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LBLOCA Analysis for Westinghouse 2 Loop Plant of Downcomer Injection by Realistic Evaluation Method

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1. Introduction

Since Code Scaling And Uncertainty (CSAU) methodology was developed, the realistic evaluation method (REM) is widely used in the safety evaluation for large break loss of coolant accident (LBLOCA). In Korea, KINS (Korea Institute of Nuclear Safety) has developed such a realistic estimate method called KINS-REM for the audit calculations to support the regulatory decision making. This paper deals with the LBLOCA analysis by realistic evaluation method using RELAP5/MOD3.3 for Westinghouse 2 loop plant which has downcomer injection as well as cold leg injection as an emergency core cooling system (ECCS). Downcomer injection is used as a low head safety injection. Assessments were basically carried out according to KINS-REM (Korea Institute of Nuclear Safety REM), which is based on, as a whole, CSAU methodology with several improvements. In addition, a method for bias evaluation related to steam binding, which had not been considered before, was developed and applied to the result.

2. Spectrum Analysis for Discharge Coefficient (C_D) & Selection of Uncertainty Variable

2.1 Spectrum Analysis for Discharge Coefficient (C_D)

Spectrum analyses for discharge coefficient were conducted to determine the worst resulting accident scenario. In this study, Kori Unit 2 is selected as a reference plant and the nodalization is shown in Figure 1. Discharge coefficient 0.4 yielded the worst peak cladding temperature (Figure 2).

2.2 Selection of Uncertainty Variable

18 variables are selected for uncertainty variable (Table 1). The treating method for some uncertainty variables (e.g. gap conductance), however, was improved properly and applied to the present study. Other variables that are not applied to this study are supposed to have a conservative value.

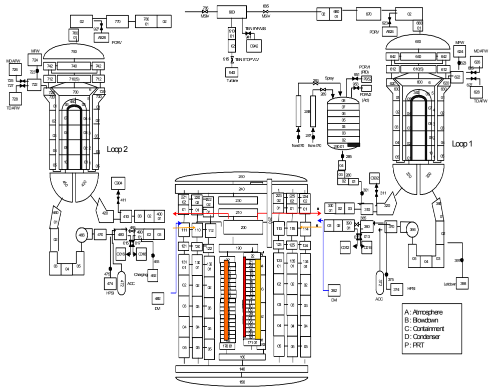

Figure 1 Nodalization for Kori Unit 2

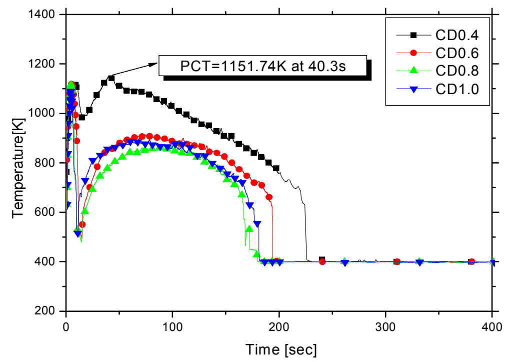

Figure 2 Spectrum analysis for C_D

2.3 Steady State Condition for 100% Power

The 'best-estimate' condition was applied for realistic LBLOCA simulation. This condition is achieved by combination of mean values of selected uncertainty variables. The principal plant conditions are obtained by referring to plant FSAR and design documents.

2.4 Uncertainty Calculation

Based on 18 uncertainty variables in Table 1, 124 independent input decks were generated, which reflected random variation of 18 uncertainty variables including gap conductance, fuel thermal conductivity, and so on. Each case was calculated using RELAP5/MOD3.3. And peak cladding temperature with 95% probability and 95% confidence level was obtained by 3rd Wilks' formula (Figure 3).

Table 1 Uncertainty variables

NO.	Variable	Mean	Range	Distribution
1	Gap conductance	0.785	0.67~0.9	Normal
2	Fuel thermal Conductivity	1	0.845~1.155	Normal
3	Core Power	1	0.98~1.02	Normal
4	Decay heat	1	0.934~1.066	Normal
5	Groeneveld CHF dial	0.985	0.17~1.8	Normal
6	Chen Nucleate boiling HT	0.995	0.53~1.46	Normal
7	T_min	1	0.54~1.46	Normal
8	Dittus Boelter, liquid dial	0.998	0.606~1.39	Normal
9	Dittus Boelter, Vapor dial	0.998	0.606~1.39	Normal
10	Bromley Film boiling	1.004	0.428~1.58	Normal
11	Break CD	0.947	0.729~1.165	Normal
12	Pump 2-phase Head Multiplier	0.5	0.0~1.0	Uniform
13	Pump 2-phase Torque Multiplier	0.5	0.0~1.0	Uniform
14	PZR Pressure [Mpa]	15.51	15.20~15.82	Uniform
15	Accumulator water temperature [K]	308.15	294.26~322.04	Uniform
16	Accumulator water volume [m3]	35.4	34.98~35.82	Uniform
17	Accumulator Pressure [MPa]	5.272	4.927~5.617	Uniform
18	RWST water temperature [K]	310.93	299.82~322.04	Uniform

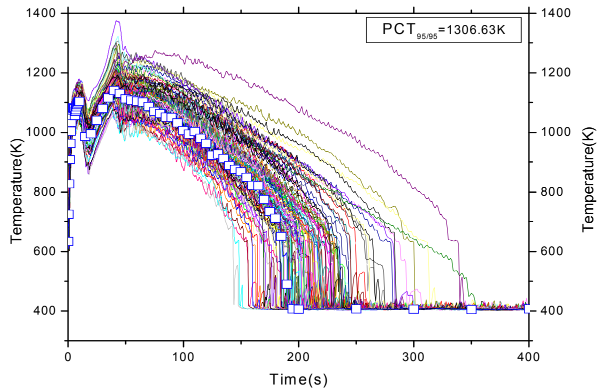

Figure 3 Behavior of peak cladding temperature

3. Evaluation of Steam Binding Bias

Analysis method of steam binding bias evaluation was developed. In this method artificial heat flux was imposed in U tubes in order to control the steam quality or enthalpy in suction part of cold leg (those results were compared with that of CCTF (cylindrical core test facility)). Such artificial heat flux in U tubes did not fatally affect the overall RCS behaviors. Consequently, the result could be evaluated as a proper bias of steam binding.

Figure 4 shows the effect of heat flux imposed in U tubes on the steam quality in suction part of cold leg. Figure 5 shows the effect of heat flux on peak cladding temperature.

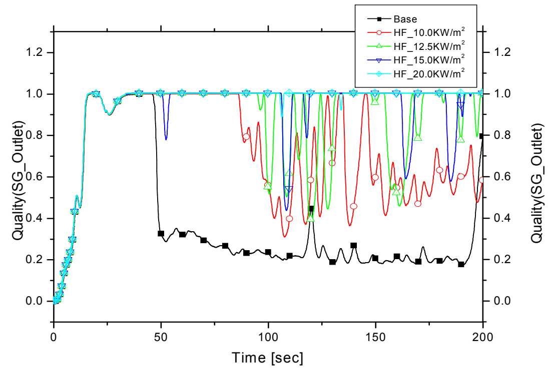

Figure 4 Steam Quality in suction part of cold leg when steam binding effect was considered

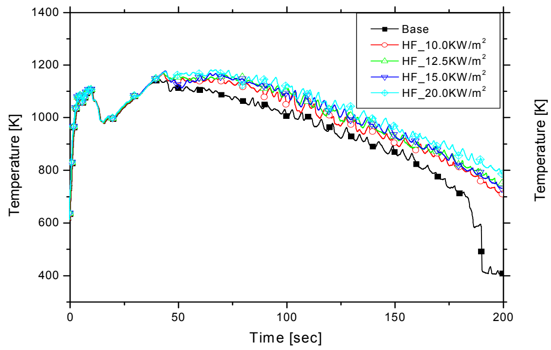

Figure 5 Peak cladding temperature when steam binding effect was considered

4. Conclusion

Throughout the uncertainty analyses and bias analyses, the final peak cladding temperature was obtained. And it was found that the peak cladding temperature was evaluated to meet the acceptance criteria. This study is expected to provide guidance for LBLOCA analysis with realistic evaluation method using RELAP5/MOD3.3 including steam binding bias for Westinghouse 2 loop plant with downcomer injection.

REFERENCES

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