A Demonstration of KINS-ASP Program for Accident Sequence Precursor Analysis

Namchul Cho [a*], Dae wook Chung [a], Huichang Yang [b], Chang-Ju Lee [a]
[a] *KINS, Guseoung-Dong Yuseong-gu Daejeon, Korea, 305-338*
[b] *ENESYS Co., Ltd., Gooam-dong Yuseong-gu Daejeon, Korea, 305-800*
[*] *Corresponding author: namchul.cho@kins.re.kr*

1. Introduction

The NRC established the Accident Sequence Precursor (ASP) Program in 1979 in response to Risk Assessment Review Group report. The ASP Program systematically evaluates nuclear power plant operating experience to identify, document, and rank the operating events that were most likely to lead to inadequate core cooling and severe core damage (precursors), accounting for the likelihood of additional failures. [1] Also, ASP analysis results are utilized to install the new systems or components and modify the emergency operating procedures to improve the safety of nuclear power plant in U.S. [2]

In Europe, many countries have also tried to apply the risk evaluation program for operational events to support the insights on nuclear power plant safety.

In Korea, Integrated Safety Performance Assessment (ISPA) Process is proposed to support the graded periodic inspection program, as a result of R&D program. KINS-ASP program which is developed to support risk assessment of operational event is one of six significant aspects in ISPA Process. [3]

In this paper, two sample case studies are performed for domestic operational events using the KINS-ASP analysis program and the results are compared with the other results.

2. Overview of KINS-ASP Program

KINS-ASP Program is designed and developed to support regulator in risk assessment of operational event. The objectives of this program are to

- provide risk insights and information for KINS ISPA process,
- support regulator in risk significance evaluation process for accidents or events at nuclear power plants (NPPs),
- provide risk significance evaluation tool to non-PSA experts.

One of the major functions of this program is to easily identify the probabilistic safety assessment (PSA) basic events connected to the affected system and component due to the event. And also, FTREX that is one of the fastest quantification engines is used in this program. Therefore, tentative risk evaluation of the event can be performed easily and quickly. Fig. 1 shows the initial screen of KINS-ASP program.

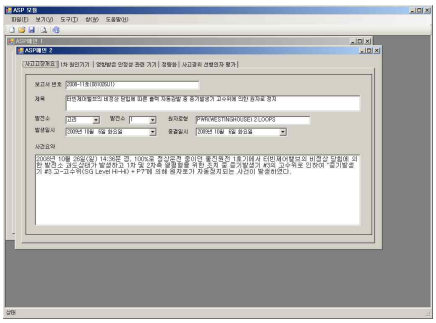

Fig. 1. Initial Screen of KINS-ASP Program

3. Results of Case Study

3.1 Case Study: Initiating Event

Description of the selected initiating event in this study is as follows:

"Ulchin Unit-4 was shutdown on April 5, 2002, for 3rd refueling outage. At the beginning stage of plant cooldown, at 18:33 Steam Generator Tube Rupture (SGTR) accident was occurred. After SGTR accident was occurred, operator reset the actuation signal for HPSI to prevent the actuation of HPSI caused by decrease in pressurizer level and pressure."

Although this event was already analyzed in previous research [4], it is selected again to compare the results of the KINS-ASP program with previous results.

In this case, the likelihood of not recovering the initiator (SGTR) is assumed to be 1.0. The failure probabilities for available systems are assigned as currently used. And also, analysis for the failure of HPSI injection is performed to consider resetting HPSI actuation signal by operator.

Table 1 shows the results of analysis for each case.

Table 1. Relative CCDP due to Modified Failure Duration

Case	CCDP
SGTR Occurred	1.200E-04
Failure of HPSI	5.958E-01

The results are not exactly the same to the previous results due to the difference in PSA model. Usually, cut sets are not provided in KINS-ASP program. But for

detailed analysis and comparison, dominant cut sets are identified in this study. As a result, it is confirmed that the dominant cut set is the same even though calculated Conditional Core Damage Probability (CCDP) is slightly different. The dominant core damage sequence involves failure of HPSI injection and failure to depressurize RCS for LPSI injection.

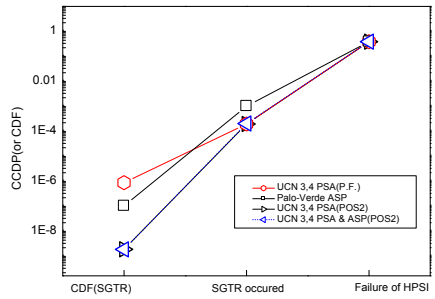

Fig. 2. Result of the Previous Research

3.2 Case Study: System or Component failure

Next, another case study for system or component failure is performed. Description of the selected event for ASP analysis in this case is as follows:

"During full power operation of Ulchin-4 on December 3, 2004, emergency diesel generator (EDG-A) is subject to periodic test but EDG-A fails to start. The test interval of EDG is 184 days for fast start and 31 days for slow start."

This event affects potentially the mitigation of LOOP initiator. The failure probability of this event (EGDGS01A: EDG-A fail to start) is assigned to be 1.0. No initiating event is incurred by this event. Failure duration of 92 days is assumed based on one-half of a test interval of 184 days for fast start. The LOOP frequency (2.83E-02/ry) and the failure duration produce an estimated LOOP probability of 6.405E-03 during the unavailability. Sensitivity analyses are also performed for the failure duration of 31 and 184 days.

Fig. 3 shows the selection and modification of relevant PSA event using KINS-ASP program.

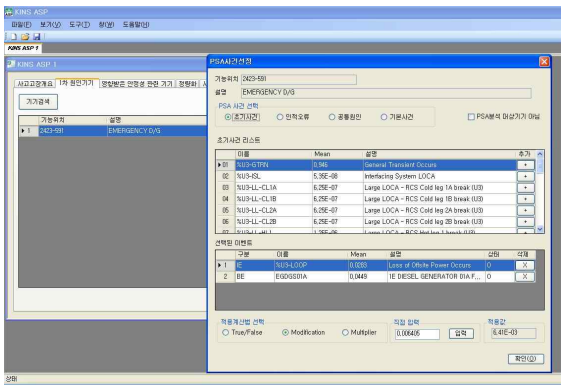

Fig. 3. Selection and Modification of Relevant PSA Event

Using KINS-ASP program, relative CCDP for each case is calculated with PRiME-U34i which is a PSA model developed by KAERI for internal events PSA of UCN unit 3 and 4. Table 2 shows the results of analysis for each case.

Table 2. Relative CCDP for Each Failure Duration

Failure duration	CCDP
92 days (one-half of fast start)	5.789E-06
31 days (slow start)	4.637E-06
184 days (fast start)	7.527E-06

Since CCDPs of all three cases are greater than 1.0E-06, this event is classified as ASP. The dominant core damage sequence is total loss of AC power combined with the failure to recover AC power before core uncovery.

4. Conclusions

In this paper, two case studies are performed using KINS-ASP program and the results are compared with the other results. Conclusively, it is confirmed that KINS-ASP program is useful in quick risk evaluation for operational events.

Another strength of KINS-ASP program is to enable non-PSA experts to perform risk evaluation easily and quickly. Therefore, this program can help many people including non-PSA experts to utilize the PSA technique in improving the safety of NPPs.

REFERENCES

[1] SECY-05-0192, "Status of the Accident Sequence Precursor (ASP) Program and the Development of Standardized Plant Analysis Risk (SPAR) Models", U.S. NRC, 2005.

[2] Jin Hee Park et. al., "A Study on Accident Precursor Analysis and Its Application to Korean NPP", KAERI, 2002.

[3] Dae Wook Chung et. al., "A Risk-Informed and Performance-Based Approach for Improving Regulatory Inspection Program in Korea", the 10th Korea-Japan Joint Workshop on PSA, 2009.

[4] Kju-Myeong Oh et. al., "Accident Sequence Precursor Analysis of Ulchin Unit 4 Steam Generator Tube Rupture", Transactions of the Korean Nuclear Society Spring Meeting, 2003.