Applicability to Control System performance analyses using safety analysis computer code

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1. Introduction

The LOFT4 computer code has been used to evaluate the control system performances for Kori 3/4 and Yonggwang 1/2 power uprate project. The LOFT4 computer code is a safety analysis code and models the overall NSSS including the detailed modeling for control and protection systems. The LOFT4 computer code dose not model the secondary system like feedwater flow rate and enthalpy. Because of these reasons, the feedwater flow rate and enthalpy following design transients should be manually input. This paper is to evaluate the applicability to the design transients response analyses using the safety analysis code.

2. Methods and Results

We compared the results from between LOFT12 code results and LOFTRAN code results with system standard feedwater flow and enthalpy following design transients. LOFT12 code has been developed for performance analysis and it internally simulate the auto feed water flow and enthalpy transient including NSSS, control and protection system, but it is applied for only one loop type of plants. Since the control system and plants operability margin analyses are loop symmetric transient, the use of the LOFT12 computer code is reasonable for Kori 3/4 and Yonggwang 1/2 units which are 3-loop of Westinghouse type plants. The LOFT12 code has been used to performance analysis for a lot of Westinghouse type plants. Because KEPRI dose not have the LOFT12 code at hand, we used a Westinghouse electric cooperation possession code.

2.1 Description of the System Standard 1.3F

System standard 1.3F[1] shows the fluid system transients to be considered when designing the major reactor coolant system components of Westinghouse standard 2-loop, 3-loop and 4loop plants with Model F steam generators. The design transients described in system standard 1.3F[1] represent umbrella cases for operational events postulated to occur during the plant lifetime. Pertinent transients in pressure, fluid temperature and flow are used to describe the transients. Other conditions which affect equipment design such as dynamic effects, water hammer or seismic loadings, are not considered in this documents.

2.1.1 Initial & Final Steam and Feedwater Temperature

The appropriate steam and feedwater temperature values at 100, 90, 50, 25, 15 and 0 percent power level are listed in Table 1. These values are derived from the Balance of Plant System Design Parameters for standard 2-loop, 3-loop and 4-loop with model F steam generators[1].

Table 1 Feedwater temperature vs. power level

Power Level(%)	System standard 1.3F			Kori3/4 Yonggwang1/2[4
	2-Loop	3-Loop	4-Loop	
100	430	440	445	445.9
90	419	428	433	430
50	362	370	375	370
25	307	313	316	321
15	270	279	281	290
0	100	100	100	100

2.1.2 Steam pressure

Steam pressure is assumed to be the saturation pressure for the steam temperature indicated.

2.2 Code Input Development

Since transient analyses are performed to evaluate the NSSS control system performances, the best estimated reactivity feedbacks are used as both LOFTRAN and LOFT12 input deck. For example, the best estimated moderator coefficient dependents on coolant temperature and boron concentrate, Doppler power defect, control rod worth by steps, etc. and then applied to both code input decks. All NSSS control and protection systems such as rod control, steam dump control, pressurizer pressure and level control, steam generator level control, OTΔT/OPΔT protection system, etc, are avaliavle without any instrument uncertainty.

Because the auto feedwater control system was applied to LOFT12 code, the internal feedwater control calculation option was set for the LOFT12 code. The feedwater flow rate and enthalpy changes following design transients which are described in system standard 1.3F was manually input for LOFT4 code.

2.3 Evaluated Transients Response Cases

These analyses are performed to confirm the adequate reactor control following design transients. The considered design transients in this study are as follows and all cases are compared between LOFT4 code results and LOFT12 code results.

- − 10% step load change
- − 5%/min ramp load change
- Large step load rejection with steam dump

- Turbine trip

2.4 Results

Figure 1 ~ Figure 5 show the some transients following 10% step load decrease. As shown in these figures, calculated results such as nuclear power, pressurizer pressure, average temperature, feedwater flow rate and enthalpy, etc, between LOFT4 and LOFT12 codes are almost same or the differences are small enough to ignore and all the other considered design transient cases have similar results.

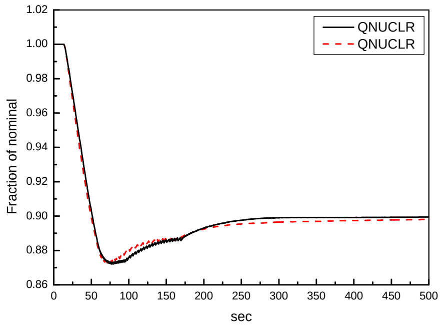

Figure 1 Nuclear power

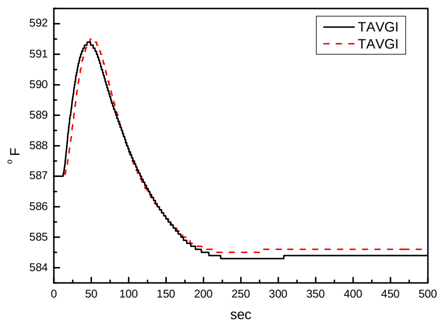

Figure 2 Average temperature

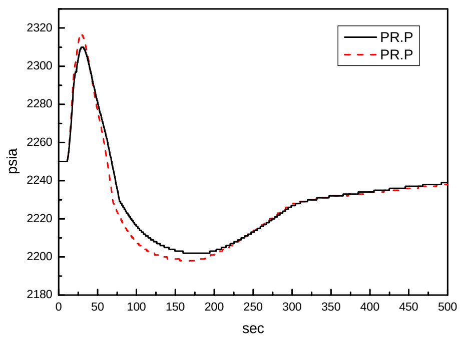

Figure 3 Pressurizer pressure

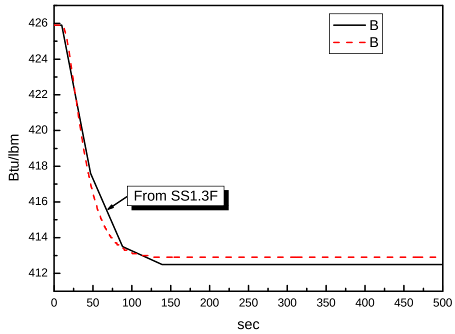

Figure 4 Feedwater temperature

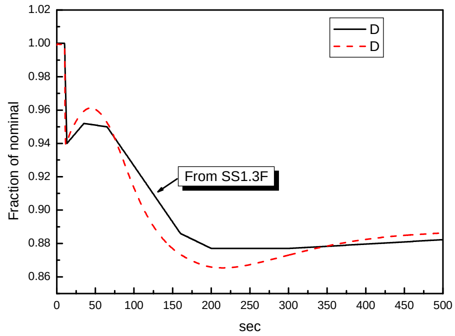

Figure 5 Feedwater flow rate

3. Conclusions

The design transients performance analyses using the safety analysis computer code(LOFT4) with system standard 1.3F data is reasonable and can be applicable to Kori 3/4 and Yonggwang 1/2 power uprate project.

4. References

[1] "SYSTEM STANDARD 1.3F, Nuclear Steam Supply System REACTOR COOLANT SYSTEM DESIGN TRANSIENTS for Standard Plants with Model F Steam Generators," Westinghouse, March 1978,

[2] G.H. Heberle, "WCAP-7878, LOFTRAN code description and user's manual", Westinghouse 1989,

[3] Letter, KFD/RD-040042M, LOFTRAN Base Deck, Korea Nuclear Fuel Company, 2004/10/29

[4] Letter, “Korea Power Uprate Technology Development Project Steam Generator Data Transmittal”, Westinghouse, September 14, 2004