

## Analysis of LOAF(Loss of All Feed Water) Accident using OPR1000 Simulator

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### 1. Introduction

Recently, a ferocious tsunami unleashed by Japan's biggest recorded earthquake slammed into its eastern coast, killing hundreds of people as it carried away ships, cars and homes, and triggered widespread fires that burned out of control. In the meantime, it damaged Fukushima nuclear power plants and it seems that radiation containing hydrochloric acid, potassium cyanide and other harmful chemicals has been released. People are concerned even if residual radiation levels are not high because Korea might be vulnerable to the spread of radiation from Japan.

In this paper, LOAF(Loss Of All Feed Water) accident will be covered to provide information on cause and effect of measures against LOAF accident using OPR1000 simulator, which is using for training operators of ShinKori-Unit 1&2 and ShinWolsung-Unit 1&2. OPR1000 simulator adopted RELAP5 R/T code for the modeling of NSSS (Nuclear Steam Supply System) TH (Thermal-Hydraulics) and Reactor Core, and selected 3KEYMASTER™, a commercial plant simulation tool for NSSS auxiliary systems modeling, BOP(Balance of Plant) modeling and simulator environment.

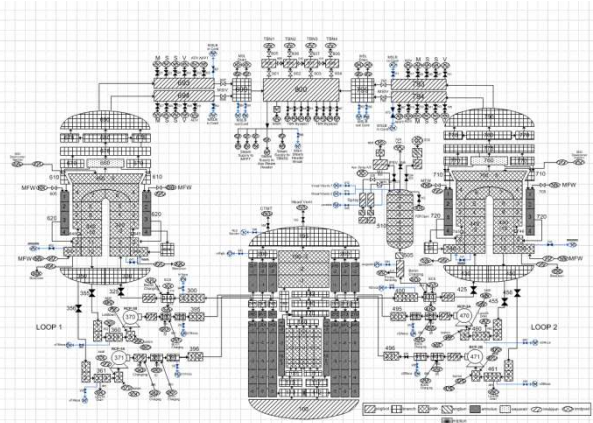


Fig. 1. RELAP5 R/T Nodalization for OPR1000

### 2. Loss of All Feed Water

In this section, several reasons and characteristics of LOAF accident.

#### 2.1 Causes of LOAF accident

Loss of All Feed water(LOAF) is an accident that steam generator cannot be provided with both of main

feed water and auxiliary feed water. Several reasons for the LOAF are as follows;

- Loss of All Main Feed Water and Auxiliary Feed Water Pumps
- Isolation of the Control Valves for Main Feed Water
- Isolation or clogging of pipes for Main Feed Water
- Rupture of pipes for Main Feed Water.

#### 2.2 Characteristics of LOAF accident

Several phenomena of variables which can be detected in MCR(Main Control Room) represent LOAF accident as follows;

- Decrease of Steam Generator Level
- Increase of Steam Generator Pressure before Reactor Trip, and Decrease and stability of Steam Generator Pressure after Reactor Trip
- Increase of Pressurizer Pressure and Level before Reactor Trip, and Decrease and stability of Pressurizer Pressure and Level after Reactor Trip
- Reactor Trip by Steam Generator Level Low Signal
- Actuation Signal for Auxiliary Feed Water by Steam Generator Level Low Signal
- Turbine/Generator Shutdown
- Main Feed Water Stop Alert by Low flowrate/Low suction pressure of Main Feed Water Pump

#### 2.3 Effects of LOAF accident

LOAF accident affects safety functions such as RCS(Reactor Coolant System) heat removal. SG(Steam generator) levels decrease when all feed waters to be provided get lost. RCS temperature starts to increase when the SG level shrinks under u-tubes because heat transfer from primary system to secondary system through steam generator. SG level decrease rate and RCS temperature increase rate are the function of Reactor Power, and the SG level decrease rate depends on feed water loss rate. Turbine and Reactor Trips happen when SG level decrease below Reactor Trip set point. Reactor shuts down within from 15 to 45 seconds after complete feed water loss at high Reactor power. SG pressure maintains at hot temperature zero power set point by main steam bypass system.

### 3. Results of LOAF accident

In this section, several results of LOAF accident are analyzed.

### 3.1 Reactor Power at LOAF accident

Reactor trip occurs when one or more SG levels drop below a set point for it. Turbine generator also stops. Reactor can be stopped manually if an operator can judge complete feed water loss before the reactor trip. Fig. 2 shows that Reactor power drops at LOAF accident.

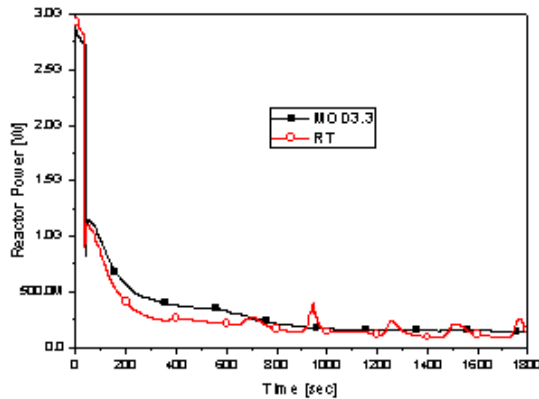


Fig. 2. Reactor Power at LOAF accident

### 3.2 Steam Generator Level at LOAF accident

Steam Generator Level is one of the most important factors representing plant status. After LOAF accident, SG levels decrease due to feed water loss. U-tubes get uncovered and SG runs out of its inventory finally if steam emission maintains without feed water insertion. Fig. 3. shows SG level(Wide Range) trend after LOAF accident.

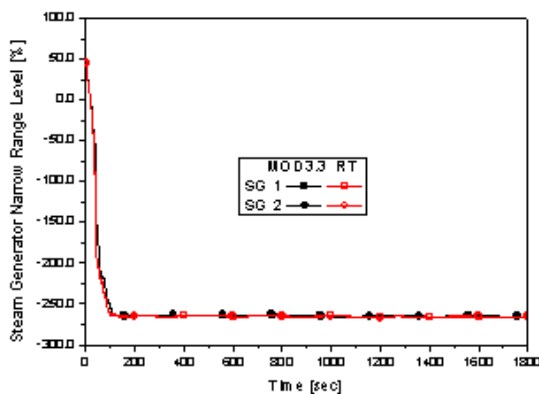


Fig. 3. Steam Generator Level at LOAF accident

### 3.3 RCS flowrate at LOAF accident

RCS flowrate can be measured by flowrate passing through RCP(Reactor Coolant Pump). RCS flowrate decreases dramatically because RCS heat transfer area reduces due to SG level depletion RCS temperature and

Pressurize pressure increase rapidly when u-tubes get uncovered due to exhaustion of SG inventory through boiling. Fig. 4. Shows RCP flow rates at LOAF accident

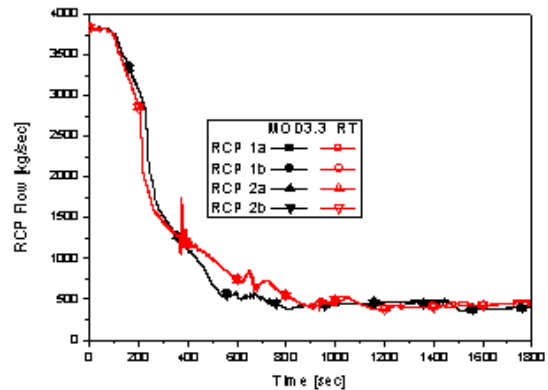


Fig. 4. RCP flowrate at LOAF accident.

## 3. Conclusions

Several phenomena at LOAF accident have been analyzed using OPR 1000. It is the first step that an operator judges feed water loss as soon as possible. Then, an operator should stop all RCP pumps for preserving SG inventory. The maintenance of the SG inventory is one of the most important strategies to minimize damages due to LOAF accident. In case that it is impossible to maintain the SG inventory, a series of measures should be taken for recovering feed water provision to SG. First, motor driven Auxiliary Feed Water Pump can be considered. If it is not possible, Turbine/Diesel driven Auxiliary Pump can be used because it can work out without power supply system

LOAF is an accident that RCS loses the capability of heat removal. Decay heat in reactor can be removed by natural circulation cooling only.

## REFERENCES

- [1] D. H. Hwang, M. S. Lee, J. H. Hong, S. J. Byon, "Improvement of Steam Generator Level Difference in OPR1000 Simulator, Transactions of the Korean Nuclear Society Autumn Meeting, Jeju, Korea, Oct. 21-22, 2010.
- [2] D. H. Hwang, M. S. Lee, J. H. Hong, S. H. Lee, J. K. Suh, "NSSS-BOP Integration of OPR1000 Simulator, Transactions of the Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, Oct. 28-29, 2009.