Conceptual Framework for Physical Protection Against Sabotage Considering Plant-specific Radiological Consequences

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1. Introduction

According to the Generation IV (Gen IV) Technology Roadmap [1], Gen IV nuclear energy systems (NESs) should highlight proliferation resistance and physical protection (PR&PP) as one of the four goals along with sustainability, safety and reliability, and economics. Especially, physical protection (PP) is the typical important characteristic of an NES that impedes the theft of materials suitable for nuclear explosives or radiation dispersal devices (RDD) and the sabotage of facilities and transportation by sub-nation entities and other non-Host State adversaries. These two subjects have been studied separately. Proliferation is commonly considered as an international concern and the past work on the PR assessments can be found. On the other hands, PP is regarded as a State security concern, much of which is classified and facility-dependent.

Recently, more concern has been focused on the PP design and regulation because of rapid environment changes including radiological consequences by internal sabotage and nuclear terrorism by RDDs. The current PP Regulation has been applied intensively to the existing nuclear facilities and could be a possible guidance for the future GEN-IV NESs.

This paper first reviews the IAEA guide document, INFCIRC/225[2], which was accepted as the standard international guideline in the physical protection area. It has been updated several times up to now, and is undergoing another revision. The paper introduces current substantial changes in the document regarding PP including the national nuclear security and sabotage in the nuclear facilities. Then, it presents a conceptual framework for physical protection against sabotage considering plant-specific radiological consequence after malicious acts within certain vital areas. The framework combines the newly developed method of vital area identification, the current PSA level 2 works, and physical protection concepts. This would help to improve a design concept of new physical protection systems and/or an effort of the reinforcement in current physical protection system based on the IAEA document.

2. INFCIRC/225 Document

An IAEA's guidance document, "The Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225)" has long been considered the internationally accepted standard for nuclear physical protection. It is not a legally binding instrument, but it is given legally binding effect in some bilateral nuclear safeguards agreements that prescribe INFCIRC/225 as the standard to be applied to nuclear material supplied under such agreements.

The document has been updated several times, the current being INFCIRC/225/Rev. 4 is undergoing a major revision, and the new document, INFCIRC /225/Rev.5, will become a key recommendation document. The document will require substantial changes to national nuclear security frameworks. The following outlines some of these changes that may require consideration by regulators and operators.

2.1 Limited Access Areas

The document introduces for the first time the concept of a limited access area, defined as a "designated area containing a nuclear facility and nuclear facility and nuclear material to which access is limited and controlled for physical protection purposes."

2.2 Performance Testing

Performance testing of the implemented physical protection measures, with an integrated physical protection system (PPS) with response by guards and response forces has been included as evaluation methods.

2.3 Unacceptable Radiological Consequences

Requirement of a state to determine the level of unacceptable radiological consequences is added in the revision 5 of INFCIRC/225 as followed: "For protection against sabotage, the state should establish its threshold of unacceptable radiological consequences in order to determine an appropriate level of physical protection taking into account existing nuclear safety and radiological protection."

2.4 Others

Some other changes are described as follows:

- Articles that emphasize the combination of safety, safeguards and security
- Physical protection measures for cyber security
- Requirements for physical protection of nuclear material against unauthorized removal and sabotage during transport have been added and strengthened.

3. Conceptual Framework for Physical Protection Against Sabotage

Many substantial changes have been made in INFCIRC/225/Rev.5 document up to now since the recent nuclear security environment is changing dramatically. Some of them could affect not only the national regulation regime in physical protection area, but maintenance efforts of safety systems and training of personnel regarding to possible radiological consequences due to sabotage.

According to the document, nuclear material or equipment, systems or devices leading to unacceptable radiological consequences after sabotage should be located within vital areas. Recently, a new method of "vital area identification" has been proposed based on the PSA Level 1 study [3]. The malicious act in a specific vital area could cause to core damage state, which leads to unacceptable radiological consequences. The process is quite complex and should be plant-specific.

This section presents a conceptual framework for physical protection against sabotage considering such plant-specific radiological consequence after malicious acts within certain vital areas. The framework first combines the method of vital area identification and the current PSA level 2 works. Then, the framework considers a process associated with these work and a threshold of unacceptable radiological consequence determined by expert's judgment. Finally, the framework establishes a procedure for determining an appropriate level of physical protection taking into account existing nuclear safety and radiological protection described in the IAEA document.

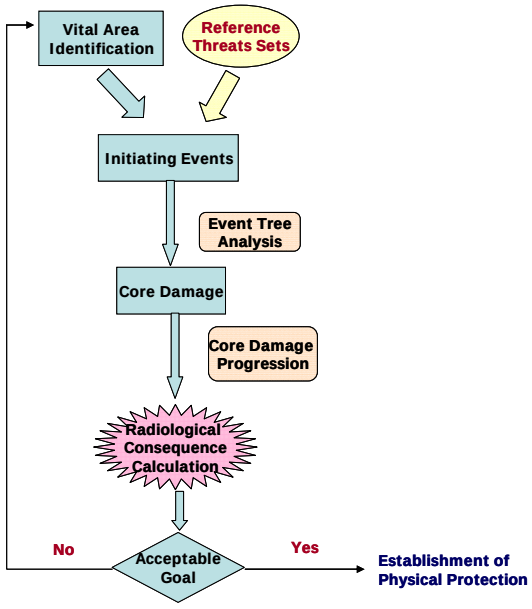

Figure 1. A Proposed Framework for Physical Protection Validity Assessment under Sabotage Scenario

Figure 1 shows the proposed framework for physical protection validity assessment under sabotage scenarios.

The reference threat description is performed by national regulatory authorities based on plant-specific conditions and policies regarding level of protection required. The threat sets from possible sabotage scenarios at certain vital area(s) identified by the method [3] could contribute to core damage state. The accident core damage progression could be evaluated by severe accident evaluation codes such as MELCORE[4]. Finally, each possible radiological consequence following by core damage progression can be calculated. If the calculated consequence does not exceed the threshold of acceptable radiological consequence, the proposed level will ensure the physical protection against plant-specific sabotage considering nuclear safety and radiological protection described in the IAEA document. Otherwise, additional physical protection capabilities should be added for these areas in case of reference threat set under assumed sabotage scenario.

4. Discussions

This paper presented the conceptual framework for physical protection in case of plant-specific radiological consequence after malicious acts within the vital area in the nuclear power plants. In order to determine the acceptable plant-specific physical protection level against the sabotage threat, this work can provide the systematic framework based on the PSA method and the IAEA guideline document.

However, the selection of the vital area based on a facility-specific conditions and the determination of State's threshold level for radiological consequences was not discussed here in detail. More work regarding to these area should be needed to validate the proposed framework and its real application.

REFERENCES

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