An Overall Investigation of Cold Leg Pipe Break Accidents of the ATLAS Facility

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1. Introduction

A previous parametric study [1] of the direct vessel injection (DVI) line breaks was re-evaluated to see their applicability to the cold leg (CL) pipe breaks in ATLAS (Advanced Thermal-hydraulic test Loop for Accident Simulation). Evaluation results of the tests and analyses for the major parameters, i.e., the pressurizer (PZR) pressure, downcomer water level, collapsed core water level, and clad temperature, were compared for four different CL pipe break scenarios. The overall trends of the major parameters showed reasonable behaviors between the tests and analyses. The clad temperature showed conservative behaviors in the analyses using the suggested options. The suggested counter-current flow limit (CCFL) options for the fuel alignment plate (FAP) and cross-over legs (COLs) can be applicable to any small-break loss-of-coolant accident (SBLOCA) scenario for the CL pipe and DVI line breaks in the ATLAS tests.

2. Methods and Results

2.1 Test Scenarios for MARS-KS[2] Analyses

Four CL pipe SBLOCA scenarios were selected, i.e., 2.0, 4.0, 6.0, and 8.5 in. CL pipe breaks, as shown in Table 1. The break nozzle of a test was modeled by a valve component in MARS analyses. A time-dependent volume was used for the simulation of the containment back pressure in the CL pipe break analysis. In the post-test analysis, the measured containment pressures with respect to time were used as the boundary condition of the time-dependent volume. For parametric evaluations, the discharge coefficient, C_d, was varied to see their effects on the PZR pressure, core water level, and peak cladding temperature under the options of CCFL model for the FAP and COLs in the DVI line break analyses [1].

Table 1. Summary of CL pipe SBLOCA tests

Test ID	Break Nozzle		Remark
	Size (in.)	*D* (mm)	
SB-CL-07	2.0	3.56	
SB-CL-05	4.0	7.12	
SB-CL-09	6.0	10.68	DSP-02
SB-CL-04	8.5	15.13	

2.2 Analyses results

The authors conducted a parametric study for the DVI line break SBLOCA tests with respect to the discharge coefficient of the critical flow model, C_d, and the CCFL options for the FAP and COLs [1]. A previous parametric study of the DVI line breaks was assumed to be applicable to that of the CL SBLOCA tests because the break sizes of the CL break tests were nearly the same as those of the DVI line break tests. Thus, in this paper, another parametric study on the CL SBLOCA tests was omitted, and instead, evaluation results of its application to the CL SBLOCA tests were discussed. In a practical aspect, it was necessary for the applicable values and options to be re-evaluated if they can also be applied to the CL pipe breaks. The evaluation results are summarized in Table 2. (Here, the abbreviations NA, Wa, and Ku represent three options for the CCFL model, i.e., non-application, Wallis, and Kutateladze options, respectively.) As shown in the table, there was one different case for the C_d value between the CL pipe and DVI line breaks, i.e., SB-CL-05. There were no differences in the applicable options of CCFL for the FAP and COL between the two break scenarios.

Table 2. Summary of proper C_d values and applicable CCFL options for CL pipe SBLOCA tests

Test ID	Break Size(in)	C_d	Applicable CCFL Options	
			FAP	COL
SB-CL-07	2.0	0.55	NA	Ku
SB-CL-05	4.0	**0.82**	NA	Ku
SB-CL-09	6.0	0.77	Wa	Ku
SB-CL-04	8.5	0.71	Wa	Ku

Comparisons between the tests and analyses for the major parameters, i.e., the PZR pressure, collapsed downcomer water level, collapsed core water level, and clad temperature, are shown in Figs. 1 through 4 for four different CL pipe break scenarios, respectively. Among the major parameters, as can be seen in the figures, there were quite different trends for the collapsed dwoncomer water levels. However, the overall behaviors of the collapsed downcomer water levels seemed to be reasonable. For the collapsed core water levels, the overall trends appeared to be quite good between the tests and analyses. In the safety analyses, the most important parameter is the fuel clad temperature. The analysis results of the clad temperature using the applicable Cd values and CCFL

options showed conservative trends compared to the tests, as shown in the figures. It can be concluded that the suggested CCFL options for the FAP and COLs can be applicable to any SBLOCA scenario for the CL pipe and DVI line breaks in the ATLAS tests.

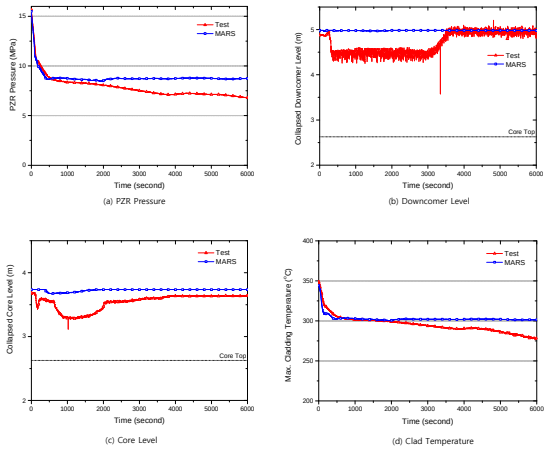

Fig. 1 Comparison between ATLAS test and MARS analysis for 2” CL pipe break (SB-CL-07)

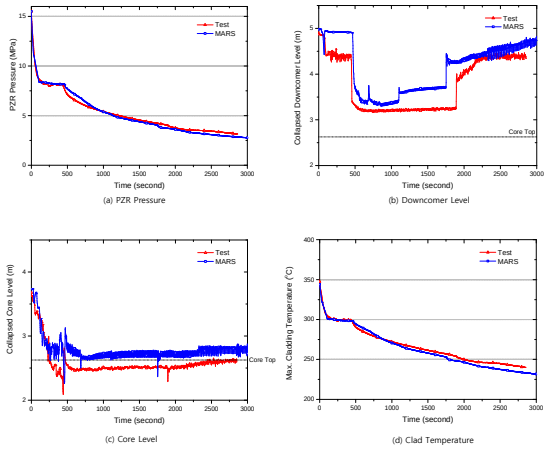

Fig. 2 Comparison between ATLAS test and MARS analysis for 4” CL pipe break (SB-CL-05)

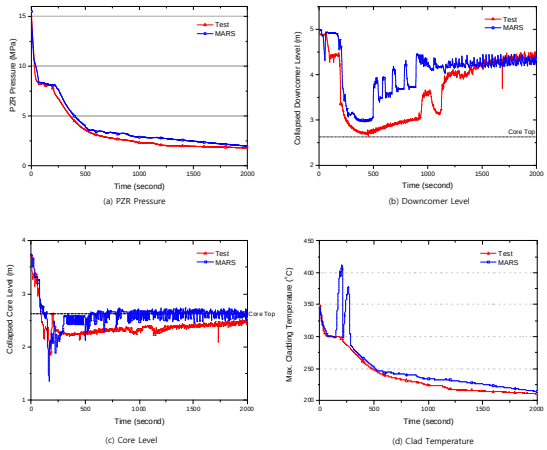

Fig. 3 Comparison between ATLAS test and MARS analysis for 6” CL pipe break (SB-CL-09)

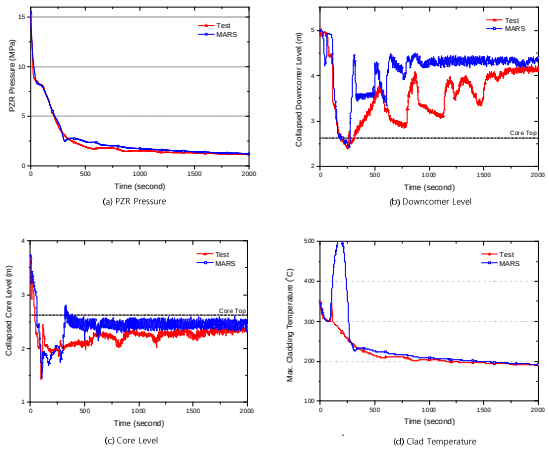

Fig. 4 Comparison between ATLAS test and MARS analysis for 8.5” CL pipe break (SB-CL-04)

3. Summary and Conclusions

In this paper, a previous parametric study of the DVI line breaks [1] was re-evaluated to see its applicability to that of the CL pipe breaks in ATLAS. The evaluation results of the tests and analyses for the major parameters, i.e., the PZR pressure, downcomer water level, core water level, and clad temperature, were compared for four different CL pipe break scenarios. The overall trends of the major parameters showed reasonable behaviors between the tests and analyses. The clad temperature showed conservative behaviors in the analyses using the suggested options. As a conclusion, the suggested CCFL options for the FAP and COLs can be applicable to the MARS post-analyses for any SBLOCA scenario of the CL pipe and DVI line breaks in the ATLAS tests.

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