Comparative Study on the Critical Sub-Models between MPAS and the Licensee's PSA

Namchul Cho [a*], Chang-Ju Lee [a], Jin-Hee Park [b]
[a]*Korea Institute of Nuclear Safety, 19, Guseong, Yuseong, Daejeon, Korea, 305-338*
[b]*Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon, Korea*
[*] *Corresponding author: Namchul.cho@kins.re.kr*

1. Introduction

The KINS has proposed a comprehensive implementation plan for achieving risk-informed and performance-based regulation since 2006, which has an objective to optimize current regulatory activities by integrating risk and safety performance information with existing deterministic approaches [1]. In this case, we believe that our own PSA models are essential for supporting independent risk information to the regulatory staffs.

Up to early 2008, for the Westinghouse 900 MWe type reactors, e.g. Kori 3&4, a regulatory PSA model called MPAS (Multi-purpose Probabilistic Analysis of Safety) has been developed. In this paper, sub-models of the MPAS are compared with those of the licensee's PSA conducted in 2003 [2].

2. Results of the Comparative Study

The MPAS models for Kori 3&4 are much modified by comparing with the licensee's PSA carried out in 2003. The design changes, resetting of success criteria by thermal-hydraulic calculation using MARS code, Human Reliability Analysis (HRA) using K-HRA methodology, modification of Event Tree (ET), and so on are applied to the MPAS model. As a result, core damage frequency (CDF) becomes 8.91E-06/year which is a little increased compared with the result of 8.38E-06/year in the licensee's PSA. However, the distributions of CDF by the initiating events (IEs) are much different. Fig.1 shows the CDF distributions of MPAS and licensee's PSA by the IEs.

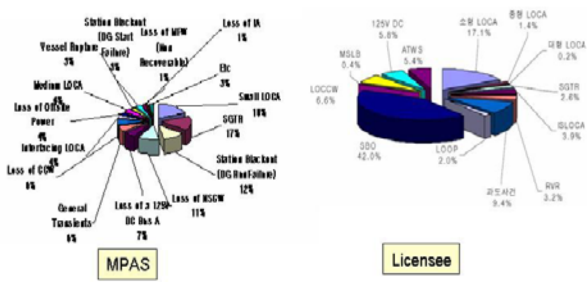

Fig. 1. Results of MPAS and licensee's PSA by IEs

In this paper, a special review on the Steam Generator Tube Rupture (SGTR) event is carried out. In addition, sensitivity analyses are performed for evaluating the effect of a methodological difference and a design change, respectively.

2.1 Modification for SGTR ET

The SGTR is initiated by a random or consequential rupture of a steam generator tube ranging from a small leak in a tube up to a double-ended break of a single tube [3]. Fig. 2 and 3 show SGTR ETs used in the MPAS and the licensee's PSA, respectively.

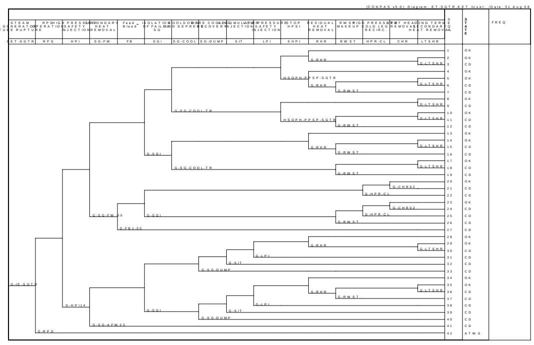

Fig. 2. SGTR ET in the MPAS model

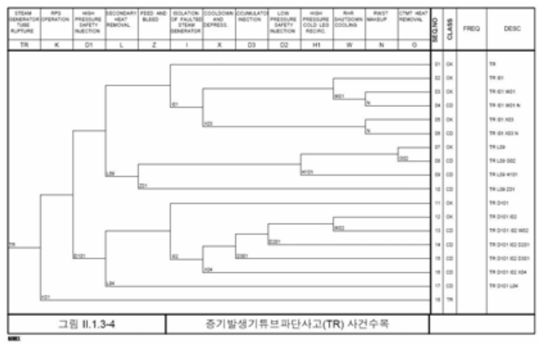

Fig. 3. SGTR ET in the licensee's PSA

As shown in the figures, three headings are added in the MPAS ET model and the other modifications are:

- If a HPI function keeps continued, RWST water can be depleted, so the RWST makeup is required. Therefore, SHPI heading is added.
- Although RWST makeup is in operation, unbalance between SI feed and makeup can be caused. In this case, the RWST makeup does not reach an end state condition. Therefore, Long Term Secondary Cooling heading is added.
- After HPI is failed, although secondary heat removal and isolation of a ruptured steam generator is in success, consequential secondary heat removal failure caused by the lack of coolant inventory should be considered.
- In the case of success of HPI and failure of the secondary heat removal, isolation of a ruptured steam generator will affect further accident

mitigation. Therefore, corresponding branches are added.

2.2 Specific Event Sequence analysis

Based on the SGTR evaluation used in the MPAS model and the licensee's PSA, top three event sequences are compared, as given in Table 1.

Table 1: Event Sequences for SGTR

	MPAS	Licensee's PSA
1	Seq. 31 (8.87E-07/year)	Seq. 14 (1.26E-07/year)
2	Seq. 33 (1.78E-07/year)	Seq. 06 (4.66E-08/year)
3	Seq. 19 (1.76E-07/year)	Seq. 17 (2.21E-08/year)

In the licensee's PSA, the first sequence is the case of HPI failure, the failure of isolation of a steam generator, and LPI failure. However, the first sequence of the MPAS is the case of the success of isolation of a steam generator and LPI failure after HPI failure – that is, even though the ruptured steam generator is isolated, the core damage can occur in case of SI failure. On the other hand, according to Licensee's PSA, even though SI is failed, the core damage does not occur if the ruptured steam generator is isolated. Therefore, Seq.14 becomes the first sequence. As mentioned in Section 2.1, the case of the secondary heat removal failure caused by the lack of coolant inventory is considered in the Seq.31.

Both Seq.06 in the licensee's SGTR and Seq.19 in the MPAS model are the same, which is due to failure of isolation, failure of making up RWST after cooldown and depressurization failure. That means the isolation of a steam generator is closely related with the core damage.

2.3 Sensitivity analysis – Methodological Difference

A sensitivity analysis is done for evaluating pure effect of the methodological difference. For this case, a major design change, i.e. AAC DG is removed in the MPAS model. As a result, the CDF goes up to 2.12E-05/year, compared with 8.38E-06/year in the licensee's PSA. Fig. 4 shows the results of the sensitivity analysis in detail.

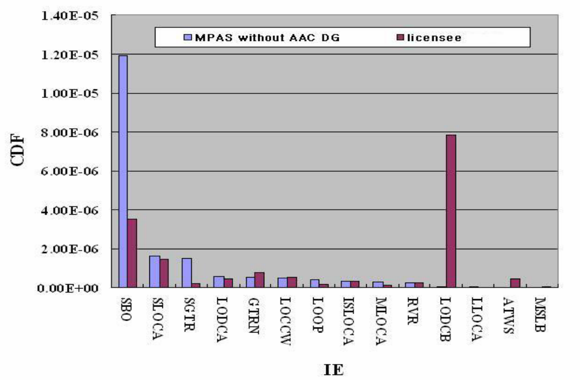

Fig. 4. Sensitivity by the Methodological Difference

As shown in Fig. 4, the CDFs by both SBO and SGTR are greatly increased, but the CDF by LODCB is decreased.

2.4 Sensitivity analysis – Design Change

Since the AAC DG is installed to the site, a sensitivity analysis is performed for estimating how CDF has decreased due to this change. As a result, CDF is decreased about 0.42 times compared with 2.12-05/year by the MPAS without AAC DG. Fig. 5 shows the results of the sensitivity analysis with and without the installation of AAC DG. As expected, the CDF by the SBO sequence is largely decreased due to the installation of AAC DG.

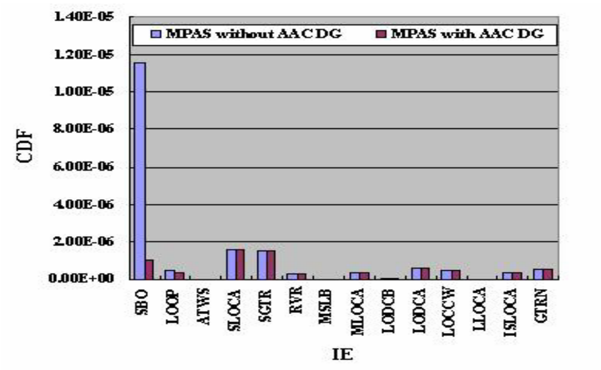

Fig. 5. Sensitivity by the Design Change

3. Conclusions

In this paper, comparisons of sub-models between the MPAS and the licensee's PSA conducted in 2003 are carried out. Especially, modification cases of SGTR ET are provided. Sensitivity analyses are also performed for identifying effects from a methodological difference and a design change, respectively.

Through the analysis, the CDF differences of some sequences between the MPAS and the licensee's PSA are found, which may need further in-depth studies for getting valuable regulatory insights.

REFERENCES

[1] D.-W. Chung, and H.-J. Lee, Use of the PSA and Safety Performance Assessment in Improving Regulatory Inspection System, International Conference on Probabilistic Safety Assessment and Management, May 2008.
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