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A Preliminary Analysis for SMART-ITL SBLOCA Tests using the MARS/KS Code

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1. Introduction

An integral-effect test (IET) loop for SMART, SMART-ITL (or FESTA), has been designed using a volume scaling methodology. It was installed at KAERI and its commissioning tests were finished in 2012. Its height was preserved and its area and volume were scaled down to 1/49 compared with the prototype plant, SMART. The SMART-ITL consists of a primary system including a reactor pressure vessel with a pressurizer, four steam generators and four main coolant pumps, a secondary system, a safety system, and an auxiliary system. The objectives of IET using the SMART-ITL facility are to investigate the integral performance of the inter-connected components and possible thermal-hydraulic phenomena occurring in the SMART design, and to validate its safety for various design basis events (DBAs) [1].

In this paper, a preliminary analysis was conducted for SMART-ITL SBLOCA tests using the MARS/KS Code.

2. Methods and Results

2.1 MARS/KS Code Input Modeling & Initial Condition

The nodalization of SMART-ITL was based on a final isometric drawing and the design reports provided by KAERI. Fig. 1 shows the nodalization diagram for the MARS/KS Code.

Guillotine type breaks are used, and their break locations are at the safety injection system (SIS) line (nozzle part of the RCP discharge), at the suction line of the shutdown cooling system (SCS) (nozzle part of the RCP suction), and at the pressurizer safety valve (PSV) line connected to the pressurizer top. The break size is the same as the scaled-down value for all simulations.

2.2 SBLOCA calculation results

Upon the guillotine break at various break positions, RCS fluid is released, and the RCS pressure decreases rapidly. When the RCS pressure reaches P_{LPP}, the reactor trip signal is generated. The control rod injection, PRHRS actuation, and safety injection are operated sequentially. Table I shows the major sequence events and their results for SBLOCAs.

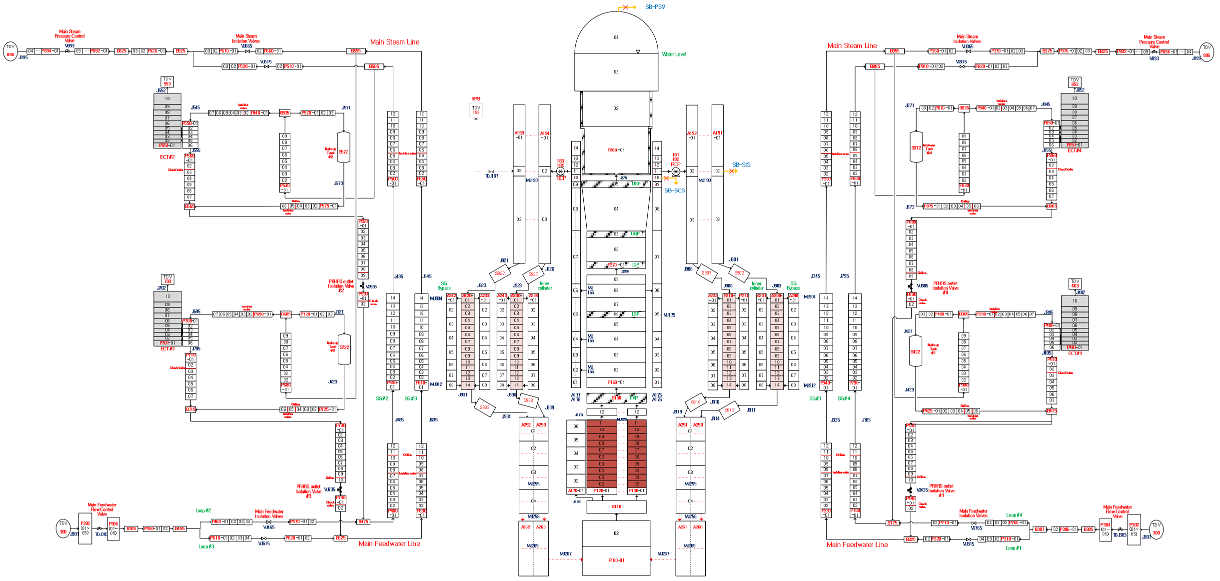

Fig. 1. Nodalization diagram of SMART-ITL for MARS Code

Fig. 2 shows the pressure behavior of the primary system. Until the PRHRS actuation, the depressurization rate is the fastest in the SB-PSV, and is faster in the SB-SCS than in the SB-SIS. The reason for this is the difference in the break location. In the SB-PSV, a rapid depressurization is caused by the discharge of steam. However, as the natural circulation cooling mode is initiated by the PRHRS actuation, the depressurization rates are reversed. The reason for this is the difference in the RCS inventory. Since the total discharge mass is the lowest in the SB-SIS, the depressurization rate is the fastest during the natural circulation cooling mode. As the safety injection is started, the pressurizer depressurizes slowly, and about after 5,000 seconds, it becomes almost the same under all three SBLOCA scenarios.

Table I: Major Sequence of Events for SBLOCAs

Event	Set-points & Time Delay	Calculation Time(s)		
		SB-SCS	SB-SIS	SB-PSV
Break	-	0.0	0.0	0.0
Reach LPP set-point	P_{LPP}	201.3	363.0	106.1
Reactor trip signal (FW Stop/ RCP Coast down)	1.1 s after P_{LPP}	202.4	364.1	107.2
Reactor Trip (Control rod injection start)	1.6 s after P_{LPP}	202.9	364.6	107.7
PRHR actuation signal	2.34 s after P_{LPP}	203.6	365.3	108.4
PRHRS IV fully open	5 s delay	208.6	370.3	113.4
MSIV/FWIV fully close	20 s delay	223.6	385.3	128.4
Safety injection signal	P_{SIAS}	709.1	637.7	794.1
Safety injection start	30 s after P_{SIAS}	739.1	667.7	824.1
Calculation End	-	7000.0	7000.0	7000.0

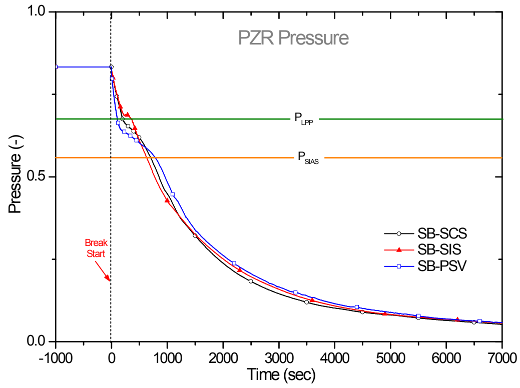

Fig. 2. Pressure in pressurizer

Two pressure peaks are found in the secondary system pressure behavior, as shown in Fig. 3. The first pressure peak occurs when the MSIVs and FWIVs are fully closed, and the pressure then decreases with the operation of the PRHRS. As the safety injection is initiated and the primary pressure is depressurized, the SI flow rate overcomes the break flow rate. Consequently, the water collapsed level for the primary side of the steam generator (RCP discharge region) begins to increase. As a result of the recovery of the water level, a second pressure peak occurs in the secondary system. Fig. 4 shows the water collapsed level of the RCP discharge region. The core is not uncovered throughout the whole SBLOCA scenario, as shown in Fig. 5.

3. Conclusions

The results of this work are expected to be good guidelines for SBLOCA tests with the SMART-ITL, and used to understand the various thermal-hydraulic phenomena expected to occur in the integral-type reactor, SMART.

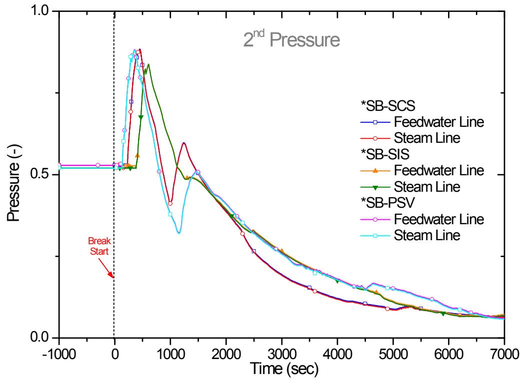

Fig. 3. Pressure in secondary system

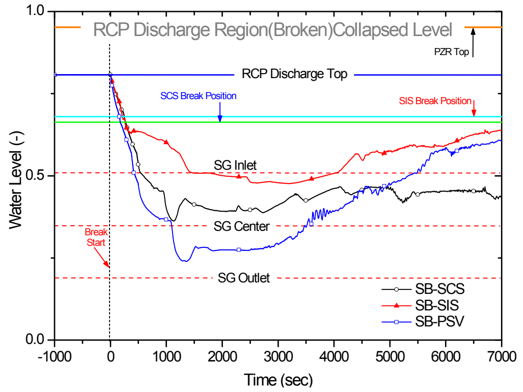

Fig. 4. Water collapsed level in RCP discharge region

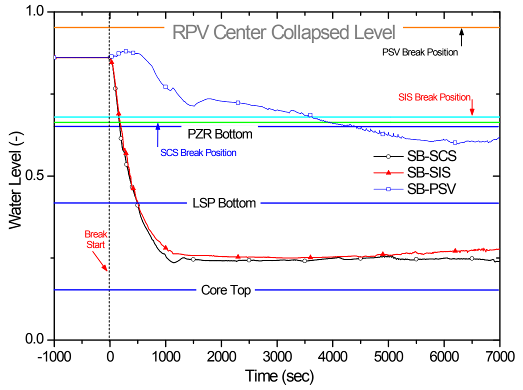

Fig. 5. Water collapsed level in RCP discharge region

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[1] H. S. Park, et al., Basic Design of an Integral Effect Test Facility, SMART-ITL for an Integral Type Reactor. The 15th NURETH Conference, Pisa, Italy, May 12-15, 2013.