Review of UCN 5,6 Fire PSA Model based on ANS Fire PRA Methodology Standard

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1. Introduction

The risk-informed applications have been studying and implementing to improve the safety and economy of the nuclear power plants. In Korea, we recognized the importance of the risk-informed applications and evaluated the quality of fire PSA model for Ulchin 5&6 units based on the ANS fire PRA methodology standard. PSA is a method to evaluate the safety of a nuclear power plant as a main element for the risk-informed applications. However, the uncertainty of the result depends on the used method, data and the level of analysis. To solve this problem, the nuclear industry and regulatory body of USA have developed a kind of standard to fulfill such requirements. The ANS has developed a standard called "Fire PRA Methodology Standard" and the objectives of this standard are to set forth requirements for fire probabilistic risk assessments (FPRAs) used to support risk-informed decisions for commercial nuclear power plants, and to prescribe requirements for using the FPRA for specific applications[1].

Now the first objective of UCN 5&6 PSA is to identify the weaknesses on the design. Therefore, there is lack of the detail of an analysis and the independent review to certificate the technical basis. For that reason, we can't use this model as a decision-making tool for risk-informed applications. To get an appropriate PSA model for the risk-informed regulation and application, it is required to identify the items to be improved, to ensure the basis and to establish the requirements for the PSA quality evaluation. Therefore, in this paper, we will review the requirements developed in the USA for the PSA standard model, and will find the method to improve the quality of domestic PSA model through the review of Ulchin 5&6 fire PSA model.

2. Review of Fire PSA Model

2.1 Compositions of ANS standard

ANS standard is composed of the 13 items, and the individual item involves the High Level Requirements (HLRs) and the Supporting Requirements (SRs).

The scope of a PRA covered by this standard is limited to analyzing accident sequences initiated by fire that might occur while a nuclear power plant is at nominal full power. Table 1 lists the main requirement contents by 13 elements in ANS standard.

Table 1. Main Requirement Contents by Elements

No.	Element	Requirements
1	Plant Partitioning	- Fire area/compartment definitions - Partitioning process - Walk-down and documentation
2	Equipment Selection	- Process of selecting equipments - Location information
3	Fire PRA Cable Selection	- Cable location information - Documentation about cable selection
4	Qualitative Screening	- Qualitative screening criteria - Insignificant area screening
5	Fire Scenario Development and Fire Modeling	- requirements associated with the identification and analysis of these fire scenarios, including the application of the fire modeling
6	Ignition Frequency	- Prohibition on assigning zero ignition frequency, using non-nuclear data - Assuming that a transient combustible fire may occur at any area of the plant
7	Quantitative Screening	- Qualitative screening criteria based on the cumulative risk impact of screened compartments on total LERF and CDF
8	Structures and Fire Modeling	- Requirements for the unscreened area/compartments which has not screened in the quantitative screening process
9	Circuit Failures	- Refinement of the understanding and treatment of fire induced circuit failures on an individual fire scenario basis
10	HRA	- Identification and quantification of events representing human failures
11	Seismic Fire	- Effects of a seismic event on the fire related issues - Four seismic-fire interaction issues presented in Fire Risk Scoping Study
12	Fire Risk Quantification	- Requirements that the quantified risk measures are to include the total CDF and LERF
13	Uncertainty and Sensitivity	- identification and treatment of uncertainties for each portion of the fire PRA

2.2 Review Results

We evaluated the quality of Ulchin 5&6 fire PSA model based on ANS standard.

According to the results, about 57% of the total supporting requirements do not satisfy the capability category II.

Table 2. Review results of the quality of fire PSA model based on ANS standard

Elements	HL	SR	<I	I	II	III	N/A
Plant Partitioning	9	10		2	7	1	
Equipment Selection	4	9	3	2	4		
Fire PRA Cable Selection	5	13	1	4	8		
Qualitative Screening	2	6			6		
Fire Scenario Development and Fire Modeling	6	44	30	1	11		2
Ignition Frequency	5	13		2	8		3
Quantitative Screening	3	4		1	1	2	
Structures and Fire Modeling	12	15	2	2	9	1	1
Circuit Failures	4	10	10				
HRA	3	5	4		1		
Seismic Fire	4	9		9			
Fire Risk Quantification	3	3	3				
Uncertainty and Sensitivity	3	9	7	2			
	63	150	60	25	55	4	6

The element relevant to the Fire Modeling requires the use of the computational fire modeling tools that is not used in the domestic Fire PRA. Many betterment items are derived from the fire modeling requirements.

The circuit failure analysis has not performed in the domestic fire PSA untill now, so many improvement items are derived.

The requirements relevant to HRA are to analyze the human action in detail need to be included in the fire PSA. It is necessary to identify the human actions and resulting the human failure events to be included in the fire PSA and to quantify the human error probabilities, whether using screening values or detailed best-estimate assessments.

The effect of a seismic event on the fire related issues are not addressed in the domestic fire PSA. As part of the seismic-fire interaction, it is necessary to include an analysis of plant equipment and electrical cable for the possibility of fire occurrence as a result of a siesmic event to the fire PSA.

This standard requires that the quantified risk measures are to include the total plant CDF and LERF due to fire-initiated events. It is necessary to quantify the fire risk as CDF as well as LERF.

The documentation and uncertainty relevant to the overall fire PSA process are needed like the results of internal PSA[2-3].

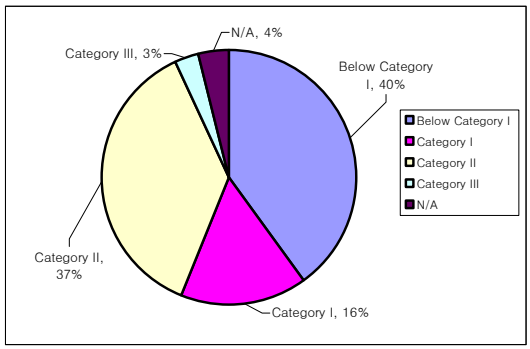

Figure 1. Review Results of the PSA Model Quality

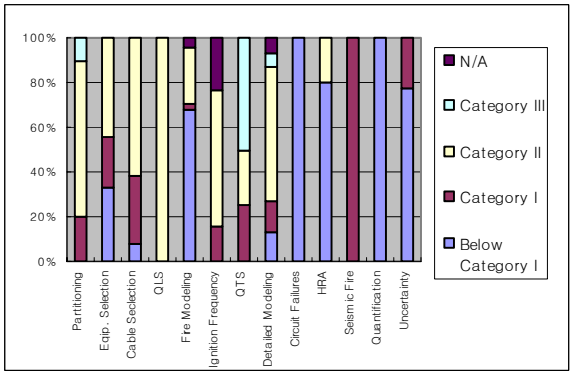

Figure 2. Review Results evaluated by 13 elements

6. Conclusions

According to the results, it is considered that the quality category of the UCN 5,6 fire PSA model is about capability category I of ANS fire PRA methodology standard.

There are many things to be resolved. But it is impossible to apply several requirements to the domestic PSA due to the environmental differences between Korea and USA.

We can say that the evaluation of PSA model quality is the basis for the risk-informed applications. Therefore, it is expected that the review results based on ANS standard is to be the important references on reviewing another PSA model to implement the risk-informed applications.

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References

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2. Review of UCN 3,4 PSA Model based on ASME PRA Standard, KAERI/TR-2509/2003.
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