Sensitivity Analysis for the Effect of SG Inventory on PAFS Performance

Kum Ho Han [a], Seong-Su Jeon [a], Soon-Joon Hong [a*], Do Hyun Hwang [b]

[a] *Department of Nuclear Thermal-hydraulic Research, FNC Technology Co., Ltd., 46,*
[b] *KHNP Central Research Institute, 1312 70-gil Yuseong-daero, Yuseong-gu, Deajeon 34101, Korea*

Tapsil-ro, Giheung-gu, Yongin-si, Gyeonggi-do 446-902, Korea
[*] *Corresponding author: sjhong90@fnctech.com*

1. Introduction

After Fukushima accident, there is a lot of interest and demand for the passive system. Among passive systems, PAFS (Passive Auxiliary Feedwater System) is a system that replaces the conventional active auxiliary feedwater system, and there have been much effort to improve the PAFS performance. PAFS is designed to operate when the SG level decreases below than set-point. As part of analyzing PAFS performance under various conditions, it is necessary to analyze the effect of SG inventory. In this study, PAFS heat removal performance was investigated according to SG inventory reduction using PASCAL (PAFS Condensing Heat Removal Assessment Loop) input model and SPACE3.22.

2. SPACE Modeling of PASCAL

Figure 1 shows the SPACE nodalization for PASCAL SS-540-P1 test facility.

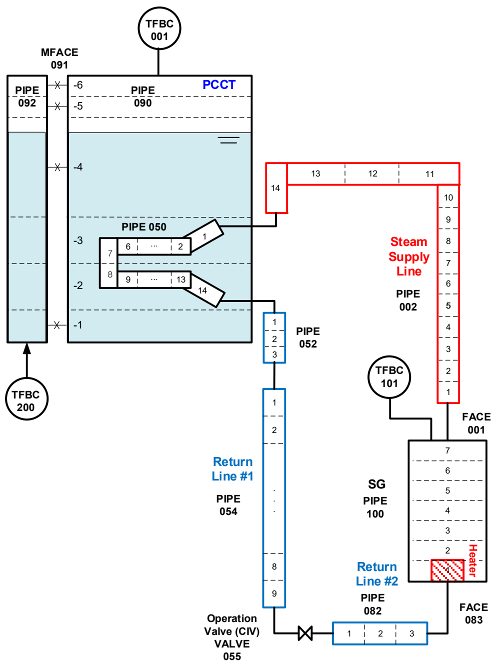

Fig. 1. SPACE nodalization for PASCAL

The input model used in this study was written based on the existing input model [1], and the differences from the existing input are as follows. 1) The heater was connected only to CELL-1 of the SG (PIPE-100), in order to the heater can be submerged in water even if the SG inventory decreases. 2) The PCCT water level was maintained at 9.3 m using TFBC-200 to obtain steady state calculation results. Where, the 9.3 m is the PCCT water level at the point of measuring the key parameters in the PASCAL SS-540-P1 test.

3. Simulation Results of Reference Input Model

Firstly, PASCAL SS-540-P1 test was simulated to check the soundness of the modified input model. Figure 1 ~ 3 show the calculation results. Generally, SPACE 3.22 predicts properly the key parameters of the PASCAL SS-540-P1 test. Sensitivity analysis was performed using this input model as a reference input model.

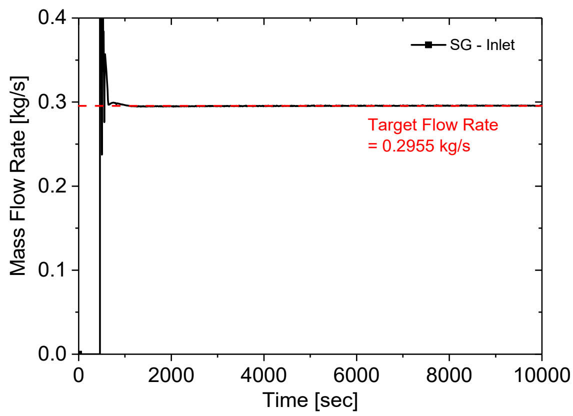

Fig. 2. Mass flow rate (SS-540-P1)

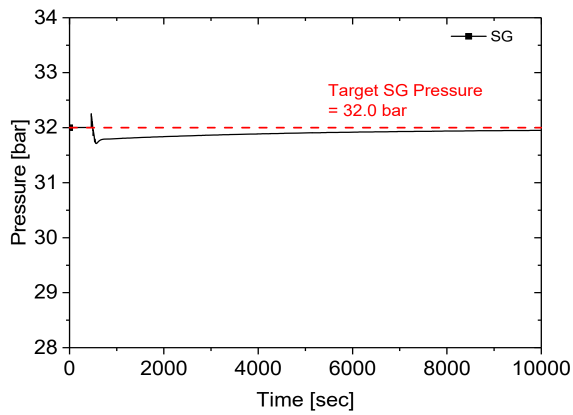

Fig. 3. System pressure (SS-540-P1)

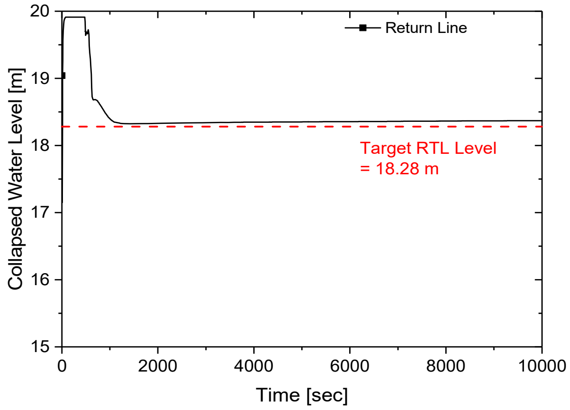

Fig. 4. Return line water level (SS-540-P1)

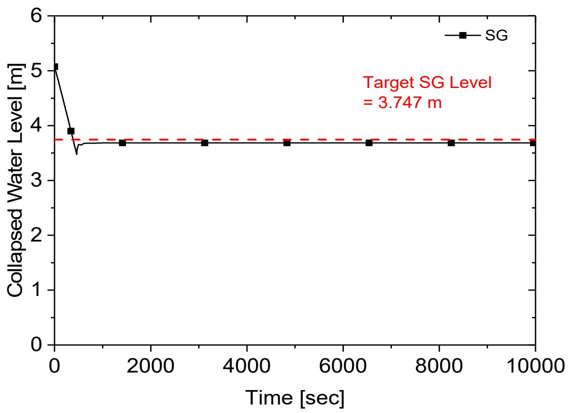

Fig. 5. SG water level (SS-540-P1)

4. Sensitivity Analysis for SG Water Level

PAFS is designed to operate when the SG water level decreases below than set-point. Therefore, in this study, PAFS heat removal performance was analyzed according to the SG inventory by adjusting the PAFS operation set-point.

In the reference input model, TFBC-101 is the pressure boundary of the SG(PIPE-100). Initially TFBC-101 is open, and as soon as PAFS operates TFBC-101 is closed.

Table I shows the initial SG water level and PAFS operating set-point for the test case. Case 0 is the test condition for the reference input model. Case 0 is the test condition for the reference input model, and the lowest PAFS operation set-point is case 4.

Figures 6 ~ 9 show the simulation results. The key findings are follows:

1) PASCAL flow rates hardly changes even if the SG inventory decreases (Fig. 6).

2) As the SG inventory decreases, the SG pressure and the return line water level decreases (Fig 7, 8).

3) When the SG inventory decreases, the water level difference between the return line & SG increases (Fig. 9).

However, the effect of the SG inventory for the PAFS performance is small.

Table I: Test Cases

Case #	SG Initial Level [m]	PAFS trip condition
0	5.076	SG level < 3.747 m
1		SG level < 2.703 m
2		SG level < 1.836 m
3		SG level < 0.950 m
4		SG level < 0.508 m

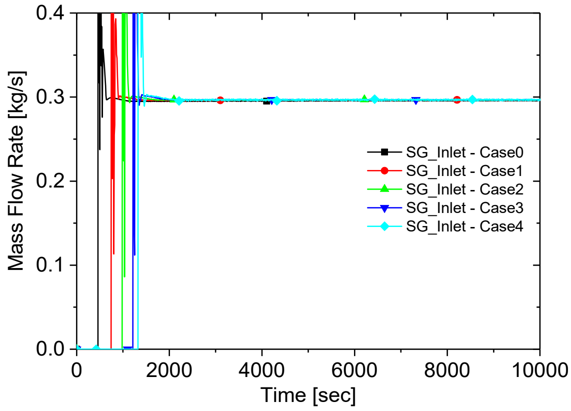

Fig. 6. Mass flow rate (case 0 ~ case 4)

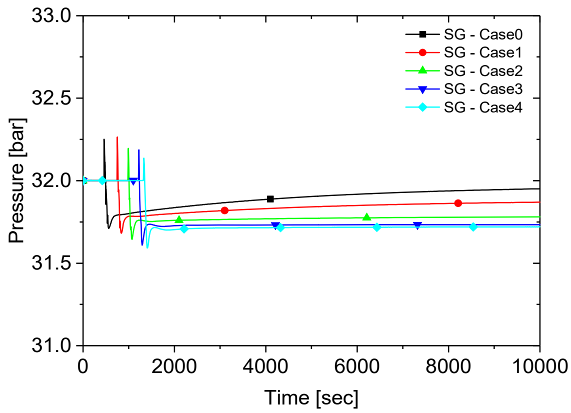

Fig. 7. System pressure (case 0 ~ case 4)

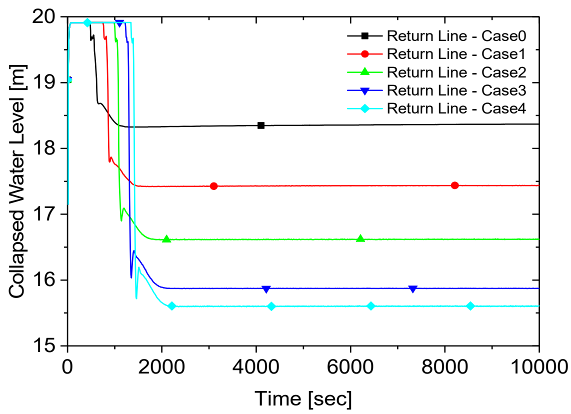

Fig. 8. Return line water level (case 0 ~ case 4)

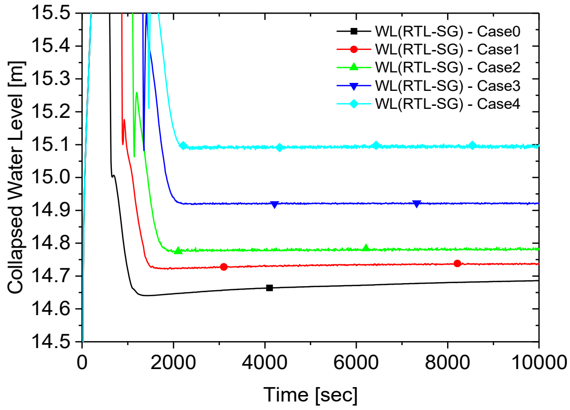

Fig. 9. Water level difference between SG & return line (case 0 ~ case 4)

5. Conclusion

To investigate the effect of the SG inventory for PAFS performance, this study analyzed PAFS heat removal performance according to SG inventory using SPACE 3.22. SG inventory was adjusted using the PAFS operating set-point. From the calculation results, it was found that the SG inventory affects the SG pressure and water level difference between return line & SG. However, generally the effect of the SG inventory for the PAFS heat removal performance is small.

Acknowledgements

This work was supported by “APR1000 Standard Design Development Project for EUR Rev. E Certification” grant funded by the KHNP.

REFERENCES

[1] S. S. Jeon, K. H. Han, S. J. Hong, and D. H. Hwang, Analysis for the Effect of Pipe Pressure Loss on PAFS Performance, Transactions of the Korean Nuclear Society Virtual Autumn Meeting, Dec. 17-18, 2021.