Study on Vital Area Identification for Physical Protection System

H. H. Lee*, E. H. Kwon, S. Y. Kim, H. D. Kim
Korea Atomic Energy Research Institute
Daedeok-daero 989-111, Yuseong-gu, Daejeon 305-353, Republic of Korea
**Corresponding author: nhhlee@kaeri.re.kr*

1. Introduction

Physical protection (PP), which is required for the security of nuclear facilities and has recently caught the attention of the international community, is a mandatory design requirement for innovative nuclear energy systems. The International Atomic Energy Agency (IAEA) to this end has recommended its member countries to implement stronger physical protection measures when it amended the previous publication and released INFCIRC/225/Rev.5 in 2011; the core of the recommendation was the identification of vital areas (VAs).

As the Korea Atomic Energy Research Institute (KAERI) has been developing an SFR fuel cycle with pyroprocessing as part of its nuclear energy R&D since the late 1990s, the concept of VAs should be incorporated at the process development and design stage in order to minimize later changes in facility design and prevent subsequent economic loss. This paper discusses the definition and process to identify VAs for the purpose of establishing physical protection systems (PPSs) for the relevant facilities in the future.

2. Basic Concept

IAEA recommends all member countries to identify and designate VAs when establishing physical protection systems of nuclear facilities through INFCIRC/225/Rev.5, which was amended and released in 2011. The publication defines a VA as "an area inside a protected area containing equipment, systems or devices, or nuclear material, the sabotage of which could directly or indirectly lead to high radiological consequences [1,2]." It also defines vital area identification (VAI) as "a process employed by safety and physical protection specialists to identify the areas containing nuclear material or the minimum set of equipment, systems, or devices to be protected against sabotage [1,2]."

According to the publication, VAI is based on four key concepts: (1) using fault trees to determine the events that can cause sabotage; (2) replacing the events in the fault trees with the locations from which they can be accomplished; (3) solving the fault trees to generate the combinations of locations that must be visited to complete sabotage; and (4) identifying the sets of locations that, if protected, will preclude possible sabotage.

Three types of sabotage scenarios are addressed during VAI described herein: (1) direct dispersal of radioactive material by explosive, incendiary, or other devices that the adversary brings into the facility; (2) disturbing facility operations in a manner more severe than the facility mitigating systems can respond to; and (3) disturbing facility operations and disabling the mitigating systems needed to adequately respond to the resulting system upset.

Design basis threat (DBT) is used to refer to the capabilities or other descriptive information about the threat that a nuclear facility PPS must be designed to withstand. It is not necessary to know the details of the DBT for carrying out VAI, but it is necessary to know whether the threat is assumed to have the resources needed to accomplish specific types of initiating events of malicious origins (IEMOs) and disablement events. In particular, it is important to know whether the DBT has explosives available as that will determine whether the destruction of large passive components must be considered in defining VAs.

2.1 Safety Input for VAI

Safety is an important consideration of the integrated engineering approach for the design, construction, and operation of a nuclear facility. Process and system safety analyses use tools such as event trees and fault trees that can address both event frequency and consequence. For VAI, it is necessary to identify the event sequences initiated by deliberate acts, including equipment disablement, which must be prevented to protect workers, the public, and the environment from the effects of sabotage. VAI can employ models and results from completed safety analyses to save both time and money.

2.2 Security Output of VAI

The output of VAI serves as part of the input requirements for the design of a PPS employed to protect against sabotage. That is, VAI focuses on what areas to protect while the PPS design addresses how these areas are to be protected. VAI identifies the areas containing the systems, components, devices, or nuclear material that must be protected without considering those threat attributes that relate to its capability to defeat security measures.

3. **VAI Process**

The steps involved in the VAI process are shown in Fig. 1 as follows:

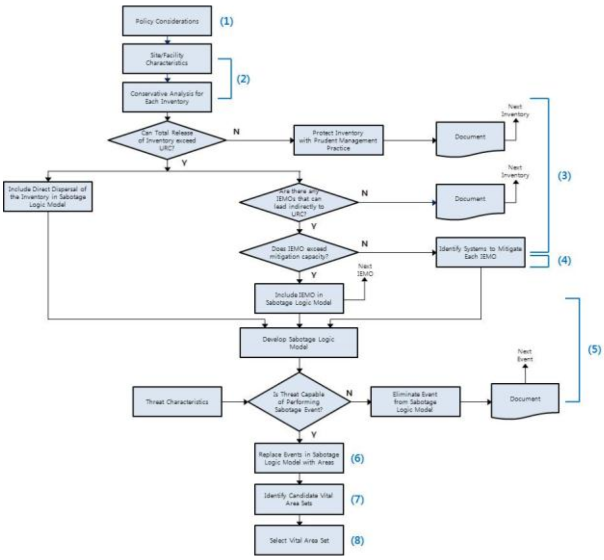

Fig. 1. Vital Area Identification Process.

(1) Address policy considerations. The State is responsible for establishing and maintaining a legislative and regulatory framework to govern physical protection. To ensure that an appropriate protection against sabotage will be provided, the State has to decide what level of protection has to be provided against sabotage. The requirements addressed by this policy should provide for operational states, facility safe state, random equipment failures, maintenance of equipment, difficult in locating equipment outside VAs, recovery actions, human error, and DBT.

(2) Identify inventories that require protection. Determine the sources of radioactive material and other information for the facility and site. Determine whether the complete release of any inventory could exceed the high-consequence criteria. Include direct dispersal of any such inventory as an event in the sabotage logic model and continue with the process described below.

(3) Identify IEMOs. Identify IEMOs that exceed the capacity of mitigation systems. Include each such IEMO as an event leading to high radiological consequences in the sabotage logic model. Identify IEMOs that are within mitigating system capacity.

(4) Identify equipment needed to mitigate IEMO. For each IEMO that does not exceed mitigating system capacity, identify the safety functions necessary to mitigate the IEMO, the systems that perform the safety functions, and the success criteria for the system.

(5) Develop a sabotage logic model. Construct a sabotage logic model that identifies the combinations of events (direct dispersal events, IEMOs that exceed mitigating system capacity, and IEMOs coupled with safety system failures) that would lead to high radiological consequences. Assess threat capabilities and eliminate from the sabotage logic model any events that the assumed threat does not have the capability to perform.

(6) Identify areas corresponding to logic model events. Identify the locations (areas) at which direct dispersal, IEMOs, and the other events in the sabotage logic model can be accomplished. Replace the events in the sabotage logic model with their corresponding areas.

(7) Identify candidate VA sets. Solve the sabotage logic model to identify the combinations of locations that must be protected to ensure that high radiological consequences cannot occur.

(8) Select a VA set. Select the VA set that will be protected to prevent sabotage leading to high radiological consequences. Engineering judgment or a more formal decision analysis process can be used to select the best set to protect based on the evaluation criteria.

4. Conclusions

As the possibility of sabotage at nuclear facilities has increased since the September 11 attacks in the US, the importance of VAs is being emphasized for the establishment of PPSs. As recommended in INFCIRC/225/Rev.5 by IAEA, all member countries should strive to identify and designate VAs when establishing PPSs of nuclear facilities. As Korea plans to amend its relevant laws and regulations to reflect the IAEA's recommendation, operators will be required to design and establish PPSs and prove the appropriateness of these systems to regulators. Adequate preparation will thus be required for when the SFR fuel cycle with pyroprocessing being developed by KAERI is eventually commercialized and introduced in Korea.

REFERENCES

[1] IAEA Nuclear Security Series No. 13, "Nuclear Security Recommendation on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5)," International Atomic Energy Agency, 2011.

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