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# Determination of Optimum Pressurizer Level for Kori Unit 1

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## Abstract

To determine the optimum pressurizer water level during normal operation for Kori unit 1, performance and safety analysis are performed. The methodology is developed by evaluating "decrease in secondary heat removal" events such as Loss of Normal Feedwater accident. To demonstrate optimum pressurizer level setpoint, RETRAN-03 code is used for performance analysis. Analysis results of RETRAN following reactor trip are compared with the actual plant data to justify RETRAN code modelling. The results of performance and safety analyses show that the newly established level setpoints not only improve the performance of pressurizer during transient including reactor trip but also meet the design bases of the pressurizer volume and pressure.

## 1. Introduction

According to the Kori unit 1 final safety analysis report (FSAR), the pressurizer volume is occupied by approximately 60% of water and 40% by steam during steady state operation. However, actual water level is 47.62% at full power which is lower about 10% lower than those of other Westinghouse plants in Korea. As the result of low water level, the pressurizer water volume decreases below the low level interlock (18.3%) following reactor trip due to shrink of liquid. Consequently, the letdown isolation occurs if operator does not manually increase charging flow. The letdown isolation causes some operational problems including possible thermal shock on the charging line connection.

To avoid letdown isolation, the existing pressurizer operation level, 47.62% at full load and 21% at no-load [1] needs to be changed. To change the level setpoints at full load to the appropriate level, "decrease in secondary heat removal" events such as Loss of Normal Feedwater accident were evaluated. For comparison, calculations for existing level setpoints was also performed. RETRAN-03 and LOFTRAN codes were used in the analysis and results of each code were compared with existing setpoints and plant data.

## 2. Kori Unit 1 Pressurizer Level Parameters

The design bases of the current pressurizer level program are as follows [2]

- linear as a function of vessel RCS average temperature

- accomodate shrink and swell for unit as loading and unloading
- minimizes the need for primary coolant charging and discharging operations
- not uncover the heaters following plant normal transients

**Table 1. Comparison of Kori Unit 1 and Other Westinghouse Plants in Korea [1,3,4]**

| Description \ Units | Kori 1 | Kori 2 | Kori 3,4/ Younggwang 1,2 |
|---|---|---|---|
| (1) Programed Level Setpoint At Full-Load (%) | 47.62 | 60.0 | 58.0 |
| Tavg (°F) | 574 | 583 | 588 |
| (2) Programed Level Setpoint At No-Load (%) | 21.0 | 25.0 | 22.0 |
| Tavg (°F) | 547 | 557 | 558 |
| Difference between (1) and (2) (Full load) - (No load) (%) | 26.62 | 35.0 | 36.0 |
| (3) Low Level Interlock (%) (L/D isolation) | 18.3 | 18.0 | 17.0 |
| (4) Margin (%) (No-Load)-(L/D isolation) | 2.7 | 7.0 | 5.0 |
| Total Operational Margin (1) - (3) | 29.32 | 42 | 41 |

Some of the post trip data of Kori 1 are shown in Table 2. In this table RCS average temperature and pressurizer level drop below programmed value under no-load condition. This is due to rapid coolant shrinkage with steam dump to condenser and the auxiliary feedwater delivery to S/G following reactor trip. During the short period of transient case, the pressurizer level behavior is mainly dependent on the RCS Tavg. Table 2 shows that the actual pressurizer level and Tavg during reactor trip event.

**Table 2. Kori 1 Actual Plant Data Relating to Pressurizer Level and Tavg During Reactor Trip Events. [5]**

| Parameter \ Cases | Programed Values | Trip Case 1 | Trip Case 2 |
|---|---|---|---|
| RCS Tavg(°F) | 547 | Min. Tavg 536.7 | 543 |
| PZR Level (%) (at No-Load) | 21.0 | Min. level 14.5 | 15.5 |

## 3. Determination of PZR Operational Level with LOFTRAN

### 3.1 PZR Level at Full Power Operation

The general method of determining a programmed level is as follow. First, select the lower limit (value at no-load temperature). Second, calculate the RCS volume expansion from no-load temperature to full load temperature. Third, calculate the upper limit (level at full load value) which is no-load value plus volume expansion calculated in the second step.

To determine the proper PZR operation level, LONF accident are analyzed with several initial conditions using LOFTRAN code. As shown Fig.1, peak water level has reached up to 96% at the condition of 55% initial PZR level. In other word, there is 4% margin to water solid during LONF accident. Therefore 55% is acceptable as the PZR level at full-load and 25% at no-load as well.

### 3.2 Limiting Condition for Operation (LCO) with respect to PZR Level

In consequence of PZR operation level change, LCO also need to be increased. The basis of LCO is that the limit on the maximum water volume in the pressurizer assures that the parameter is maintained within the normal steady state envelope of operation assumed in the safety analysis report assumptions. The limit of 67.4 percent of instrument span corresponds to 646.2 cubic feet in the pressurizer. The new LCO value of 67.4% is determined as summation of 55% at full power operation level and 12.4% of pressurizer level uncertainty.

## 4. Performance Analysis with RETRAN-03

### 4.1 RETRAN Modeling

System geometry, heat source, characteristics of heat transfer and hydraulic behavior, for Kori unit 1 are modelled with 55 control volume and 79 normal junction, 9 fill junction, 11 thermal conductors, 25 valves, and 2 pumps.

For primary system, 7 volumes for reactor vessel, 8 volumes for hot leg and steam generator, pump, pressurizer are modelled. Also, as heat source and thermal conductor, 3 volumes for core in reactor vessel and 4 volumes for steam generator, are modelled respectively. In addition, the pressurizer is modelled in detail with non-equilibrium model to simulate the effect of the two-phase flow. Finally charging flow and letdown flow are modelled.

### 4.2. Performance Analysis Result

Fig.3 represents RETRAN-03 result obtained from the condition of actual plant initial coolant temperature which is trip case 1 on the Table 2. Results are compared with some typical plant trip data [5]. These results show good agreement with plant data.

Fig.4 shows that calculated pressurizer level with initial condition of programmed coolant temperature at full-load, 55% span is acceptable to prevent the plant from the letdown isolation during transient.

## 5. Safety Analysis

### 5.1 Analysis Method of Loss of Normal Feed Water

To increase the pressurizer level setpoint, safety analysis must be performed. For safety analyses, LOFTRAN code is used with conservative assumptions. Events that are significantly affected by the initial pressurizer water level and pressure are LONF/SB and Turbine Trip/Loss of Offsite Power. Safety criteria for these events are that the pressurizer will not be fully filled with water and peak primary side pressure is within the limit during transient. Due to the reduction of steam generator water inventory and increase of steam generator temperature, loss of normal feedwater causes reduction of energy removal of reactor core. As a result, the loss of normal feedwater transient results in increase the pressurizer level and pressure following this accident.

For a more conservative result, +12.4% of pressurizer level uncertainty[6] was added to calculate pressurizer setpoint (55%) for initial condition.

### 5.2 Result of Safety Analysis

As shown in Fig. 5, pressurizer level approaches to the stabilized condition following LONF transient. In other words, although pressurizer level is adjusted to 55 %, the pressurizer is not fully filled with water.

## 6. Conclusion

Optimum pressurizer level setpoints for Kori unit 1 were determined as 55% at the full power and 25% at zero power. From the results of performance and safety analyses, it was confirmed that the new level setpoints are acceptable

New setpoints improve pressurizer pressure and level control during reactor trip and plant transients.

## References


1. KEPCO, *"Kori 1 Precautions, Limitations & Setpoints (Rev. 2)"*, ( 1992)
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4. KEPCO, *"Kori 3/4 Precautions, Limitations & Setpoints (Rev. 1)"*, (1988)
5. KEPCO, *"Sequence of Event Trip Record of Kori Unit 1"*, (1987~1995)
6. KEPCO, *"Reload Transient Safety Report for Kori Unit 1"*, Westinghouse/KNFC, (1995)

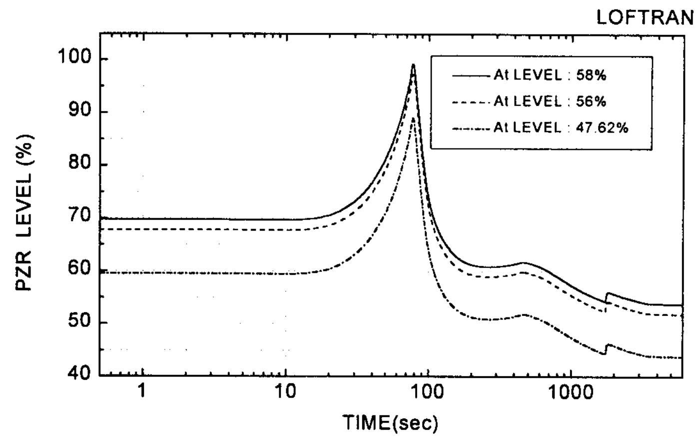


Fig.1 Comparison of Pressurizer Level at each Initial Condition

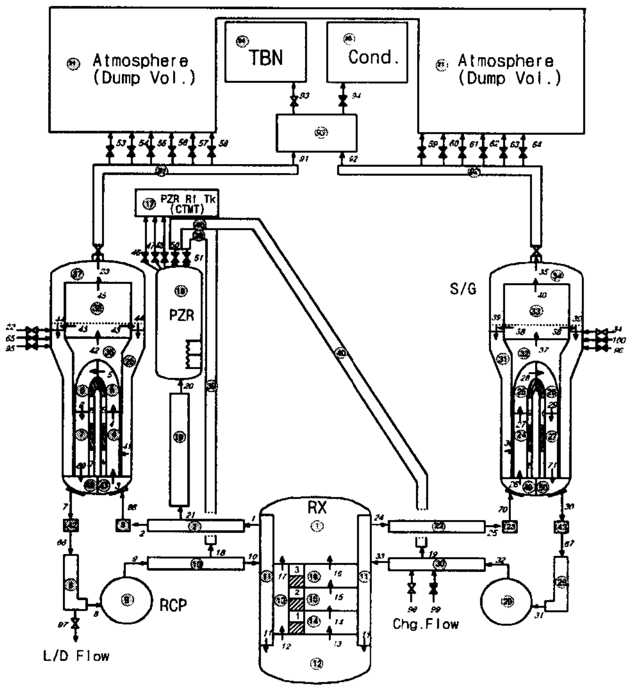


Fig.2 RETRAN-03 Nodalization of Kori unit 1

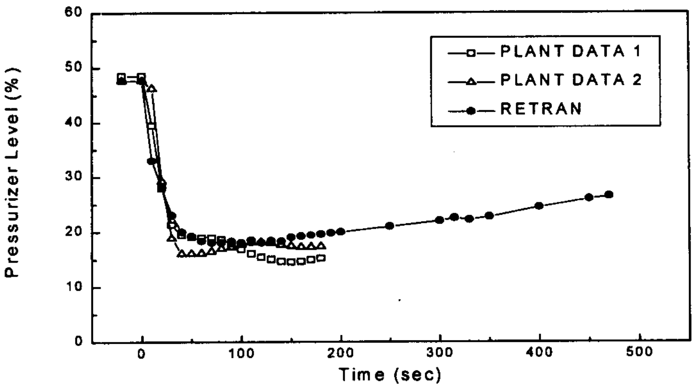


Fig.3 Comparison RETRAN Result with Actual Plant Data

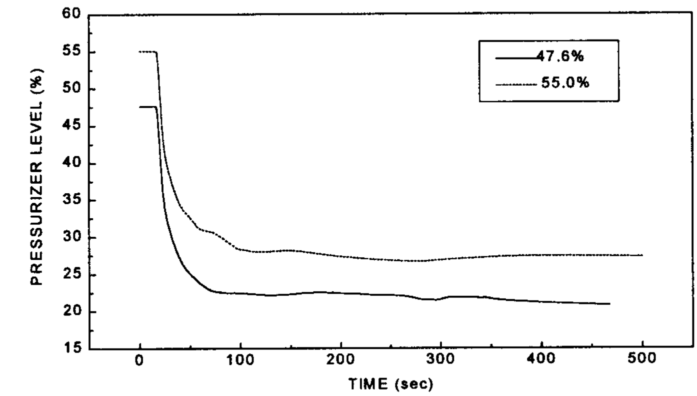


Fig.4 Comparison New Level(55%) with Existing Level(47.6)

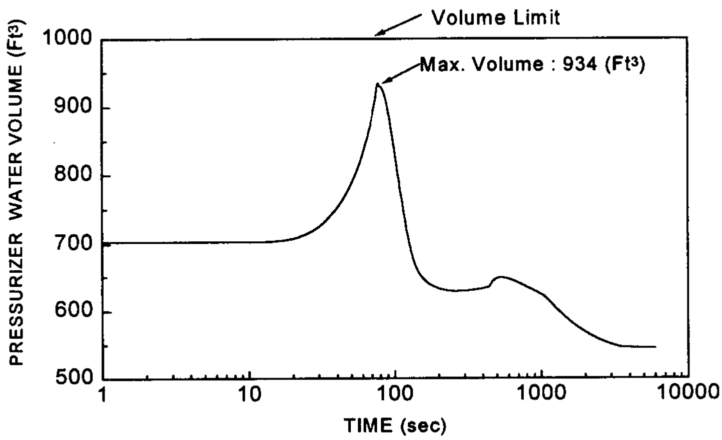


Fig.5 Trend of Pressurizer Water Volume during LONF