Simplified RETRAN Model for SGTR Analysis of Ulchin Unit 3/4

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1. Introduction

Korea Electric Power Research Institute(KEPRI) has been developing safety analysis methodology for non-loss of coolant accident(non-LOCA) analysis of Korea Standard Nuclear Power Plant(KSNP). This new methodology uses RETRAN as main safety analysis code. The standard RETRAN nodalization of KSNP includes a detailed 14-node steam generator secondary modeling and main steam safety valves(MSSV) with accumulation and blowdown characteristics.

However, some transients, such as steam generator tube rupture(SGTR), does not require detailed steam generator secondary side modeling. In this paper, as a comparative study, simplified RETRAN model is used for SGTR analysis and the results are compared with results from more complex RETRAN model. Simplified RETRAN model include 2-node steam generator secondary side model, simplified MSSV opening-closing characteristics and simplified ruptured tube break flow model. Reference plant for analysis is Ulchin Unit 3/4. With simplified model, similar results can be obtained with less computing time.

2. Methods and Results

In this section the standard RETRAN model and simplified RETRAN model used for SGTR analysis are described.

2.1 The Standard RETRAN Model for KSNP

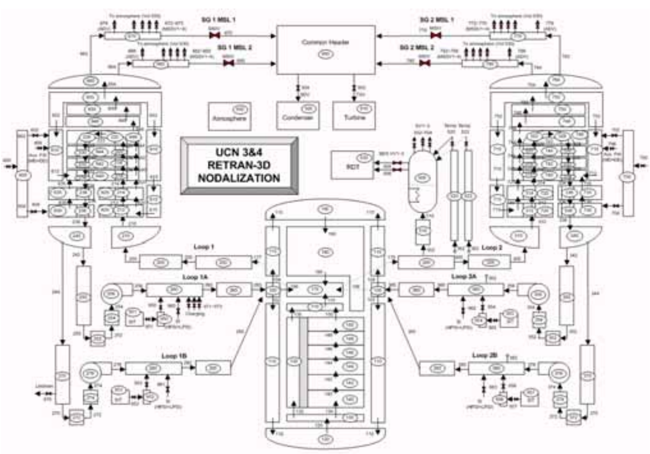

Figure 1. RETRAN Nodalization for Ulchin Unit 3/4

Figure 1 shows nodalization for standard RETRAN basedeck for Ulchin Unit 3/4. The basedeck includes one reactor vessel, one pressurizer and 2 separate RCS loops with 1 hotleg and 2 coldlegs per loop. Each loop contains 2 reactor coolant pumps and 1 steam generator. The U-tube section of the steam generator primary side is divided into 12 volumes. The secondary side of the steam generator is modeled using 14 volumes. Four main steam lines with total of 16 MSSV's are modeled.

2.2 Simplified Steam Generator Model

The detailed 14-node steam generator model includes separate volumes for downcomer, economizer, evaporator, primary separator, secondary separator and steam dome. The detailed steam generator has the advantage of ability to model recirculation flow in the steam generator secondary side. Modeling recirculation flow may give more accurate heat transfer coefficient. However, in steam generator tube rupture accident, the primary concern is radioactivity release during first 2 or 8 hours of transient. The activity release is more related to cumulated heat generated over certain time interval rather than instantaneous heat transfer rate. Therefore simple 2-node steam generator model for secondary side is selected. The primary side model was not changed.

2.3 Simplified MSSV Model

The MSSV model used in standard RETRAN model for KSNP includes accumulation and blowdown modeling. Accumulation means for a MSSV to open fully, higher pressure than setpoint pressure is required. It is a conservative assumption useful when calculating maximum pressure during a transient. Blowdown means a MSSV will remain open below opening setpoint pressure. Modeling accumulation and blowdown might be a more realistic representation of actual MSSV actuation. However, this leads to pressure fluctuations in steam generator. Combined with relatively small volumes associated with 14-node steam generator, these pressure fluctuations lead to small timesteps and longer analysis time.

For simplified model, linear valve opening is assumed, where the valve begins to open at blowdown pressure and fully opens at accumulation pressure. This allows relatively smooth steam pressure, which in turn allows larger timestep size.

2.4 Simplified Ruptured Tube Model

In previous RETRAN SGTR analysis by KEPRI, the ruptured tube was modeled separately by adding 3 volumes representing single U-tube. While this may represent more accurate flow rate through the ruptured tube, addition of nodes with very small volume limits the maximum timestep size.

In the simplified model, 2 junctions connecting steam generator plenum and secondary side were used to model the ruptured area. No volumes were added to model the single U-tube. The contraction coefficient and friction factor for the junctions were adjusted to give similar break flow to more detailed model.

2.5 Results

Since radioactivity release is the major concern for SGTR, important output results are MSSV total flow rate for each loop and total break flow from primary to secondary.

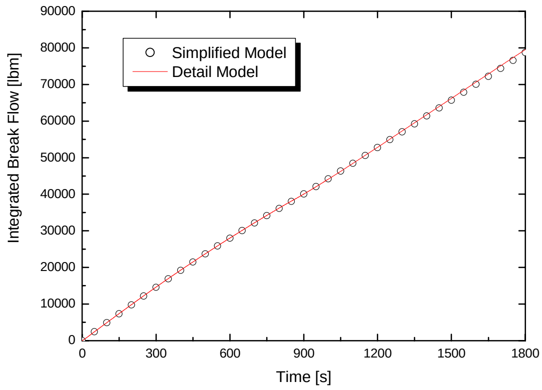

Figure 2. Comparison of integrated break flow

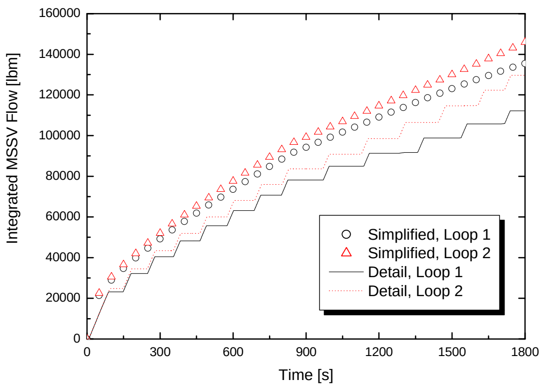

Figure 3. Comparison of integrated MSSV flow

Figure 2 shows comparison of integrated break flow for simplified and detail model. The total break flow over 1800 seconds is almost the same. Figure 3 shows comparison of integrated MSSV flow for simplified and detail model. Lower MSSV opening pressure assumed in simplified model leads to more steam release through MSSV. Since more steam release is more conservative in terms of radioactivity release, simplified model is acceptable.

3. Conclusion

Steam generator tube rupture analysis of Ulchin unit 3/4 were performed using simplified RETRAN model. The simplified model includes 2-node steam generator secondary model, simplified MSSV model and simplified ruptured tube model. The results show that the break flow through the ruptured tube is very similar to detailed RETRAN model. The simplified model predicts more steam release through MSSV than detailed model. Since more steam release is conservative, simplified RETRAN model is acceptable for safety analysis. With simplified RETRAN model, larger timestep size is possible, which translates to less analysis time.

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