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Update of the INPRO Collaborative Project, Proliferation Resistance and Safeguardability Assessment (PROSA) Tools

H.L. Chang*, E.H. Kwon, S.K. Ahn, W.I. Ko, H.D. Kim
Korea Atomic Energy Research Institute, 1045 Daeduk-daero, Yuseong-gu, Daejeon, Korea 305-253
**Corresponding author: hlchang@kaeri.re.kr*

1. Introduction

The objectives of the INPRO Collaborative Project, Proliferation Resistance and Safeguardability Assessment (PROSA) Tools are to make the INPRO proliferation resistance (PR) assessment methodology simpler and easier to use, to allow for different users and depths of analysis, to demonstrate the value and its usefulness of the refined assessment methodology to potential users, through a test with a reference case, and to provide input to a revision of the INPRO PR assessment manual. A summary of the project is described herein, including the procedure of PR assessment process and a case study using a SFR metal fuel manufacturing facility (SFMF) which is currently in the conceptual design phase at KAERI.

2. Proliferation Resistance (PR) Assessment Process

The existing INPRO manual in the area of PR [2] is based on a Basic Principle that states: "*PR intrinsic features and extrinsic measures should be implemented throughout the full life cycle for nuclear energy systems to help ensure that NESs 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 should be considered sufficient by itself.*" The assessment process developed under PROSA is consistent with the BP of the INPRO PR methodology but reduces the process into three simplified user requirements (UR), along with relevant criteria, indicators, acceptance limits, and evaluation parameters. Consistent with the definition of PR [1], PROSA addresses only the diversion of nuclear material or misuse of technology from a defined nuclear energy system (NES). The PROSA assessment process calls for assessing the NES at three levels; at the State level, NES level and facility level, including facility-specific pathways. Firstly, an assessor will document the intrinsic characteristics of the nuclear material, facilities and other locations and activities that comprise the NES within the State and its jurisdiction (NES information catalogue). In a second step, the assessor will evaluate the States' commitments, obligations, policies, and institutional arrangements regarding non-proliferation (UR1) at the State level. In a third step, the assessor looks at the facilities and activities for features that facilitate the implementation of IAEA safeguards, measuring whether safeguards can be implemented effectively and efficiently (UR3). Finally, the assessor is asked to evaluate whether all technically plausible diversion paths are covered by multiple and mutually supportive intrinsic features and extrinsic measures, compatible with other design requirements, that are suitable to increase the resistance to use of these diversion paths (UR4). Fig.1 shows the simplified draft PR assessment process.

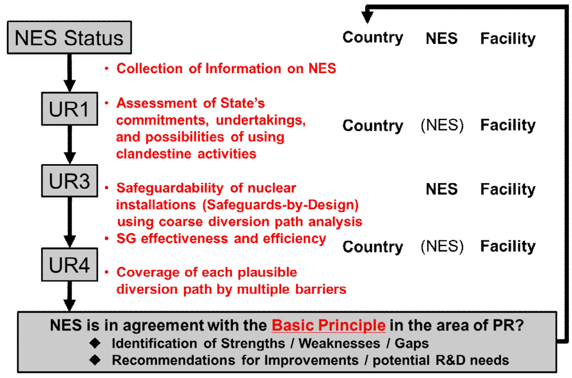

Fig.1. Simplified PROSA process

PR assessment is a continuous iterative process, and owner of the process, i.e. host state, is to fill gaps and weaknesses which require actions or R&D to improve the sustainability of a NES in the area of PR. Prospective users of the INPRO methodology are nuclear technology developers, experienced nuclear technology users with a well-established nuclear power program, and a country embarking on a new nuclear power program.

3. Case Study

PROSA process has been applied to a Sodium-cooled Fast Reactor (SFR) Metal Fuel Manufacturing Facility (SFMF), representing novel technology that is still in the conceptual design phase at KAERI. Main purposes of the case study were to validate the proposed PROSA process, to demonstrate its usefulness, and to provide input to a revision of the INPRO manual in the area of PR.

As a first step an information catalogue was prepared in support of the PR assessment of SFMF design under development, a specific facility of a closed pyroprocess fuel cycle with six SFR units. NES information catalogue covers a list of the material type, quantity, category, form and accessibility of nuclear material (inventories and flows) for IAEA inspection, including nuclear fuel cycle R&D activities. In the case study the material type is transuranics (TRU) ingots produced from the pyroprocessing module of the SFR fuel cycle facility (SFCF) with 38.62 MTHM annual throughput, which is composed of spent SFR fuel pyroprocessing module, SFR metal fuel rod fabrication module, and SFR fuel assembly assembling module. Process materials of feedstock, interim product, and final product all have the same composition. Fissile Pu content is around 51% and timeliness goal of one month is assumed as a basis for safeguards-by-design considerations.

ApplyingUR1 on State's commitments to Korea as an example results in the conclusion that legal commitments, obligations and policies on non-proliferation and its implementation are adequate to fulfil international requirements and good practice to provide for credible assurance of the exclusive peaceful use of the NES, including a legal basis for verification activities by the IAEA.

In the assessment of UR3 on safeguardability which has 2 indicators (INs) and 6 evaluation parameters (EPs), while each EP has subsequent screening questionnaires. Four potential targets materials were identified and coarse diversion scenario with plausible concealment strategies has been developed for each target material.

Table 1: Assessment of UR3

User Requirement UR3: *The diversion of nuclear material should be detectable.*			
Indicators IN	**Evaluation Parameter EP**	**Eval. Results Yes**	**Eval. Results No**
IN3.1 Effectiveness of IAEA Safeguards	EP3.1.1 The accounting system implemented by the operator provides accurate and complete information on nuclear material, forms, amounts, flows, locations, transfers and identification of inventory changes	X (some reservation)	(int'l std of account'n not defined)
	EP3.1.2 All types of nuclear material flows and inventories can be verified adequately by SSAC/SG inspectorates/IAEA methods for the independent verification of operator's declarations	X (methods need validation)	
	EP3.1.3 .... EP3.1.4		
IN3.2 Efficiency of Safeguards Implementation	EP3.2.1 Safeguards can be implemented by the IAEA at equal or lower cost and effort for the IAEA than at a facility of the same type	Prob. Yes	
	EP3.2.2 Safeguards can be implemented at the facility at equal or lower cost and effort for the operator than at a facility of the same type	Prob. yes	

Table 1 shows exemplary results obtained based on the subsequent screening questionnaire for the first exemplified diversion scenario. In the same way, results can be obtained for other EPs for the 1st exemplified diversion scenario. Safeguards tools and measures required were identified in the safeguardability test, including gaps for further R&D needs to improve the proliferation resistance of the NES.

Exemplary results of assessing UR4 for the first segment of the diversion pathway are shown in Table 2. As can be seen in the table, the coarse diversion path analysis demonstrated that diversion path is covered by multiple intrinsic features and extrinsic measures on the facility and/or country level. Similar analysis has been carried out for three other plausible diversion paths. All diversion paths of exemplified coarse diversion scenarios are covered by intrinsic features, which are compatible with other design requirements, and by extrinsic measures on the facility or country level that reduce the attractiveness of an acquisition path for diversion and misuse, and that intrinsic features and extrinsic measures are not in conflict with each other.

Table 2: Assessment of UR4

Diversion Path 1:		Facility / NES level	Country-level
Step 1: Diversion of fuel slugs from the Fuel Slug Temporary Storage {17} and loading of fuel slugs into a waste container	**Extrinsic measures (SG)**		
	All fuel containers are registered (Identification No, tare, gross, net), continuous monitoring of all movements, balancing of inventories and reconciliation with operating records (NRTA), maintaining Continuity of Knowledge (Cok)	X	
	Transfer routes for TRU fuel and heel/scrap (product stream) should be strictly separated from transfer routes for waste, to make the transfer of TRU fuel and heel/scrap into waste containers impossible	**Resultant design requirement**	
	Other Extrinsic measures		
	All NM is US-obligated	X	X
	Comment: This extrinsic measure above apply to all diversion paths at SFMF		
	Intrinsic features		
	High radiation, NM can be handled only remotely.	X	X
	Material element composition is not favorable for a nuclear weapon		X
	Discrete separation of TRU or un-irradiated Plutonium inside SFMF is not possible.	X	
	Isotopic composition of Plutonium is not convenient for a nuclear weapons program		x
	SFMF is highly automated, interference will be possible only for maintenance and at an emergency	X	
	....		

In summary, the case study demonstrated that the questionnaire approach is suitable to assess the compliance of the NES with criteria in the area of proliferation resistance. The case study also demonstrated that weaknesses and R&D needs for PR requirements can be identified, including design requirements in the safeguards-by-design process.

3. Conclusions

The PROSA process with questionnaire approach is simpler and easier to perform that the original INPRO PR methodology with qualitative scale from "weak" to "very strong" to be determined by expert judgment. The PROSA process can be applied from the early stage of design showing the relationship of PR assessment to the SBD process. The diversion path analysis required showed that the assessment could provide reasonable insights regarding safeguardability, demonstrating the availability of SG tools and measures for the implementation of effective and efficient safeguards, including the coverage of NEAS by multiple intrinsic features and extrinsic measures.

REFERENCES

[1] International Atomic Energy Agency, Proliferation Resistance Fundamentals for Future Nuclear Energy Systems, IAEA STR-332, IAEA Department of Safeguards, IAEA, Vienna (2002).
[2] International Atomic Energy Agency, Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems, INPRO Manual – Proliferation Resistance, Volume 5 of the Final Report of Phase 1 of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), IAEA-TECDOC-1575, IAEA Vienna, 2007.