Simulation of OECD/ATLAS A4.1 Test with TRACE Code

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1. Introduction

The OECD/NEA ATLAS (phase 1) project started from April 2014, with a three-year project period. This joint project focused on key LWR thermal-hydraulic safety issues related to multiple high risk failures highlighted from the Fukushima Daiichi accident utilizing the ATLAS facility [1].

In the frame of project, the A4.1 test was performed to investigate the thermal-hydraulic phenomena during a cold-leg intermediate break LOCA (IBLOCA) and address the scaling issues [2-3].

In this study, we assess the TRACE V5.0 patch5 and our TRACE input model against OECD/NEA ATLAS A4.1 test. By comparing with the experimental data, we evaluate how well the code calculation predict the main thermal-hydraulic phenomena during the transient.

2. Description of OECD/ATLAS A4.1 Test

The A4.1 test is a counterpart test for Large Scale Test Facility (LSTF) 17% cold-leg break IBLOCA. An upward long break nozzle was installed at downstream of the reactor coolant pump 1-A to simulate a double-ended Guillotine break of ECCS nozzle as shown in Fig. 1. A single failure of the ECC injection (high pressure injection (HPI) and low pressure injection (LPI)) and a total failure of the auxiliary feedwater system were assumed. The ECCS water was injected to the cold-legs of the intact loop with pressurizer (PZR). Loss of off-site

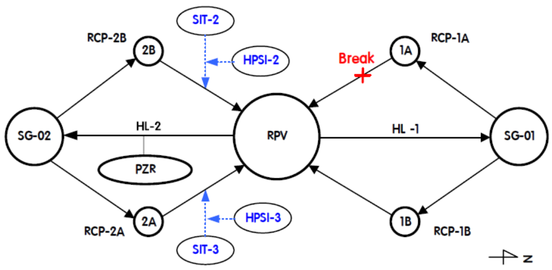

Fig. 1. Location of break unit and ECC injection point [2].

power concurrent with the scram of reactor was assumed. The transient was initiated by opening the break valve. The main steam isolation valves were assumed to be open during the entire transient.

3. Description of TRACE Input Model

Figure 2 shows the TRACE nodalization of A4.1 test. The reactor vessel is modeled by three dimensional VESSEL component and the RCS loops are simulated by one dimensional pipe components.

The reactor vessel is nodalized with four rings in radial direction, six sectors in azimuthal direction, and twenty levels in axial direction. The three inner radial rings represent the core flow region, and correspond to the flow area of heater groups G-1, G-2, and G-3, respectively. The outmost fourth ring represents the downcomer (DC).

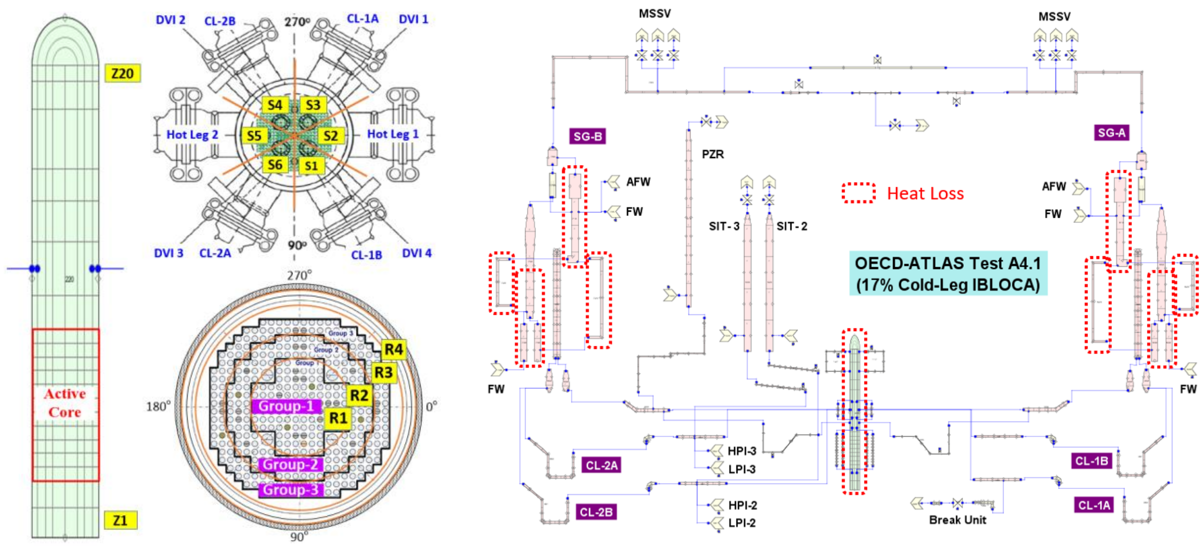

Fig. 2. TRACE nodalization.

The six azimuthal sectors are symmetrical. The cold-leg 1-B is connected to the sector 1. The cold-leg 1-A where the break unit is installed is connected to the sector 3. The axial levels of 3 to 13 represent the active core.

The break unit from the cold leg outer wall to the break valve is modeled. The heat losses from primary and secondary systems to atmosphere are modeled. All heat losses of the primary side is assumed to occur only on the outer surface of the reactor vessel. The counter-current flow limitation options are activated on the fuel alignment plate, the hot-leg riser, the steam generator (SG) u-tube inlet, and the intermediate leg outlet.

4. Results and Discussion

The main results of TRACE calculation are compared with the experimental data. All data are plotted with dimensionless values on the figures.

Figure 3 shows the comparison of the predicted primary and secondary pressures with experimental data. After the initiation of the break, a rapid depressurization of the primary system caused the core to trip. After HPI actuation, the primary system pressure presented a plateau, then the loop seal clearance (LSC) made it decrease again. After LPI actuation, the primary system was maintained without significant difference until the end of the transient. The secondary system pressure gradually decreased by the heat loss and the reverse heat transfer to the primary system [2].

The primary and secondary system pressures are well predicted by the code except that the calculated primary system pressure are slightly lower than the experimental data at non-dimensional time period of 0.5 to 0.7. The pressure difference in this period affects LPI actuation time.

Figure 4 depicts the collapsed water level results in the core and DC. The calculation well reproduces the collapsed water levels. The increase in the core level by LCS is well captured by the code. The difference in DC level between TRACE and experimental data after about non-dimensional time of 0.64 results from earlier actuation of LPI in the calculation.

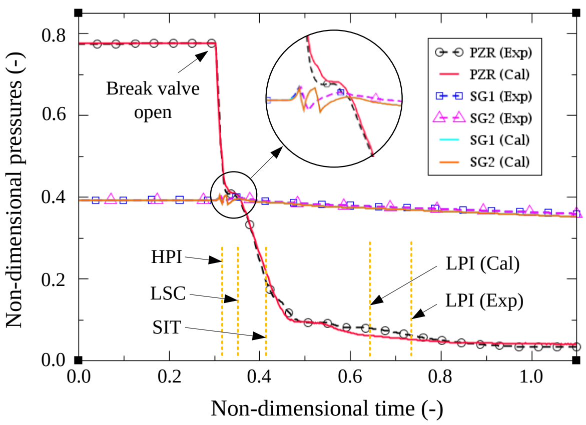

Fig. 3. Primary and secondary system pressures.

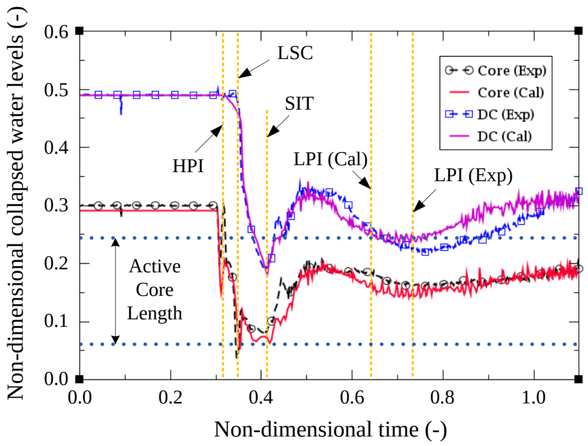

Fig. 4. Collapsed water levels of core and downcomer.

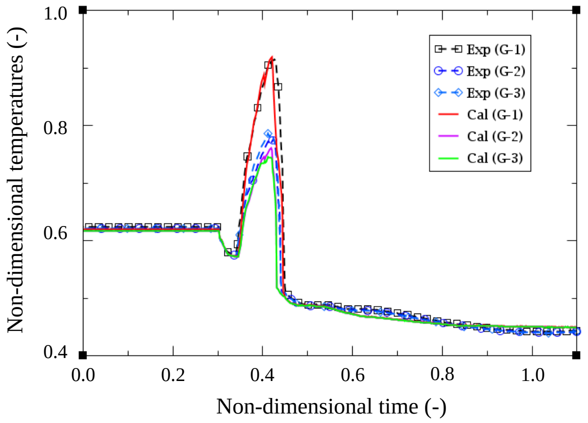

Fig. 5. Maximum cladding temperatures.

Figure 5 shows the results of maximum cladding temperatures of heater group. The calculated maximum rod surface temperatures of each heater group have the similar peak values as those of experiment. The core heat-up and quenching times are also well predicted.

5. Conclusions

We assessed the capability of TRACE V5.0 patch5 using OECD/NEA ATLAS A4.1 test. It was found that the TRACE code using our input model was able to reproduce adequately main thermal-hydraulic behaviors observed during 17% cold leg IBLOCA.

REFERENCES

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