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Evaluation for a 6-inch Cold Leg Break Test of ATLAS Using TRACE Code

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1. Introduction

ATLAS (Advanced Thermal-Hydraulic Test Loop for Accident Simulation) is an integral effect test facility in KAERI. It had installed completely to simulate the accident for the OPR1000 and the APR1400 in 2005. After several tests for LBLOCA and DVI line break have been performed successfully to resolve the safety issues of the APR1400, tests for small break LOCA (SBLOCA) were conducted for different break sizes and locations. Among the SBLOCA scenarios, test for the 6-inch SBLOCA was performed as a counterpart test for LSTF (Large Scale Test Facility) of JAEA (Japan Atomic Energy Agency) to identify the scaling issues of large scale test facilities [1].

For the 6-inch SBLOCA in ATLAS, several analyses using MARS and RELAP codes were performed in the ATLAS DSP-02 (Domestic Standard Problem) meetings [1]. However, TRACE code has not used as a simulation code of participants. TRACE code has developed as the unified code for the reactor thermal hydraulic analyses in USNRC [2]. In this study, the 6-inch SBLOCA in ATLAS was evaluated by TRACE code. The objectives of this study are to identify the prediction capability of TRACE code for the major thermal hydraulic phenomena of a cold leg SBLOCA in ATLAS.

2. Modeling of ATLAS

The reactor vessel of ATLAS was modeled as a VESSEL component of TRACE with 3 radial, 6 azimuthal and 28 axial volumes [3]. The core, lower & upper plenums were modeled in an inner two radial parts and an outer radial part was downcomer. The core was divided as 12 volumes and two heaters (1 average rod, 1 hot rod) were modeled in each volume. The core bypass and CEA guide tube bypass were modeled as 4 channels respectively. The two reactor coolant loops were modeled with two cold leg, one hot leg and one steam generator respectively. The pressurizer was connected to the one hot leg. The APR1400 has four mechanically separated hydraulic trains and two electrically separated divisions. Therefore, if the break was occurred simultaneously with the worst single failure for a loss of a diesel generator, the safety water was injected only through two nozzles including the nozzle close to the broken cold leg. Also, four SITs were considered as the available safety injection flow and the low flow region for the fluid device in each SIT was modeled by adjusting the flow area when the SIT water level was less than a specific set point. The break line was modeled as a single junction and a FILL component to simulate the initiation of the cold leg break to the containment.

3. Analysis Results

The initial conditions were obtained from the steady state calculation of TRACE. The calculated initial conditions showed a good agreement to the measured values for the major parameter such as a core power, pressurizer pressure and hot & cold leg flow rates [4].

The cold leg break was started by the opening trip in the FILL component at 204 sec. After then, the pressurizer pressure decreased and reached to a low PZR set pressure (~ 10.7 MPa) at ~243 sec. The LPP time of TRACE was ~ 15 sec later than that of ATLAS. This may result from the characteristic of the choke model in TRACE code. The decay of heater power was modeled to start at same time (~ 235 sec) with the experiment. The major sequence of events is listed in Table I.

Table I. Major Sequences of Events

Events	Time (sec)	
	ATLAS	TRACE
Break open	204.0	204.0
Low pressurizer pressure(LPP)	228.0	243.2
Reactor trip by LPP	LPP+0.354	243.5
Turbine isolation	LPP+0.07	243.3
Feed water isolation	LPP+7.08	250.2
SIP injection	LPP+28.29	271.4
Loop seal clearing at 1A & 2B loops	370.0	372.0
SIT injection start	655.0	662.3

The pressurizer pressure is shown in Fig. 1. As soon as the initiation of break, primary pressure rapidly decreased due to the sudden coolant loss. After the initial rapid depressurization ended by the flashing and boiling, the primary pressure reached a plateau during a period between the SIP injection and the loop seal clearing (LSC). The predicted pressure agreed relatively well with the experimental data.

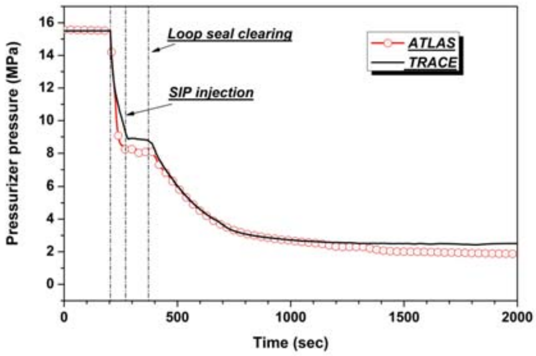

Fig. 1 Pressurizer Pressure

Fig. 2 shows the calculated PCT with the measured PCT and Fig. 3 shows the calculated and measured downcomer and core collapsed water levels. The measured temperature behavior agreed well to the TRACE prediction and the peaking behavior was not observed either in the measurement or in the prediction.

As shown in Fig. 3, for initial ~ 50 sec, the predicted core level dropped slowly and the decreased depth was under-predicted. After that, the predicted core level was not increased again as the measured level and it might be considered to be a detection error. From ~ 250 sec, the measured core level reduced continuously before the LSC. However, the predicted core level was much higher than the measured value at the time of LSC. Generally, a LSC promotes the steam venting to the break and decreases rapidly the core level. However, this behavior was not predicted in the core level properly. After LSC, the code predicted relatively well the trend of core level. Also, the downcomer water level showed a relatively good prediction except the level decrease just after the break. It resulted from the difference of the downcomer fluid temperature. The predicted temperature was higher than that of the experiment and it was close to the hot leg temperature. The rapid drop of downcomer level at the LSC was predicted well. After the SIT injection, the predicted downcomer level increased more rapidly than the measured one due to the over-estimation of SIT flow.

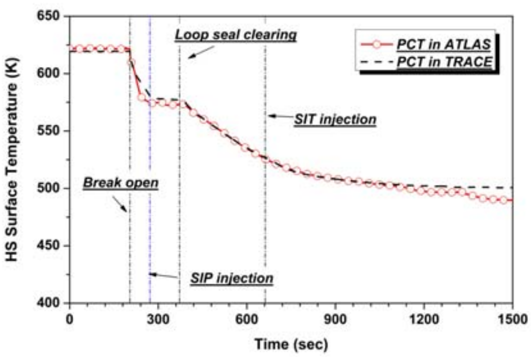

Fig. 2 Max. Cladding Temperature at Hot Rod

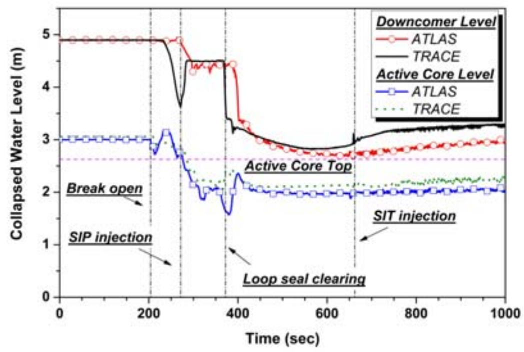

Fig. 3 Core & Downcomer Collapsed Water Level

The two loop seals in cold legs 1A and 2 B were fully cleared at ~ 370 sec like the measured data as shown in Fig. 4. Therefore, the location and the time of LCS were predicted very well.

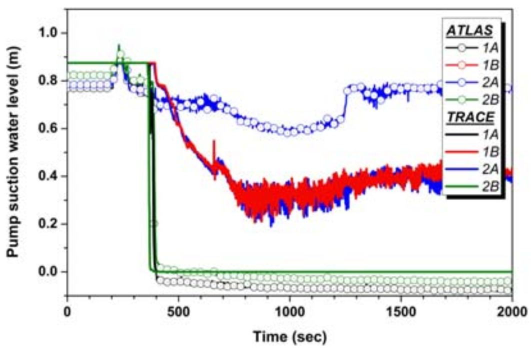

Fig. 4 Intermediate Leg Water Level

4. Conclusion

The calculation for the 6-inch cold leg break of ATLAS was performed with the TRACE code. From the calculation results, the initial and boundary conditions were defined well with the measured values. The major behavior of the cladding temperature, the downcomer and core water levels could be predicted well with TRACE code. However, the further study will be needed to resolve the differences of the choke flow, the water inventory, etc.

REFERENCES

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