Preliminary Analyses of Vital Area Identification in Nuclear Power Plant

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1. Introduction

Recently, international societies such as IAEA try to strengthen the physical protection of nuclear installations. As one of such activities, vital area identification (VAI) is to be identified systematically. KAERI (Korea Atomic Energy Research Institute) has developed a technique to identify VAI by PSA (Probabilistic Safety Assessment) methodology. In this paper, VAI preliminary analyses are described for the reference nuclear power plant (NPP).

2. Vital Area Identification Modeling and Results

The concept of sabotage-induced risk assessment was set up previously. [1] Vital area identification based on probabilistic assessment techniques is useful for improving the physical protection system of nuclear fields. In this section, the frame work of how to analyze VAI and its results are described.

2.1 Vital Area Identification Main Scheme

Vital area identification (VAI) is defined as the area where the important equipment and systems are located in. At present, KAERI is executing VAI intensively for various initiating events and mitigating progression. The VAI analysis scheme includes vital area identification information preparing, modeling, VAI mapping for a plant status and its application for decision making for expected plant behaviors in terms of vital area identification.

2.2 Vital Area Identification Preparing and Modeling

Once the initial plant data must be prepared such as building/room drawing, piping/Instrument/Cable drawing, physical protection partition and component information, the VAI scheme is structured to capture the various elements of the physical protection related VAI risk by a previous study. [2] PSA model for reference plant was constructed by the modification of internal PSA model. To develop the VAI model, components located at rooms of a fire initiation or propagation and cables going through them were identified. VAI of the sabotage-induced risk is a relatively new terminology which should be defined more carefully. Conceptually, the VAI assessment may not be much different from a typical PSA as shown in Figure 1. However, the identification of all possible accident sequences and the estimation of their respective frequencies differ greatly, mainly because the accidents are intentionally incurred and the usual mitigating systems may fail together with the initiating events.

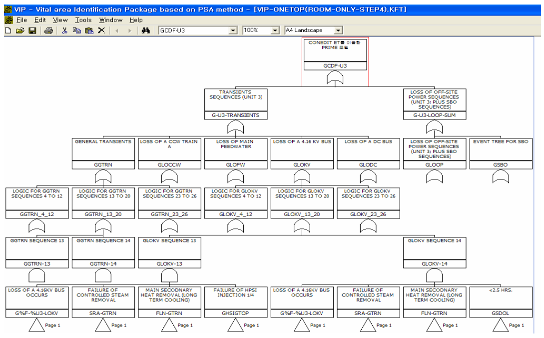

Figure1. PSA initial model for vital area identification

2.3 Vital Area Identification Analysis

VAI analysis module takes charge of fast calculation and prediction for specified plant responses. For this analysis, the VAI assessment system provides a user-friendly interface for the user to explore the contents of the module and to obtain assessment results for modeled facilities.

- Vital Area Identification Mapping

A VAI is applied to the screening models without detailed fault tree models using a software VIP (Vital area Identification Package) using the PSA fire mapping technique. [3] But, specific modeling for sabotage induced realistic phenomena will be more detailed than that of fire PSA. Analyst must identify internal PSA basic events to add new events besides them for the mapping technique. The mapping tables shown in Figure 2 include (a) sabotage-induced initiating events (b) transfer events (c) internal PSA basic events of an accident initiation and the probabilities of accident propagation.

Room	Frequency	TransferedRoon	EventTree	CondProbaName	CondProb	Events
000-UAT	0.001		%U3-GTRN		1	NOXHYUATA, NOXHYUATB
000-SAT	0.001		%U3-GTRN		1	EOXHYSATA, EOXHYSATB
000-SWYD	0.001		%U3-GTRN		1	EOSYFTRIP
000-ESWA	0.00108		%U3-GTRN	P%F-000-ESWA	1	HHABRAH01A, HHABRAH02A, SWMPR001PA, SWMPR002PA, SWMVT0067A
000-ESWB	0.00106		%U3-GTRN	P%F-000-ESWB	1	HHABRAH01B, HHABRAH02B, SWMPR001PB, SWMPR002PB, SWMVT0068B
000-HDGA	0.0101		%U3-GTRN	P%F-000-HDGA	1	EGDGR01A, EMBSYMC02A, HDABR-03A, HDABR-04A, HDABR-05A, HDABR-06A
000-HDGB	0.0101		%U3-GTRN	P%F-000-HDGB	1	CCMVO0106B, EDBYABT01S, EGDGR01B, EGDGR01E, EKBSYSW01E, ELBSYLC01E, EMBSYMC01E, EMBSYMC02B, EMBSYMC02E, HDABR-03B, HDABR-04B, HDABR-05B, HDABR-06B, HDABR15E, HDABR17E, HDABR19E
000-TBB	0.0582		%U3-GTRN	P%F-000-TBB	1	BDAVO017, BDAVO023, BDMPR022, EOXHYSATA, EOXHYSATB, IAACRCM01A, IAACRCM02B, MFCVO058, MFMPR07P, MFMVO093, NDBCYBC01M, NDBCYBC01N, NKBSYSW02M, NKBSYSW02N, NLBSYLC03M, NLBSYLC03N, NLBSYLC09N,
047-A01A	0.000653		%U3-GTRN	P%F-047-A01A	1	HCCQRLPPA, HSLVT0659A, HSLVT0660B, HSMVT0667A, LSMPRLPSI1A, LSMVT0669A, LSMVT0691A, LSMVT307A, SCMVO0657A, SCMVO0693A, SCMVO0695A
047-A01B	0.000653		%U3-GTRN	P%F-047-A01B	1	HCCQRLPPB, HSLVT0659A, LSMPRLPSI1B, LSMVT0692B, LSMVT306B, SCMVO0694B

Figure 2. Display of VAI Mapping in Computer Monitor

The VAI mapping value is estimated by a multiplication of the probability of fire shape propagation and the probability of a component failure caused by sabotage. The component failure probabilities are pre-estimated as its failure mode and component circuit configuration for VAI mapping probability.

- *Vital Area Identification Results*

The modeling in the present paper is consistent and the most complete for identifying the vital areas to be protected since it has been based on well-proven PSA technology. [4] VAI assessment results shown in Figure 3 are from using a fast run algorithm for fault tree analysis. [5] The present VAI management system is very useful in a number of applications including support for a mitigation, training and understanding of the accident phenomenology, and assistance in a sabotage-induced risk management.

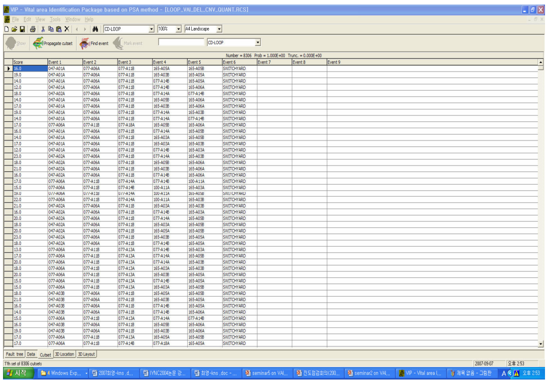

Figure 3. Display of VAI Results in Computer Monitor

3. VAI Application and Future Work

The VAI assessment system has been developed graphic display for a plant status, previous assessment results, and the expected plant behavior using VAI results. This VAI based display system will provide decision-making functions for physical protection management to monitor plant status. The VAI monitor checks the status of the plant physical barrier system and displays the optimal success path based on each mimic drawings selected by the user.

As future wok for completeness of VAI, physical protection / monitoring systems must be analyzed besides safety and process systems of facilities. Also, every possible phenomena and accident risk related to sabotage will be scrutinized as detailed as possible. For example, flooding analysis will be included in VAI modeling scope as another sabotage possible sequence. Therefore, the complementary improvement of risk informed VAI will be essentially useful for physical protection.

4. Conclusion

These VAI analyses have been effectively tested through a set of full scope models whose elements are a plant specific status and accident propagation progression. Therefore VAI analyses may play a central role as an information source for the decision-making for a physical protection management, and will be used as a training tool for a physical protection. In particular, the PSA based VAI analyses help to identify plant vulnerabilities and appropriate plant responses to the specific challenge for plant physical protection.

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