Loss of Coolant Accident Simulation for the Top-Slot break at Cold Leg Focusing on the Loop Seal Reformation under Long Term Cooling with the ATLAS

Jongrok Kim[a,*], Yusun Park[a], Byoung-Uhn Bae[a], Nam-Hyun Choi[a], Kyoung-Ho Kang[a], and Ki-Yong Choi[a]
[a] *Korea Atomic Energy Research Institute, Daedeok-daero 989-111, Yuseong, Daejeon 305-353, Korea*
**Corresponding author: jongrok@kaeri.re.kr*

1. Introduction

During a certain class of Loss of Coolant Accident (LOCA) in a PWR like an advanced power reactor of 1400 MWe (APR1400), the steam volume in the reactor vessel upper plenum and/or upper head may continue expanding until steam blows liquid out of the intermediate leg (U-shaped pump suction cold leg), called loop seal clearing (LSC), opening a path for the steam to be relieved from the break [1]. Prediction of the LSC phenomena is difficult because they are varies for many parameters, which are break location, type, size, etc. This LSC is the major factor that affects the coolant inventory in the small break LOCA (SBLOCA) or intermediate break LOCA (IBLOCA).

There is an issue about the loop seal reformation that liquid refills intermediate leg and blocks the steam path after LSC. During the SBLOCA or IBLOCA, the Emergency Core Cooling System (ECCS) is operated. For long term of the top slot small or intermediate break at cold leg, the primary steam condensation by SG heat transfer or SIP, SIT water flooding (reverse flow to loop seal) make loop seal reformation possibly. The primary pressure increase at the top core region due to the steam release blockage by loop seal reformation. And then core level decreases and partial core uncover may occur [2].

In the present paper, loss of coolant accident for the top-slot break at cold leg was simulated with the ATLAS, which is a thermal-hydraulic integral effect test facility for evolutionary pressurized water reactors (PWRs) of an advanced power reactor of 1400 MWe (APR1400). The simulation was focused on the loop seal reformation under long term cooling condition.

2. Description of experiment

The target scenario for this experiment is the IBLOCA with the cold leg top-slot break that the loop seal reformation is occurred repeatedly for long term cooling. In the experiment, a 7.12mm nozzle was installed on upward direction at cold leg 1A of ATLAS to simulate a 4.0 inch top-slot break for the APR1400. (Fig. 1). To simulate conservative condition, 4 SIPs with maximum flow rate and 4 SITs were credited and SI fluid temperature was ambient temperature (about 16 ℃). This experiment performed until the reactor vessel was full-filled by coolant to simulate the long-term cooling condition.

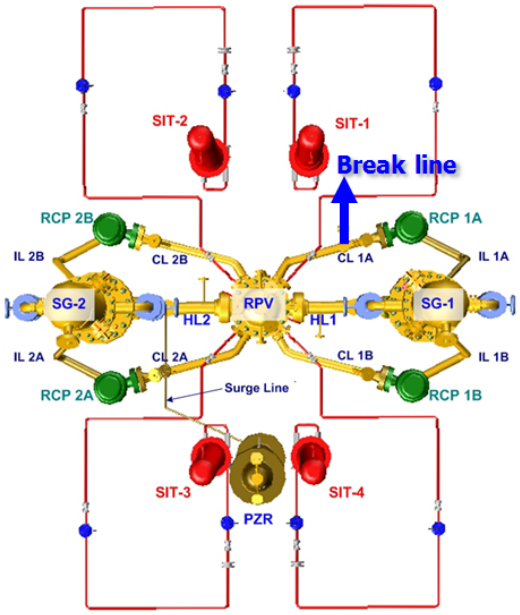

Fig. 1. Schematic diagram of ATLAS and break position

3. Experimental Results

Overall system behaviors observed in the experiment is shown in Fig. 2. With the start of the brea006B, the reactor, all four RCPs, a turbine, a MFIV, and a MSIV were tripped simultaneously. The closure of MSIV led to an increase in the secondary system pressure until the set point of the opening of the MSSV.

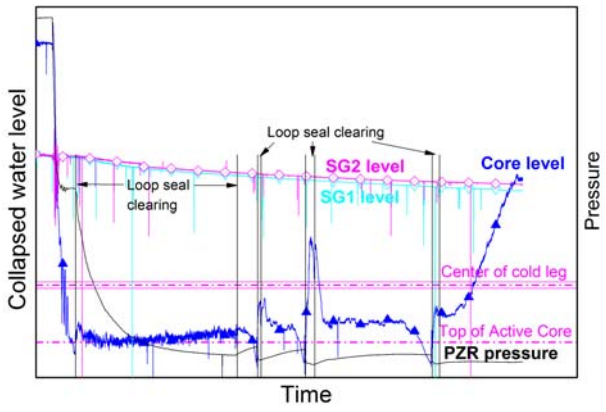

Fig. 2. Overall system behaviors observed in the experiment

The secondary side inventory of the steam generators was discharged into the condensation tank through MSSVs. When the primary coolant temperature was lower than secondary side, SGs were cooled down by reverse heat transfer. Core level were decreased near of top of active core continuously and increased sharply when the loop seal clearing was occurred.

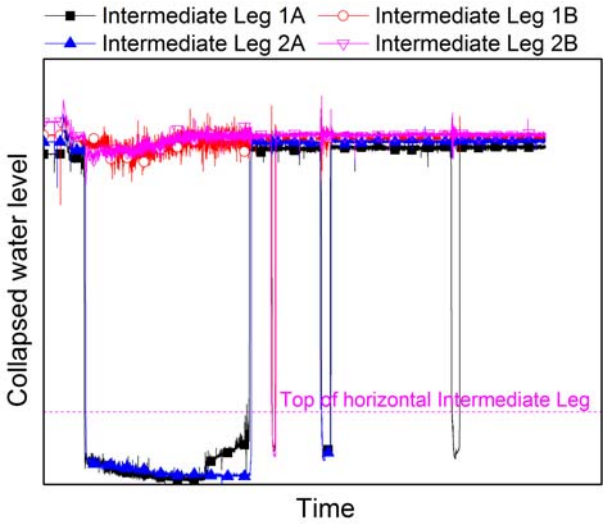

Fig. 3. Collapsed water level in the Intermediate legs (RCP suction side).

Loop seal phenomena are shown in Fig. 3. When the collapsed water level is lower than the top of horizontal intermediate leg, loop seal is cleared. As you can see, loop seal clearing and loop seal reformation were occurred repeatedly.

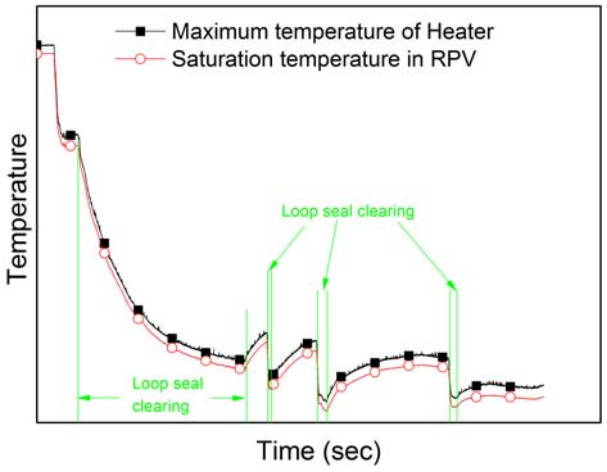

Fig. 4. PCT behavior

When the loop seal reformation occurred, heater temperatures were increased. However, the reason of increase was saturation temperature increase by increased system pressure. Therefore, the loop seal reformation didn't occur PCT.

4. Conclusion

The loss of coolant accident for the top-slot break at cold leg was simulated with the ATLAS. The loop seal clearing and loop seal reformation were occurred repeatedly. When the loop seal reformation occurred, heater temperatures were increased. However, the reason of increase was saturation temperature increase by increased system pressure. Therefore, the loop seal reformation didn't occur PCT.

Acknowledgements

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