# Analysis of LOFT Experiments L6-1 and L6-5 Using MEDUSA Code

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## 1. Introduction

MEDUSA is a code developed by Korea Power Engineering Company (KOPEC) for non-LOCA and LOCA analyses, providing two-fluid, three-field representation of two-phase flow [1]. In order to verify applicability of MEDUSA as a system analysis code, comparative simulations by the CESEC-III and MEDUSA computer codes for various non-LOCA events have been performed [2,3]. In this paper, as a series of code validation effort, anticipated transient experiments L6-1 and L6-5 performed at the Loss-of-Fluid Test (LOFT) facility, are analyzed using MEDUSA code, where Test L6-1 simulates a loss of steam load in all steam generators, and L6-5 dose a complete loss of feedwater to all steam generators, respectively.

## 2. Analysis Methodology and Results

### *2.1 LOFT System Description*

The LOFT facility is a down scaled model of a 4-loop commercial PWR to provide data on the system thermal-hydraulic conditions during a LOCA or a pressurized transient. Coolant volumes and flow areas in LOFT are scaled using the ratio of the LOFT core (50MW(t)) to a commercial PWR core (3000MW(t)). Also, components used in LOFT are similar in design to those of a commercial PWR. The facility consists of an intact loop with an active steam generator, pressurizer, two primary coolant pumps in parallel and a broken loop to simulate hot or cold leg breaks. The detailed descriptions on the LOFT system are given in Reference [4].

### *2.2 Test Description*

Experiment L6-1 is initiated by closing the main steam flow control valve (MSFCV). The pressurizer cycling heaters are on at experiment initiation and shut off at 6.1s as the primary pressure continues to increase because of the loss of the secondary heat removal. The pressurizer spray is initiated at 9.1s to reduce the primary coolant system (PCS) pressure, and remains on until 30.4s. The PCS pressure continues to rise, causing the reactor to scram at 21.8s. After the reactor scram, the PCS starts to depressurize. The MSFCV automatically begins to open to reduce the steam generator secondary side pressure, and is closed after pressure decrease.

Experiment L6-5 is conducted in order to investigate plant response to a transient in which feedwater flow to the secondary side of the steam generator is stopped. The experiment is initiated by turning the main feedwater pump off. The PCS pressure and pressurizer liquid level initially rise following termination of feedwater flow and then are decreased rapidly following scram. The reactor is manually scrammed at 23.7s after experiment initiation when the steam generator liquid level drops to -0.126m. The MSFCV automatically regulates steam generator pressure and steam flow after reactor scram.

### *2.3 Results*

In Experiment L6-1, the PCS temperature begins to rise as the secondary side heat removal is reduced due to decreased steam flow rates. The increase of PCS temperature results in a pressurizer pressure increase to the reactor trip analysis setpoint. PCS pressure begins to decreases after reactor scram. As shown in Figure 1 and 2, the time variations of pressure and temperature are in good agreement with measured data.

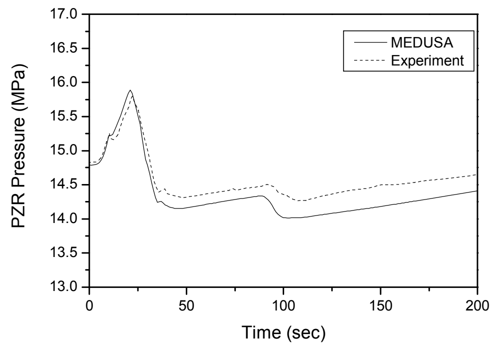


Figure 1. Pressurizer pressure (L6-1)

The loss of heat removal causes the steam generator pressure to increase. The MSFCV automatically begins to open to reduce the secondary side pressure, and is closed after pressure decrease (Figure3). After reactor scram, the increasing rate of pressure during the period of the MSFCV closure is reduced due to less energy being deposited to the steam generator secondary side.

Experiment L6-5 is initiated by terminating all feedwater flow into the steam generators. This degrades primary-to-secondary heat transfer, which subsequently results in heatup and pressurization of the primary system (Figure 4).

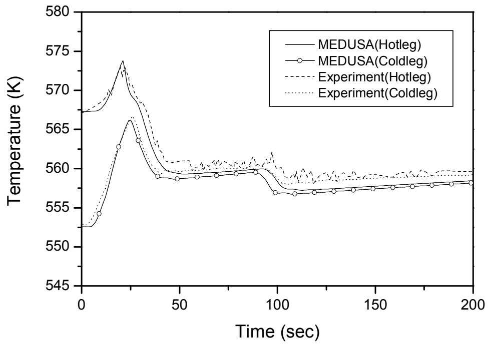


Figure 2. PCS temperature (L6-1)

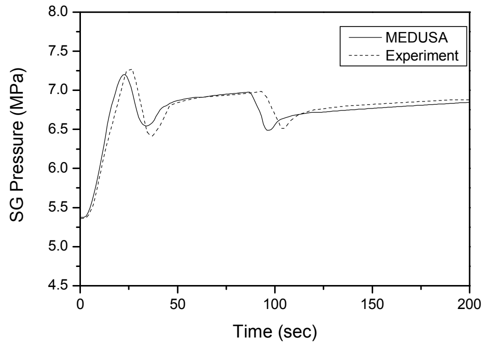


Figure 3. Steam generator pressure (L6-1)

The reactor is manually scrammed, when the steam generator level reaches the low steam generator level setpoint. Following the reactor trip, the primary system pressure drops due to a sudden decrease in heat generation from the core. After a short period, the PCS pressure begins to increase due to the reduced primary-to-secondary heat transfer caused by the MSFCV closing about 34s.

Termination of feedwater flow leads to an increase in the specific enthalpy of the steam generator fluid, reducing the primary-to-secondary temperature difference and the heat transfer rate. As steam continues to flow out through MSFCV, the SG inventory gets depleted and the pressure increases slightly due to increasing specific enthalpy until reactor scram occurs. The pressure begins to rise rapidly, during a short period when the MSFCV closes following reactor scram. Then the increasing rate of pressure is reduced, as the decay heat becomes balanced with the leakage through the MSFCV (Figure 5).

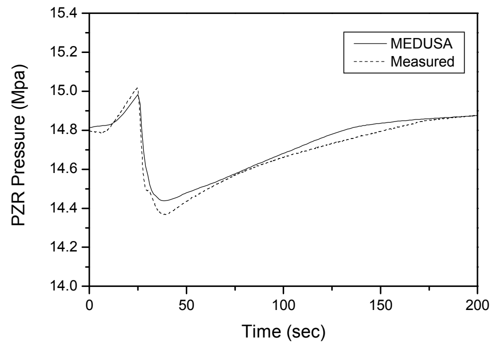


Figure 4. Pressurizer pressure (L6-5)

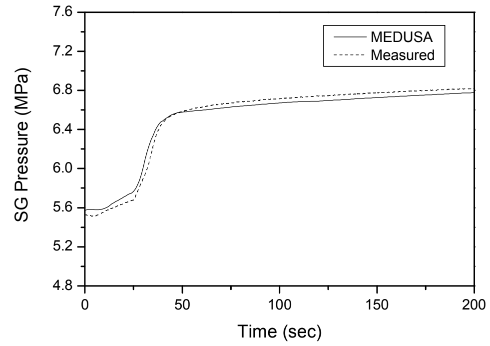


Figure 5. Steam generator pressure (L6-5)

## 3. Conclusion

Anticipated transient experiments L6-1 and L6-5 performed at the LOFT facility, were analyzed using MEDUSA code. The predictions of transient behaviors by MEDUSA show a good agreement with experiment data. Consequently, it is concluded that MEDUSA code is applicable to the analysis of PWR system response to Non-LOCA transients such as loss of steam load and loss of feedwater.

## REFERENCES


[1] C. E. Park, MEDUSA and its Application to Non-LOCA Analysis, 2nd Safety Analysis Symposium, 2004.

[2] S. C. Moon, Comparison of the LDLB Event Analyses by using the MEDUSA and CESEC-III Codes, Korean Nuclear Society Spring Meeting, 2005.

[3] J. C. Park, Comparative Analysis of SLB for OPR1000 by using MEDUSA and CESEC-III Codes, , Korean Nuclear Society Spring Meeting, 2005.

[4] NUREG/CR-0427, LOFT System and Test Description, July, 1978