Operator Strategy for Cold Overpressure Mitigation during SBLOCA for Kori Units 3 & 4 and Ygn Units 1&2.

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1. Introduction

This paper performed analysis to develop the operator response guideline when a primary small bore loss of coolant accident (SBLOCA) in shutdown operation occurs. Break is isolated early since operator recognizes that drain line is opened inadvertently. However, safety injection continues during a fifteen minute since operator action is taken inadequately. Reactor coolant system (RCS) experiences a cold overpressure. A cold overpressure mitigation system (COMS) is actuated normally. On this paper, operator response guideline for the phenomena has been developed based on best-estimate analyses for Kori Units 3&4 and Ygn Units 1&2 power uprate.

2. Analysis Methodology

In order to determine the operator strategy of cold overpressure mitigation for the SBLOCA, the small pipe break (1 inch) in cold leg was selected as a limit case to cover the SBLOCAs during Mode 3 operation after accumulators are isolated. It is because a small break will pressurize more severely the core than the large pipe break due to the lower break flow. Therefore, the operator would have more time to take actions for the larger breaks.

Table 1. Major Parameter before/after Power Uprate

Parameters	Before Power Uprate	After Power Uprate
NSSS Power(MWt)	2787	2912
Thermal Design Flow, m3/sec	6.03	5.94
RCS Avg. Temperature, °C	311.4	310.7
SG Steam Pressure, MPa	6.65	6.33
SG Steam Temperature, °C	282.2	279.1
Steam/Feedwater Flow, 10^3 kg/sec	7.92	8.28
Steam Dump Capacity, %	70.0	59.1

3. Analysis Scenario

Transient results are shown in Figures 1 through 4. As a result of the LOCA, both pressurizer level and RCS pressure begin to decrease. Since pressurizer level is known to fluctuate while the plant is in a shutdown process, no operator actions are performed until the letdown isolation setpoint is reached. When pressurizer level falls below the letdown isolation setpoint, operator action is initiated and charging flow is adjusted to its maximum flowrate to provide RCS makeup. After three minutes, pressurizer level is still decreasing and one charging pump is realigned through the BIT.

Pressurizer level and subcooling are monitored for thirty seconds to determine if SI flow would provide adequate RCS makeup. The single charging/SI pump is adequate and the recovery continues. Pressurizer level and subcooling are monitored to determine if SI flow is required five minutes later. Both indications are satisfactory and SI flow is not required.

The break is isolated at five minutes after identifying that SI flow is not required. RCS pressure and pressurizer level begin to rise immediately due to the makeup flow from the SI pump.

As expected, the RCS pressure ranges below 45 kg/cm^2. Charging flow corresponding to normal charging/SI pump miniflow is initiated at 24 minutes after the break is isolated.

The RCS cooldown is continued using the RHR System over five minutes following the depressurization. Charging flow is decreased to prevent any further increase in pressurizer level. At this point the plant stabilizes, both pressurizer level and RCS pressure are constant and a cooldown of the RCS is in progress.

4. Analysis Results

In this analysis, the break is isolated at 6 minutes, the COMS opens at 23 minutes and the SI is terminated at 30 minutes initiating normal charging flow, as shown in Figure 2. It shows that it takes 17 minutes to reach at the set pressure required to open the COMS after break isolation. Therefore, the operator should terminate HPSI within 17 minutes to prevent the inadvertent opening of the COMS by administering a safety injection.

In the respect of the safe plant operation, in order to terminate the SI flow before the start of COMS open during the SBLOCA cooldown phase, we determined the operator SI termination time as the 15 minutes after an operator isolated a break pipe of the SBLOCA.

Also, these analyses results showed that the temperature and pressure curves after these SBLOCAs had a sufficient margin from the technical specification limit curve to prevent the cold overpressure for the case that the criterion of operator action time should had been observed, as shown in Figure 5.

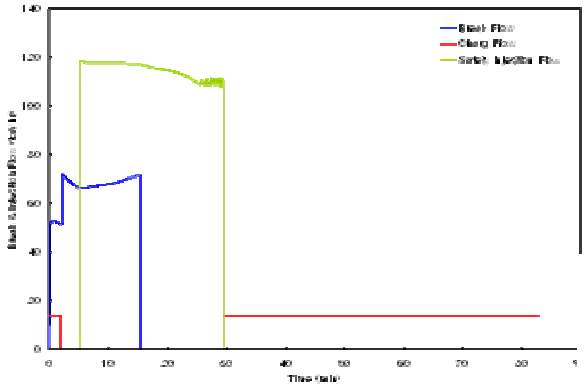

Figure 1. Break Flow, Charging Flow and Safety Injection Flow in SBLOCA

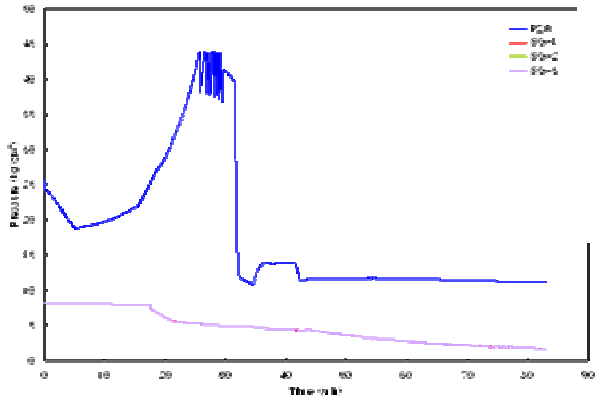

Figure 2. Pressurizer and Steam Generators Pressure in SBLOCA

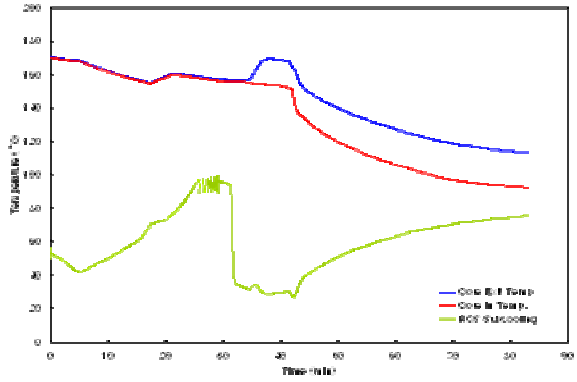

Figure 3. Core Exit Temperature and RCS Subcooling in SBLOCA

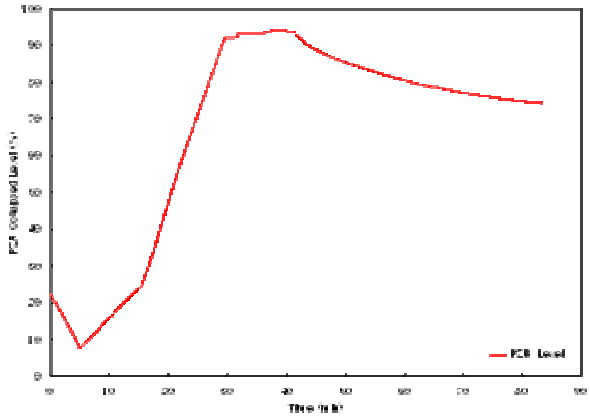

Figure 4. RCS Collapsed Level in SBLOCA

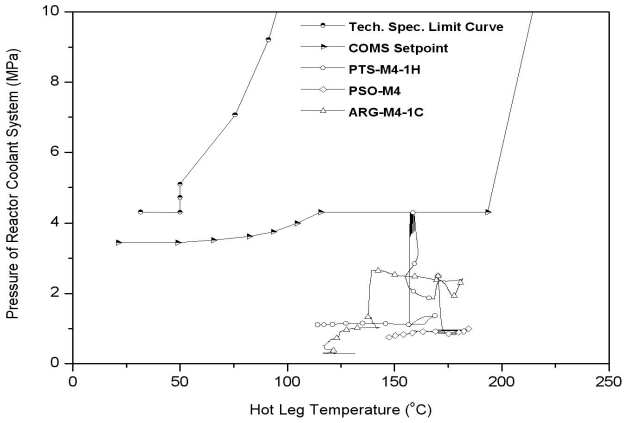

Figure 5. Pressure and Temperature Relationship in SBLOCA

5. Conclusions

In conclusion, this analysis showed that the operator guideline could be used successfully to cool down and depressurize the RCS without cold overpressurization following a SBLOCA.

We drew a conclusion that a safety injection should be terminated within 15 minutes in order to prevent the cold overpressure after the break isolation during shutdown SBLOC.

REFERENCES

[1] J. S. Ivey et al., Evaluation of LOCA During Mode 3 and Mode 4 Operations for Westinghouse NSSS. WCAP 12476, November 1991.

[2] USNRC, Shutdown and Low-power Operations at Commercial Nuclear Power Plants in the United States, NUREG-1449, September 1993.

[3] ANS, Time Response Design Criteria for Safety-related Operator Actions, ANSI/ANS-58.8-1994.