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Effect of Break Location during ATLAS SBLOCA Tests for APR1400

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1. Introduction

The APR1400 has been developed by Korean industry. It adopts a new safety feature of a DVI (Direct Vessel Injection) system that supplies the ECC (Emergency Core Coolant) directly into the reactor pressure vessel. During the SBLOCA (Small-Break Loss Of Coolant Accident) the thermal-hydraulic characteristics could be varied due to different break size, break location and system design characteristics. The URD (Utility Requirement Document) published by the EPRI (Electric Power Research Institute) recommends that the core uncover should be prevented for an SBLOCA up to an equivalent break diameter of 6 inches by a best-estimate thermal-hydraulic analysis. [1]

In the present paper, test results from two integral effect tests are discussed to investigate the effect of break location. One is SB-DVI-09 test [2] for a 6-inch (50% break area) DVI line break and the other is SB-CL-06 test [3] for an equivalent break size of cold leg. The comparison results could be used to assess the capability of safety injection system and to understand the thermal-hydraulic phenomena expected to occur in the core and down-comer during the SBLOCA scenario.

2. Test Conditions and Procedure

Table 1 shows the detailed test conditions for the SB-DVI-09 and SB-CL-06 tests. All the parameters were set to be the same except for the break location.

Table 1 Test conditions of SB-DVI-09 and SB-CL-06

Test ID	SB-DVI-09	SB-CL-06
Break location	DVI line	CL bottom
Break size (%)	50.0 (DVI line)	4.0 (CL)
Break size (inch)	6.0	
Beak nozzle diameter (mm)	10.68	
Bypass (DC-UH, %)	0.5	
Bypass (DC-HL, %)	1.4	

As a single failure is assumed and the safety injection flow to the broken DVI-4 nozzle is not credited, the safety injection flow by the safety injection pump (SIP) is only injected through the DVI-2 nozzle opposite to the broken DVI-4 nozzle during the SB-DVI-09 test. Three safety injection tanks (SITs), excluding the SIT connected to the broken DVI-4 nozzle, are used to provide the safety injection flow by the SIT. In case of the SB-CL-06 test, except for the break location the other parameters such as the break size and initial/boundary test conditions are matched to be the same with the SB-DVI-09 test. Figure 1 shows the loop arrangement and their break locations.

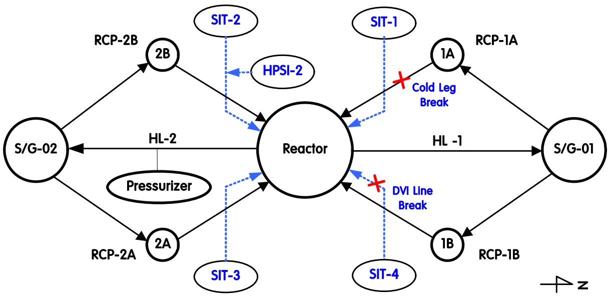
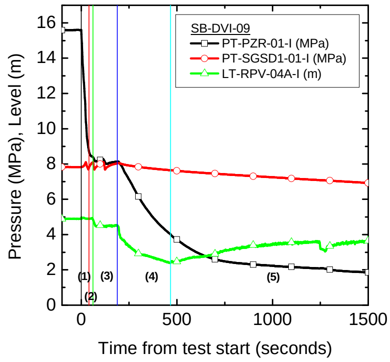
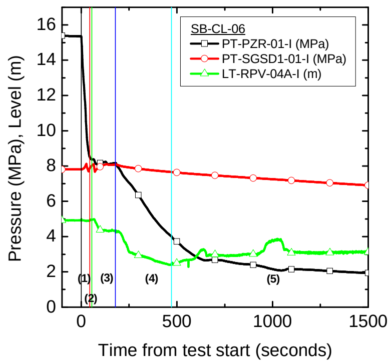


Fig. 1 Loop arrangement and break locations

3. Effect of Break Location during SBLOCA Tests



(a) SB-DVI-09



(b) SB-CL-06

Fig. 2 Behaviors of system pressures and collapsed water level in the down-comer

As shown in Fig. 2, the thermal-hydraulic characteristics could be divided into 5 phases during the SBLOCA scenario. It was observed that the pressure behaviors were similar for both breaks. However, the collapsed water level in the down-comer decreased more rapidly after the loop seal clearance in case of SB-DVI-09 test, as shown in Fig. 3.

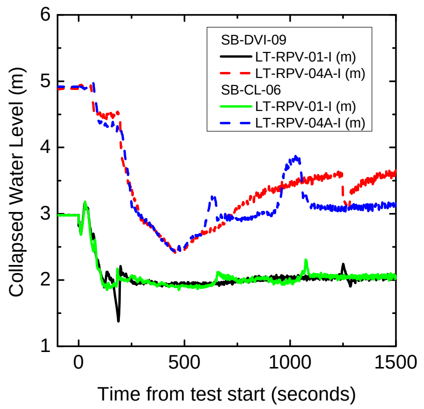


Fig. 3 Behaviors of collapsed water levels in core and down-comer

Fig. 4 shows the behaviors of differential pressure between down-comer and upper head. The maximum differential pressure is higher in the SB-DVI-09 test than in the SB-CL-06 test because the former test needs more differential pressure than the latter one due to the higher break location of DVI line than the cold leg.

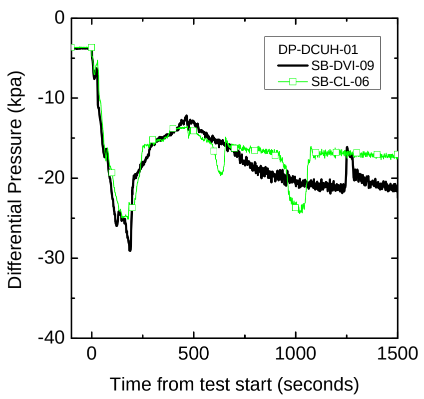


Fig. 4 Behaviors of differential pressure between down-comer and upper head

Table 2 shows the thermal-hydraulic phases during the SBLOCA scenario. The start of loop seal clearance is delayed 6 seconds in the SB-DVI-09 test when compared with the SB-CL-06 test. The delayed loop seal clearance could increase the possibility of the abrupt increase of core heater temperature because the core might be uncovered with the decrease of the collapsed water level, the lowest value of which is usually around the loop seal clearing.

Table 2 Thermal-hydraulic phases during SBLOCA scenario

Typical Phases	Start time (seconds)	
	SB-DVI-09	SB-CL-06
(1) Blow-down start	0	0
(2) Natural circulation	40	39
(3) Loop seal clearance	61	55
(4) Boil-off	189	178
(5) Core recovery	467	471

Fig. 5 shows the behavior of maximum heater surface temperatures. There was a temperature peak of core heater surface during the SB-DVI-09 test but not during the SB-CL-06 test.

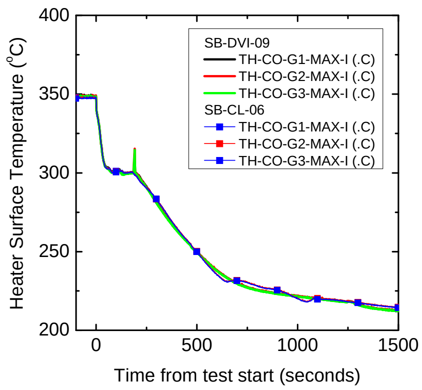


Fig. 5 Behaviors of maximum heater surface temperatures

4. Conclusion

Counterpart tests for a SBLOCA scenario were performed with the same control logic and initial/boundary conditions except for different break locations of DVI line and cold leg. The results showed that the maximum heater surface temperature increased higher in the SB-DVI-09 test than in the SB-CL-06 test due to the delayed loop seal clearance, the decrease of collapsed levels, and the uncover of core heater.

REFERENCES

[1] EPRI, "EPRI Utility Requirement Documents for the Advanced Light Water Reactor (Chapter 5)," EPRI, USA (1995).
[2] Choi, K.Y., et al., "OECD/NEA/CSNI International Standard Problem No. 50, ATLAS Test, SB-DVI-09: Comparison Report Volume I Analysis of Blind Calculations," NEA/CSNI/R(2010)x, KAERI, Korea (2010).
[3] Cho, S., et al., "Cold Leg SBLOCA Simulation Test with the ATLAS," Transactions of the KNS Autumn Meeting, Gyeongju, Korea, October 29-30 (2009).