Preliminary Best-estimate Analysis of APR1400 Large Loss-of-Coolant-Accident in 8% Power Level

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1. Introduction

The adoption of Direct Vessel Injection (DVI) and removal of Low Pressure Safety Injection (LPSI) in APR1400's (Advanced Power Reactor 1400MW's) result in considerably different trends for large Loss-of-Coolant-Accident (LOCA) from conventional PWR of Cold Leg Injection (CLI) and LPSI. The important phenomena related cover three dimensional phenomena in downcomer including Emergency Core Cooling (ECC) water bypass, steam condensation in downcomer, downcomer boiling, and so on, and new phenomena are now additionally reported [1,2].

Several analyses for large LOCA for APR1400 of full power with RELAP5 have been reported [2,3,4]. And this study accomplishes the same analysis with the change of initial core power, 8%. 8% power is also the initial condition of Advanced Thermal-hydraulic Test Loop for Accident Simulation (ATLAS), which is now under construction in Korea Atomic Energy Research Institute (KAERI)[5]. In this study the results of 8% power level are discussed in comparison with 100% power level for both steady state analysis and transient analysis (large LOCA).

2. Steady State Analysis

The nodalization for these analyses is presented in figure 1. The operation parameters which changes according to power level are core power, enthalpy of main feedwater inlet, Steam Generator (SG) recirculation ratio, pressurizer water level, steam pressure in SG dome, and the temperatures in hot and cold legs. Detailed values for this operation parameters are attributed to reference 6.

The steady state for 8% power level was achieved from input of the full power level with the modification in above operation parameters but without any change in geometry inputs except for occasional cases, for example, SG heat transfer areas for the sake of heat balance.

For steady state results, SG heat transfer rate was artificially raised for the heat balance, as mentioned above. In order to maintain the same primary flow rate the head of reactor coolant pump (RCP) was slightly increased compared with full power steady state. There was also some gaps in pressure drop in loop. The pressure drop by minor loss coefficient was not so much different, but that by friction was comparatively large. Thus, the pressure drops in fuel and U-tube are different from those at full power.

In secondary system the SG narrow range water level was set 37% (required condition is 44%), because trying to set the level 44% induced the asymmetry of both SG water levels. The calculated SG recirculation ratio was 17, while the required value in 8% power level was 32. However, no adjustment for the recirculation ratio was carried out, since the recirculation ratio was not a fatal parameter in large LOCA.

These steady state results are, in some sense, expected operation conditions containing much uncertainties, and in some the other sense, are the discussion limits of following transient.

3. Transient Analysis

As shown in figures 2 to 4, the pressurizer pressure, break flow, and Safety Injection Tank (SIT) are not far different in full power and 8% power, and some small gaps are readily caused by the difference in decay heat power. However, the core recovery in figure 5 shows much difference. It means that the core recovery is much influenced by the decay heat power, which eventually is related with the steam generation rate in core or in its vicinities. And, there was no core reheating near 380seconds in 8% power level.

Detailed discussions are described in reference 6.

4. Conclusion

Large LOCA of 8% power level in APR1400 was preliminarily analyzed using RELAP5/Mod3.3. The steady state was not directly obtained from the full power input: it required some adjustment in heat transfer rate in SG. And there were some gaps between required operation condition and calculated condition. The difference in decay heat caused by the different power level finally have much effect on core recovery and core reheating in large LOCA.

REFERENCES

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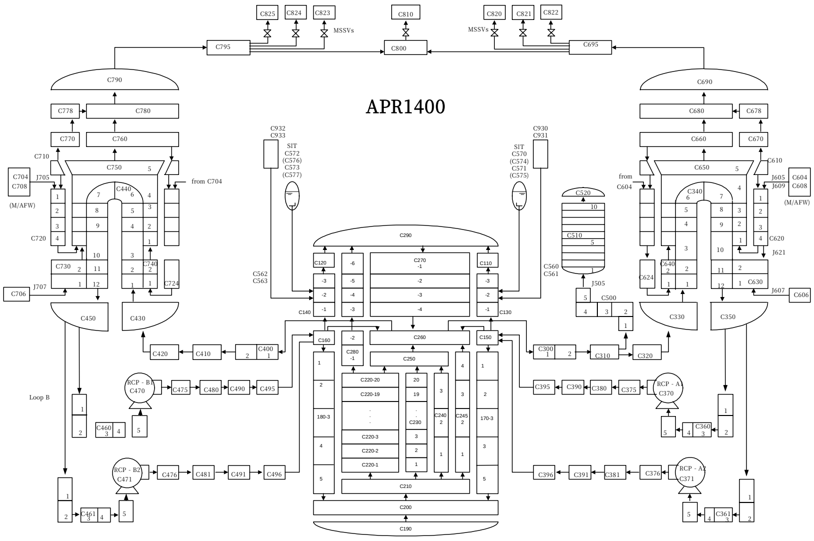

Figure 1. Nodalization of APR1400 for RELAP5 Analysis

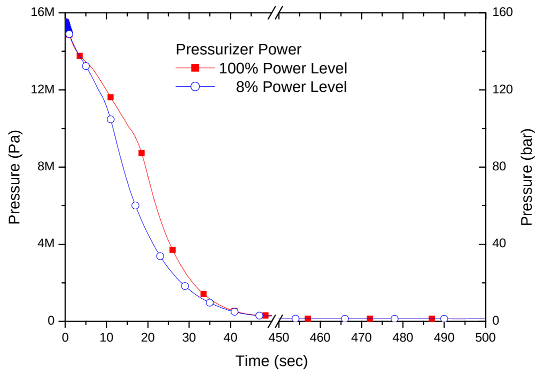

Figure 2. Pressurizer Pressure

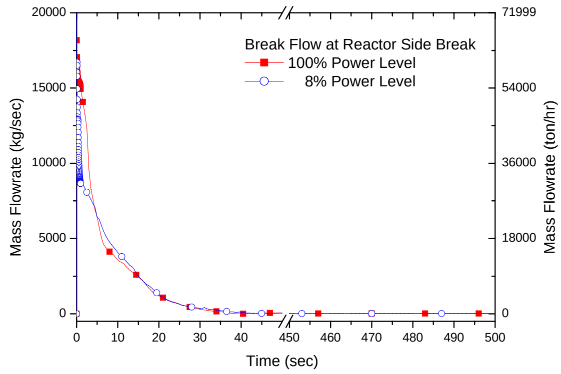

Figure 3. Break Flow from Reactor Side Break

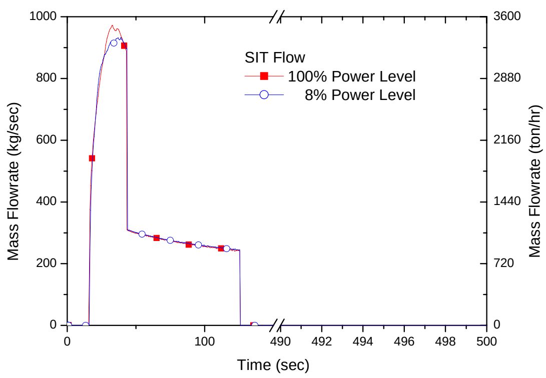

Figure 4. SIT Flow

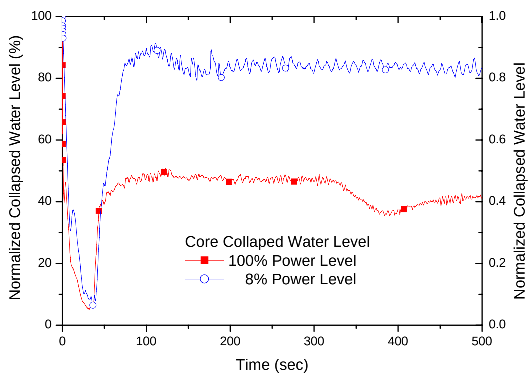

Figure 5. Core Water Level