# The Similarity Analysis of the ATLAS in Respect of a DVI-Line Break LOCA

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## 1. Introduction

A thermal-hydraulic integral effect test facility, ATLAS (Advanced Thermal-hydraulic Test Loop for Accident Simulation), is being constructed at the Korea Atomic Energy Research Institute (KAERI). The ATLAS is a 1/2-height and 1/288-volume scaled test facility based on the design features of the APR1400, an evolutionary pressurized water reactor developed by the Korean industry. [1] In this study, pre-test analysis of a direct vessel injection(DVI) line break accident is performed to understand the general behavior of the ATLAS and to assess the similarity between the test loop and the prototype reactor. The analysis is performed by using a best-estimate code, MARS[2] which was developed by KAERI, with the same control logics, transient scenarios and nodalization scheme for the two systems. The analysis result provides an insight into the unique design features of the ATLAS and will be used for developing the optimized experimental operation procedure and control logics.

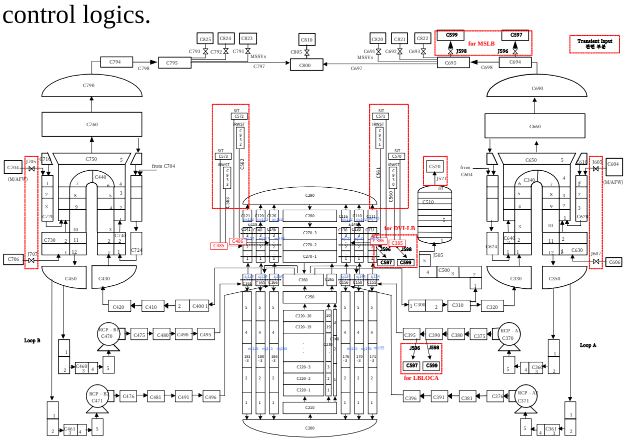

Figure 1 MARS-1D nodalization for the APR1400 and the ATLAS

## 2. Method for the Analysis

Two ATLAS models were considered in the analysis: (a) the scaled full power model and (b) the 8% scaled power model. The nodalization for both systems is identical except for a minor difference of the core bypass flow modeling. For the DVI line break assessment, the break line is assumed to be one of the available safety injection lines. Therefore, only one of the 4 HPSIs and 3 of the 4 SITs are assumed to be active for the transient based on a single failure assumption. The break area is set to be reduced according to the flow rate scale ratio, not to the global area scale ratio since the break flow would be choked.

Table 1 Comparison of the major design parameters at a steady state condition

| Design Parameter | APR1400 | APR1400 | ATLAS-Full | ATLAS |
|---|---|---|---|---|
| Case Description | Design | Calculated | Scaled Full Power | 8% of Scaled Full Power |
| Reactor Vessel | | | | |
| Normal Power, MWt | 3983 | 3983 | 19.56 (1/204) | 1.56(8.0% of 1/203.6) |
| Pressurizer P., MPa | 15.5 | 15.5 | 15.5 (1.0) | 15.5 (1.0) |
| Core Inlet .Temp., K | 564 | 564. | 564. (1.0) | 564 (1.0) |
| Core Outlet .Temp., K | 597 | 598. | 597. (1.0) | 597 (1.0) |
| Core Flow, kg/s | 20277 | 20279 | 100.1(1/202) | 8.2 (8.2% of 1/203.6) |
| Steam Generator | | | | |
| Number of SGs | 2 | 2 | 2 | 2 |
| Steam/Feedwater Flow Rate/SG (kg/s) | 1152.4 | 1152.2 | 5.54(1/208) | 0.444 (7.9% of 1/203.6) |
| Recirculation ratio | 3.82 | 3.82 | 3.90 | 15.0 |
| Steam Pressure(MPa) | 6.89 | 6.90 | 6.59 | 7.70 |
| .Steam Temp.(K) | 558. | 558. | 555. | 565 |
| Primary piping | | | | |
| Hot Leg Flow (kg/s) | 10496 | 10497 | 51.5(1/204) | 4.1 (8.0% of 1/203.6) |
| Hot Leg Temp.(K) | 597. | 597. | 597.(1.0) | 597 (1.0) |
| Cold Leg Temp.(K) | 564. | 564. | 564.(1.0) | 564 (1.0) |

## 3. Results of Similarity Analysis

Table 1 shows the design parameters and the calculated major design parameters of the APR1400, the ATLAS at a steady state. The results show that most of the thermal hydraulic parameters of the reactor system agree well with the calculated ones. Table 2 lists the major sequence of events observed during the present analysis. The thermal-hydraulic behavior in the ATLAS happens the square root two times faster than in the APR1400 according to the time scale ratio. Table 2 shows a good similarity between the APR1400 and the two ATLAS models in respect of the sequence of events.

For the scaled full power ATLAS model, the same power curve as the APR1400 is used. For the 8% power ATLAS model, the core power is controlled so that the integrated core power is the same as that shown in figure

2(a). Figure 2(b) shows the primary pressure variation. Although the two ATLAS models show a slight distortion in the primary pressure from the prototype, the similarity is very good between the ATLAS and the APR1400.

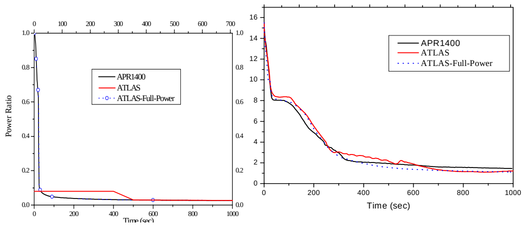

Figure 2. Calculation results – (a) core power, (b) pressurizer pressure

Table 2 Major sequence of events for DVI Line Break

| Event description | Time (sec), APR1400 (Time for ATLAS) | Time (sec) ATLAS (Scaled Full Power) | Time (sec), ATLAS (Scaled 8% Power) |
|---|---|---|---|
| DVI Break begins | 0.0 (0.0) | 0.0 | 0.0 |
| Reactor trips | 20.9 (14.8) | 10.4 | 15.5 |
| Turbine trip | 21.1 (14.9) | 10.5 | 15.6 |
| RCP trip | 21.4 (15.1) | 10.8 | 15.9 |
| MFIS signal | 31.4 (22.2) | 17.9 | 23.0 |
| SIP begins | 59.8 (42.0) | 37.9 | 43.0 |
| SIT begins | 239.2 (169.1) | 169.9 | 174.9 |

Both the ATLAS models over-estimate the break flow during the saturated blowdown phase in the meantime the break flows during the subcooled blowdown and the long term cooling phase are similar to that of the APR1400. This distortion during the saturated blowdown is due to an inertia effect in the downcomer. The APR1400 has a strong inertia directed at the lower downcomer at the earlier phase of the blowdown period, in the meantime, the ATLAS system has a low inertia in the downcomer to the nominal flow direction especially for the ATLAS 8% conditions. The safety injection flow is shown in Figure 3(b). The initiation time and the flow rate of the safety injection are well conserved in a scaled time domain.

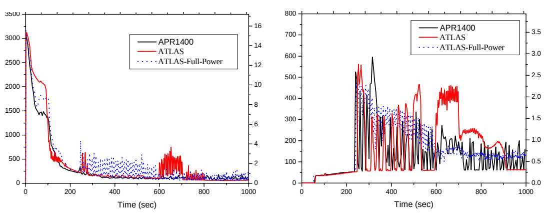

Figure 3. Calculation results – (a) break Flow (b) safety injection flow

The water levels in the core and the downcomer are shown in Figures 4(a) and (b), respectively. The lower minimum points of the two ATLAS models than the APR1400 are due to the high break flows of the two ATLAS models. The disagreement of the levels after that time is caused by the inherent characteristics of the reduced scale facilities: a larger wall stored energy and a reduced hydro-static head at the lower downcomer than the prototype system and a power logic of the 8% power condition.

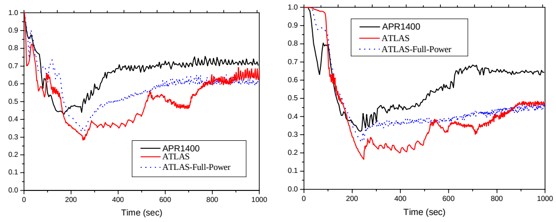

Figure 4. Calculation results – (a) core water level (b) downcomer water level

### 3. Conclusions

A DVI line break event has been analyzed with a best-estimate code, MARS, to assess a thermal-hydraulic similarity between the ATLAS and the prototype plant APR1400. Two ATLAS models were considered in the analysis: (a) the scaled full power model and (b) the 8% scaled power model. The present similarity analysis provides us with a good insight into the unique design features of the ATLAS facility. Further analyses are being performed to further reduce the distortion and to set up an optimized experimental procedure.

### Acknowledgement

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### REFERENCES

[1] W.P.Baek, "The KAERI Thermal Hydraulic Integral Effect Test Program for Advanced PWRs: Program Overview and the ATLAS Design", NTHAS4, Sapporo, Japan, 2004.

[2] J.J.Jeong et al., "Development of a Multi-Dimensional Thermal-Hydraulic System Code, MARS 1.3.1." Annals of Nuclear Energy. 26(18), pp.1611-1642, 1999