# Insights from Guideline for Performance of Internal Flooding Probabilistic Risk Assessment (IFPRA)

Sun Yeong Choi and Joon-Eon Yang

*Korea Atomic Energy Research Institute, Integrated Safety Assessment Div., P.O. Box 105, Yuseong-Gu, Daejeon, Korea, 305-600*
*Corresponding author: sychoi@kaeri.re.kr*

## 1. Introduction

An internal flooding (IF) risk assessment refers to the quantitative probabilistic safety assessment (PSA) treatment of flooding as a result of pipe and tank breaks inside the plants, as well as from other recognized flood sources. The industry consensus standard for Internal Events Probabilistic Risk Assessment (ASME-RA-Sb-2005) includes high-level and supporting technical requirements for developing internal flooding probabilistic risk assessment (IFPRA). This industry standard is endorsed in Regulatory Guide 1.200, Revision 1 as an acceptable approach for addressing the risk contribution from IF events for risk-informed applications that require U.S. Nuclear Regulatory commission (NRC) approval [1].

In 2006, EPRI published a draft report for IFPRA that addresses the requirements of the ASME PRA consensus standard and have made efforts to refine and update the final EPRI IFPRA guidelines [2].

Westinghouse has performed an IFPRA analysis for several nuclear power plants (NPPs), such as Watts Bar and Fort Calhoun, using the draft EPRI guidelines for development of an IFPRA. Proprietary methodologies have been developed to apply the EPRI guidelines.

The objectives of the draft report for IFPRA guideline are to:

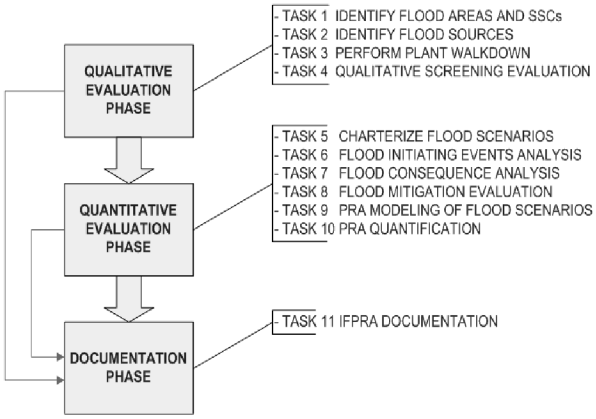
- Provide guidance for PSA practitioners in the performance of the elements of a PRA associated with internal flooding events consistent with the current state of the art for internal flooding PRA
- Provide guidance regarding acceptable approaches that is sufficient to meeting the requirements of the ASME PRA Standard associated with internal flooding
- Incorporate lessons learned in the performance of internal flooding PRAs including those identified as pilot applications of earlier drafts of this procedures guide

The purpose of this paper is to present a vision for domestic nuclear power plants' IFPRA by comparing the method of the draft EPRI guidelines with the existing IFPRA method for domestic NPPs.

## 2. Methods and Results

### *2.1 Methodology by EPRI Guideline*

The IFPRA guidelines have organized into three major phases.




- The first four tasks involve the systematic identification of flood areas and flood sources, the definition of flood scenarios (including the identification of propagation paths), and the qualitative screening evaluation by various screening criteria. The systematic approach and the level of detail required in this initial phase are significantly different from the existing approach used in domestic NPPs.
- The next four tasks involve the complete characterization of the flooding scenarios that have not been screened out on a qualitative evaluation by developing the initiating event frequency, identifying the consequences of the scenario and evaluation of the flood mitigation strategies. Significant differences from the existing analysis for domestic NPPs include the more rigorous calculation of the initiating event frequency, the assessment of spray vulnerability and the analysis of potential flood mitigation strategies using accepted human-error calculation methods.
- The next two tasks are the actual integration of the IFPRA scenarios into an existing internal event PRA model and the relative quantification.
- The final step is the documentation of the IFPRA.

### *2.2 Comparison Methodology by EPRI Guideline with Existing Methodology for Domestic IFPRA*

Compared to the existing method for domestic IFPRA, the systematic approach and the level of detail required in EPRI guideline are different for several tasks.

- Characterization of Flood Scenarios (TASK 5)

In Task 5 a preliminary list of flood scenarios is developed for the flood areas not screened out in the previous step. The purpose of this task is to model the potential flooding scenarios for each flooding source by identifying the flood source and mode, the propagation paths of the fluid and the affected structure, system, and components (SSCs). However, domestic IFPRA divides the quantitative evaluation into two steps. First, a systematic quantitative screening of all flood areas not screened out will be performed to determine in a conservative manner which flood locations are potentially significant contributors. At this stage core damage frequency will be assessed on the basis that all equipment, susceptible to damage in the area, will fail given a flood occurs or propagates to damage that area. The second stage, in which a detailed analysis of the flood areas found to be potentially significant during the first stage is performed, will follow the same method of Task 5 in the EPRI guideline [3].

- Flood Initiating Event Analysis (TASK 6)

For Capability Categories II & III, the ASME standard directs an analyst to gather plant-specific information on plant design, operating practices and conditions that may impact flood likelihood. The EPRI report complements the results of a companion report, EPRI 1013141 Revision 1, which provides piping system failure rates for use in IFPRA and recommends the flooding frequency result as a good generic data [4]. The report includes pipe failure rates for three different pressure boundary failure modes (spray, flood, and major flood). The dimension of all calculated failure rates is per linear foot and reactor calendar year. In the EPRI guideline, at each level of flood hazard evaluation different types of passive component pressure boundary failure are also considered.

For a domestic IFPRA, a flooding frequency per each flooding area having no consideration for failure modes is estimated. We suggested a methodology for flooding frequency estimation for a domestic IFPRA by using the EPRI data and plant-specific data based on the method proposed by EPRI [5].

- Flooding Consequence Analysis (TASK 7)

The EPRI guideline mentioned that flood can be characterized by its volumetric flow rate and quantity of the fluid that has been discharged from a fluid system to a specific area. However the existing domestic IFPRA did not consider a flow rate.

- Flood Mitigation Evaluation (Task 8)

The EPRI guideline suggests more conservative human error probability than that of domestic IFPRA. For example, all human errors that require local action in an area where access would be restricted should be set to a failure probability of 1.0.

## 3. Conclusions

The purpose of this paper is to present a vision for domestic nuclear power plants' IFPRA by comparing the method by the draft EPRI guidelines with the existing domestic IFPRA method. We figured out the systematic approach and the level of detail required in EPRI guideline are different from the existing method for domestic IFPRA for several tasks. Especially, we need to modify flooding frequency estimation method with plant-specific data and perform a detailed analysis to address the ASME standard.

## REFERENCES

[1] U.S. NRC, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-informed Activities," Reg. Guide 1.200 Rev 1, 2007.
[2] Karl N. Fleming and Bengt O.Y. Lydell, "Guidelines for Performance of Internal Flooding Probabilistic Risk Assessment (IFPRA)," Final Draft Report, EPRI, 2006.
[3] KHNP, 98NJ14, "Probabilistic Safety Assessment for UCN 5&6: External Event Analysis, " 2002.
[4] EPRI-1013141, "Pipe Rupture Frequencies for Internal Flooding PRAs, Rev. 1," EPRI, 2006.
[5] S. Y. Choi and J. E Yang, "Estimation of Internal Flooding Frequency for Screening Analysis of Flooding PSA by Using the Latest Generic Data and the Korean Plant Operation Data," KNS, 2009.

## ACKNOWLEGEMENT

This work was supported by Nuclear Research & Development Program of the Korea Science and Engineering Foundation (KOSEF) and Engineering Foundation grant funded by the Korean government (MEST).