Application of the RETRAN Safety Analysis Model to Increase the Safety Margin during Overpressure Transients

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1. Introduction

The safety of a nuclear plant is mainly assessed using an Evaluation Model code (EM code). The EM code is a plant-specific code developed by the reactor vendor to consider the specific plant. Thus, it is difficult to apply an EM code to plant design changes or to other types of reactors. As there have been plant design changes since the 90's, attempts have been made to substitute EM code with RETRAN[1] for Non-LOCA safety analyses. RETRAN is a very flexible code for changes to the nodal configuration that is applicable to every reactor type. However, differences in the analysis results between RETRAN and EM code have not been verified due to complex code algorithms. Nevertheless, the analysis results should have good agreement irrespective of the analysis code under the same analysis assumptions. In this study, a RETRAN analysis is performed under the same assumptions used with the EM code model, and a method to increase the safety margin during overpressure transients is discussed.

2. Methods and Results

A limiting overpressure transient is Turbine Trip event in which the steam generator (SG) pressure increases and the reactor heat sink capacity decreases due to the Turbine Trip[2]. Turbine Trip event is classified as Condition 2 events according to the ANSI 18.2 specifications. However, the peak pressure should be limited within 110% of the design pressure. Present analyses of Turbine Trip event is performed with the LOFTRAN[3] EM code. Figure 1 shows the nodal configuration of LOFTRAN.

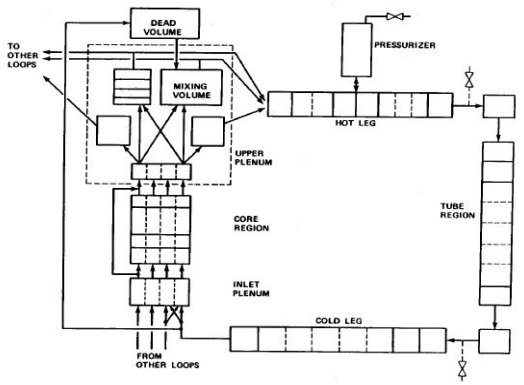

Figure 1. The nodal configuration of LOFTRAN

2.1 The comparison between RETRAN and LOFTRAN

LOFTRAN was developed by Westinghouse for Non-LOCA evaluations in Safety Analysis Reports. The LOFTRAN code was submitted to the U.S. Nuclear Regulatory Commission (NRC) for regulatory review in 1972, and the NRC accepted the use of LOFTRAN. However, the pressure loss and volume of the main steam pipe from the SG to the turbine are not considered because the Main Steam System (MSS) is not modeled in LOFTRAN. Thus, the Main Steam Safety Valve (MSSV) is modeled as open in LOFTRAN when the SG pressure surpasses the MSSV set pressure by more than 20 psia.

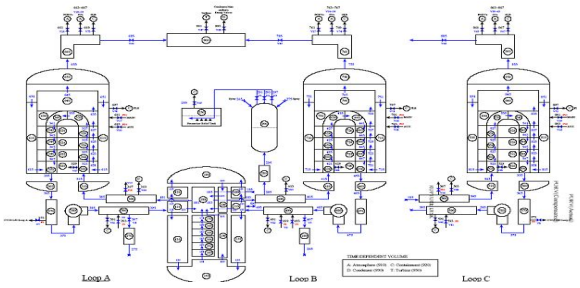

Figure 2. The nodal configuration of RETRAN

RETRAN is a flexible thermal hydraulic computer code that is used to assess the safety margin during Non-LOCA transients. The original code version, RETRAN-01 was released by EPRI in December of 1978. RETRAN-03D was developed to account for three-dimensional core kinetics RETRAN-03D was approved by the NRC via SER for Non-LOCA licensing analyses in January of 2001.

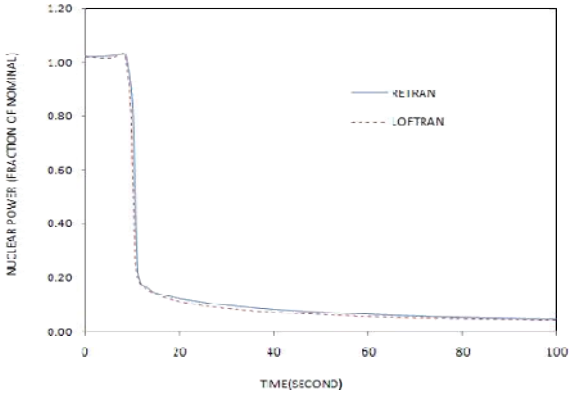

Figure 3. A comparison of the reactor power

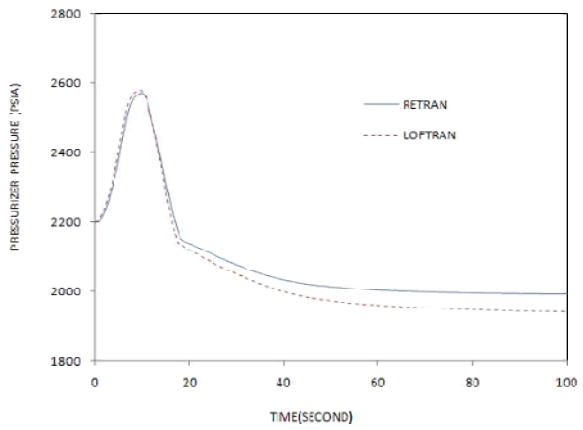

Figure 4. A comparison of the pressurizer pressure

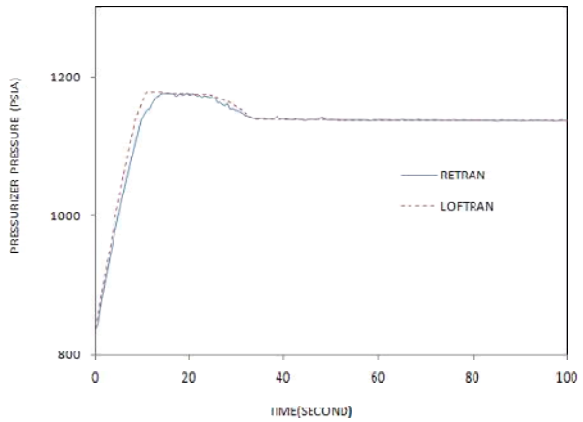

Figure 5. A comparison of the SG pressure

Figure 2 shows the nodal configuration of RETRAN-03D as used in this study. However, the same assumptions used with LOFTRAN regarding MSS are made here as well. Comparisons of the results of both the RETRAN and LOFTRAN analyses methods are shown in Figs. 3, 4, and 5. According to comparison results, the RETRAN analysis results are in good agreement with those of LOFTRAN. However, a pressure difference appears after 18 seconds, as shown in Figure 3, when the thermodynamic condition changes from a subcooled condition to a saturated condition. This occurs because the vaporization of reactor coolant is not modeled in LOFTRAN whereas it is modeled in RETRAN. However, the pressure difference after the peak pressure time has no meaning in terms of nuclear safety.

2.2 Detailed analysis using RETRAN

To analyze the effect of a detailed modeling of MSS, the RETRAN model is modified to consider the volume and pressure of the main steam pipe. The analysis results are shown in Figure 6 and Figure 7. According to the detailed analysis results, the peak pressure and saturated temperature of the SG decrease owing to an increase in the steam volume. Additionally, the decreased saturated temperature in the SG reduces the Reactor Coolant pressure.

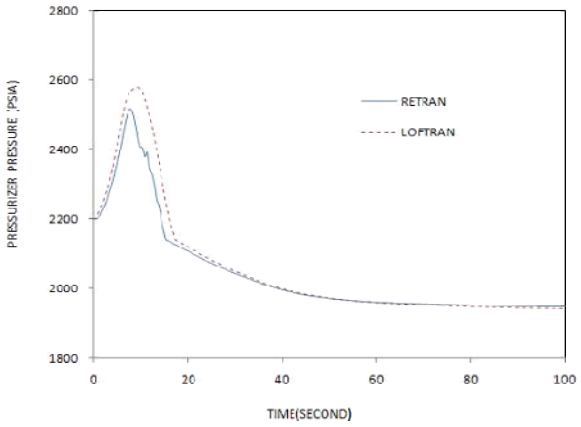

Figure 6. The pressurizer pressure in the detailed model

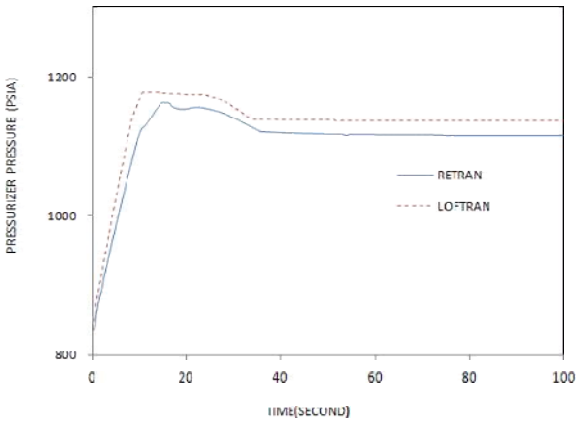

Figure 7. The SG pressure in the detailed model

3. Conclusions

This study verified that the analysis results by RETRAN and the EM code of LOFTRAN are characterized by exact agreement under the same assumptions. Nevertheless, various physical phenomena can be simulated in RETRAN due to the flexibility inherent in modifying the model. The application of RETRAN was found to increase the safety margin due to the model flexibility.

REFERENCES

[1] RETRAN-03D – A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid, EPRI, November, 2004

[2] Final Safety Analysis Report for Ulchin 1 and 2 units, Korea Hydro & Nuclear Power Co

[3] Westinghouse Electric Company, LOFTRAN Code Description and User's Manual, WCAP-7878, Rev. 6., Feb. 2003