Study of the Possibility of Blocking the Safety Injection Signal Caused by High Differential Pressure between the Main Steam Lines

J. B. Lee
Korea Hydro and Nuclear Power Co. Ltd., 25-1 Jang-dong, Yuseong-gu, Daejeon, 305-343, Rep. of Korea
jbdoll@khnp.co.kr

1. Introduction

The Ulchin 1&2 units have a unique safety injection (SI) signal which is actuated when the differential pressure between the main steam lines is greater than the set pressure of 7 bar.

This SI signal originated in the design concepts of Westinghouse nuclear plants in the early 1970s'. However Westinghouse has not used the SI signal since the development of their newer analysis methods in 1978.

In this study, the possibility of blocking the SI signal during operation modes 4 and 5 of the Ulchin 1&2 units is investigated. The investigation is conducted in two steps. The first step is to select limiting transient case which can actuate the SI signal during operation modes 4 and 5. The second step is to perform analysis of the selected transient case in order to analyze whether the SI signal can be actuated.

2. Transients which can actuate the SI signal

Two transients can actuate the SI signal due to the high differential pressure between the main steam lines during operation modes 4 and 5.

The first involves a break of the main feedwater system line. However, if the main feedwater system line is broken, the SI signal caused by the high pressure of containment is actuated before the actuation of the SI signal caused by the high differential pressure between the main steam lines. Thus, the SI signal due to the high differential pressure between the main steam lines would not apply in this case.

The second case in which the SI signal is actuated due to the high differential pressure between the main steam lines involves a break of the main steam lines. When a break occurs in one of the main steam lines, the differential pressure of the steam lines can exceed the SI actuation set pressure of 7 bar.

Therefore, a break of the main steam line is selected as the limiting transient case in this study.

3. Assumptions and Initial Conditions

3.1. Computer code

The RELAP5/Mod3 computer code is used to evaluate transients. RELAP5 was developed to describe the behavior of a light water reactor subjected to postulated transients such as loss of coolant from large or small pipe breaks or pump failures. RELAP5 calculates fluid conditions such as velocity, pressure and thermal conditions, etc.

3.2. Plant Modeling

Figure 1 shows the RELAP5/Mod3 nodalization of Ulchin 1&2. The reactor coolant system is modeled as three loops, and each loop consists of a hot leg, SG u-tubes, a reactor coolant pump, and a cold leg. Each loop also has a high head safety injection line and a safety injection tank to simulate the emergency core cooling system.

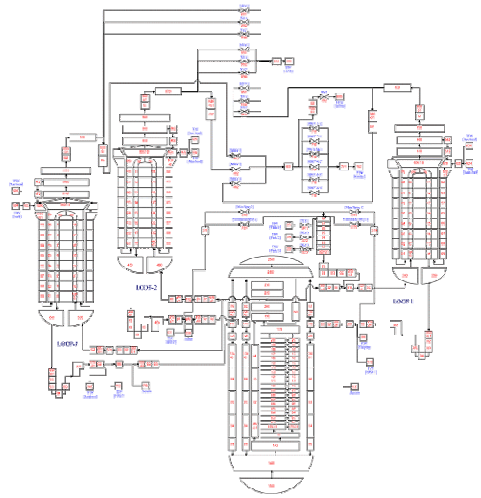

Fig. 1. RELAP5/Mod3 Nodalization of Ulchin 1&2

3.3. Assumptions and Initial Conditions

Transients start in operation modes 4 and 5. In order to reach operation modes 4 and 5, we started with full power operation conditions with modifications to reactor trip logic, the temperature and pressure of the reactor coolant system, and the SI actuation logic.

The residual heat removal system is operating and a reactor coolant pump is running during operation modes 4 and 5. In addition, the fluid status of the pressurizer is in one phase in mode 4 and is in two phases in mode 5. The average pressure of the steam lines is 8 bar in both modes.

The initial conditions are summarized in Table 1.

Table 1. Initial Conditions

	Mode 5	**Mode 4**
Thermal Power	1% of normal power	1% of normal power
Pressurizer Level	32%	99%
Fluid Status of Pressurizer	2 phases	1 phase
RCS Temperature	169 ℃	169 ℃
RCS Pressure	27 bar	24 bar
Steam Line Pressure	8 bar	8 bar
Reactor Coolant Pump	1 running	1 running
Residual Heat Removal System	In service	In service

4. Evaluation of the Transient

Evaluations were made of two cases. The first transient case involves a break in a main steam line during mode 5. The second transient case involves a break in a main steam line during mode 4. The point of the break is assumed to be in front of the main steam isolation valve. The break size is assumed to be that of the flow restrictor which is located at the top of the steam generator.

Fig. 2 shows the results of the first case. The pressures of two intact steam lines, one broken steam line, and the differential pressure between the intact and the broken steam lines are shown. The pressure of the broken steam line decreases rapidly in the beginning of the transient. The rate of decrease slows as time passes, and the maximum differential pressure between the steam lines becomes 6.28 bar at 360 sec., which is below the set pressure of the SI actuation signal of 7 bar. Thus, the differential pressure of the steam lines does not trigger the SI signal.

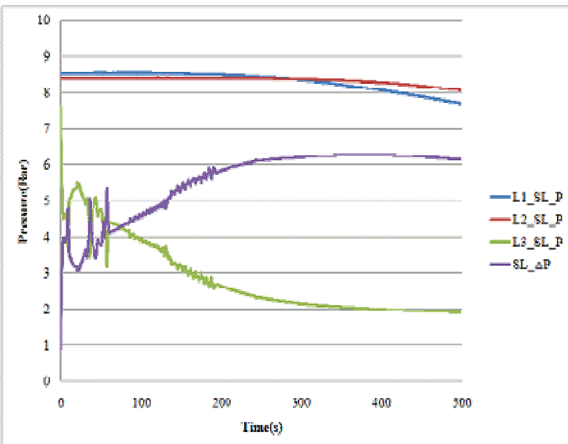

Fig. 2. Pressure of the main steam lines and the differential pressure during mode 5

Fig. 3 shows the results of the second case. The pressure trend is similar to that in the first case. The maximum differential pressure between the steam lines is 6.11 bar at 300 sec. The differential pressure of the main steam lines does not cause the SI signal to actuate.

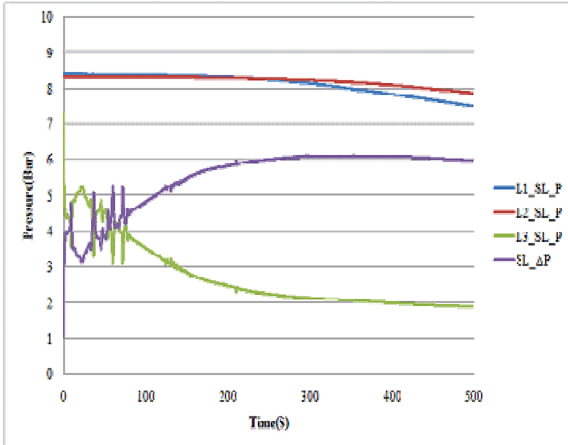

Fig. 3. Pressure of the main steam lines and the differential pressure during mode 4

5. Conclusions

The purpose of this work is to ensure that the SI actuation signal caused by the high differential pressure between the main steam lines is not activated during operation modes 4 and 5 when the residual heat removal system is in service. The transient case tested here, in which the SI signal would normally be actuated, involved a break of the main steam line. In such a case, a transient analysis showed that the maximum differential pressure between the main steam lines is below the set pressure of the SI actuation signal. Therefore the SI actuation signal during operation modes 4 and 5 for Ulchin 1&2 can be blocked without impeding the safety of the plant.

REFERENCES

[1] WCAP-9226-R1, Reactor core response to excessive secondary system releases, Westinghouse, 1978

[2] Safety Injection System, EP/PP/DC.784, Framatome, 1983

[3] 2006-8(060507U1), Inadequate safety injection signal actuation during heating up the reactor coolant system, KINS, 2006

[4] TR.A07NJ32.S2008.30, Block of Main Steam Line High DP SI Signal in Operation with RRA System, KHNP, 2008