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Vulnerability Analysis of Physical Protection System at Wolsung Nuclear Power Plant

Won Moog Jung, Ho Jin Lee, Donghan Yu, Gyungsik Min
NNCA Verification Technology Dept. P.O.Box 114 Yuseong, Daejoen, Korea 305-600.

1. Introduction

The 9/11 event in the U.S.A has increased international terror possibilities against nuclear facilities including nuclear power plants(NPPs). It is necessary to assess the performance of an existing physical protection system(PPS) at nuclear facilities based on such malevolent acts. A PPS is a complex configuration of detection, delay, and response elements. Several methods are available to analyze a PPS and evaluate its effectiveness. Sandia National Laboratory(SNL) in the USA was developed a System Analysis of Vulnerability to Intrusion (SAVI) computer code for this purpose. It is powerful software for evaluating the effectiveness of PPS against outsider threats.

This study presents the performance assessment of the PPS at Wolsung NPP using SAVI code. First, the site-specific Adversary Sequence Diagrams(ASDs) of the PPS is constructed. It helps to understand the functions of the existing PPS composed of physical areas and Protection Elements(PEs) at Wolsung NPP. Then, the most vulnerable path of an ASD as a measure of effectiveness is determined. Finally, the probabilities of interruption(PI) for these paths are calculated.

The results in the analysis can used to suggest the possible physical protection system upgrades to the most vulnerable paths for Wolsung NPP.

2. Methods

2.1 SAVI computer code

The calculational steps of the SAVI code are as follows[1]:

a) Identify targets & Construction a site-specific ASD
b) Define safeguards at each PE in ASD
c) Assign delay and detection values to each safeguard
d) Define adversary characteristic
e) Define response force characteristic
f) Analyze and review results

The analysis results provide information on Probability of Interruption, Critical Detection Point (CDP) and Time Remaining after Interruption (TRI) for the most vulnerable path and a specified response force time. The interpretation of these could suggest the need for sensitivity analysis of data that has been input to the code, as well as a possible PPS upgrade to the most vulnerable path[2].

2.2 Description of PPS at Wolsung NPP

The PPS of Wolsung NPP was selected and analyzed.

- The NPP is bound on the north and west by inland and the east and south by sea.
- The perimeters are protected by dual fences with guard posts and established fences with CCTV and intrusion detection sensors.
- Main entrance/exit gate is operated by a control-center with armed persons.
- Security gates are monitored by CCTV.

2.3 Adversary Penetration Scenario

The analysis performs the following three adversary penetration scenarios:

1) Adversaries intrude into the NPP through a main gate.
2) Adversaries intrude into the NPP through inland.
3) Adversaries intrude into the NPP through sea.

2.4 Analysis of PPS using the SAVI code

The main assumptions for the analysis using the SAVI code are as follows;

- The threat type is a terrorist foot.
- The intrusion is a combination of force and stealth.
- The response strategy is a containment.
- The Response Force Time (RFT) is set to 300 seconds.

Figure 1 shows the PPS in Wolsong NPP using ASD. Each protection layer consists of several specific protection systems shown in the figure. For example, five protection systems are existed between B layer and C layer.

Figure 2 shows a vulnerable path analysis based on the scenario for an intrusion through sea. Based on the analysis, the CDP is started from the Overpass(OVP) protection system located between the offsite and the front gate in case of RFT = 300 seconds. The red color shows the most vulnerable path from offsite to target area, i.e., a fresh fuel storage tank in the analysis.

The sensitivity analysis of the RFT for the most vulnerable path described in Figure 2 is shown in Figure 3. The PI is calculated as 0.97 in case of RFT = 133 seconds. When the RFT is greater than 133 seconds, the PI is calculated as 0.01. It means that when the time of arriving response forces for the intrusion is less than 133 seconds, the protection system could delay the success of a intrusion to the target area before a response force arrives.

Figure 4 shows the PI for the 10 selected intrusion paths in case of RFT=133 seconds. The results show that the probabilities of interruption for the intrusion are calculated as 0.97 for the RFT=133 seconds. That means that the most of intrusion would be interrupted with the existing protection systems at Wolsung NPP when a response force is ready to arrive less than 133 seconds after the intrusion starts.

Figure 1. Site-specific ASDs of PPS at Wolsong NPP

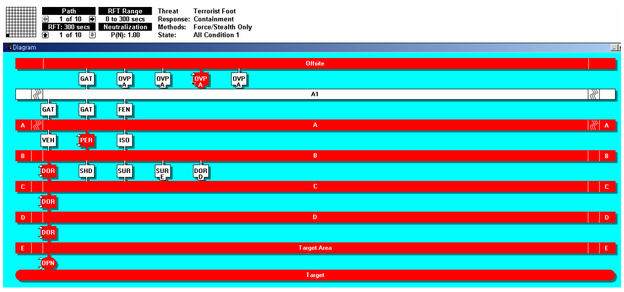

Figure 2. Intrusion path diagram of Wolsung PPS in case of RFT= 300 seconds

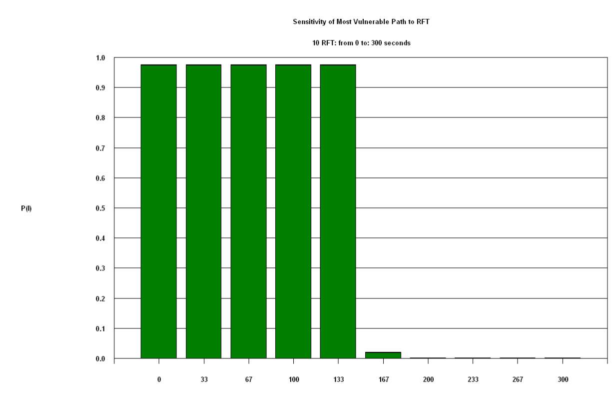

Figure 3. Sensitivity analysis of RFT for the vulnerable paths

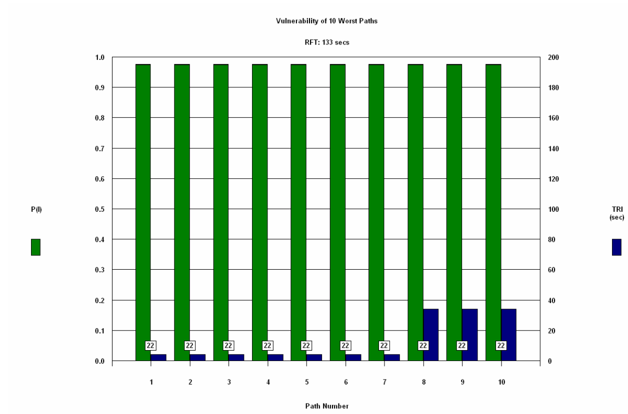

Figure 4. The probability of interruption for the 10 worst intrusion paths in case of RFT = 133 seconds

3. Conclusion

This paper presented the vulnerability analysis of the PPS at Wolsong NPP using the SAVI code. The vulnerable paths and sensitivity analysis of RFT for the paths were analyzed, and the probabilities of interruption for the intrusions were calculated for the PPS at Wolsung NPP.

The results showed that the worst vulnerable intrusion path was the intrusion through the sea. In this case, the probability of interruption was calculated as 0.01 when the RFT was equal to 300 seconds. However, the probability increased to 0.97 when the RFT was equal to 133 seconds. This means that most of intrusion would be interrupted with the current PPS at Wolsung NPP when a response force is ready to react against the intrusion within 133 seconds.

The results could not be applied directly to the real situation in the domestic NPPs since the input data used in the analysis were obtained from the USA cases and the scenarios may not be logical for domestic situations. However, the analysis would be helpful to understand the functions of the existing physical protection systems and improve the possible performance upgrade for the system at Wolsung NPP.

REFERENCES

[1] Ann Bouchard, SAVI Coures South Korea, Cooperative Monitoring Center, p. 25-1-25-10, 2001.

[2] SNL, Physical Protection System Design, Workshop Material on Physical Protection System Methodology, 1996