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Developing a Vital Area Identification in Nuclear Power Plants Using PSA Results

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1. Introduction

After 9/11, a physical protection and vital area identification (VAI)[1] became important. In the well known VAI methodology[1], fault trees (FTs) to mitigate the initiating events caused by sabotage or terror should be prepared for the VAI. The KAERI VAI method is to develop FTs by using Probabilistic Safety Assessment (PSA) and Risk Informed In-service Inspection (RI-ISI) results.

In this paper, how to develop a VAI model by using PSA and RI-ISI results is described.

2. Methods and Results

2.1 Adopting the Results of Fire PSA and RI-ISI

If the terrorists attack a room inside in a nuclear power plant (NPP) with bombs, all equipment including cables located in the room could become useless, which in turn could cause reactor core damage if the NPP is operating since some mitigating systems could be destroyed by the terror attack. Similarly, if a fire occurs inside a room, all the equipment including the cables inside the room could be destroyed, which in turn could cause reactor core damage if the NPP is operating when the fire occurs. Thus, the core damage event of a NPP caused by a terrorist attack could be similarly modeled by using the fire PSA model.

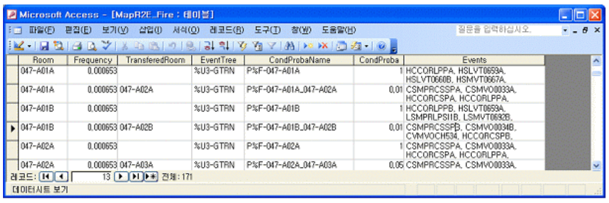
VAI is the process for identifying the areas in a nuclear facility around which protection will be provided in order to prevent or reduce the likelihood of a terror attack. Also, since VAI can be performed by a TEP algorithm[1-3] based on a PSA model, VAI can be done by the fire PSA model.

The method to use the existing fire PSA model to do VAI is the original method developed by KAERI, which is better than the other ones which develop FTs and event trees caused by a terror explosion from scratch. Thus, the KAERI method saves on a lot of resources and is more accurate.

A fire that occurs in a room causes PSA events, and it is implicitly described in a Fire-Room-PSA Mapping DB as shown in Table 1. In Table 1, the first line indicates that if a fire occurs in room 047-A01A where the LPSI pump is located, then a general transient initiating event occurs and the HCCQRLPPA, HSLVT0659A, HSLVT0660B, and HSMVT0667 events occur.

In Table 1, the second line means that the fire of room 047-A01A is transferred to the next room 047-A02A with a 0.01 probability, which causes a general transient initiating event and the CSMPRCSSPA, CSMVO0033A, HCCQRCSPA, and HCCQRLPPA events.

Table 1. Fire-Room-PSA Mapping DB for UCN 3



Room	Frequency	TransferedRoom	EventTree	CondProbaName	CondProba	Events
047-A01A	0.000653		%U3-GTRN	P%F-047-A01A	1	HCCQRLPPA, HSLVT0659A, HSLVT0660B, HSMVT0667A,
047-A01A	0.000653	047-A02A	%U3-GTRN	P%F-047-A01A_047-A02A	0.01	CSMPRCSSPA, CSMVO0033A, HCCQRCSPA, HCCQRLPPA,
047-A01B	0.000653		%U3-GTRN	P%F-047-A01B	1	HCCQRLPPB, HSLVT0659A, LSMPRLPSIIB, LSMVT0692B,
047-A01B	0.000653	047-A02B	%U3-GTRN	P%F-047-A01B_047-A02B	0.01	CSMPRCSSPB, CSMVO0034B, CVMVOCH534, HCCQRCSPB,
047-A02A	0.000653		%U3-GTRN	P%F-047-A02A	1	CSMPRCSSPA, CSMVO0033A, HCCQRCSPA, HCCQRLPPA,
047-A02A	0.000653	047-A03A	%U3-GTRN	P%F-047-A02A_047-A03A	0.05	CSMPRCSSPA, CSMVO0033A,

A room explosion could destroy pipes inside the room as well as equipment and cables. Thus, in order to reflect the effect of the pipes rupture due to the explosion, RI-ISI results should be additionally used for the VAI. To reflect the rupture of pipes, pipes inside each room should be identified and how the core damage frequency would be changed should be modeled when the pipes are broken. This information could be obtained from RI-ISI. Actually, RI-ISI for UCN 3 [4] supplies a lot of information, but the following procedure should be followed to obtain the very important information, i.e., Room number and Line number.

Step 1. Line Number is found by checking the segment description in P&ID. Segment is given in the RI-ISI results.

Step 2. Systems are identified by checking the line number in the Piping Plan file and ISO Drawing file. Then the position coordinates and neighboring equipment are identified.

Step 3. Through the room number design drawing of FSAR, the room number is identified.

With the RI-ISI information and the Line number found by following the above procedure, a Pipes-Room-PSA Mapping DB for UCN 3 can be developed as shown in Table 2.

Table 2. Pipes-Room-PSA Mapping DB for UCN 3

Room (1)	Initiator (2)	Events (3)	Events Comments (4)	Flood Area (5)	LineNumber (6)	Segment ID (7)	Segment Description (8)	P&ID Drawing (9)	P&ID Drawing Location (10)	Piping Plan Drawing (11)	ISO Drawing (12)	Consequence ID (13)	Treatment (14)	PRA Run Number (15)	Failure Effects (16)	PSA Comments (17)
047-A03B		CVTKBRWT00_HSSPPSUMP	Run for all initiating events	D047-A03B	SI004CA-10	HS-073	10" high pressure safety injection suction line on header 1 from 14"x10" reducer through valve V470 to high pressure safety injection pump 1	9-441-W105-001 Rev. 6	B7	9-321-P190-070, [0700197].dgn	9-321-P193-052-01, 9-321-P193-052-02, 9-321-p193-052-03, 9-321-p193-052-04, [0700864-68].dgn	HS052	SYS	PSA-HS017	Loss of RWT inventory resulting in loss of containment sump, HPI, HPR, HPH, LPI, LPR, CSI, CSR and charging using CVCS	

2.2 Test of the Model with Four Rooms

In order to test the terror model using the fire PSA and RI-ISI results, four rooms such as the LPSI Pump Rooms A/B (047-A01A/B) and the Encapsulation Tank Rooms A/B (077-A18A/B) were selected, and the plant risk change induced by the destruction of the equipment, cables, and pipes in the four rooms was investigated. The locations of the four rooms are shown in Figures 1 and 2.

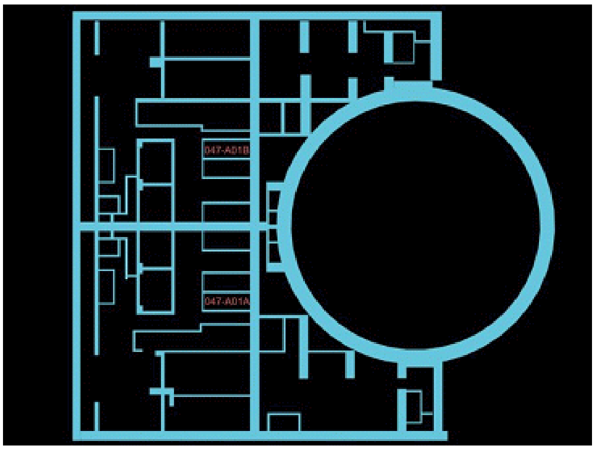


Figure 1. The Location of Rooms 047-A01A/B

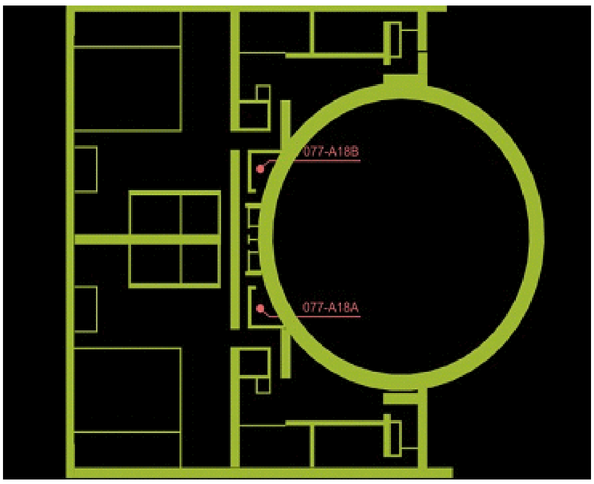


Figure 2. The Location of Rooms 077-A18A/B

Even though the terror model is not yet finished, it shows interesting results. If the piping rupture model is not included when the four rooms are exploded, then only two cutsets are found as important cutsets related to the four rooms as shown in Table 3. When the piping rupture model is included, then additional cutsets are found as shown in Table 4.

Table 3. The Generated Cutsets Related to the four Rooms

BE# 1	BE# 2	BE# 3	BE# 4
077-A18A	NR-AC1HR	P%F-077-A18A	#GSBO-34
047-A01A	#GCSGTR-33		

Table 4. The Additional Cutsets Found After Including the Pipes-Room-PSA Mapping DB

BE# 1	BE# 2	BE# 3	BE# 4
077-A18A	P%F-077-A18A	#GCSGTR-33	
000-TBB	077-A18A	P%F-000-TBB	#GCSGTR-33
000-HDGB	077-A18A	#GCSGTR-33	

3. Conclusions

The KAERI approach for the VAI is to use PSA and RI-ISI results, which is a more accurate and resource-saving approach. To enhance this approach, the room number should be added during the RI-ISI project. Since a piping rupture caused by an explosion also affects the core damage, the Pipes-Room-PSA Mapping DB should be included in the VAI.

Acknowledgement

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REFERENCES

[1] Chang-Kue Park, et. al., "A PSA-based vital area identification methodology development ", Reliability Engineering & System Safety 82 (2003)

[2] Woo Sik Jung et. al., "Vital Area Identification Methodology for the Physical Protection of Nuclear Power Plants", IEEE International Conference on Technologies for Homeland Security and Safety, Gdansk University of Technology, Poland, Sept. 28-30, 2005

[3] Jaejoo Ha, et. al, "The Application of PSA Techniques to the Vital Area Identification of Nuclear Power Plants", Nuclear Engineering and Technology, Korea Nuclear Society, 2005

[4] KEPRI, Application of Risk-Informed Method to Piping Inservice Inspection to Select Locations, 00NJ16, April 2004