

## Development of an Abnormal Response Procedure for the Shutdown LOCA for Kori Unit 1

Jong Beom Lee and Jong Woon Park

*Nuclear Engineering and Technology Institute, KHNP, 25-1 Jang-dong, Yuseong-gu, Daejeon, 305-343, Korea*

Goen Han Lee

*Kori Nuclear Power Site, KHNP, 216 Kori, Jangan-eup, Gijang-gun, Busan, 619-711, Korea*

### 1. Introduction

USNRC issued Information Notice 95-03, "Loss of Reactor Coolant Inventory and Potential Loss of Emergency Mitigation Functions While in a Shutdown Condition," on January 12, 1995, to alert addressees to an incident at the Wolf Creek plant involving the loss of reactor coolant inventory while the reactor was in a hot shutdown condition. And through the Generic Letter 98-02, USNRC requested utilities assess the susceptibility of RHR and ECCS to common-cause failure as a result of RCS draindown while in a shutdown condition and submit certain information concerning the suitability of surveillance, maintenance, modification and operating practices and procedures.

Performing the Periodic Safety Review for Kori Unit 1, KHNP found that the plant lacked a proper operational procedure in case of LOCA during Mode 3 and Mode 4 operation and made it as one of its safety improvement items to develop the operational procedure for the LOCA during Mode 3 and Mode 4.

Several analyses were performed to develop the procedure in accordance with the WOG's guideline. And the resultant procedure has been applied to the Kori Unit 1 as an abnormal response procedure for the shutdown LOCA.

### 2. Requirements of the Shutdown LOCA

There are no domestic requirements for the LOCA while the plant is in shutdown conditions. But the regulatory body requested that the shutdown LOCA analysis should be performed while reviewing the technical specifications for Ulchin Units 5&6 and the ISTS for Yonggwang Units 1&2.

Similarly, there are no specific requirements in the USA for the shutdown LOCA. But, through the Generic Letter 88-17, USNRC requested several actions to address loss of decay heat removal events that occurred while reactors were in a shutdown condition. And through the Generic Letter 98-02, USNRC requested utilities assess the susceptibility of RHR and ECCS to common-cause failure as a result of RCS draindown while in a shutdown condition and submit certain information concerning the suitability of surveillance, maintenance, modification and operating practices and procedures.

In response to the requests of the USNRC, WOG performed a generic shutdown LOCA analysis. They demonstrated the adequacy of the present Westinghouse

ECCS design for a LOCA during shutdown conditions[1]. Also they published a guideline for an operational procedure for the shutdown LOCA[2] and suggested to their members that they should apply the guideline to their plants.

### 3. Evaluation of the Shutdown LOCA

The evaluations have been performed in two steps. The first step is to confirm that establishing safety injection from one high head SI pump within 10 minutes and flow from a second high head SI pump within 30 minutes will successfully mitigate a small break LOCA (less than six inches in diameter). According to the evaluation summarized in Table 1, the ECCS of Kori Unit 1 is adequate to prevent excessive peak cladding temperatures (the limiting peak cladding temperature was 1676.3F).

**Table 1** SB LOCA Analysis with RHR Pumps

Time Sequence of Events	
Event	Time(sec)
Reactor Trip	-7200
Break Occurs	0
Pressurizer Empties	9
Hot Leg Subcooling Lost	17
Top of Core Uncovered	272
Operator Initiates SI	627
Peak Clad Temperature Occurs (Peak Clad Temperature, F)	818 (1676.3F)
Core Recovered	1156

**Table 2** Transient Cases for Small Break LOCA

Case	Mode	Break Size (inch)	Break Location
M4-1C	4	1	CL
M4-1H	4	1	HL
M4-3C	4	3	CL
M4-3C-NL	4	3	CL
M3-1H	3	1	HL
PSO-M4	4	2.13	Stuck Open PZR PORV
PTS-M4-1H	4	1	HL

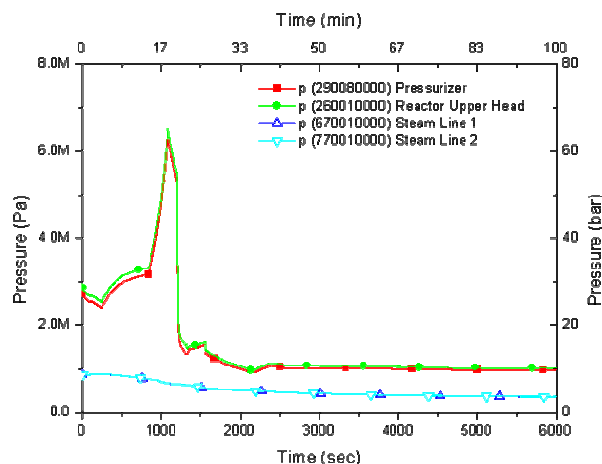
The second step is to verify the effectiveness of the operator actions specified in the abnormal response procedure. The procedure is applicable during both

Mode 3 following the isolation of the accumulators and Mode 4. Therefore, analyses were performed using both plant configurations.

Seven test transients, as shown in Table 2, were run to determine if the procedure provides appropriate guidance for recovering from a LOCA in Mode 3 or Mode 4 operation.

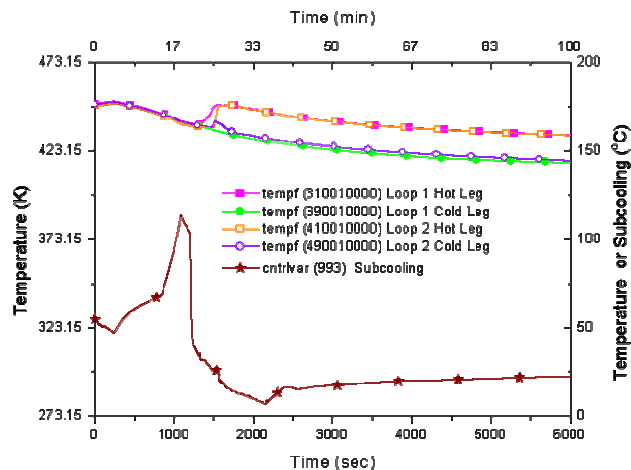
**Table 3** Time Table of Events [case : M4-1H]

Time Sequence of Events	
Event	Time(sec)
1" LOCA in Hot Leg	0
Isolate Letdown Line	56
Start One High Head SI	236
Isolate Break	836
RCS Cooldown using SG PORVs	956
Turn off PZR Heaters	1016
Stop HHSI Pump	1076
Depressurize using PZR Spray	1196~1316
Stop RCPs on Low RCS Pressure	1316
Depressurize using PZR PORV	1556~2156
Continue RCS Cooldown using RHR System	2456
End of Analysis	6000

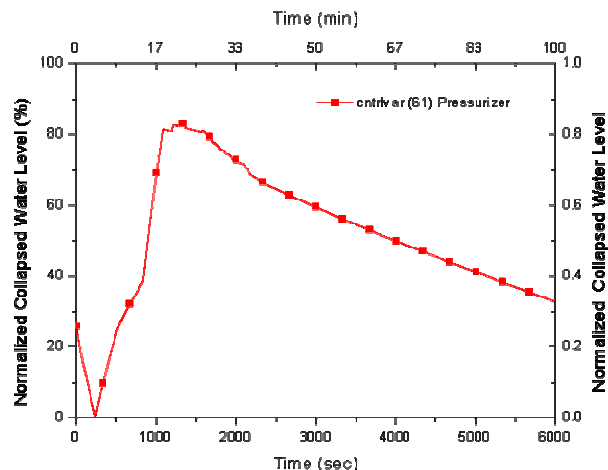


**Fig. 1** RCS and SG Pressure [case : M4-1H]

The transient analyses were run with RELAP5/MOD3. The analyses show that the final plant configuration for all of the transients presents stable RCS pressure and pressurizer level and temperatures trending toward cold shutdown conditions. Sample results for one of the cases, M4-1H, are shown in Table 3 and Fig. 1 through Fig. 3.



**Fig. 2** RCS Temperature and Subcooling [case : M4-1H]



**Fig. 3** Pressurizer Level [case : M4-1H]

#### 4. Conclusions and Discussions

There are two purposes of this work. One is to ensure that the ECCS of Kori Unit 1 is adequate to prevent excessive peak cladding temperatures. The other is to confirm that the actions taken by the operator as directed by the procedure are efficient and appropriate. The peak clad temperature is within the limits of 10CFR50.46. The final plant configuration for all of the transients is stable and trends toward cold shutdown conditions. Therefore the abnormal response procedure for Kori Unit 1 provides appropriate guidance for a LOCA during Mode 3 or Mode 4 operation.

#### REFERENCES

- [1] WCAP-12476, Rev.1, Evaluation of LOCA during Mode 3 and Mode 4 Operation for Westinghouse NSSS, Westinghouse Electric Corporation, Nov., 2000.
- [2] ARG-2, Background Information for WOG Abnormal Response Guideline, WOG, Feb., 1992