# Comparisons of MARS Code Analysis Results on DVI Line break LOCAs at Different Break Sizes between SNUF and the APR1400 for Sensitivity Studies

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## 1. Introduction

The APR1400(Advanced Power Reactor 1400MWe), a next generation nuclear reactor of Korea [1] , is an advanced PWR(Pressurized Water Reactor). APR1400 adopts a DVI (Direct Vessel Injection) system as the advanced feature of the ECCS(Emergency Core Cooling System). Therefore, the DVI system requires an additional safety analysis on the DVI line break LOCA(Loss-of-Coolant Accident) and the conventional analysis models should be estimated and modified for understanding of this accident [2].

Recently, ATLAS(Advanced Thermal-Hydraulic Test Loop for Accident Simulation), a thermal-hydraulic integral effect test facility for APR1400, was utilized to simulate the DVI line break accident [3]. Especially, a series of sensitivity tests on DVI line break sizes, 100%, 50% and 25% of the cross section of the DVI nozzle, were carried out with the ATLAS. However, the results of the sensitivity tests with ATLAS were not validated with any other counter-part tests. Thus, the SNUF(Seoul National Univ. Facility) will be utilized to perform the sensitivity test which is similar as the experiment performed with ATLAS for obtaining the valuable counter-part test data.

Since the SNUF is a RHRP(Reduced Height Reduced Pressure) test facility, the test conditions of the experiments should be determined with an appropriate scaling method for performing the SNUF experiment. Therefore, in this paper, the test conditions were determined according to the energy scaling method [4]. Also, the test conditions were estimated by the MARS code analysis, which contains comparisons between the prototype and the SNUF at the different break areas: 100%, 50% and 25% of the cross section of the DVI nozzle.

## 2. Determination of the Test Conditions

### *2.1 A Description of the SNUF*

The SNUF test facility which is a RHRP integral loop test facility is designed to simulate the APR1400. The geometric configurations of the SNUF are similar to that of the APR1400: reactor vessel, two loops, four DVI lines, and two steam generators, etc. The scaling factors of the primary system are 1/6.4 in length and 1/178 in area with respect to the prototype. The maximum operation power is 150 kW, and the maximum operation pressure is 0.8 MPa. The three intact DVI lines can supply the SI water into the upper downcomer. The one broken DVI line is connected to the discharge tank [2].

### *2.2 Test Conditions*

To determine the test conditions, it is necessary to obtain the transient results of the thermal-hydraulic phenomena in the prototype. Thus, the MARS code was utilized to analyze the DVI line break LOCA in SNUF and APR1400 at different DVI line break sizes.

For simulating the accident scenario reasonably in the SNUF, the energy scaling method [4], which is derived from the non-dimensional mass and energy conservation equations of the coolant in the primary system, was applied. The test conditions obtained from the energy scaling method for the SNUF experiment are listed in Tables 1 and 2.

Table 1. The Steady-State Conditions of APR1400 and SNUF

| Parameter | APR1400 | SNUF |
|---|---|---|
| Core Power | 4,063 MW | 108 kW |
| Primary System Pressure | 157 bar | 6.3 bar |
| Secondary System Pressure | 69 bar | 1.725 bar |
| Hot-leg Temperature | 324.53 $^oC$ | 145.51 $^oC$ |
| Cold-leg Temperature | 290.85 $^oC$ | 126.91 $^oC$ |
| Mass flow rate in the core | 10,496 kg/s | 0.673 kg/s |
| Mass flow rate in $2^{nd}$ system | 4,400 kg/s | 3.53 kg/s |

Table 2. The Transient Conditions of SNUF

| Parameter | 100 % | 50 % | 25 % |
|---|---|---|---|
| Core Power<br>0 ~ 100 s<br>100 ~ 300 s<br>300 ~ 1000 s | <br>71.4 kW<br>47.6 kW<br>37.4 kW | <br>72.7 kW<br>47.6 kW<br>37.5 kW | <br>73.1 kW<br>47.8 kW<br>37.6 kW |
| Break Size | 158 $mm^2$ | 78 $mm^2$ | 39 $mm^2$ |
| HPSI flow rate | 45.9 g/s | 40.3 g/s | 31.8 g/s |
| SIT flow rate | 28.0 g/s | 20.4 g/s | N/A |
| SIT temperature | 20.27 $^oC$ | 20.27 $^oC$ | 20.27 $^oC$ |

## 3. Analysis Result

According to the test conditions which were determined in the previous section, the MARS code analyses were carried out. And, the results were compared to the calculation results of the APR1400. In this paper, the primary system pressure and the core water level, which are the main parameters of the general LOCA, are discussed.

The pressures of primary systems with respect to time are depicted in Figures 1 through 3. The change rate of the primary system pressure of the SNUF shows good agreement in each type of the accidents during the transient with the results of the APR1400. It means that the mass and energy of the primary system are conserved well with the energy scaling method. On initiation of the break, a sudden pressure drop is occurred in the primary system due to an abrupt loss of the coolant through the broken DVI nozzle. After the sudden pressure drop, the primary system pressure stays at a plateau region for about: 50 s in the 100% break accident, 100 s the 50 % break accident, and 400 s the 25% break accident.

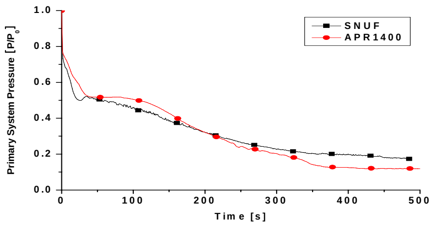


Figure 1. Primary System Pressure of 100% Break Accident

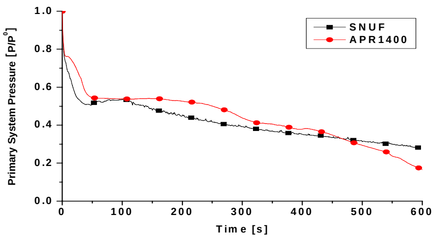


Figure 2. Primary System Pressure of 50% Break Accident

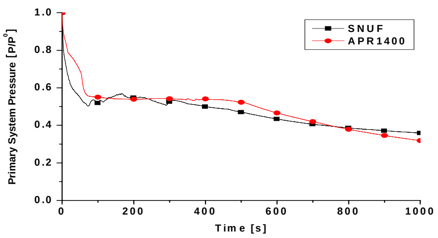


Figure 3. Primary System Pressure of 25% Break Accident

As shown in Figures 4 to 6, after the break, the core water level decreases rapidly. In the accident with larger DVI break size, the core water level decreases more rapidly in both the SNUF and the APR1400. However, the trends of the core water level between the SNUF and the APR1400 does not agree well with each other. Moreover, the analysis results of the 25% break accident of SNUF show lower core water level than that of the 100% DVI line break accident, whereas the results of the APR1400 present the opposite trends.

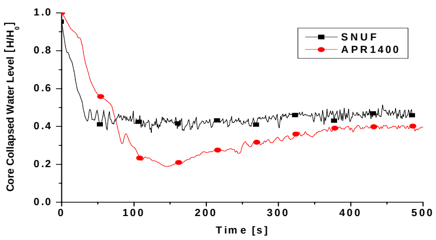


Figure 4. Core Water Level of 100 % Break Accident

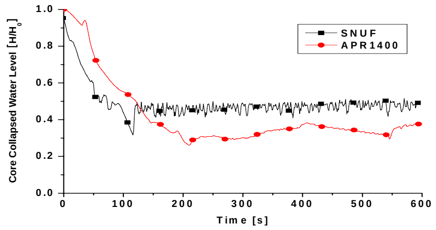


Figure 5. Core Water Level of 50% Break Accident

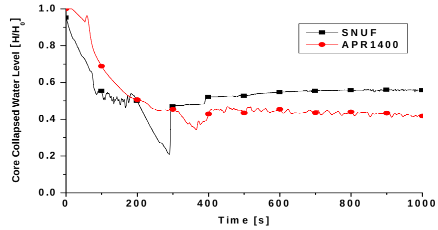


Figure 6. Core Water Level of 25% Break Accident

## 4. Conclusion

In order to study the sensitivity to the break sizes in DVI line break LOCA, the test conditions in the SNUF have been determined according to the energy scaling method. The analysis of MARS code shows that the scaling procedure and conditions are reasonable for predicting the behavior of the prototype from the standpoint of the mass and energy conservation of the primary system. However, the core water level, which is directly related to the core exposure, shows different trends between the SNUF and the APR1400. As to the deviation of the core water level, the detail analysis will be performed with the comparison of the experimental results between the SNUF and ATLAS after conducting the SNUF test. Also, the results of the SNUF test will be valuable as the counter-part test data of the ATLAS facility.

## REFERENCES

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