# Research on Gaps in Domestic Regulatory Documentation Based on Security Regulatory Cases

# of SMRs in Other Countries

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**Abstract**

This study analyzed the current SMR development in ROK and international security regulatory frameworks, with a specific focus on developing a strategy for security regulatory documentations of an innovative small modular reactor (i-SMR) in ROK. By examining cases from key regulatory bodies in countries like the United States (US) and United Kingdom (UK), this study compares ROK and international security regulatory frameworks to identify the most effective strategies for developing security regulatory documentation.

## INTRODUCTION

Small Modular Reactors (SMRs) are defined as reactors of small to medium size, producing up to 300 MW(e) (small-sized or small modular) or 300 to 700 MW(e) (medium-sized). More than 80 SMRs are under development worldwide, such as the US, UK, Canada, Russia, China, and others. Under SMR development, nuclear regulatory bodies in the U.S., U.K., and Canada have established close cooperation with SMR developers and are proceeding with the review process.

Currently, the Republic of Korea (ROK) is in the process of developing an innovative Small Modular Reactor (i-SMR) capable of producing up to 170 MW(e). The major milestones include finalizing the basic design and standard design by 2026 and obtaining regulatory certification by 2028. Conducting a gap analysis between domestic regulatory documents and international SMR security-related regulatory frameworks is essential to prepare for the development of i-SMR.

In this study, firstly, a review of security regulatory documents applicable to i-SMR in the ROK is necessary. Secondly, an analysis of regulatory documents developed and applied for SMR security abroad is required. Then, this study derives a development strategy for security regulatory documents through gap analysis between international and ROK security regulatory documents.

## Development and Regulation of SMR in ROK

### Development of i-SMR

In ROK, the i-SMR capable of producing up to 170 MW(e) has been under development since 2020, and operators, research institutes, designers, and suppliers are participating in the development. According to the operator’s plans, the major milestones for the development of the i-SMR are to complete the basic design by 2023, complete the standard design by 2026, and obtain standard design approval by 2028.

### Regulation of i-SMR

In order to conduct proactive regulatory activities in line with the i-SMR development plan, the Nuclear Safety and Security Commission (NSSC) launched the "Development of Technology for Safety Regulations for Small and Medium-Sized Reactor” research project in 2022. The development of the safety regulation framework and safety regulation technology for this project is being carried out by the Korea Institute of Nuclear Safety (KINS), while the development of nuclear Non-proliferation and nuclear security regulation technology is being handled by the Korea Institute of Nuclear Nonproliferation and Control (KINAC).

In 2023, the NSSC published the "SMR Regulatory Direction," which outlines four basic directions and four design guidelines. Guideline 4 states, "The design of an integrated approach between safety, security, and safeguards should be considered to ensure that nuclear security, non-proliferation, and safety are achieved" as shown Fig 1 [1].



FIG 1. SMR REGULATORY DIRECTION [1]

Recently, an i-SMR pre-design review process has been introduced. This process involves reviewing the applicability of authorization standards according to laws and regulations before applying for standard design approval. In October 2023, the operator applied for a pre-design review of the i-SMR and submitted some technical reports for the review. Regulatory expert organizations are conducting review activities and plan to operate the review process until the operator submits the standard design approval application.

### Security Regulation of i-SMR

As part of the research project conducted by the NSSC, the KINAC is undertaking the research titled "A Regulatory Research for Nuclear Security on LWR type SMR” (2022-2028). The ultimate goal of this project is to develop regulatory strategies, guidelines, and key assessment criteria/requirements related to nuclear security (physical protection and cyber security) for the standard design of i-SMR.

With the introduction of the pre-design review process for i-SMR, the KINAC is reviewing the technical reports submitted by operators to assess regulatory issues related to physical protection and cybersecurity aspects.

## International regulatory cases for smrs

### U.S. Nuclear Regulatory Commission (NRC)

#### NuScale Case

* Pre-Application Review (PAR) (2008 - 2016)

The pre-application review is kind of a policy of encouraging early discussion to offer licensing guidance and to identify and resolve potential licensing issues early prior to DCA (Design Certification Application). Prior to submitting the DCA, NuScale requested the PAR to NRC in 2008 and submitted design documents supporting the review. The NRC carried out the PAR activities from 2008 to 2016 [2]. In 2010, the NRC, in collaboration with the Department of Energy (DOE), designers, and applicants, identified 17 technical issues impacting SMR designs (SECY-10-0034 [3]). Among these, 'security and safeguards requirements for SMRs' was classified as highly important, being one of the key operational issues. Furthermore, through several meetings between the NRC and applicants, closer cooperation was achieved to share the concept of "Security by Design" [4].

* Development of the Design-Specific Review Standard (DSRS) (2015 - 2016)

The DSRS for NuScale has been developed to provide guidance to the NRC technical staff for review of those areas of the NuScale design that are not covered by the existing NRC Standard Review Plan (SRP) (NUREG-0800). The draft NuScale DSRS was available for public comment in 2015. The final DSRS was released in 2016 [3]. To develop the DSRS, NRC staffs determined the applicability of SRP each section to NuScale design [5]. Security-related criteria in the DSRS are included in Chapter 13.6 (Physical security, cyber security plan etc.) and Chapter 14.3.12 (Physical security hardware – inspections, tests, analyses, and acceptance criteria). For those criteria, the NUREG-0800 SRP section was applicable to the NuScale review and be used [6].

* Review of DCA (2017 - 2020)

The NRC received DCA from the applicant in 2017 and reviewed the application documents submitted by the applicant and then issued the Final Safety Evaluation Report (FSER) in 2020 [7]. In FSER, the results of the security assessment were documented in Chapter 13, Conduct of Operations, specifically in Section 13.6, Physical Security [8]. During this review process, approximately 2,400 Requests for Additional Information (RAIs) were conducted, of which about 70 were related to security.

* Amendments to Laws and Regulatory Guide (2018 -)

Based on the review experience with NuScale, the NRC has undertaken relevant regulatory law and guidance. The NRC issued Regulatory Guide (RG) 1.232 in 2018, which provides Principal Design Criteria applicable to advanced reactor technologies, and RG 1.233 in 2020, which outlines Technology-Inclusive, Risk-Informed, and Performance-Based regulatory guidance for SMRs. In addition, NRC has initiated a rulemaking process referred to as Title 10 of the Code of Federal Regulations (CFR) Part 53 and Part 73.110, aimed at suggesting a new regulatory framework for advanced reactors along with accompanying regulatory guidance. The NRC staff is expecting to issue the Final Rule by July 2025.

#### Insights

In the U.S. licensing framework, the concept of “Security by Design” is applied to ensure security by considering physical and cyber security from the initial design stages. In contrast, due to the dualization of laws dealing with nuclear safety and security in the ROK licensing framework, it is challenging to conduct practical security assessments by applying the “Security by Design” concept. Therefore, regulatory activities are required throughout the entire licensing process in the ROK to ensure that the “Security by Design” concept is applied to i-SMR.

In comparison to the NuScale case, applicants should be required to submit security related technical reports during the pre-design review process, and then regulatory bodies should discuss regulatory issues related to security throughout pre-design review process. Additionally, in preparation for the upcoming standard design review stage, it is necessary to analyze whether the existing security regulatory requirements can be applied to i-SMR. Based on the applicability analysis of the security regulatory requirements, it is essential to develop i-SMR specific review guidelines that can be utilized in the standard design review.

In the standard design review process, it is necessary to document the results of the security assessment and the review inquiries conducted to perform the evaluation. Furthermore, by documenting the lessons learned and regulatory experiences during the standard design review process, this information can be used to adjust future regulatory laws and guidelines.

### UK ONR

#### General Design Assessment (GDA)

The GDA is a process for the safety and security assessment of new nuclear power plants intended to be constructed and operated in the UK. This process will be applied where the Office for Nuclear Regulation (ONR) is asked to assess a proposed design in advance, or in parallel to an application for a nuclear site license application. By applying the GDA process, regulatory considerations can be addressed from the early design stages of new nuclear power plants, thereby reducing regulatory evaluation time and resolving potential regulatory uncertainties that site operators might face in the future. Due to these inherent advantages, the GDA is not a mandatory process but is requested for new nuclear power plants intended for construction in the UK. The GDA process consists of three steps in total, with the ONR defining the evaluation objectives and security-related requirements for each step [9].

* Step 1. Initiation (12 months)
* Step 2. Fundamental (12 months)
* Step 3. Detailed (12 months)
* Step 4. Resolution of GDA Issues (Agreed between ONR and the applicants)

To conduct the GDA, the ONR evaluates the suitability of applicants' safety-security cases across the 22 technical assessment topics defined in the Table 1, with security being one of the required items **[**9].

TABLE 1. GDA TECHNICAL ASSESSMENT TOPICS

|  |
| --- |
| **Topic** |
| Chemistry | Fault Studies | Radioactive Waste Management | Civil Engineering | Fuel and Core |
| Safeguards | Control and Instrumentation (C&I) | Human Factors | **Security** | Conventional Fire Safety |
| Internal hazards | Severe Accident Analysis (SAA) | Conventional health and Safety | Management for Safety and Quality Assurance | Spent Fuel Management |
| Decommissioning | Mechanical Engineering | Structural integrity | Electrical Engineering | Probabilistic Safety Analysis (PSA) |
| External Hazards | Radiological Protection |  |  |  |

#### Security Regulation

The ONR utilizes Security Assessment Principles (SyAPs) and supporting Technical Assessment Guides (TAGs) to guide security regulatory judgements when conducting security regulatory assessments of the applicant’s security submission. The SyAPs provide essential foundations for introducing outcome-focused regulation across all security disciplines: physical, personnel, transportation, cyber security, and information assurance. The SyAPs are supported by TAGs to further assist regulator’s decision-making

and providing guidance for each technical security aspect [9].

The SyAPs consist of Fundamental Security Principles (FSYP), which FSYP 7 defined that “Duty holders must implement and maintain effective cyber security and information assurance arrangements that integrate technical and procedural controls to protect the confidentiality, integrity and availability of sensitive nuclear information and technology.” [10].

* FSYP 1. Leadership and management for security
* FSYP 2. Organisational culture
* FSYP 3. Management of human performance
* FSYP 4. Nuclear supply chain management
* FSYP 5. Reliability, resilience and sustainability
* FSYP 6. Physical protection systems
* **FSYP 7. Cyber security and information assurance**
* FSYP 8. Workforce trustworthiness
* FSYP 9. Policing and guarding
* FSYP 10. Emergency preparedness and response

The SyAPs are supported by TAGs to further assist regulator’s decision-making and providing guidance for each technical security aspect. Particularly, in 2021, the ONR released guidance within the GDA activities for regulators to aid in regulatory judgments. This TAGs contains guidelines to inform ONR inspectors in exercising their regulatory judgment during GDA related to the adequacy of generic designs for new nuclear reactors. It aims to provide general advice and guidance to ONR inspectors on how security aspects should be assessed working within the wider GDA process. The output expected from the applicants at the end of GDA is the Generic Security Report Development (GSR). The key elements of a GSR submission are target identification, categorisation for theft and sabotage, and cyber security [11].

#### Insights

According to the UK ONR licensing framework, the “Security by Design” concept is applied by considering security as a technical assessment topic during the GDA process. This approach ensures robust security by integrating physical and cyber security into the reactor design stage. As mentioned before, the dualization of laws regarding nuclear safety and security in the ROK makes it challenging to apply “Security by Design” concept. Therefore, as evidenced in the UK ONR licensing framework, it is essential to ensure that “Security by Design” concept is integrated from the design stage of SMR within the ROK licensing framework.

The UK ONR requires security submissions from applicants and, through a progressive GDA process, demands comprehensive and summarized a security related report. Therefore, in the ROK, it is necessary to require the submission of security relevant documents from applicants in the design stage and to define the document lists required for security regulatory assessment.

In 2021, the UK ONR released the TAGs to inform ONR inspectors in exercising their regulatory judgment during GDA related to the adequacy of generic designs for new nuclear reactors. Similarly, the ROK needs to develop regulatory guide for security regulatory assessments.

Additionally, applicants are provided with security principles and are required to design in compliance with these principles. These security principles apply to all nuclear power plants, including new ones. Therefore, it can be inferred that the criteria for security assessment do not significantly change, even for new nuclear power plants.

## StrateGy for Developing Regulatory DOCUMENTATION on Security

To ensure robust security from the i-SMR design phase, it is necessary to establish legal or similar basis for security regulation across the entire licensing framework in the ROK. According to the licensing framework in the US and UK, it has been confirmed that the “Security by Design” concept is applied within the early licensing phase, ensuring security through the integration of physical and cyber security from the early design stage. In contrast, within the ROK licensing framework, the dualization of laws regarding the nuclear safety and security make is challenging to conduct security assessments by applying “Design by Security” concept.

During the pre-design review process, regulatory bodies ought to define review item for security assessment and specify the necessary documents for supporting the assessment, which should be requested from applicants. Moreover, close collaboration during the pre-design review process allows for the identification of security regulatory issues concerning i-SMR. Additionally, in preparation for the upcoming standard design review, it is essential to develop specialized security assessment guidelines for i\_SMR by reviewing whether the existing security guidelines and requirements can cover the i-SMR design.

As part of the standard design review process, it is essential to document the outcomes of security evaluations and inquiries conducted to facilitate the assessment. Moreover, detailed documentation of regulatory experiences acquired during the standard design review process will be invaluable for future reference.

## Conclusion and Future Plan

This paper introduces the current development status of i-SMR in the ROK and the associated security regulatory activities. AS i-SMR applicant have a plan to apply for SDA by 2026, regulatory bodies responsible for nuclear security need to make efforts to establish a comprehensive security regulatory framework for the i-SMR licensing review. As part of this effort, this study analyzes the regulatory frameworks and documentation of nuclear regulatory bodies in the U.S. and the UK, summarizing the lessons learned. In conclusion, we analyzed the differences between the ROK and international security regulatory frameworks and cases, and then identified development strategies for security regulatory documentation in the ROK.

Future plan includes conducting the deep dive analysis of documentation submitted by applicants, as well as documentation issued by regulatory bodies in the US and UK. It aims to organize these documentations systematically to enhance the development strategy of security-related regulatory documentation. The goal is to gain insights that can be applied to improve the security regulatory framework in the ROK.

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