# Study on MELCOR Modeling for Emergency External Water Injection Scenario of SBO in APR1400

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## 1. Introduction

During a prolonged station blackout accident, the emergency cooling water could play an important role in core cooling. Based on this concept, the injection flow paths for the emergency cooling water from the external water source are being installed for the domestic NPPs.

In the present study, a MELCOR model for APR1400 was developed and applied to analyze a SBO scenario selected to confirm the effectiveness of the means[1]. In this analysis, the primary and secondary emergency cooling water injection were considered. Leakage from the Reactor Coolant Pump (RCP) seal and opening of the Atmosphere Dump Valve (ADV) were modeled as well to simulate the external pump injection strategy.

## 2. Analysis Methods

In order to develop the MELCOR modeling for the primary and secondary emergency cooling water injection, the nodalizations for the Reactor Coolant System (RCS) and the steam generator secondary side were established as shown in Fig.1 and Fig.2, respectively.

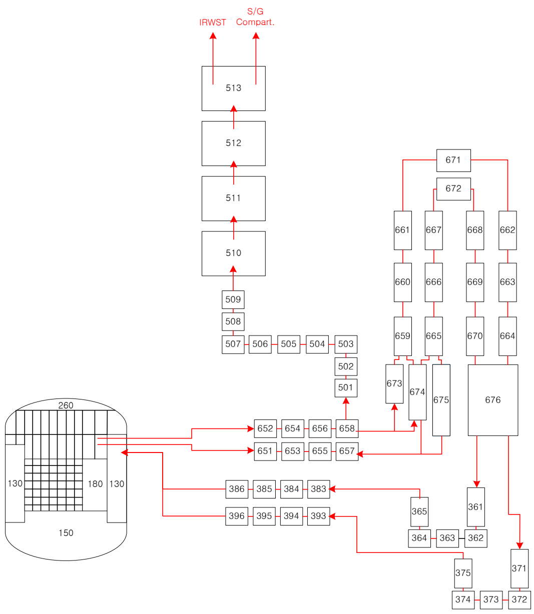


Figure 1. Nodalization of Primary Cooling System

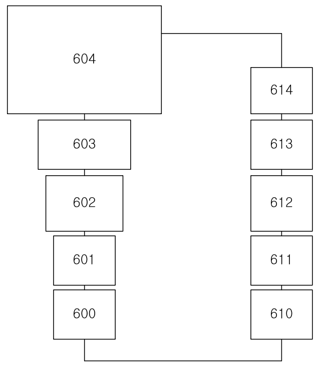


Figure 2. Nodalization of Steam Generator Secondary Side

### *2.1 Modeling of External Injection to RCS*

The external injection to the RCS is possible when the RCS pressure reaches below 1.47 MPa, the cut-off pressure for a fire engine water pump, according to the pump performance curve. The injection flow path is connected to the downcomer(CV130 in the MELCOR model) in the reactor vessel as shown in Fig.3.

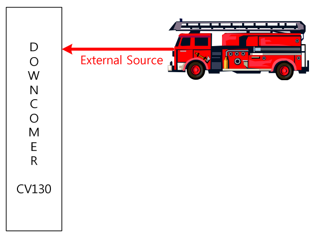


Figure 3. Illustration of External Injection to RCS

### *2.2 Modeling of External Injection to SG Secondary Side*

The external injection to the steam generator secondary is possible when the S/G secondary pressure reaches below the pump cut-off pressure. The injection flow path is connected to the downcomer(CV610) in the steam generator as shown in Fig.4.

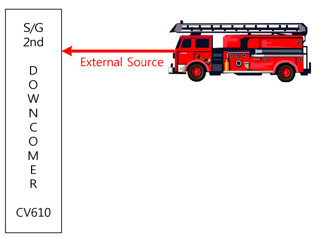


Figure 4. Illustration of External Injection to SG

### *2.3 Scenario Sequence*

A SBO sequence was considered as shown in Table 1. The RCP seal leakage was assumed to occur at 900 seconds after the reactor trip.

Table 1. Accident Sequence for Analysis

| Time (sec) | Event |
|---|---|
| 0.0 | - Reactor trip<br>- Stop to supply MFW<br>- Start to supply TDAFW (34kg/s) |
| 900.0 | - RCP seal leakage (21gpm)[3] |
| 28800.0 | - Stop to supply TDAFW |
| 30600.0 | - ADV manual open |
| Set Point :<br>1st Pressure < 15 $kg/cm^2$ | - Injection into the primary system |
| Set Point :<br>2nd Pressure < 15 $kg/cm^2$ | - Injection into the secondary system |

## 3. Analysis Results

Figure 5 shows the time-history pressure curve of the primary and secondary systems. The ADV open after the stop of auxiliary feedwater supply sharply dropped the secondary pressure to the setpoint of the emergency pump injection at 9.1 hr. After this injection to the primary system was started at about 19.2 hr. Both of the primary system pressure and the S/G secondary pressure were kept to be depressurized.

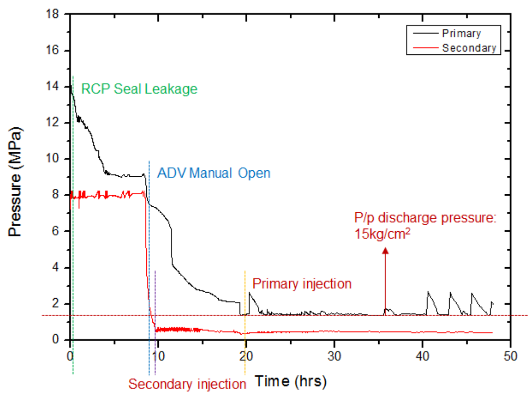


Figure 5. pressure curve of the primary and secondary systems

Figures 6 and 7 show the injection flow rates into the primary and secondary system, respectively. The oscillatory injection flow took place, following the pump performance curve.

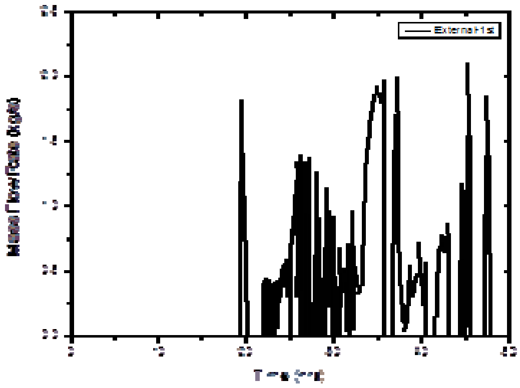

Figure 6. Injection flow rate into the primary system

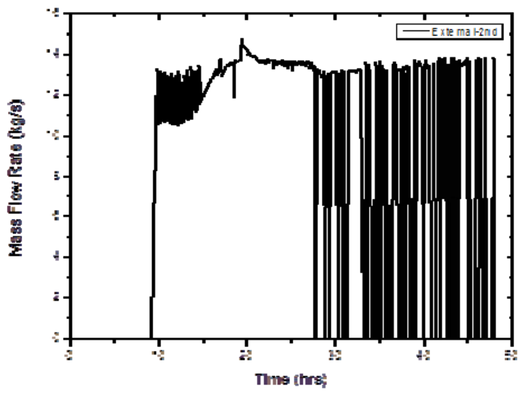


Figure 7. Injection flow rate into the secondary system

The collapsed water levels in the secondary side of the steam generator A and B were shown in Fig.8. When one ADV connected to the steam generator A was opened at 8 hrs, its water level was dramatically decreased. Then, the level was recovered by the injection into the secondary system.

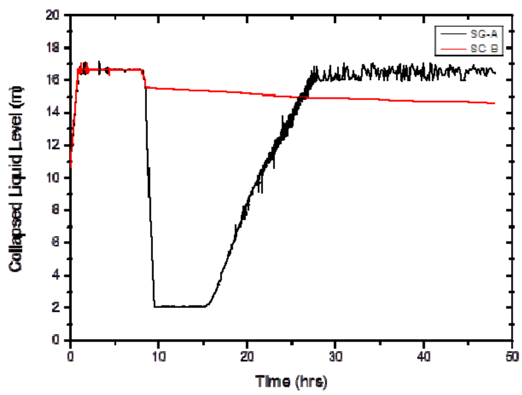


Figure 8. Collapsed Water Level in SG Secondary Side

The reactor core was sufficiently cooled down by means of the external water source as shown in Fig.9.

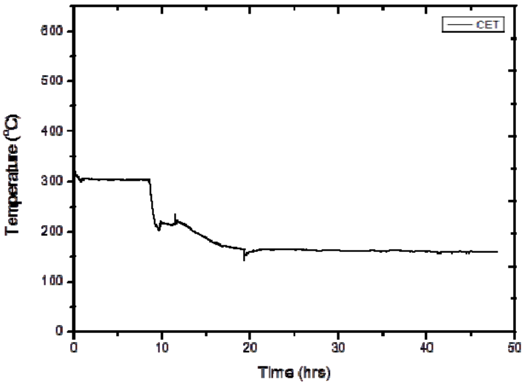


Figure 9. Core Exit Temperature

## 4. Conclusions

In this study, the analysis results showed that the external injection strategy with an ADV manual opening could successfully cool down the reactor for a station blackout accident through its effective implementation. It was found that the RCP seal leakage rate is a sensitive parameter for depressurization of the RCS. In this regard, further study is needed to develop a realistic RCP seal leakage model, referring to detailed technical data.

## REFERENCES

[1] Han-Chul Kim et al., Modeling of Station Blackout Accident for APR1400 with Recent MELCOR Versions, Transactions of the Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, October 24-25, 2013.
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[4] MELCOR Computer Code Manuals, Primer and Users' Guide, Version 1.8.6