Fault Tree Development of Kori Nuclear Unit 2 for Regulatory PSA Model

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1. Introduction

The purpose of this study is to develop fault trees of regulatory Probabilistic Safety Assessment model for independent risk evaluation of Kori Nuclear Unit 2, and to gain regulatory perspectives and insights through this study.

2. Methods and Results

This study is comprised of two major parts. One is the system review and the fault tree (FT) development. The other is the development of Initiating Event (IE) FT.

2.1 System FT Development

System FTs were developed for each system and the major features of system FTs were as below.

2.1.1 High Pressure Safety Injection (HPSI) System
Due to positive reactivity in vessel during an Main Steam Line Break(MSLB) event, HPSI should provide not only emergency core cooling but also emergency boration for Kori Unit 2. Therefore, new top event named by GSI-HPI4-TOP, which represented those functions of HPSI during MSLB event, was modeled in HPSI FTs. This top events was added to model the emergency boration function to deliver the borated water in Refueling Water Storage Tank(RWST) to vessel via Boron Injection Tank which contains high concentration boric acid. Figure 1 shows difference between licensee's FT model and regulatory's FT model.

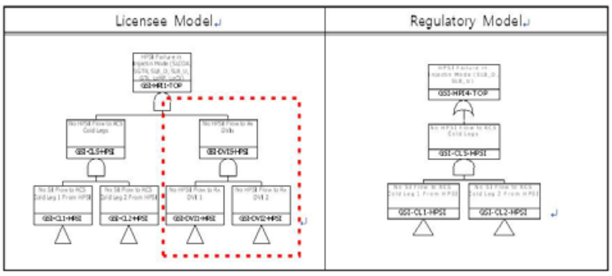

Figure 1. Regulatory FT model for GSI-HPI4-TOP

2.1.2 Low Pressure Safety Injection(LPSI) System
When the recirculation operation through cold-leg is required, water source should be changed from RWST to sump because RWST is not available for makeup water source at that time. Therefore, emergency sump and related paths were modeled as cooling water source for cold-leg recirculation operation.

According to Residual Heat Removal(RHR) system operation procedure of Kori Unit 2, when RHR operation is required, the MOV-8812A/B and MOV-8809A/B should be closed by operator. Because these valves were not modeled in previous PSA models, basic events related to MOV fail to close event, Common Cause Failure(CCF), and supporting system were added and automatic start signal for RHR pumps was deleted in regulatory's FT.

2.1.3 Safety Injection Tank (SIT) System
The success criteria for SITs were changed from 2-out-of-2 to 1-out-of-2 logic for SLOCA and SGTR events.

2.1.4 Auxiliary Feedwater (AF) System
In licensee's AF FT about LOOP(Loss of Offsite Power) the starting signal for AF B train pump was generated by SIAS. That was corrected to LOOP signal.

2.1.5 Main Steam (MS) System
According to Emergency Operation Procedure (Emergency-3) for SGTR, After SGTR is occurred, operator should isolate Turbine Driven Pump(TDP) steam supply valves, SG blowdown valves, SG sampling valves, MSIVs, MSBVs, FWIVs and AFIVs. The model for FWIVs and AFIVs were omitted in licensee's FT. Those valves isolation models were included in Regulatory's FT. Figure 2 showed difference between licensee's FT model and FT model in regulatory PSA model.

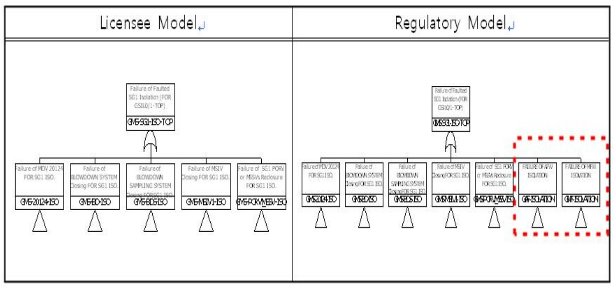

Figure 2. Regulatory FT model for isolation valve after SGTR

2.1.6 Containment Spray (CS) System
Spray additive tank isolation valves(MOV-9050A/B) is automatically closed in order to block air inserted from the tank to the CS pump for protecting CS pumps when tank's level is low. The success criteria of

isolation valves is all to be close. Therefore The CCF events for those valves were deleted in regulatory's FT model. Because the CCF events are not required in this case. There were no basic events related to spray nozzle isolation manual valves(9106A/B) in licensee' FT. Transfer closed basic events for 9106A/B were modeled. Test period for those event is 1 year.

2.1.7 Engineered Safety Features Actuation (FS) System
The calibration error basic event of transmitter was not modeled in licensee's FS FT. That event was added in Regulatory's CS FT and probability value for that was 6.09E-03.

2.2 Development of Initiating Event FT

LOIA and LOCCW IE frequencies for regulatory PSA model were developed as fault tree form called as Initiating Event Fault Tree(IE FT) for the purpose of providing convenience during quantification. The IE FT submitted by licensee in 2007 was reviewed and modified and for each IE, the contents of modification were shown below.

a. Loss of Instrument Air(LOIA)
In licensee's LOIA FT, simultaneous failure of IA systems for both Kori Unit 1 and 2 was modeled for LOIA initiating event. But in actual fact the failure of IA system of Kori Unit 2 causes IE of LOIA. When IA system in Kori Unit 2 is failed, IA system of Kori Unit 1 can provide instrument air to Kori Unit 2 through cross-tie line. Therefore, IA system of Kori Unit 1 should be deleted in LOIA IE FT of Kori Unit 2. Figure 3 shows regulatory LOIA IE FT.

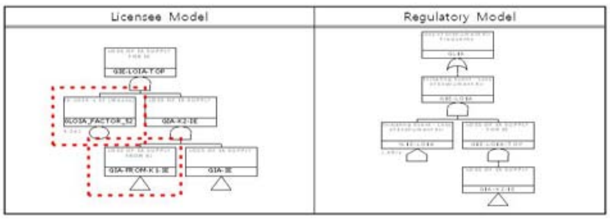

Figure 3. Regulatory IE FT model for LOIA

b. Loss of Component Cooling Water(LOCCW)
Loss of Service Water System event directly causes LOCCW. Therefore, in Regulatory's LOCCW FT, Service Water System was modeled in LOCCW FT. Figure 4 shows regulatory LOCCW IE FT.

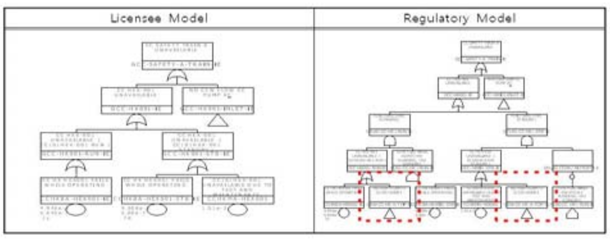

Figure 4. Regulatory IE FT model for LOCCW

3. Conclusions

Though the review for the systems and procedures of Kori Nuclear Unit 2, fault tree models were developed. Insights from the review for the models of licensee were reflected. Insights from this study may contribute to the quality enhancement for the regulatory PSA model for Kori Nuclear Unit 2 and the results from this study can be utilized during the risk-informed decision making process.

REFERENCES

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[4] Sang Hoon Han, et al., “User’s Manual for AIMS Release 1.6”, KAERI, 2007