# Determination of Pressure Losses in the Primary System of the ATLAS

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## 1. Introduction

The ATLAS (Advanced Thermal-Hydraulic Test Loop for Accident Simulation) was constructed in KAERI for integral effect tests of advanced pressurized water reactors (PWRs). The ATLAS facility was designed to have a geometric similarity with APR1400 and specific design characteristics of OPR1000. The ATLAS will be used to simulate accident and transient scenarios for the design and operation of the evolutionary PWRs.

Pressure losses in the primary system characterize the overall steady-state condition and in-vessel thermal-hydraulic phenomena, and thus they were determined experimentally in the ATLAS facility.

## 2. Experiments

The primary system of the ATLAS was fully closed with 27 differential pressure transmitters. The cold leg for the large break loss of coolant accident (LB LOCA) simulation has a different feature compared with the intact cold leg. It has an excessive curvature in the cold leg pipe line that creates a three-dimensional geometric distribution in pressure field. This cold leg pipe line was detected totally with one differential pressure transmitter. 11 pressure transmitters were relocated to enclose the primary loop and to escape the curved location.

After the primary system was fully filled with the water, a set of experiments were performed by changing pump velocity from 20% to 80% under non-heated condition at the pressure of 0.385 MPa. Pressure transmitters changed differential pressure results into electrical signals, and that were gathered in a data acquisition system with sampling frequency of 10 Hz for 20 seconds. Experiments were performed with a maximum error of 7.7 %. The test matrix and experimental condition are summarized in table 1.

Table 1. Test matrix and experimental condition

| Parametric test condition | |
|---|---|
| Temperature | 28.5 ℃ |
| Pressure | 0.385 MPa |
| Density of water | 996.3257 kg/m$^3$ |
| Mass flow | 15.98 ~ 66.03 kg/sec |

## 3. Results and Discussion

Pressure losses were detected at each loop and component. Pressure loss increased linearly as the squared value of the mass flow increased. Overall experimental results are shown in Fig. 1.

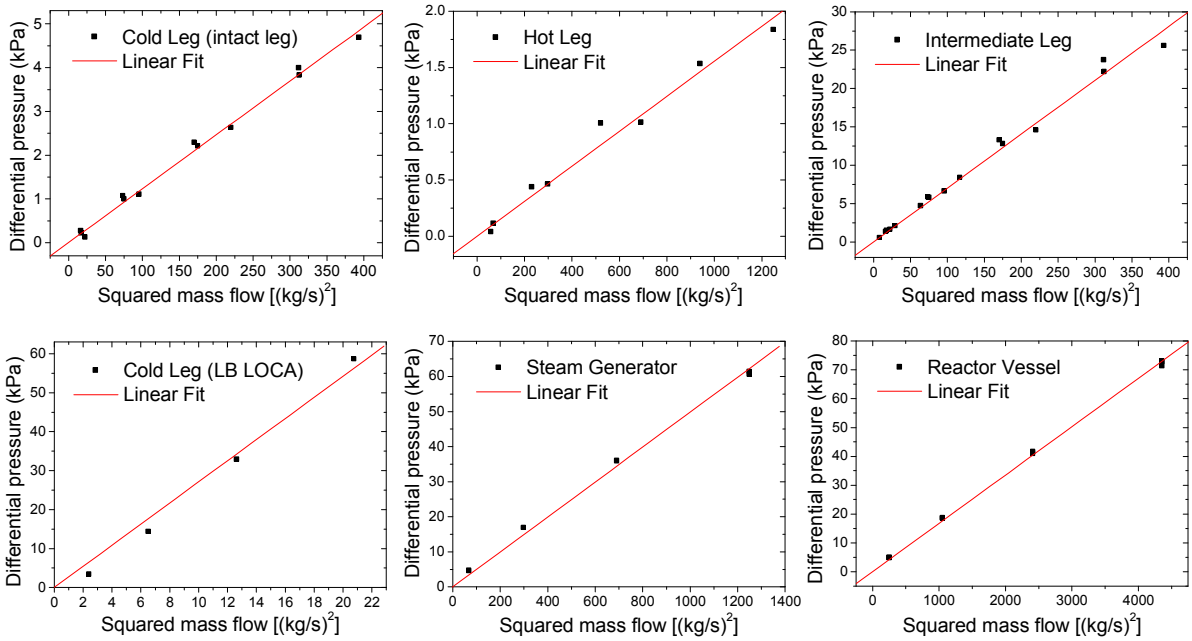


Figure 1. Pressure losses in the primary system of the ATLAS

Table 2. Pressure loss distributions in a primary system

| | APR 1400 | | ATLAS (Design) | | ATLAS (Experiment) | |
|---|---|---|---|---|---|---|
| | % | ratio | % | ratio | % | ratio |
| Total Head Loss | 100 | 1 | 100 | 1.01 | 100 | 1.72 |
| Cold Leg | 1.11 | 1 | 2.35 | 2.13 | 2.52 | 3.89 |
| Reactor Vessel | 64.58 | 1 | 58.50 | 0.91 | 47.53 | 1.26 |
| Hot Leg | 0.71 | 1 | 0.99 | 1.41 | 1.34 | 3.26 |
| Steam Generator | 27.0 | 1 | 20.32 | 0.76 | 33.69 | 2.14 |
| Intermediate Leg | 6.62 | 1 | 17.84 | 2.71 | 14.92 | 3.87 |

Pressure loss coefficient ($K$) could be expressed as a function of the pressure losses and flow rate for each component. [1]

$$R = \frac{K}{A^2} = (2\rho)\cdot\left(\frac{\Delta P}{m^2}\right) \qquad (1)$$

Pressure losses ($\triangle P$) were calculated using equation (1) and friction factors ($\lambda_T$) were calculated using Zigrang-Sylvester approximation to Colebrook-White correation, which is expressed as equation (2). [2]

$$\frac{1}{\sqrt{\lambda_T}} = -2\log_{10}\left\{\frac{\varepsilon}{3.7D} + \frac{2.51}{\mathrm{Re}}\left[1.14 - 2\log_{10}\left(\frac{\varepsilon}{D} + \frac{21.25}{\mathrm{Re}^{0.9}}\right)\right]\right\} \qquad (2)$$

The ATLAS has 1/2 height, 1/144 area, and 1/203.6 mass flow ratio compared with APR1400. Pressure losses were compared at a mass flow rate of 100 %, which are shown in Fig.2.

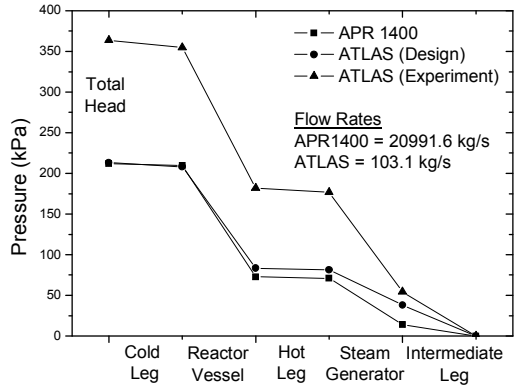


Figure 2. Pressure losses in the primary system

Calculated pressure losses and their relative ratios on APR1400, based on experimental data in the ATLAS primary system are summarized in Table 2. [3,4]

Overall pressure losses in the ATLAS were about 1.72 times higher than those in APR1400. Pressure losses in the reactor coolant system (RCS) loop pipes were approximately 3.67 times higher than those in APR1400, which can affect break flow rate during the accident simulation. Especially, pressure losses in the intermediate leg and the steam generator had 48.61 % of the overall pressure loss in total, which could affect various phenomena through reverse-heat-transfer through steam generators after a reactor trip.

The ATLAS was designed to match the pressure drop characteristics of APR1400, but additional pressure losses were measured in RCS loop pipes and steam generators from these tests. It seems that the additional pressure losses are caused by installed pressure lines and pluggings for measuring instruments such as pressure transmitters and thermocouples.

## 4. Conclusion

Pressure loss characteristics in the primary system of the ATLAS were evaluated with a mass flow rate of 20~80 % pump capacity in a non-heated condition at a pressure of 0.385 MPa. Pressure loss coefficients of each component of the primary system were detected and calculated. The ATLAS pressure loss data were compared with the designed pressure loss data of APR1400. The ATLAS had 1.72 times higher pressure loss at a primary system than APR 1400 due to the installed measuring devices. This could affect the break flow rate and the reverse-heat-transfer through the secondary system. The present data could be used to the revised steady-state input deck of the RELAP5/MOD3 for the ATLAS.

## REFERENCES

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[3] K. Y. Choi et al. MARS input data for 8% state calculation of the ATLAS, KAERI/TR-3046, 2005
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