A Preliminary PSA for Spent Fuel Pool of Hanul Unit 3

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1. Introduction

After Fukushima accident of 2011, the safety of spent fuel pool (SFP) has become important. In 2014, EPRI published a PWR SFP PSA [1] which included the impact on SFP by the reactor core melting and containment failure, and considered 7 days for SFP evaluation instead of 24 hours. Since the EPRI PWR SFP PSA is a generic framework which can be easily adapted to a plant specific one, a SFP PSA of Hanul Unit 3 is being built up by adapting the EPRI framework. In this paper, it is described how the EPRI framework is adapted to the SFP PSA of Hanul Unit 3.

2. Methods

Before Fukushima accident of 2011, the PSA of SFP considered only the failure of SFP during full power operation or shutdown. However, after Fukushima accident, the impact on SFP caused by a severe accident such as SFP failure due to containment failure is considered in the SFP PSA. Also, the evaluation time of SFP was extended to 7 days instead of 24 hours to reflect whether a nuclear power plant can endure for a long term loss of cooling.

Since EPRI suggested a generic PWR SFP PSA framework [1], every plant can easily perform his own plant specific SFP PSA by adapting the EPRI SFP PSA framework. In the following subsections, how Hanul Unit 3 SFP PSA was prepared through the adaptation is explained. The whole adaptation steps are shown in Fig.1.

2.1 Level 2 PSA results

In Fig. 1, the first step is mapping from Hanul CET release sequence bins to the containment conditions.

The existing full power level 2 containment event tree (CETs) are divided into release sequence bins representing the following conditions of containment:

a. Energetic containment failure (ECFSFP)
b. Containment Isolation failure (CIFSFP)
c. Break Outside Containment (BOCSFP)
d. Containment Intact (Core Damage occurs) (CISFP)
e. OK (Core damage does not occur) (SFP-IE)

The plant specific frequency of each release sequence bin is derived from the Level 2 PSA of Hanul Unit 3 [2]. The results are shown in Table 1 although the value of Hanul level 2 PSA are not official. In Table 1, the probability of containment intact even though a core damage occurs is much higher in Hanul Unit 3.

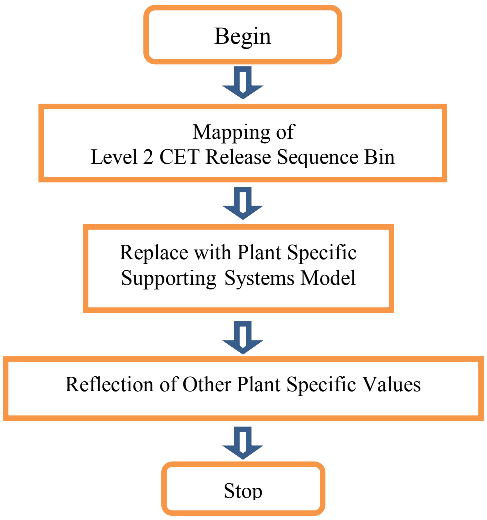

Fig. 1. The Adaptation Steps for Hanul Unit 3 SFP PSA Model

Table 1: Mapping of Release Sequence bins of CET

EPRI SFP PSA		Level 2 CET of Hanul 3	
Containm't Condition	Freq.	Sequences	Freq.
ECFSFP	4.57e -6	3,4,5,6,7,8,9,10,1 1,12,13,14,16,17	8.07e-7
CIFSFP	1.08e-8	18,19	3.71e-9
BOCSFP	1.06e-6	20, 21	2.12e-7
CISFP	1.08e-8	1, 2, 15	1.80e-6

2.2 Supporting Systems

The supporting systems such as electrical system, component cooling water system, and HVAC system are used and modeled in SFP PSA as well as in level 1 reactor PSA model. Therefore, since the level 1 reactor PSA model is the plant specific one, the supporting systems for SFP PSA should be modified with the plant specific supporting systems.

2.3 Others

The frequencies of plant specific data such as loss of offsite power frequency should be used instead of those of EPRI generic framework model. Also, the cooling system using the river should be modified. It is modeled that spent fuels could be cooled with air without water in the EPRI generic framework. However, since it is not analyzed in the Hanul unit 3, the air cooling should be conservatively deleted.

3. Results

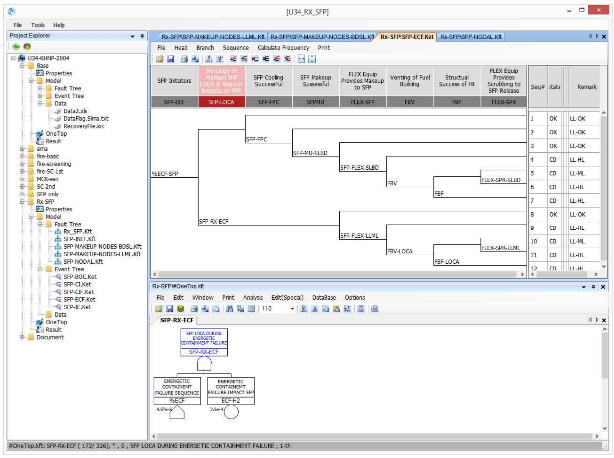

Fig. 2. An Example Screen of Hanul Unit 3 SFP PSA Model

A Hanul unit 3 full power internal SFP PSA is developed as shown in Fig. 2. However, it should be further enhanced by considering external events and shutdown mode.

Like the 7 day SFP evaluation of EPRI SFP PSA, Hanul SFP PSA adopts the same evaluation time. Practically, the evaluation time should be long enough since the spent fuel will not be damaged before about 58 hours even though there would occur a loss of SFP cooling in Hanul Unit 3 according to a thermal hydraulic calculation [3]. In other words, there would be no risk in the SFP due to the loss of SFP cooling if the mission time is assumed as 24 hours.

Containment failures would cause damage on SFP and other supporting system. The probabilities of the damages are given in the EPRI generic framework, and the values are used in this Hanul SFP PSA. An example is shown in the fault tree of Fig. 2. However, plant specific data should be used in the later study.

In EPRI SFP PSA model, internal reactor PSA model and SFP PSA model are separately quantified even though they are related to each other. It is the same case in Hanul Unit 3 SFP PSA.

As shown in the example event tree of Fig. 2, since the EPRI generic framework has considered several mitigating methods in the SFP accident, such as FLEX equipment which provides scrubbing to SFP release, a sensitivity analysis can be easily performed for a severe accident management. Those mitigating methods in the SFP accident can be easily reflected as house events in the plant specific model.

4. Conclusions

The new approach considering the impact on SFP from reactor accident & containment failure, suggested by EPRI PWR SFP PSA [1], is appropriate trend, and Hanul Unit 3 SFP PSA is being developed with the same approach.

The generic framework suggested by EPRI can be well adapted to develop the plant specific SFP PSA. However, the probability and impact on SFP and its supporting system caused by the reactor accident & containment failure should be studied further. With this new SFP PRA model, the severe accident management of Hanul Unit 3 could be further enhanced.

Acknowledgement

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