ATLAS MSLB accident analysis using the SPACE code

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1. Introduction

An integral effect test for a main steam line break (MSLB) was performed with the ATLAS (Advanced Thermal-Hydraulic Test Loop for Accident Simulation) on December 6, 2012 by KAERI (Korea Atomic Energy Research Institute) [1]. A MSLB is defined as a pipe break in the main steam system. This integral effect test was named as the SLB-GB-02T. This data was used to validate the safety analysis code SPACE (Safety and Performance Analysis Code for Nuclear Power Plants). In the SLB-GB-02T test, a double – ended guillotined break of the main steam line was simulated. This study presents SPACE analysis and experimental results of the SLB-GB-02T test.

2. Methods and Results

In this section some of the techniques used to analysis the ATLAS MSLB accident. The techniques include a SPACE nodalization, test conditions, test procedures, steady and transient results.

2.1 Description of the ATLAS

The ATLAS has the same two-loop features as the APR1400 and is designed according to the well-known scaling method suggested by Ishii and Kataoka [2] to simulate various test scenarios as realistically as possible. It is a half-height and 1/288-volume scaled test facility with respect to the APR1400. The fluid system of the ATLAS consists of a primary system, a secondary system, a safety injection system, a break simulation system, a containment simulation system, and auxiliary systems. The ATLAS has two steam generators and each steam generator consists of a lower plenum, a U-tube assembly, middle and upper steam generator vessels, two down-comer pipes. The break flow from the affected SG (SG-1) is directly discharged to a re-fueling water tank (RWT) and the break flow from the intact SG (SG-2) is discharged to an atmosphere through a silencer in the SLB-GB-02T test. A detailed description of the signal processing system and control system of the ATLAS can be found in the literature [3, 4].

SPACE model is equal to the geometrical structure of the ATLAS. SPACE model has two steam generators, four safety injection pumps, four reactor coolant pumps and one pressurizer. 2 break flows were simulated at the end of a steam pipe of SG-1 as TFBC components with valves.

2.2 Test Conditions

A flow restrictor was installed at the steam exit nozzle of each SG to restrict the steam flow rate within the critical flow rate during the MSLB accident. The flow restrictor was designed according to the scaling law of the ATLAS facility. The initial heater power was controlled to be maintained at about 1.634MW. During the test period, the heat loss rate of the primary loop was estimated to be about 90kW, and the heat loss through two steam generators was about 60kW [5].

2.3 Test Procedures

After steady-state, the test was started by opening the break simulation valves. With the start of the test, a pressure of the secondary system was decreased rapidly below 6.11MPa, which is the set-point of the LSGP signal. With the occurrence of the LSGP signal, the secondary system was isolated. The SIP actuation signal was issued by the LPP signal whose set-point is 10.72MPa. Table 1 shows the sequence of the events observed in the present SLB-GB-02T test. Detailed description of the test procedures can be found in the literature [6].

Table 1: Actual sequence of events of the SLB-GB-02T test

Event	DAS Time (sec)	Remarks
Break open	303	
LSGP (Rx trip)	310	PT-SGSD1-01 < 6.11MPa
RCP trip	311	LSGP trip + 1.0s delay
MSIS	315	LSGP trip + 3.54s delay: SG isolation
MFIS	303	Coincident with the break
Decay power start	322	LSGP trip + 12.07s delay
SIP	505	LPP + 28.28s delay
AF injection start	364/361	AFAS + 43.45s delay

AFAS: Auxiliary Feedwater Actuation Signal (Set-poiint: LT-SGSDRS1,2 < 2.78m)
LPP: Low Pressurizer Pressure (Set-point: PT-PZR-01 < 10.7244MPa
MFIS: Main Feedwater Isolation Signal
MSIS: Main Steam Isolation Signal

2.4 Overall Thermal-Hydraulic Behaviors

When the MSLB event was initiated by opening the break simulation valve, the SG was depressurized shown in Figure 1. The calculation results and experimental values are different. Reason is the difference of the flow rate corresponding to the break point. Figure 2 shows the variation of the collapsed water level in the down-comer regions. Figure 3 shows the variation of the flow rates in the cold leg, respectively. Asymetric thermal-hydraulic behavior was clearly observed between the loops. Figure 4 shows the variation of the fluid temperature in the RPV.

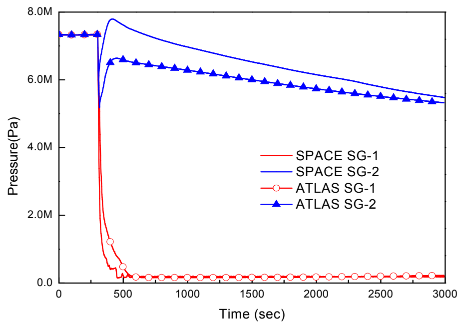

Fig. 1. Pressure trend at the steam generator steam dome.

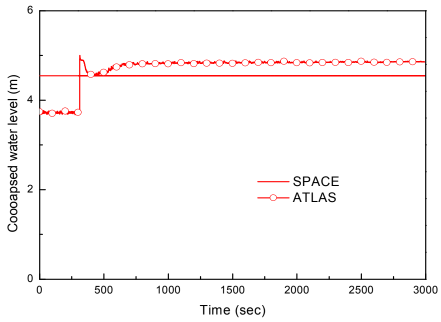

Fig. 2. Variation of the collapsed water level in the down-comer region.

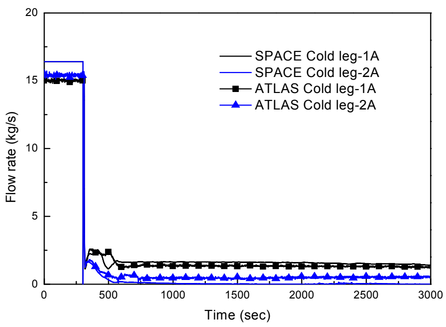

Fig. 3. Variation of the flow rates in the cold leg.

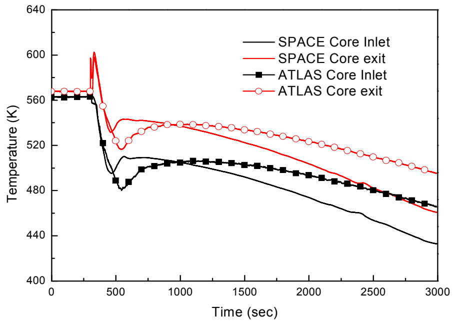

Fig. 4. Fluid temperature in the reactor pressure vessel.

2.5 Estimation of the Break Flow

The break flow was measured by two orifice flow meters, for the downstream of SG outlet nozzle of the SG-1 and SG-2, respectively. As a complementary method to the direct measurement of the break flow, a RWT inventory-based break flow estimation method was applied. The break flow from the SG-1 was condensed in the RWT through a sparger and the break flow could be estimated based on the inventory increase in the RWT. The orifice flow meter was installed for the measurement of the break flow from the intact SG before the occurrence of the MSIS. The break flow was decreased to zero level with the actuation of the MSIS.

3. Conclusions

In order to validate the SPACE code, simulate a double-ended guillotine break of the main steam line in the ATLAS. Most of the results are same between experiment data and code value. However, primary system temperature and pressurizer pressure and level were difference a little. Pressurizer component of SPACE has to be considered to heater, pressure dummy cell and charging. For the future, this study will present the exact results.

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