2020, when the ROP was adopted in Japan, were integrated into the regulatory inspection. Inspection procedures for the physical protection cornerstone in Japan are mainly composed of eight parts. It is somewhat different from the composition of the NRC inspection procedures. Within each inspection procedure, several sub-procedures for inspection area are included. The number of sub-inspection procedures is given in parentheses in Table 4.

Unlike Japan where the ROP was adopted in 2020, the historical inspection data of US-NRC over 10 years are publicly available because the ROP was introduced to the US in 2000. According to Figure 3, as a result of checking the number of inspection findings above “Green” grade from 2012 to June 2022 by cornerstone, the number of inspection findings of the security cornerstone was the second highest after the mitigating system cornerstone.[6]

Table 4. Inspection Procedures of the US/JAPAN

USA	71130 Security	
	71130.01	Access Authorization
	71130.02	Access Control
	71130.03	Contingency Response – Force-On-Force Testing
	71130.04	Equipment Performance, Testing and Maintenance
	71130.05	Protective Strategy Evaluation and Performance Evaluation Program
	71130.06	Protection of Safeguards Information (SGI)
	71130.07	Security Training
	71130.08	Fitness-For-Duty (FFD) Program
	71130.09	Security Plan Changes
	71130.10	Information Technology Security (Cyber Security)
	71130.11	Materials Control and Accountability (MC&A)
	71130.14	Review of Power Reactor Target Sets
JAPAN	Inspection Procedures for Physical Protection	
	PP11	Management of Specified Nuclear Fuel Materials (6)
	PP12	Management of Physical Protection (4)
	PP13	Entry Approval (7)
	PP14	Entry Control (13)
	PP15	Physical Protection (36)
	PP16	Protection System of Information (4)
	PP17	Protection System of Nuclear Material (6)
	PP21~27	Experimental research reactor/Utilization Facility

In the case that the reactor operation is impossible due to a safety system failure in the periodic inspection of the reactor’s operator, the operation limit conditions of the technical guidelines are not complied with. Thus, this makes it easy to track through reports. That’s why the number of inspection findings due to mitigating system cornerstone is the highest. The Greater Than Green (GTG) grade means a grade with greater significance than a “Green” grade and less significant than a “White” grade. There are no inspection findings for security above “White” grade.[6]

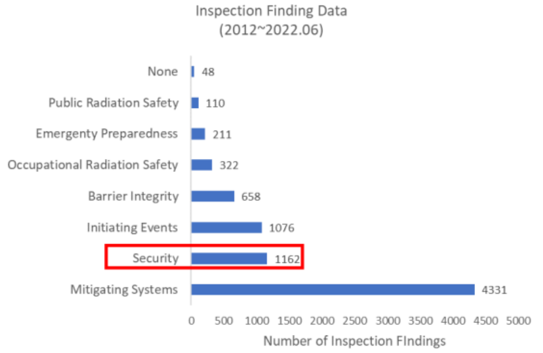

Fig 3. Historical Analytics of Security Inspection Findings (2012~2022.6)

As mentioned above, details of security-related inspection findings are not disclosed. However, in the inspection finding report, it is disclosed that the discovered problem of inspection is assigned to the Cross-Cutting Area (CCA). So, from this, the causes of the problem can be identified.

Table 5 shows the number of CCAs assigned from security inspection findings greater than "Green" from 2012 to June 2022. Except for those that were difficult to assign to CCA, the number of findings assigned to (H.8) Procedure Adherence was the largest. The Procedure Adherence is related to individuals follow processes, procedures, and work instructions.[7]

In the case of Japan, there was a security inspection finding with the “Red” grade in 2020. Therefore, it was evaluated as the 4th grade for response in the NRA annual comprehensive evaluation. Partial loss of function of physical protection equipment at Kashiwazaki-Kariwa Nuclear Power Plant is the reason of the “Red” grade. Table 6 shows security-related inspection findings greater than the “Green” grade in 2020 in Japan.

Table 5. Number of assigned CCA by security findings from 2012 to June 2022.

Assigned CCA by Security Findings	# (Security Findings)
None	197
(H.8) Pocedure Adherence	123
(H.14) Conservative Bias	115
(H.12) Avoid Complacency	92
(H.7) Documentation	62
(H.3) Change Management	57
(H.13) Consistent Process	55
(H.1) Resources	51
(P.2) Evaluation	50
(P.3) Resolution	49
(H.9) Training	38
(H.11) Challenge the Unknown	37
(H.2) Field Presence	37
(P.5) Operating Experience	36
(P.6) Self Assessment	34
(H.5) Work Management	33
(H.4) Teamwork	30
(P.1) Identification	28
(H.6) Design Margins	24
(H.10) Bases for Decisions	8
(P.4) Trending	6

4. Conclusion

The status and application examples of the security ROP in the US/Japan were reviewed. The ROPs of the US and Japan are similar in view of the overall concept, the regulatory framework and the flowsheet to perform ROP, because Japan introduced the ROP in 2020 by benchmarking the one of the US.

Table 6. The Security Inspection Findings Greater than “Green” in 2020 in Japan.

Grade	Inspection Findings	Reactor
Red	Loss of some functions of physical protection equipment	Kashiwazaki-Kariwa 1~7
White	Illegal use of power plant ID cards	Kashiwazaki-Kariwa 1~7
Green	Physical protection, Access approval, Access Control	Fukushima-2 1~4
	Access Approval	Hamaoka 1~5
	Protection System of Information	Shimane 1, 2
	Physical protection	Ikata 1~3

However, in the ROP for security, there were differences in inspection areas and the history of inspection findings. In the case of the US, it is difficult to confirm the details of the test results, but the main cause could be identified through the assigned CCA. Unlike in the US which has not had an inspection finding above “White” grade for the past decade, Japan has the “Red” grade of inspection finding in 2020.

Japan provides the legal basis where the NRA can delegate parts of its responsibility for implementing safeguards(security) to designated NMCC(Nuclear Material Control Center). As mentioned in the introduction above, in Korea, similar to Japan, safety and security are separated and managed by each regulatory agency, thus the case of Japan can be referred when the ROP for security is adopted to Korea.

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