# Preliminary Analysis of SBLOCA with Loss of Safety Injection Pump for ATLAS facility using MARS-KS

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## 1. Introduction

According to the IAEA report [1], the additional DECs(Design Extension Conditions) have been derived from PSA. LOCA plus loss of one emergency core cooling system is one of those DECs. This accident scenario was chosen as the test item of the DSP-06 exercise by considering the current issue related to the CRDM(control rod drive mechanism) penetration nozzle with regard to micro cracks in welds.

In the present paper, as the first step of DSP-06, the blind phase analysis has been carried out by simulating the small break loss of coolant accident (SBLOCA) with loss of safety injection pump for the ATLAS Test facility [2]. In the blind analysis, the MARS-KS code has been used and only the initial and boundary conditions of the experiment were provided to the participants. All the analysis results were normalized by an arbitrary value for the confidential problem.

## 2. Analysis Methodology

The MARS-KS V1.4 code has been used to model the ATLAS Test facility for the analysis of the Multiple Failure Accident, especially SBLOCA with loss of safety injection pump.

### *2.1 ATLAS Test facility*

ATLAS is a thermal-hydraulic integral effect test facility, which has been constructed at KAERI. It is a 1/2 height and 1/288 volume scaled test facility with respect to APR1400 [2]. Thus, ATLAS can simulate full pressure and temperature conditions of APR1400.

### *2.2 Modeling of the ATLAS test facility*

Fig. 1 presents the node structure of ATLAS test facility. The break size was determined to be the area corresponding to the two CRDM penetration nozzles located at the upper plenum of the RPV, shown in Fig. 2. The two atmospheric dump valves were installed on the secondary system of steam generator. The safety injection system consists of only four SITs excluding the safety injection pumps. In order to deliver the coolant into both steam generators after the core trip, two auxiliary feedwater system has been added.

In the present analysis, it is assumed for the sake of convenience that the heat generated from the core does not escape to the ambient air. In other words, there is no heat loss at the ATLAS test facility.

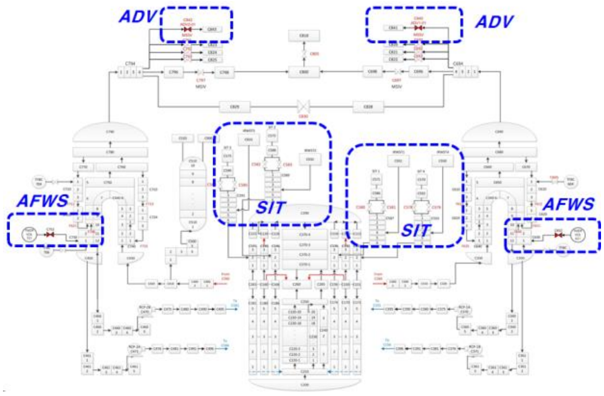


Fig. 1. Node structure for modeling of the ATLAS facility

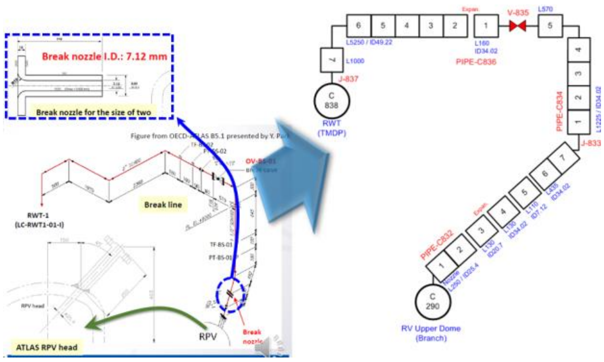


Fig. 2. Node structure for modeling of the CRDM penetration rupture

## 3. Analysis Results

### *3.1 Sequence of Event*

The sequence of major events was summarized in Table I.

Table I: Sequence of events

| Description | Time (s) | Remark (Set point) |
|---|---|---|
| Rupture | 10 | V-835 Open |
| LPP Trip | 76 | 10.72 MPa |
| MSIS | 80 | LPP + 3.54s |
| MFIS | 83 | LPP + 7.07s |
| Power decay | 88 | LPP + 12s |

| | | |
|---|---|---|
| ADV open | 1550 | PCT over 350$^{o}$C |
| SIT injection | 1590 | 4.03 MPa |
| AFW injection | 1648/1633 | SG level < 2.78 m |

### *3.2 Depressurization after the break*

Fig. 3 and 4 show the system pressures and the break flow rate, respectively. As presented in Table I, the reactor trip occurs at 76 seconds due to low pressurizer pressure signal. The pressurizer pressure decreases rapidly after break of the CRDM penetration nozzle. The break flow rate decreases rapidly at the beginning, but maintains a somewhat constant flow rate, similar to the primary system pressure behavior.

After a certain time period, it was confirmed that the pressurizer pressure decreased to a lower value than the secondary side system pressure.

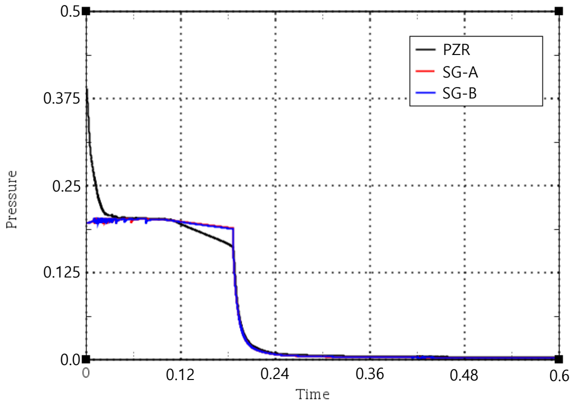


Fig. 3. Pressure behavior after the break in the primary and secondary systems

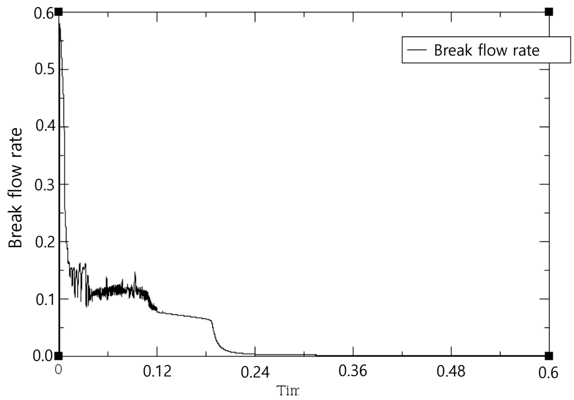


Fig. 4. Variation of the break flow rate.

### *3.3 Cooling operation by opening the ADVs*

When the core water level becomes sufficiently low, the core is exposed to the steam environment. Accordingly, the cladding surface temperature rises sharply. In this analysis, when the surface temperature rises above 350 degrees Celsius, the operator takes action to open the ADV to remove the decay heat through the steam generator.

Since it was confirmed that the ADV was opened about 1500 seconds after the reactor trip, it can be seen that the grace time is about 25 minutes. As shown in Figs. 5 and 6, it was found that the opening of ADVs was very effective in depressurization and heat removal through a steam generator

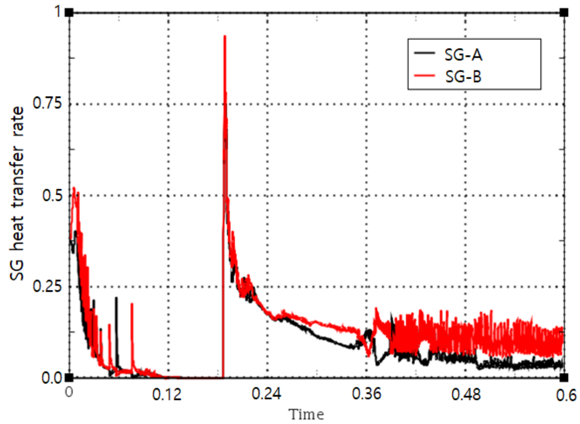


Fig. 5. Variation of heat transfer rate through U-tubes of SGs

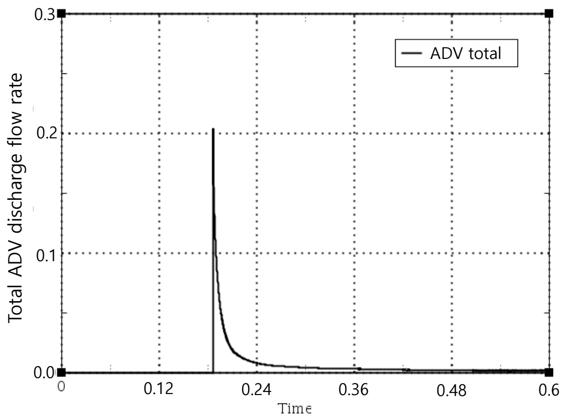


Fig. 6. Total discharge flow rate through ADVs

But, as presented in Table I, the auxiliary feed water system was actuated at only 90 seconds after the ADV opening. This means that even though the ADV opening is very efficient for depressurization and heat removal, the reduction in the steam generator water level proceeds very quickly.

Although the water level of the steam generators decreases rapidly, it was confirmed through the calculation that the water level could be restored due to sufficient supply of cooling water through the auxiliary feed water system.

## 4. Conclusions

As the first step of DSP-06, the blind phase analysis has been carried out by analyzing SBLOCA + loss of

SIP for the ATLAS Test facility. Major outcomes can be summarized as follows:

- the grace period up to operator’s action : ~ 1500 seconds
- ADV opening results in rapid reduction in SG water level and depressurization of both the primary and the secondary sides
- SG water level could be restored due to sufficient supply of cooling water through AFWS

## REFERENCES

[1] IAEA, Considerations on the application of the IAEA safety requirements for the design of nuclear power plant, IAEA-TECDOC-1791, Vienna, 2016
[2] J.B. Lee et al., Description Report of ATLAS facility and instrumentation (third revision), KAERI/TR-8106/2020, Korea Atomic Energy Research Institute, 2020