Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

A proposed model for evaluating a Physical Protection System of nuclear material and nuclear facility

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1. Introduction

A Physical Protection System (PPS) at a nuclear facility is to minimize the possibilities for the unauthorized removal of nuclear material and/or radiological sabotage of nuclear facilities. Designers of nuclear facilities should evaluate the PPS effectiveness against any illicit actions to accomplish the basic purposes of the system [1, 3].

The purpose of this study is to propose a PPS model which can be used to evaluate the effectiveness of the PPS.

A proposed model has been assessed through the KAVI software which has been developed to assess the PPS.

2. Modeling Concepts of the PPS

2.1 Protection in depth

Protection in depth means that an adversary should be required to avoid or defeat a number of protective devices in sequence [4]. For example, an adversary might have to penetrate three separate barriers before gaining entry to a reactor control room. The times to penetrate each of these barriers may not necessarily be equal but the effectiveness of each barrier may be quite different. A separate and distinct act by the adversary will be required at each barrier as he moves along his path. The effect of the PPS designed by protection-in-depth will be 1)to increase uncertainty about the PPS, 2)to provide the adversary more extensive preparation prior to attacking the PPS and 3) to create additional steps where the adversary may fail or abort his mission

2.2 Balanced protection

Balanced protection implies that, no matter how an adversary attempts to accomplish his goal, he will encounter effective elements of the PPS. Consider, for example, one of barrier surfaces surrounding a reactor control room. This surface may consist of barriers of several types such as walls, floors, ceiling of several types, doors of several types and openings of various types, etc. For a completely balanced PPS, the minimum time to penetrate each of these barriers would be equal, and the minimum probability detecting penetrations of each should be equal.

However, a complete balance is probably not possible or desirable. Certain elements such as walls may be extremely resistant to penetration not because of physical protection requirements but because of structural or safety requirements.

Features designed to protect against a certain specific threat should not be eliminated because they could overprotect against another threat. The objective should be to provide adequate protection against all threats on all possible paths and to maintain a balance with other considerations, such as cost, safety, or structural integrity.

3. The proposed modeling of the PPS

3.1 Assumption

We need two assumptions to model the PPS such as adversary threat and neutralization.

Firstly, we have assumed the adversary threat that two outsiders have some hand tools to penetrate delay barriers such as wall, fences etc. And they know well about the characteristics of the PPS as a target. Also, we exclude a threat from the insider such as employees because consideration of the insider threat is very complex.

Secondly, the probability of neutralization assumes 1.0, which means the response force can neutralize the outsiders when they fight against each other. We only consider every single path from outside to the target. Therefore, it is no consideration on the radiological sabotage and the unauthorized removal of nuclear material.

3.2 Description of model

The model consists of two layers of detection and delay system as shown figure1. Delay system should be installed at the place where detection system is installed. Because the delay time after detection will be available to give the response force enough time to respond.

First layer consist of main gate and rear gate which is general, double fence which has enough space for detectors and/or CCTV camera between the fences, and the vehicle barrier near the outer fence. In case of detection system, we suggest that two different kinds of detectors should be installed in the fences to reduce the nuisance or false alarm. Second layer consist of only entrance gate and double fences which are the same as the first layer. In this layer, vehicle barrier is not needed because all the vehicles between two layers should be allowed to enter.

Central Alarm System (CAS) should be positioned inside the facility to control all the devices related to the PPS. We assume that the CAS is located inside the second layer. Also, the response force should be working inside the CAS to respond timely to all the alarms.

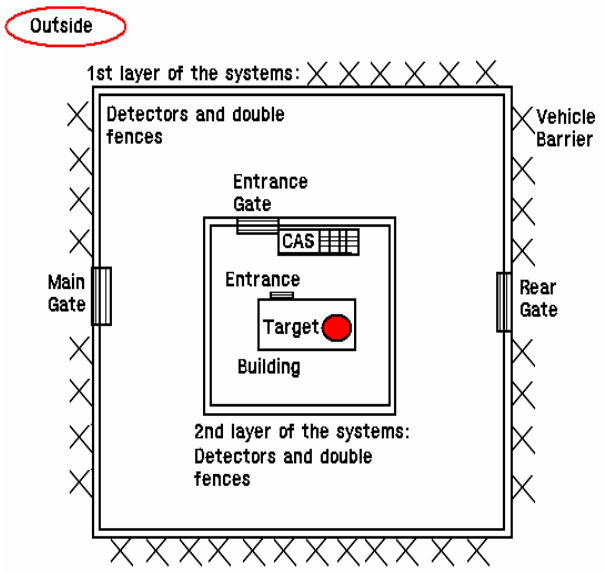

Figure1. Prototype model diagram of PPS

4. KAVI software assessment

4.1Modeling

For assessing the model by the KAVI software [5, 6], we should analyze all the paths at first. Using the concept of the balanced protection already explained above, we can assume the model as the several single paths from outside to target. We can classify three areas through the single path as follows:

Area*	Protective Elements
1st Area	1)Main gate 2)1st fence with detectors, CCTV, vehicle barrier 3)Rear gate
2nd Area	1)Entrance gate with CAS 2)2nd fence with detectors, CCTV
3rd Area	1)Entrance 2)Building
Target	1)Container for nuclear material

* Area along with the single path

The time which the outsiders and response force travel between the areas is the same as 100 seconds which is unrealistic value. The max response force time (RFT) that the response force respond can be 200 seconds on consideration the distance from 1st layer to the target .

4.2 Results

As a result, all the paths the outsiders penetrate have the same protection effectiveness in the model.

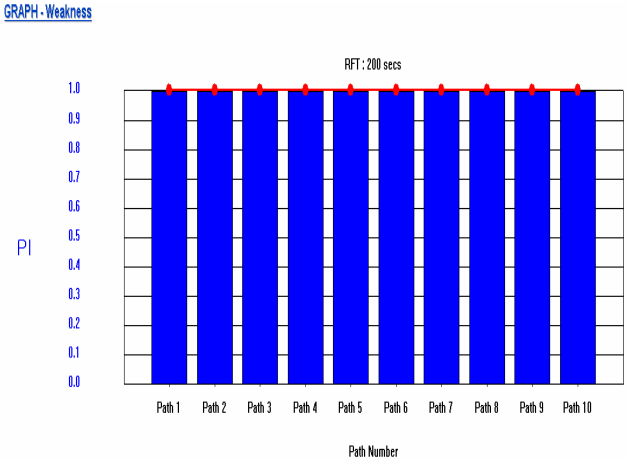

Figure2. Probability of Interruption (PI) by the response force

Figure2 shows the weakness graph that there is no path to be penetrated in the model even though the RFT is the maximum. And PI is 1.0 for all the paths.

From the results, the model has been assessed to be accomplished to the concepts such as protection in depth, balanced protection. Also, the response force may neutralize the outsiders until they reach the target.

5. Conclusion

We have offered the model for evaluating the effectiveness of the PPS in the nuclear facilities containing nuclear material and evaluated the proposed model using the KAVI software.

In the current status that there are no technical guidelines in nuclear facilities, this model can be a better guideline to evaluate the facilities.

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