Safety Evaluation of Low-Temperature Overpressurization Events for Yonggwang Units 1&2

Jongbeom Lee
Korea Hydro & Nuclear Power Co., Ltd., Munji-Dong Yuseong-Gu, Daejeon, 103-16, Korea
Tel:+82-42-865-7631 , Fax:+82-42-865-7609 , Email:jbdoll@khnp.co.kr

1. Introduction

The purpose of this paper is to show the capability of Low-Temperature Overpressurization Protection(LTOP) of the RHR suction relief valves in Yonggwang Units 1&2.

Overpressurization events at low temperature conditions such as plant startup or shutdown operation could make the reactor pressure vessel exposed to conditions of fast propagating brittle fracture. To protect the reactor pressure vessel from the low temperature overpressurization, LTOP System is equipped to the plant and those satisfy the requirements of the Generic Letter(GL) 90-06 issued by USNRC. The LTOP System controls RCS pressure at low temperatures so the integrity of the reactor coolant pressure boundary(RCPB) is not compromised by violating the pressure and temperature (P/T) limits of 10 CFR 50, Appendix G [1].

According to the Standard Technical Specifications, NUREG-1431[2], the LTOP System for pressure relief consists of two PORVs with reduced lift settings, or two RHR suction relief valves, or one PORV and one RHR suction relief valve, or a depressurized RCS and an RCS vent of sufficient size. Two RCS relief valves are required for redundancy. One RCS relief valve has adequate relieving capability to keep from overpressurization for the required coolant input capability. But in the Technical Specifications of Yonggwang Units 1&2 the LTOP System using RHR suction relief valves is omitted due to the lack of safety evaluations. When the LTOP System using RHR suction relief valves is applied to the Technical Specifications, it's possible to give the system more redundancy and operational convenience.

2. Analysis Method

The calculation uses the RETRAN-3D[3] computer code to evaluate the acceptability of the current RHR relief valve setpoints for the applicable range of heat input and mass input cases consistent with the USNRC approved LTOP methodology established in WCAP-14040[4].

The following design basis events are identified as the most severe accidents among the anticipated scenarios to be consistent with the WCAP-14040 methodology.

① Mass addition events during water solid condition.
② Energy addition events during water solid condition.

- **Mass Addition Evaluation**

The initial RCS pressure is assumed to be between 300 psig and 400 psig as necessary to ensure subcooled liquid conditions at the RCS temperature. The initial RCS pressure does not affect the transient since there is sufficient time to evaluate the transient response prior to reaching the opening setpoint of the RHR suction relief valves.

- **Energy Addition Evaluation**

The RCS is assumed to have been cooled down to a steady state condition via RHR flow such that the RCS liquid in the SG tubes, the SG tube and shell, and the SG secondary liquid are all at a higher temperature than the remainder of the RCS. The temperature difference between the RCS and the SG secondary side is assumed to be at the Technical Specification maximum plus uncertainty when an RCP is started in one loop.

3. Calculations

The limiting LTOP events are analyzed assuming a water solid and subcooled RCS conditions such that the two region non-equilibrium RETRAN-3D pressurizer model is not needed. In addition, the pressurizer heater and spray models including associated junctions and control systems are not needed. The other significant RETRAN-3D model for the LTOP analysis is the simplification of the steam generators. Each steam generator is modeled as a homogeneous single volume with a time-dependent volume model. The LTOP analysis does not credit any primary to secondary heat transfer in the mass input cases and the heat input cases only model reverse heat transfer from the steam generator to the RCS during shutdown conditions. The single volume steam generator model and the appropriately conservative RETRAN-3D heat transfer characteristics are consistent with the Westinghouse LTOP methodology.

The RETRAN-3D nodalization diagram and the calculation results are shown below for initial RCS temperatures at 70F, 120F, 180F, and 200F, respectively.

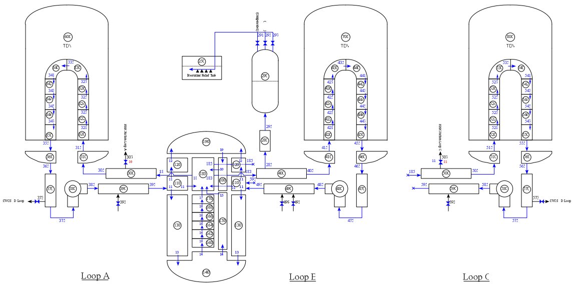

Figure 1. RETRAN Nodalization Diagram for LTOP

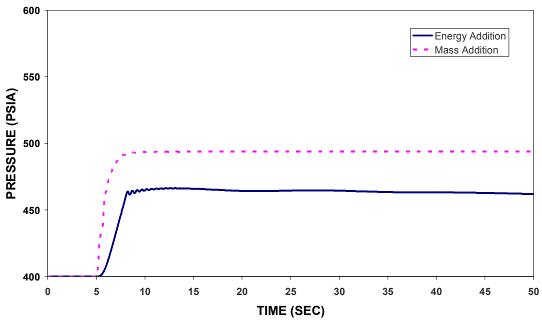

Figure 2. PZR Pressure initially at 70F

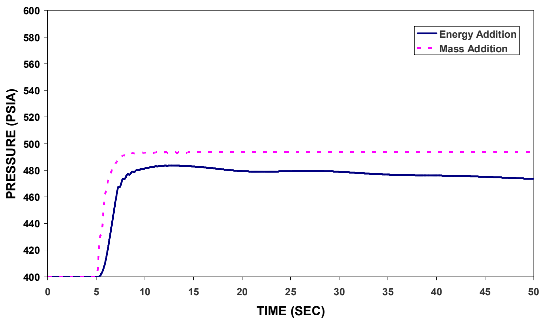

Figure 3. PZR Pressure initially at 120F

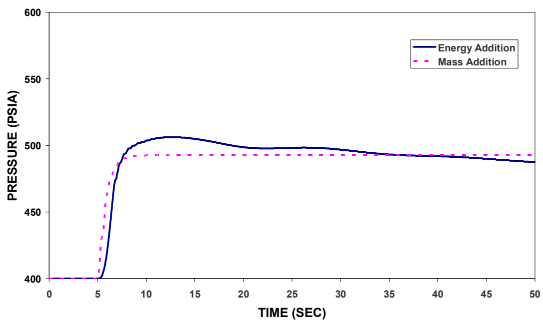

Figure 4. PZR Pressure initially at 180F

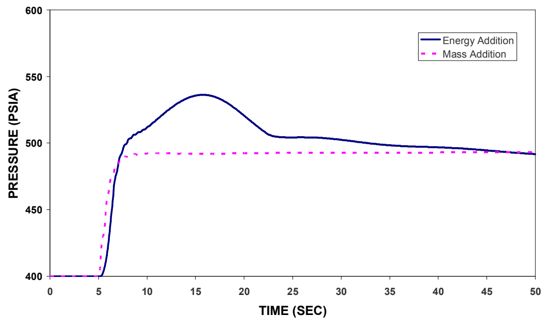

Figure 5. PZR Pressure initially at 200F

4. Analysis Results and Conclusion

The capability of LTOPS for RHR relief valves in Yonggwang Units i&2 has been analyzed with some conservatism on instrument errors and safety relief valve tolerance. The calculated peak RCS pressures during water solid condition is lower than the P/T limits provided by the plant Technical Specifications. Therefore, it can be concluded that the safety relief valve at the entrance of RHR system satisfy the functional requirements of a LTOP System.

REFERENCES

1. USNRC, Code of Federal Regulations, Title 10, Part 50, “Fracture Toughness Requirements for Light-Water Nuclear Power Reactors,” Appendix G, Fracture Toughness Requirements.
2. USNRC, NUREG-1431, “Standard Technical Specifications for Westinghouse Plants,” Revision 2.
3. J. H. McFadden, et al., “RETRAN-3D : A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems,” EPRI NP-7450s, EPRI.
4. Westinghouse, WCAP-14040-A, “Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves,” WOG Program MUHP-3024 Revision 4.