

## Regulatory PSA Model Development for Risk Evaluation of Kori Nuclear Unit 1 Continued Operation

Huichang Yang<sup>a\*</sup>, Jae Won Lim<sup>a</sup>, Hyung Suk Kim<sup>a</sup>, Dong Joo Chang<sup>b</sup>, Key Yong Sung<sup>b</sup>

<sup>a</sup> ENESYS Co., Gooam-dong 328 Yusug-gu Daejeon, Korea, 305-800

<sup>b</sup> KINS, Guseong-dong 19-0 Yusung-gu Daejeon, Korea, 305-338

\*Corresponding author: hcyang@enesys.co.kr

### 1. Introduction

This purpose of this study is to develop regulatory PSA(Probabilistic Safety Analysis) model for independent risk evaluation of Kori Nuclear Unit 1 continued operation from regulatory perspectives and to quantify CDF(Core Damage Frequency) within Level 1 PSA scope and to gain regulatory insight through this study.

### 2. Methods and Results

This study is comprised of major four categories. The first is the review and modification of ET(Event Tree) model and the second is review and modification of FT(Fault Tree) model. The third is the sensitivity analysis of CDF according to facilities design improvement. The last is related with the CDF sensitivity analysis with Initiating Event(IE) frequency variation.

#### 2.1 Review and Modification for ET Model

CHR(Containment Heat Removal) heading was added in ET models. CHR heading was not included in the model submitted by licensee in 2002 although HPR(High Pressure Recirculation) and LPR(Low Pressure Recirculation) headings were included. CHR is required for depressurization and heat removal in pressurized containment. The CHR is performed by containment recirculation system and containment spray system. Success criteria of CHR heading is 1) 2/4 Containment fan or 2) 1/4 Containment fan + 1/2 Containment spray system. Figure 1 shows large loss of coolant accident ET including CHR heading.

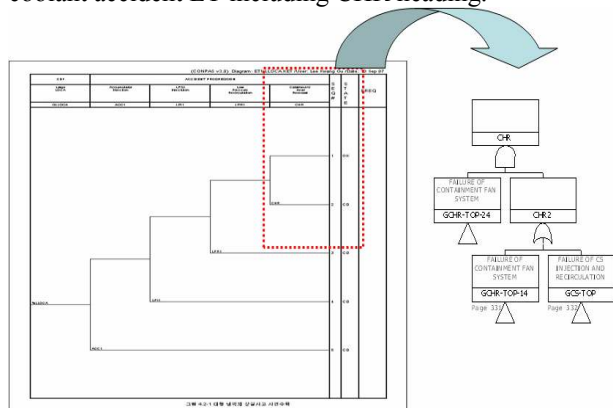


Figure 1 Modified Large Loss of Coolant Accident ET

#### 2.2 Review and Modification for FT Model

FT models were modified and the contents of modification were shown below.

- a. Safety Injection System (SI)
  - Basic events for human error for VSI-8807A/B and VSI-8809A/B were added.
  - Basic event for rupture of residual heat removal system heat exchanger was added.
- b. Pressurizer system (PZ)
  - Basic event for Common Cause Failure of VRC-8000A/B was added.
- c. Chemical and volume Control system (CS)
  - Basic event for human error of BATP XPP-12B(FTS) was added.
- d. Auxiliary Feedwater System (AF)
  - Recovery actions for VFE-38 and VFE-4A/B were deleted.
- e. Component Cooling Water System (CC)
  - 4 manual valve basic events for top gate(CC-IA-AC) were added.
- f. Component Cooling Seawater System (SW)
  - Model for SW pump suction line blockage phenomenon was added.
- g. Chilled Water System (CW)
  - Detailed model for XHX-17C/D was added.
- h. Heating, Venting & Air Conditioning System (HVAC)
  - Basic events for CCF of ITD-2561A /2562A/2565A/2566A were added.

Through modification of ET and FT, regulatory PSA model has been developed and CDF(Baseline) is  $1.185E-04/Ry$ . Baseline CDF has increased about 1.01 times of CDF( $=1.170E-04/Ry$ ) by licensee model.

#### 2.3 Sensitivity Analysis - Facilities Design Improvement

Sensitivity analysis was performed with facilities design improvement. Selected facilities design improvement items are 1) installation AAC DG, 2) connecting instrument air system of Kori Nuclear Unit 2 and 3) automatic operation for LPR.

For each item, CDF has decreased to  $1.072E-04/Ry$ ,  $1.161E-04/Ry$  and  $1.141E-04/Ry$  respectively.

When all three items were applied to baseline model together, CDF has decreased to  $9.807E-05$ , or about 0.82 times of the baseline CDF( $=1.185E-04/Ry$ ).

Figure 2 shows sensitivity analysis results in which 3 facilities design improvement items were applied.

REFERENCES

- [1] Kewaunee PSA Report, Kewaunee NPP.
- [2] Probabilistic Safety Assessment Report for Kori Units 1, KOPEC, 2002.
- [3] Probabilistic Safety Assessment Report for Kori Units 1, KOPEC, 2007.
- [4] Sang Hoon Han, et. al., "User's Manual for AIMS Release 1.6", KAERI, 2007.

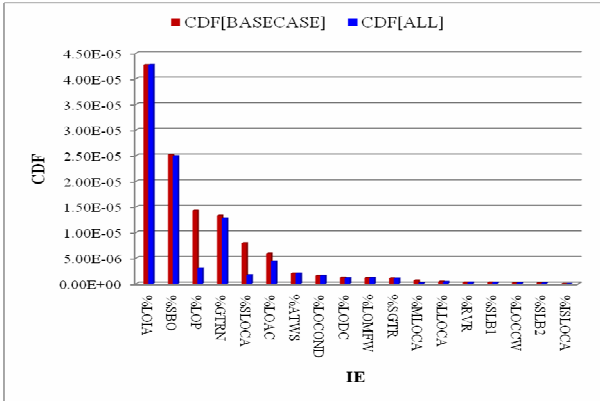


Figure 2 Sensitivity Analysis Results - Facilities Design Improvement

2.4 Sensitivity Analysis - IE Frequency Variation

Sensitivity study was performed using changed IE frequencies which were specified in the licensee PSA report in 2007. Calculated CDF using changed IE frequencies was 4.397E-05/Ry.

In case of Loss of Instrument Air(LOIA), CDF has decreased to 9.17E-09/Ry and this value is about 2.15E-04 times of the baseline CDF(=4.27E-05/Ry).

Figure 3 shows sensitivity analysis results reflecting IE frequency variation.

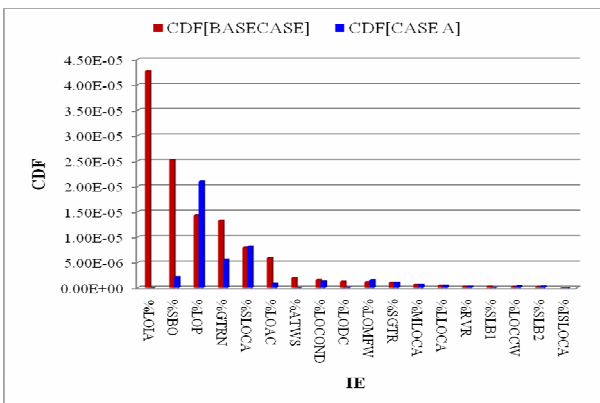


Figure 3 Sensitivity Analysis Results - IE Frequency Variation

3. Conclusions

The purpose of this study is to develop regulatory PSA model for independent risk evaluation of Kori Nuclear Unit 1 continued operation from regulatory perspectives.

To achieve the purpose, modification of ET and FT were carried out and baseline CDF was calculated. In addition, sensitivity analysis was performed for facilities design improvement and for IE frequency variation respectively. Through this study, the effect of facility design changes on CDF was estimated and this result can be utilized during the regulatory process for Kori 1 nuclear unit continued operation.