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Internal Flooding PSA Reevaluations using the EPRI Guideline

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1. Introduction

This document is intended to reevaluate an internal flooding probabilistic safety assessment (PSA) for a Korean nuclear power plant (NPP) as a part of efforts to develop a Korean site risk profile (KSRP) based on all-mode, all hazard level 1/2/3 PSA including the extreme risk factors. This IF-PSA was updated using a part of the EPRI draft guidance report.

In 2009, the electric power research institute (EPRI) published a guideline for the development of IF-PRA that addresses the requirements of the ASME/ANS RA-Sa-2009 PRA consensus standard. The EPRI guideline delineates a level of detail and assessment complexity that has been significantly increased with respect to the guidance for IF assessment performed for the individual plant examination (IPE) to address Generic Letter 88-20 [1]. The main differences include:

- A more systematic approach to the definition of flood area
- The identification, screening and analysis of flooding sources and scenarios
- The calculation of the initiating-event frequency (IEF) based on the actual length and characteristics of the piping
- The inclusion of spatial effects such as spray from pipe leaks
- The specific documentation associated with the plant walkdowns

Among these differences, this research focused on the third and fourth items when performing the internal flooding PSA. This is done by identifying the pipe and fluid characteristics, assessing the pipe pressure, characterizing the pipe (i.e., pipe diameter, length, etc.) and determining the pressure boundary failure frequency. The results were summed for the various piping systems within a given flood area to arrive at an overall internal flood initiating frequency for a given flood mode (i.e., spray, general flood, or major flood) for that particular area. Characterizations of spray scenarios were evaluated to determine their impact on plant risk caused by internal flooding events [2].

This paper will discuss the results of each of IF PSA implementation steps.

2. Analytical Methods

IF-PSA guidelines have been organized into three major phases of the analysis in Figure 1 [3].

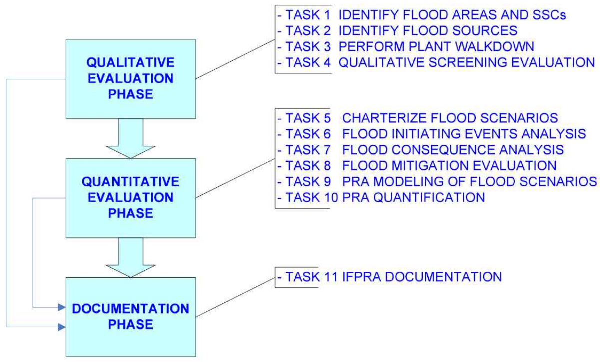

Figure 1. Major Phases and Tasks of IF-PSA

2.1. Qualitative Evaluation Phase

In the first phase of IF-PSA, Qualitative Analysis, the information that is needed for the IF-PSA is collected and the initial qualitative analysis tasks are performed. The major outputs of this phase include the screening out of plant flood areas based on criteria associated with flood sources, flood propagation pathways, and potential impacts of floods on SSCs and the selection of flood areas for quantitative evaluation. There are four key tasks that are completed in this phase for the identification of flood areas and SSCs, identification of flood sources, performance of a plant walkdown, and completion of a qualitative screening evaluation of plant locations [3].

2.2. Quantitative Evaluation Phase

Quantitative evaluations plant locations, which have not been screened out are addressed in six separate tasks that comprise the quantitative evaluation phase of IFPRA. These tasks are organized around the key steps in defining flood scenarios and quantifying their impacts in the PRA model in terms of their contributions to core damage frequency (CDF) and large early release frequency (LERF). These steps include the definition of flood scenarios in terms of flood initiating events, the consequences of the flood on SSCs, human actions to mitigate the consequences of the flood and to control the plant, and the interfacing of the flood scenario with the PRA event tree/fault tree logic. Once the scenarios have been properly characterized, this phase also addresses the quantification of the flood initiating event frequency, CDF, and LERF [3].

3. Quantification Results

3.1 Screening Analysis

To screen out a flood area, a quantitative screening analysis is conducted if the sum of the product of the frequencies of the flood scenarios for the area and the conditional core damage probability (CCDP) is less than 1.0E-07. In the screening analysis, the human failure events (HFEs) for IF-PSA were five times higher than internal Level 1 scenarios. Total 265 flooding scenarios for 71 flood areas were identified and quantified using the AIMS-PSA (Advanced Information Management System for PSA). Of them, total 59 flood areas were screened out with 1.0E-07 of cut-off value, and 12 flood areas are required a quantitative detailed analysis to know more realistic risk.

3.2 Detailed Analysis

Total 12 flood areas were identified and quantified with more realistic pipe rupture frequencies for the flood areas and the additional human failure event analysis. Insulated and lagged pipes were not considered to be significant spray sources and as such were not included in the calculation of the spray frequency. In this detailed analysis step, the additional human event probability analysis was done to get more realistic values reflected the additional workload, stress, effect of flood on mitigation, required response, timing, and recovery activities.

Each contribution to the overall internal flooding induced CDF was obtained by combining the values of flood scenario frequency, flood barrier failure probability and CCDP as shown in Table 1 and Figure 2.

Table 1. Contribution to CDF by Flood Areas

Name	Description	CDF
D058-A00A	PAB General Access Area 58' - Div. A	8.52E-09
D058-A00B	PAB General Access Area 58' - Div. B	8.49E-09
D077-A04A	PAB HVAC Equipment Room - Div. A	1.59E-08
D077-A04B	PAB HVAC Equipment Room - Div. B	1.64E-08
D077-A13A	PAB General Access Area 77' - Div. A	1.14E-08
D077-A13B	PAB General Access Area 77' - Div. B	7.75E-09
D144-A20	PAB Access Aisle 144'	9.11E-09
D077-P00	SAB Access Aisle 77'	2.94E-09
D100-P00	SAB Access Aisle 100'	2.05E-09
D000-ESWA	ESW Intake and CCW HX Area A	7.81E-08
D000-ESWB	ESW Intake and CCW HX Area B	1.30E-08
D000-TB	Turbine Building	7.03E-08
SUM		4.47E-07

4. Conclusions

This IF-PSA was updated using a part of the EPRI draft guidance report. Total 265 flooding scenarios for the 71 flood areas were identified and quantified using the AIMS-PSA. The quantitative detailed analysis was conducted for 12 flood areas to get more realistic risk. D000-ESWA flooding is dominant contribution to total CDF, and it provides about 32% of the total CDF. The most dominant cutset to CDF is the combination of Div. B switchgear room cooling failure and its recovery failure after D000-ESWA flooding.

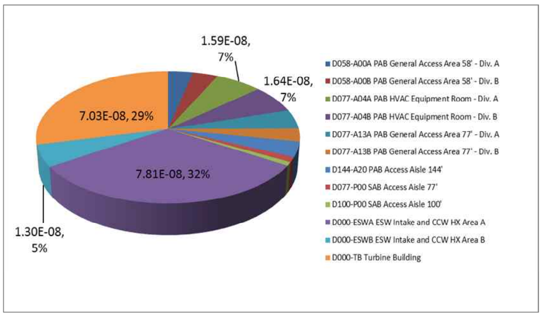

Figure 2. Contribution to CDF of Each Flood Area

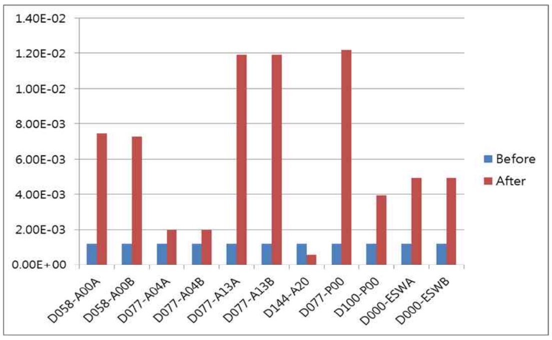

Figure 3. Comparison of the Initiating Frequencies in before and after reevaluation

The flood area for the detailed analysis was nothing in the previous IF-PSA. Total 12 flood areas were identified for the detailed analysis in this study, and the final result indicates a point estimate of 4.47E-07/yr for the overall CDF attributable to internal flooding events.

The most important and dominant contributor to CDF is expected to be the increase in flood initiating frequencies of flood areas, shown in Figure 3.

ACKNOWLEDGMENT

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