Sensitivity studies on the approaches for addressing multiple initiating events in fire events PSA

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1. Introduction

A single fire event within a fire compartment or a fire scenario can cause multiple initiating events (IEs). As an example, a fire in a turbine building fire area can cause a loss of the main feed-water (LOMF) and loss of off-site power (LOOP) IEs. Previous domestic fire events PSA[1] had considered only the most severe initiating event among multiple initiating events. NUREG/CR-6850 and ANS/ASME PRA Standard require that multiple IEs are to be addressed in fire events PSA [2, 3, 4]. In this paper, sensitivity studies on the approaches for addressing multiple IEs in fire events PSA for Hanul Unit 3 were performed and their results were presented.

2. Methods and Results

Fire events PSA model can be constructed with or without fault trees of the IEs [5]. In this study, it was constructed without fault trees of the IEs.

2.1 Construction of a PSA model

- Identification of equipment: for each fire compartment or scenario, equipment which, if affected by a fire, could cause an IE including cables is to be identified. Depending on the strategy of equipment selection, equipment relating to specific IE may be not explicitly selected. In this case, the specific IE is assumed to occur at all fire compartments or scenarios.
- Mapping of fire-induced initiating events to internal events PSA IEs: Each fire-induced IE that is identified is mapped to the internal IE that closely reflects the impact of the fire-induced IE on the plant [2]. For an example, a fire in a compartment containing the motor operated valve for the component cooling water system should be mapped to the loss of component cooling water system IE. Table I shows an example of the mapping tasks.
- Construction of a PSA model: The IPRO-ZONE (interface program for constructing zone effect table) was used for the construction of one-top fire events PSA model [6]. Fig. 1 shows the relationship between the IPRO-ZONE, the AIMS-PSA, and one-top fire events PSA model. The multiple spurious operation (MSO) scenarios were incorporated into the constructed one-top fire events PSA model. Limited works for fire modeling and circuit analyses were performed for construction of fire events PSA model.

Table I: An example of the mapping tasks.

Zone	Path	TransferZone	Frequency	EventTree
100-ADGA	DO	100-A01A	0.00114	%ILOKVA
100-ADGA	SE	100-A01A	0.00114	%ILOKVA
100-ADGA	SE	100-A03A	0.00114	%ILODCA
100-ADGA	DO	100-A01A	0.00114	%ILOFW
100-ADGA	SE	100-A01A	0.00114	%ILOFW
100-ADGA	SE	100-A03A	0.00114	%ILOFW

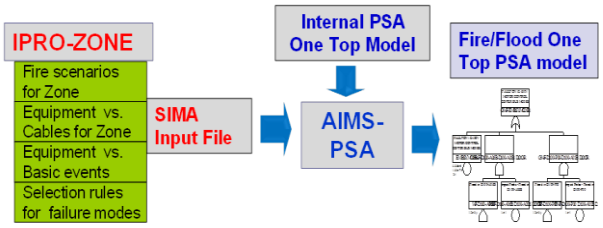

Fig. 1. Relationship between the IPRO-ZONE, the AIMS-PSA, and one-top fire event.

2.2 Sensitivity studies on the approaches for addressing multiple IEs

Table II presents the sensitivity analysis results on the approach for addressing multiple IEs. In the previous fire events PSA based on EPRI's method [1,7], only the most severe initiating event among multiple initiating events was assumed to occur. For the case of No. 4 and 5 in Table II, equipment for LOMF IE was not explicitly selected because of difficulties in selecting and identifying components and cables for LOMF IE. In other words, LOMF was assumed to occur at all fire scenarios. In the preliminary study, equipment and cables for LOMF IE were identified. However, the appropriateness of the selections for equipment and cables for LOMF IE could not be justified. For the case of No. 4, LOMF IE was not considered for the fire scenarios causing LOOP IE because of the generation of the same cutsets. Table II shows an example of the same cutsets. In Table III, the cutsets for No. 1 and 2 are same. Because the probabilities of "NR-AC15HR"and " /RCP-seal_2S" are one. From the sensitivity analysis results, we can find that the incorporations of multiple IEs into fire events PSA model result in the core damage frequency (CDF) increase and may lead to the generation of the same cutsets. Thus, the review works of cutsets for quantification results are to be essentially conducted for addressing the same cutsets.

Table II: Sensitivity analysis results on the approach for addressing multiple IEs

No.	Approach for addressing multiple IEs	CDF increase
1	Previous domestic approach without MSO IE scenarios	0%
2	Previous domestic approach with MSO IE scenarios	14.4%
3	Consideration of multiple IEs for only MSO scenarios	22.3%
4	Consideration of multiple IEs except LOOP IE	24.1%
5	Consideration of multiple IEs for all fire scenarios	118.29%

Table III: An example of the same cutsets

No.	Cutsets					
1	%F-TBB073-T07	EGDGK3T-1A1B1E	/PSV	#GIE-LOFW-6		
2	%F-TBB073-T07	EGDGK3T-1A1B1E	NR-AC15HR	/PSV	/RCPSEAL_2S	#GIE-SBOR-07
3	%F-TBB100-T06H	EGDGR01A	EGDGR01B	/PSV	#GIE-LOFW-6	
4	%F-PA-165LAB	SDOPHEARLY	#GIE-LSSB-AB-FIRE-5			
5	%F-TBB073-T07	EGDGW3T-1A1B1E	/PSV	#GIE-LOFW-6		
6	%F-TBB073-T07	EGDGW3T-1A1B1E	NR-AC7HR	/PSV	/RCPSEAL_2S	#GIE-SBOS-07
7	%F-PB-165LAB	SDOPHEARLY	#GIE-LSSB-AB-FIRE-5			
8	%F-TBB135-T01	EGDGK3T-1A1B1E	/PSV	#GIE-LOFW-6		
9	%F-TBB135-T01	EGDGK3T-1A1B1E	NR-AC15HR	/PSV	/RCPSEAL_2S	#GIE-SBOR-07

3. Conclusions

In this paper, sensitivity studies on the approaches for addressing multiple IEs in fire events PSA are performed and their results were presented. From the sensitivity analysis results, we can find that the incorporations of multiple IEs into fire events PSA model result in the core damage frequency (CDF) increase and may lead to the generation of the duplicate cutsets. Multiple IEs also can occur at internal flooding event or other external events such as seismic event. They should be considered in the constructions of PSA models in order to realistically estimate risk due to flooding or seismic events.

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