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Generation of Risk Importance Information from Severe Accident PSA Model

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1. Introduction

One of the important objects conducting Probabilistic Safety Assessment (PSA) is the relative evaluation of importance of the component or function that is greatly affected to the plant safety. This evaluation is performed by the importance assessment methods such as Risk Reduction Worth, Risk Achievement Worth, and Fussel-Vessley method from the aspect of core damage frequency (CDF). In the Level 1 PSA model, the importance of each component can be evaluated since the CDF is calculated by the combination of the branch probability of event tree and the component failure probability in the fault tree. But, the Level 2 PSA model in order to assess the containment integrity cannot evaluate the risk importance by the above methods because the model is consisted of 3 parts, plant damage status, containment event tree, and source term category. So, in the field that the Level 2 PSA risk importance information should be reflected, such as maintenance rule program, risk importance has been determined by the subjective judgment of the model developer.

This study was performed in order to generate the risk importance information more objectively and systematically in the Level 2 PSA model, focused on the containment event tree in the domain PHWR Level 2 PSA model [1].

2. Methods and Results

2.1 Basic Methodology

As described in introduction, Level 2 PSA model is consisted of 3 parts according to the analysis step.

1) Plant Damage State (PDS): defines the status of system and damage by the accident after the core damage.
2) Containment Event Tree (CET): models the containment behavior according to the severe accident phenomena in the containment and calculates the containment failure frequency combined with the Decomposition Event Tree.
3) Source Term Category (STC): models the radionuclide release to the environment according to the containment failure mode.

While the risk information can be generated at each part, the more realistic risk importance information should be obtained through the integration of 3 parts. But, it is very difficult to obtain it from the integration since the integration of 3 parts is performed by grouping and re-branching off the results of each step.

So, first of all, the methodology for generating risk importance information from CET model is considered because CET model consider the severe accident progressions and the operation of system for severe accident mitigations in the containment. However, the accident sequences analyzed separately in special CET model, such as Steam Generator Tube Rupture, Interface System LOCA, and Containment Isolation Failure, are not included in this analysis since these accident sequences do not experience the severe accident phenomenon or mitigation actions in the containment and released radioactive materials to the environment right after the accident is initiated.

2.2 Generation of Risk Importance Information

The first heading in the PHWR CET model is the "End Shield Cooling (ESC)". If the end shield cooling is available in most accidents, the core damage accident progression is limited only in the calandria and the containment dose not fail because the integrity of containment is maintained during the period of PSA mission time (3 days after the accident begins). So, it is judged that the end shield cooling is very important function from the view point of containment failure. However, the result of risk importance assessment for this function from the view point of CDF is assessed as low since it is not directly related with the core damage.

The second heading in the PHWR CET model is the "Secondary Heat Removal (2HR)". In case of Loss of Coolant Accident, if the broken loop is successfully isolated right after the accident occurs and then the water supply to the steam generator in the unbroken loop through the feedwater system or the Emergency Water System is successful, the integrity of the half core is maintained and the pressurization of containment is delayed. Also, the amount of fission products or hydrogen generated in the core is decreased. As a result, the failure of calandria and the containment does not happen during the period of PSA mission time. For the successful secondary side heat removal, the "loop isolation actuation signal supply" functions and the MOVs which perform the isolation are important. However, the results of risk importance assessment for these functions from the view point of CDF are assessed as low since they are not directly related with the core damage. Also, the feedwater supply function to the unbroken loop steam generator after the isolation is assessed as a high risk importance, but emergency water supply function is assessed as low risk importance.

The third heading is the "Continuous Local Air Cooler (CLAC)". If the LAC is in continuous operation,

the containment pressure is maintained near the atmospheric pressure. So, the containment does not fail with the exception of the case that the strong hydrogen explosion occurs. However, the effect of LAC for the containment cooling is smaller than that of spray system, and there is some limitation for protection of containment integrity when the peak pressure due to hydrogen explosion is occurred. The result of risk importance assessment for LAC from the view point of CDF is assessed as low since it is not directly related with the core damage.

The fourth heading is the "Dousing Spray (SPRAY)". The spray system acts as the short term heat sink while the LAC acts as the long term heat sink. And, in spite that the water source for the spray system is exhausted within a matter of hours, it is effective for the spray operation to remove heat from the containment atmosphere. Since the water sprayed in the containment floor acts as the late heat sink, the containment over pressurization can be delayed. Also, it can affect the concentration of radioactive material in the containment. For the successful spray operation, the functions that supply the spray actuation signals and operate each spray valves are important. However, the results of risk importance assessment for these functions from the view point of CDF are assessed as low since they are not directly related with the core damage.

The fifth and sixth heading in the PHWR CET model is "Late Containment Failure" and "Very Late Containment Failure". Since these headings are not related with the system functions, there is no risk importance information.

2.3 Comparison of the Results

In Table 1, the risk importance information results generated in the CET model are compared with the risk determination results of Maintenance Rule Program [2].

Table I: Comparison of the Risk Importance Generated

CET Heading	MR Function	Risk Determination			CET Risk
		PSA	Delphi	Final	
ESC	34410-01	Low	Low	Low	High
2HR - ISO	34320-06	Low	High	High	High
	33310-02	Low	High	High	High
	33320-02	Low	High	High	High
	33350-02	Low	High	High	High
2HR - FW /EWS	43230-03	High	High	High	High
	34610-01	High	High	High	High
	34610-04	Low	High	High	High
CLAC	73110-01	Low	Low	Low	High
SPRAY	34310-01	Low	High	High	High
	34310-02	Low	High	High	High

As shown in Table 1, the most functions assessed as risk high in the CET model have been assessed as risk low except the water supply function to steam generator, since they were not directly related with the core damage. However, the Expert Panel determined the risk importance of these functions as "High" agreeable to the recommendation of the PSA model developer. Even so, the end shield cooing function and the local air cooler function remained as risk low.

3. Conclusions

In this study, the methodology for generating risk importance information from CET heading ties with the severe accident mitigation function was considered. But this methodology is still in the qualitative analysis. For the quantitative risk importance assessment, the CET branch probability including the DET quantification results should be analyzed.

However, through this approach, it is expected that the risk importance information of the system function for the severe accident mitigation that has been assessed subjectively by the expert can be obtained more objectively and systematically.

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