# consideration of a regulatory framework for safeguards in SMRS

Hosik YOO

Korea Institute of Nuclear Nonproliferation and Control (KINAC)

Yuseong-daero, Daejeon, Republic of Korea

hsyoo@kinac.re.kr

Seungho JEONG

Korea Institute of Nuclear Nonproliferation and Control (KINAC)

Yuseong-daero, Daejeon, Republic of Korea

Seungho AHN

Korea Institute of Nuclear Nonproliferation and Control (KINAC)

Yuseong-daero, Daejeon, Republic of Korea

Seungmin LEE

Korea Institute of Nuclear Nonproliferation and Control (KINAC)

Yuseong-daero, Daejeon, Republic of Korea

Chul HEO

Korea Institute of Nuclear Nonproliferation and Control (KINAC)

Yuseong-daero, Daejeon, Republic of Korea

**Abstract**

This study proposes a legal framework to integrate Safeguards by Design (SBD) principles from the design phase of Small Modular Reactors (SMRs), addressing the gap in current practices where safeguards are not considered early in the design and construction phases. The International Atomic Energy Agency (IAEA) encourages early cooperation among designers, operators, regulators, and itself to include detailed nuclear facility information from the beginning of the design phase. However, the existing process only mandates the submission of a preliminary Design Information Questionnaire (DIQ) seven months before construction, with a final DIQ submitted seven months before nuclear material arrival, missing early SBD adoption.

The current legal foundation and licensing process, based on the Nuclear Safety Act, outlines construction and operation permit requirements but lacks integration of safeguards in the early stages. The study suggests amending the Nuclear Safety Act to include safeguards-related documentation in the licensing process, thereby facilitating SBD implementation. This includes expanding the Material Accounting Regulation for Nuclear Facilities (MARN) content to support SBD practices effectively.

Additionally, utilizing subsidiary documents and the Regulation on the Reporting of International Strategic Materials (RISM) could enforce SBD principles by requiring the submission of design information at each construction stage. This approach requires proactive collaboration from licensees and a regulatory framework that includes specific penalties for non-compliance with design change disclosures.

The study concludes that incorporating safeguards into the licensing process through legislative amendments or by leveraging existing regulations could ensure SBD implementation from the initial design phase, emphasizing the need for close collaboration among all stakeholders to overcome current challenges in safeguard integration.

## INTRODUCTION

The International Atomic Energy Agency (IAEA) strives to create a comprehensive framework that incorporates Safeguards by Design (SBD) principles at the initial stages of Small Modular Reactor (SMR) development. This requires synergistic cooperation between designers, operators, regulators, and the IAEA, with designers needing to share detailed information about the nuclear facility with both the State System of Accounting and Control (SSAC) and the IAEA from the beginning of design phase. Currently, in the Republic of Korea (ROK), licensees are required to submit design information, including construction and operational timelines, along with a preliminary project plan, within one month of receiving the construction permit [1]. However, specific actions related to safeguards, beyond submitting a preliminary Design Information Questionnaire (DIQ) seven months prior to the start of construction, are lacking. The final DIQ is submitted seven months before the nuclear material is transported to the facility, revealing a significant gap in adopting SBD principles during detailed design and construction phases [1-2]. This study proposes a legal framework to integrate SBD principles from the SMR design phase through a comprehensive review of existing construction processes for nuclear facilities, focusing on safeguards regulations.

## current process

This section provides an overview of the legal foundation and licensing procedures for nuclear power plant construction.

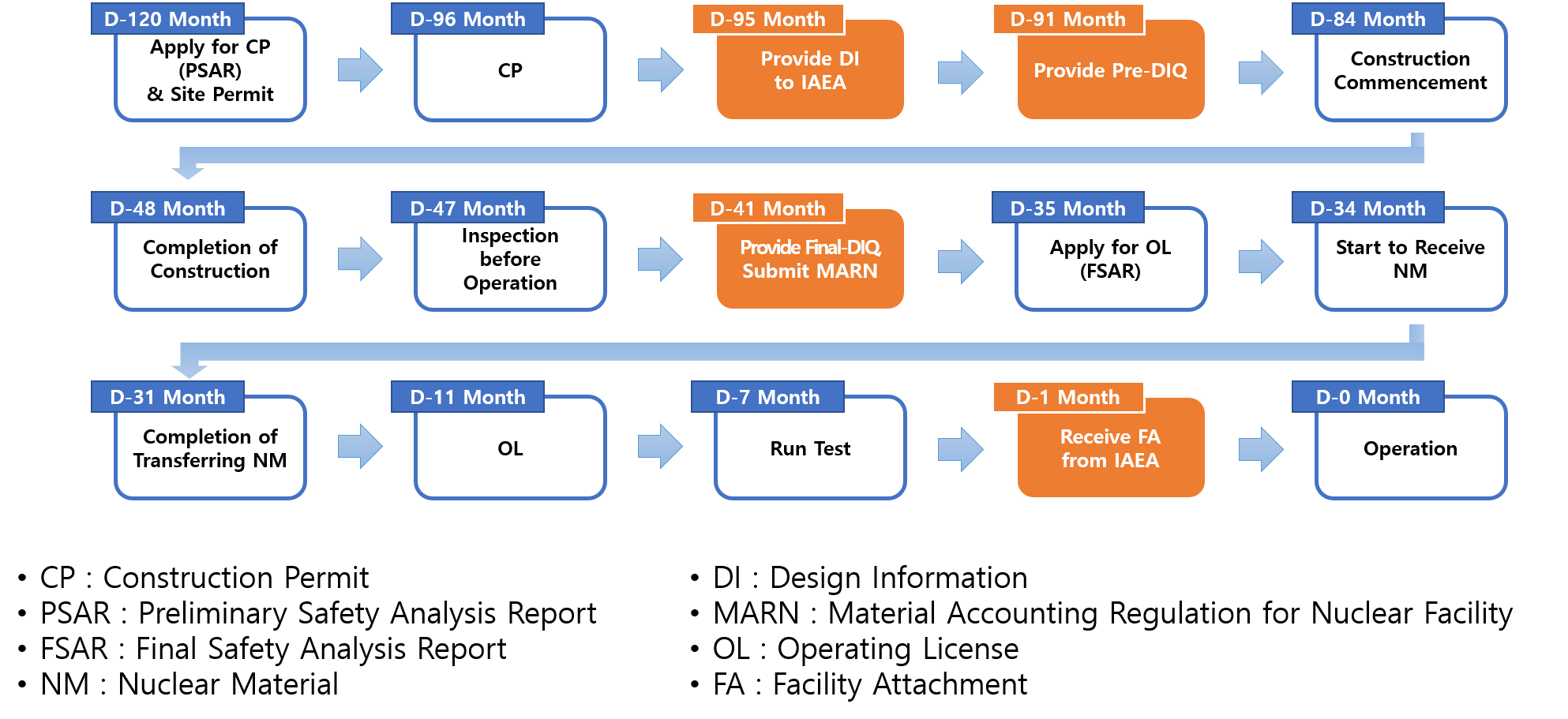
### Legal Foundation

The Nuclear Safety Act [1] forms the legal basis for the nuclear power plant construction licensing process. It outlines two licensing pathways: one for constructing a nuclear power plant with a defined plan, and another for standard design approvals for reactors without specified construction plans. Article No. 10 pertains to construction permits for nuclear power plants, while Article No. 20 covers operating permits. The application for standard design approval (standard design is defined as the repeated design, in the case of repeated construction of power reactors and related facilities of the same design) is detailed in Article No. 12. Article No. 15 requires licensees to submit a “Material Accounting Regulation for Nuclear Facilities (MARN)” to the SSAC for approval before using nuclear material within the facility. The regulatory body must complete its review of construction and operating permit documentation within 24 months from the application date. Article 98 of the Nuclear Safety Act outlines the requirements for submitting design information for nuclear facilities. It mandates that operators of nuclear installations must provide detailed design information to the regulatory authority. Using this information, IAEA gives the Facility Attachment (FA) to stat regulatory authority (SRA) and operators. The FA is a detailed document that outlines the specific safeguards measures and requirements that will be applied to the facilities. Table 1 shows the legal system of the nuclear safety regulation in Republic of Korea.

TABLE 1. NUCLEAR SAFETY REGULATORY LEGAL SYSTEM OF ROK

|  |  |  |
| --- | --- | --- |
| **Name** | **Features** | **Organization** |
| Nuclear Safety Act | Act, governing legislation  - lays down the legal basis and defines matters for nuclear safety regulations | Nuclear Safety and Security Commission (NSSC) |
| Enforcement Decree of  Nuclear Safety Act | Presidential Decree  - defines administrative matters necessary for the implementation of the Nuclear Safety Act | Nuclear Safety and Security Commission |
| Enforcement Rules for Nuclear Safety Act | Ordinance of the Prime Minister  - defines administrative matters necessary for the implementation of the Nuclear Safety Act and its enforcement decree | Nuclear Safety and Security Commission |
| Rule on Technical Standards for Nuclear Reactor Facilities, etc.  Rule on Technical Standards for Radiation Safety Management | Rules of the NSSC  - defines licensing procedures, application, and technical standards necessary for the implementation of the Nuclear Safety Act and its enforcement decrees and rules | Nuclear Safety and Security Commission |
| NSSC notifications | Notifications  - defines detailed matters related to technical standards and administrative procedures | Nuclear Safety and Security Commission |
| Regulatory Guidance of the TSO (Technical Support Organization) and Industrial Standards | Regulatory standards, guidance, review and inspection manuals, etc. | Korea Institute of Nuclear Non-proliferation and Control (KINAC) and Korea Institute of Nuclear Safety (KINS) |

### Licensing Process



*FIG. 1. Licensing process for the construction of nuclear power plant*

The licensing process for constructing a nuclear power plant, illustrated in Fig. 1, shows the timeframe and documents required for licensure [1-2]. Orange boxes are activities related to IAEA safeguards. It typically takes 10 years from site determination to operational status for a nuclear power plant, with safeguards not included in the licensing process. The operator must submit the preliminary design information to the IAEA as soon as construction authorization is granted. The completed DIQ based on ‘as-built’ is submitted to the IAEA as early as possible, no later than 180 days before receiving nuclear material at the facility. Current practices do not allow for consideration of safeguards from the early design stage since DI and DIQ are excluded from licensing documentation. Although a nuclear power plant cannot operate without approved material accounting regulation (Article 15 and its provisions mutatis mutandis), this document, focused only on organization, procedures, and training, does not directly relate to IAEA safeguards. Moreover, safeguards perspective modifications cannot be applied when this document is submitted, as construction is already complete.

## Strategies for Improvements

### Amending the Safety Act or Decrees

Amending the Nuclear Safety Act is seen as a direct and effective way to include safeguards regulations from the initial design phase of nuclear power plants. Modifying Articles No. 10, 12, 15, and 20 to include necessary documentation for construction, standard design, and operation licensing could facilitate SBD implementation. Including MARN in the licensing documents would allow the SSAC to participate from the early design stages, assuming licensees submit safeguard-related information. Thus, expanding MARN's content can be a solution to support SBD practices effectively, including details on nuclear materials, spent fuel pool locations and capacities, and specifics on nuclear fuel transportation and storage.

As another way for SBD implementation, the most intuitive and direct solution is addition of design information into article 12 of NSA. Since the reporting of international strategic materials are mentioned in Article 98 and its related notifications, a modification shown in table 2 can be considered. Similarly, adding the design information or DIQ in decree level can also be considered. These ideas of amending legislation can be very authoritative, but they have the disadvantage of being complex, lengthy and requiring significant effort.

TABLE 2. IDEAS FOR LEGISLATIVE IMPROVEMENTS FOR SBD

|  |  |  |  |
| --- | --- | --- | --- |
| **NSA procedure** | **Article No.** | **Current Requirement** | **Improvements** |
| Construction Permit | 10, ② | A permit application form with,  - radiation environment impact assessment report  - preliminary safety analysis report  - quality assurance plan  - dismantlement plan  - other documents specified by prime minister’s decree | Same as left,  - adding Preliminary design information or DIQ by Article 98 |
| **Standard Design Approval** | 12, ② | An application form with,  - standard design documentation  - other documents prescribed by the prime ministerial decree | Same as left,  - adding **Preliminary design information by Article 98** |
| Operating License | 20, ② | An application form with,  - operating technical guidelines for the nuclear power reactor and related facilities  - the final safety analysis report  - the accident management plan (including the severe accident management plan)  - the quality assurance plan for operation  - the radiological environmental impact Assessment (only the parts that differ from the radiological environmental impact assessment submitted under Article 10, paragraph ②)  - the decommissioning plan for the nuclear power reactor and related facilities (only the parts that differ from the decommissioning plan submitted under Article 10, paragraph ②)  - the plan for the discharge of radioactive materials in liquid and gaseous states (including the total discharge amounts by site, period, and radionuclide group)  - other documents prescribed by the Prime Ministerial Decree. | Same as left,  - adding Design Information Questionnaire by Article 98 |

### Amending the notifications of Article 98

Directly amending the notifications of NSSC related to Article 98 [3] is also a good way to implement the SBD concept for SMRs. Amending the relevant notification of Article 98 (as shown in Table 3) of the Nuclear Safety Act is one of the easiest ways and most effective methods. However, there is an issue with this notification, as it currently defines the entities obligated to submit design information (DI) as specific nuclear material users, making it unclear whether the applicant for standard design approval falls under this category.

Thinking conversely this situation, while it has traditionally acceptable to prepare for the review of design information once the facility’s design has significantly processed, such as during construction or operation, the emergence of facilities like SMRs, where standardisation is crucial, has made it an important decision whether to include this safeguards-related information within the scope of this standardisation.

TABLE 3. THE LIST OF NSSC NOTIFICATIONS FOR SAFEGUARDS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name of Notifications** | **Nuclear Safety Act** | **Presidential Decree** | **Prime Ministerial Decree** | **Contents** |
| Regulation on the Subject of International Strategic Materials (No. 2017-81) | Article 2, Item 17 | - | Article 3 | Nuclear materials, non-nuclear materials and equipment, definitions of other international strategic materials |
| Regulation on the Preparation of Material Accounting Regulation for Specific Nuclear Materials  (No. 2017-82) | Article 15, and provisions mutatis mutandis | Article 25, and provisions mutatis mutandis | Article 13, 14 | Guidelines for the preparation the Material Accounting Regulation for Nuclear Facilities (preparing MARN), notification of approving procedures, and reporting procedures for minor matters |
| Regulation on the Inspection of Material Accounting Regulation for Specific Nuclear Materials  (No. 2017-83) | Article 16, and provisions mutatis mutandis | Article 26, and provisions mutatis mutandis | - | Types, scopes, frequencies and others of inspections |
| Regulation on Reporting of International Strategic Material and others [3]  (No. 2017-84) | **Article 98** | Article 138 or 142 | Article 127, 129, 130 | The scope of reporting entities, reporting items, deadlines, verification of reporting content, and the basis for inspection by the IAEA |
| Regulation on Training of the Nuclear Control | Article 106 | Article 150 | Article 141 | Training participants, training hours, methods and contents |

Moreover, Notification 2017-84 related to Article 98 explains the types of DIs and DIQs, but does not specify the detailed information that should be included. Therefore, it is necessary to clearly explain what specific contents should be included in DIs (or DIQs) to ensure it aligns well with the IAEA’s DIQ [4]. Thus, it is also necessary to add the following phrase to the enforcement decree or notification.

*The design information or design information questionnaire related to the management of international strategic materials must include the following items in accordance with the guidelines established and notified by NSSC:*

1. *General information about the facility and reactor, and their intended use.*
2. *Detailed design information related to nuclear material, fuel assemblies, paths, and relevant diagrams*
3. *Systems for the transfer of nuclear material and main storage locations, along with related diagrams*
4. *Coolant information and diagrams for estimating core powers and operational status*
5. *Management plans and diagrams for nuclear material accountancy*
6. *Protection and safety measures for the facility*
7. *Facility decommissioning plan, including methods for nuclear material removal and recovery*

### Using Existing Regulation

Table 4 shows that licensees are required to submit Design Information (DI) or DIQ at each nuclear power plant construction stage. The SSAC may request these documents one month earlier than specified in the subsidiary arrangement for timely review before IAEA submission. The Regulation on the Report of International Strategic Materials (RISM) outlines document submission deadlines.

TABLE 4. DOCUMENT SUBMISSION TIMELINE

|  |  |  |
| --- | --- | --- |
| **Subject** | **Subsidiary**  **Arrangement** | **RISM** |
| Provision of preliminary design information for new facilities | As soon as the decision to construct or authorize construction has been taken, whichever is earlier | Within one month after the construction plan or authorization |
| Provision of further information designs of new facilities | As design is developed. Information to be provided early in the project definition, preliminary design, construction and commissioning phases. | Within one month after design is developed and further detailed design is determined |
| Provision of completed Agency design information questionnaire for new facilities based on preliminary construction plans | As early as possibly, and in any event not later than 180 days prior to the start of construction. | Not later than 7 months prior to the start of construction. |
| Provision of completed Agency design information questionnaire for new facilities based on “as-built” design | As early as possibly, and in any event not later than 180 days before the first receipt of nuclear material at the facility | Not later than 7 months before the first receipt of nuclear material at the facility |

Currently, licensees submit only the DI, pre-DIQ, and final DIQ. The SSAC can request design updates as further details are established, following RISM provisions. Thus, effectively using subsidiary arrangements and RISM can facilitate SBD implementation. This approach demands proactive collaboration and support from licensees, as the current regulatory framework lacks specific penalties for non-compliance with design change disclosures.

## conclusions

This discussion explores SBD implementation for new reactors, highlighting the challenges within current licensing processes across design and construction stages. The lack of a legal framework to enforce safeguards within the licensing process is a significant challenge. Incorporating safeguards into the licensing process through amendments to Articles No. 10, 12, and 20 of the Nuclear Safety Act could enable the submission of safeguards-related information by licensees. However, amending the Act faces many challenges. Alternatively, leveraging existing regulations on safeguards by requesting documentation at each design stage, as designs are finalized according to subsidiary arrangements and RISM, allows the SSAC to engage from the initial design phase to the operation of the nuclear power plant. This strategy emphasizes the need for close collaboration with licensees to ensure successful SBD implementation.

Nevertheless, it is anticipated that effective application of SBD principles will be achieved by linking the provision of DI for safeguards to the standard design approval process for SMRs. If mandating the provision of DI as part of the licensing documents is too burdensome, it could be considered to add the timing of the information provision at the notification level, like discussed earlier. Additional research will provide various alternatives to the government.

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