An Approach to Develop Regulatory Requirements of Nuclear Energy Systems in the Area of Proliferation Resistance

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1. Introduction

The objective of the INPRO collaborative project, ROK1, "Proliferation Resistance: Acquisition/Diversion Pathway Analysis (PRADA)" was to further contribute to the completion of the INPRO methodology in the area of proliferation resistance (PR methodology), which is to assess proliferation resistance and to provide guidance to improve the proliferation resistance of the innovative nuclear energy system (INS) [1]. Following the PRADA project, Korea Atomic Energy Research Institute (KAERI) is currently developing potential regulatory requirements in the licensing process of nuclear energy systems which should comply with the Basic Principle (BP) of the INPRO PR methodology [2]. This paper presents general concepts and fundamentals that should be considered in the regulatory requirements for the licensing process of nuclear energy systems.

2. Concepts and Fundamentals of Proliferation Resistance

Proliferation Resistance (PR) is that characteristic of a nuclear energy system (NES) that impedes the diversion or undeclared production of nuclear material, or misuse of technology, by States in order to acquire nuclear weapons or other nuclear explosive devices [3]. The degree of proliferation resistance results from a combination of, inter alia, technical design features, operational modalities, institutional arrangements and safeguards measures. Observing proliferation resistance in the licensing process of INSs does not mean that it prevents technologies that have been proven to be safe, secure and economical (following the INPRO definition of sustainability) but to assure that the system will "continue to be an unattractive means to acquire fissile material for a nuclear weapons program". Regulatory requirements on PR in the licensing process of INSs are part of States' commitment to non-proliferation, and should answer fundamental questions about commonly used criteria such as:

- Nuclear material attractiveness: can the nuclear material in the NES be easily used in a nuclear weapons program? (suitability for a nuclear explosive device, effort and difficulty of further processing required to get material in a weapon usable form, material availability, etc.);
- Nuclear technology attractiveness, can the NES be misused for the production of nuclear material that could be easily used in a nuclear weapons program?
- Difficulty and detectability of diversion/misuse: does design and operation of the NES facilitate the implementation of IAEA safeguards? Can the NES be safeguarded effectively and efficiently by the safeguards authorities (accountability, amenability for C/S measures and other monitoring, transparency of design and processes, etc.)?
- Optimization of design: does design and operation of the NES provide cost-efficient PR both to the facility operator and the safeguards authorities and compatibility with other design considerations as safety, security, and operation?
- Institutional arrangements: do institutional structural arrangements like multinational ownership or commercial arrangements that control access to and use of nuclear material support facility and enterprise undertaking to PR?

3. INPRO Requirements for Proliferation Resistance

The INPRO PR methodology provides a framework for the qualitative evaluation of the proliferation resistance of nuclear reactors and fuel cycles at State-level, NES level, and facility level, including specific pathway level [1]. The INPRO method is structured in a hierarchical order:

- Basic principles (BP)
- User requirements (UR) and
- Criteria (CR), each consisting of one or more indicator(s) and an acceptance limit(s).

The highest level in the INPRO structure is the **Basic Principle**, *"Proliferation resistance intrinsic features and extrinsic measures shall be implemented throughout the full life cycle for innovative nuclear energy systems to help ensure that INSs will continue to be an unattractive means to acquire fissile material for a nuclear weapons program. Both intrinsic features and extrinsic measures are essential, and neither can be considered sufficient by itself."* The Basic Principle is a statement of a general goal that is to be achieved in INS and provides broad guidance for the development of an INS (or a design feature thereof).

The second level in the INPRO hierarchy is called a **User Requirement (UR)**. URs are the conditions that should be met to achieve users' acceptance of a given INS, i.e., the user requirements define the means of achieving the goal set out in the basic principle. All user requirements of a basic principle should be fulfilled to achieve a sustainable INS. The INPRO URs set out measures to be taken by technology developers or designers, by owners/operators of nuclear facilities, and by the State to ensure fulfilment of the basic principle(s) to which they relate.

Finally, a **Criterion (CR)** (or more than one) is required to enable the INPRO assessor to determine whether and how well a given user requirement is being met by a given INS. An INPRO criterion consists of an **Indicator (IN)** and an **Acceptance Limit (AL)**. Indicators may be based on a single parameter, an aggregate variable, or a status statement. The Acceptance Criteria allow to answer the fundamental PR related questions and show strengths and weaknesses regarding proliferation resistance of an INS.

To achieve the general goal of proliferation resistance in an INS, INPRO methodology asks via 5 user requirements, namely:

- **the State** to establish a sufficient legal framework, e.g., NPT, comprehensive safeguard agreement, body of law, regulatory body, etc. (UR1);
- **the designer** to keep the attractiveness of nuclear material (NM) acceptably low (UR2); make diversion of NM difficult and detectable (UR3); incorporate multiple barriers (UR4); and to optimize costs (UR5) of multiple proliferation resistance features and measures, including safeguards.

4. Responsibilities for Establishing Regulatory Requirements on PR in NES Licensing

To minimize the proliferation concerns associated with NESs, proliferation resistance intrinsic features and extrinsic measures shall be implemented throughout the full life cycle for INSs, from initial planning, design, and operation to the decommissioning stage.

The government establishes State's commitments, obligations and policies regarding non-proliferation and is responsible for its implementation. The government legislates observance of proliferation resistance requirements in the design and operation of NESs. The government also supports the nuclear industry in establishing institutional structural arrangements (e.g. multinational ownership) that are capable to enhance proliferation resistance. The government assigns for deployment of an NES the responsibility for the early consideration of proliferation resistance to the nuclear industry and the regulatory body, as designated by the government.

The regulatory body is responsible for establishing regulatory requirements for the licensing process (design, operation, and maintenance) of NESs, in line with State's commitments, obligations and policies regarding non-proliferation. The regulatory body will examine, as part of the licensing process, whether fundamentals of proliferation resistance have been observed in design and operation of an NES by examining the answers to fundamental questions about commonly used criteria as described in Section 2, to be provided by the nuclear industry. The regulatory body is also the interface between the nuclear industry and the international safeguards authority (IAEA) in safeguards implementation related aspects of proliferation resistance.

The developer/designer/operator shall consider the proliferation resistance as soon as sufficient technical information is available in the development of a new INS. This should be no later than the conceptual stage and could begin as early as fundamental design concepts are discussed. Early consideration provides opportunity for the design to be guided, in part, by proliferation resistance, before significant design decisions are finalized. A developer/designer/operator shall include a PR/safeguards expert in the design team from the very beginning.

The process of how to take proliferation resistance aspects in design and operation of the NES into account should be documented based on the technical codes and standards. The result should be described by answering the fundamental questions about commonly used criteria for PR as described in Section 2 for proliferation resistance, whereby showing strengths and weaknesses regarding PR of the system. Considerations on proliferation resistance shall also follow the Safeguards-by-Design concept. Starting from the basic technical and operational characteristics of the planned NES, operational needs, safeguards requirements and its impact on the facility design are to be determined.

Determining safeguards requirements and its impact on the facility design and operation would require a diversion pathway analysis, which includes potential/ plausible diversion and misuse scenarios, potential concealment strategies of the host State and safeguards tools and measures to cover those scenarios. Based on this, it must be shown that safeguards goals can be met effectively and efficiently.

5. Conclusion

A preliminary study on the regulatory requirements in the licensing process of nuclear energy systems has been carried out. The study indicates that reasonable guidelines can be developed based on the concepts, principles and fundamentals of proliferation resistance.

6. REFERENCES

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