Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-18, 2012

Thermal-Hydraulic Analysis for SBLOCA in OPR1000 and Evaluation of Uncertainty for PSA

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1. Introduction

Probabilistic Safety assessment (PSA) is a mathematical tool to evaluate numerical estimates of risk for nuclear power plants (NPPs). But PSA has the problems about quality and reliability since the quantification of uncertainties from thermal hydraulic (TH) analysis has not been included in the quantification of overall uncertainties in PSA. From the former research, it is proved that the quantification of uncertainties from best-estimate LBLOCA analysis can improve the PSA quality by modifying the core damage frequency (CDF) from the existing PSA report.

Basing on the similar concept, this study considers the quantification of SBLOCA analysis results. In this study, however, operator error parameters are also included in addition to the phenomenon parameters which are considered in LBLOCA analysis.

2. Analysis Method

In this study, MARS3.0 code is used to analyze SBLOCA in OPR1000, which is best-estimate code and has been developed at Korea Atomic Energy Research Institute (KAERI) by consolidating and restructuring the RELAP5/MOD3.2 code and COBRA-TF code. Optimized Power Reactor 1000 (OPR1000), which is the standard nuclear power plant in Korea, is selected as the objective plant. Figure 1 shows the nodalization of OPR1000 for MARS code analysis.

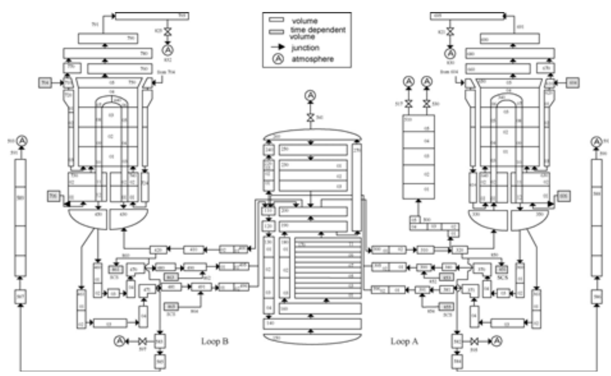

Fig. 1. Nodalization used for MARS code calculation

2.1 Accident Sequence

Among the results of SBLOCA from the existed PSA report, two sequences are picked up as the accident sequences. One sequence has the highest CDF from the existed PSA report. During the accident heads, steam removal via atmosphere dump valves fail but core is stably cooled down. Although it does not have the high CDF of all SBLOCA sequences, the other sequence ends in the core melt since core decay heat removal by bleed RCS operation fails.

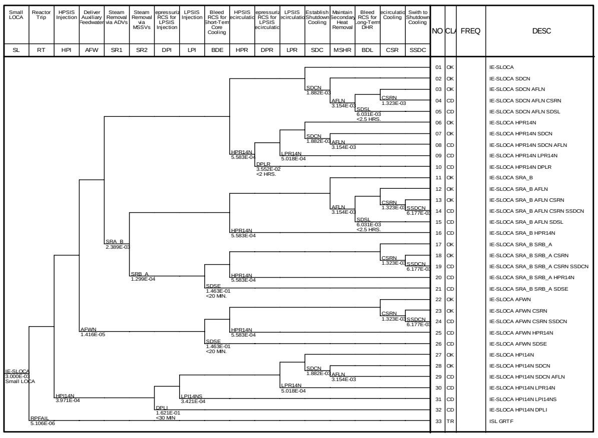

Fig. 2. Event tree of SBLOCA

2.2 Effective Parameters

A set of effective parameters should be chosen for the evaluation of uncertainty. The set of parameters can affect the result of thermal hydraulic analysis by the uncertainty range of each. There are two types of parameters : phenomena identification and ranking table (PIRT) and operation parameters. Phenomena parameters come from the research for LBLOCA analysis which is already performed[1] and operation parameters are chosen considering the system of the plant and necessary operation actions to cope with the accident. Table 1 and table 2 show PIRT and operation parameters, respectively.

2.3 Random Sampling

The parameters in table 1 and table 2 have each uncertainty range. Each certain value randomly picked from each range is entered into MARS code input. Therefore one input is got considering the multiple effect of uncertainty of all parameters. In this study, 200 input decks by random sampling are used to evaluate the uncertainty.

3. Conclusions

The study to evaluate the uncertainty effect is ongoing. This research is expecting that an accident

Table 1: PIRT

	Parameter	Distribution	Uncertainty Range	Reference Value	Description
1	Gap Conductance	Uniform	0.05 mm – 0.360 mm	0.092 mm	3σ
2	Power Peaking Factor	Uniform	1.50535 - 1.71465	1.61	2σ(±5.6%)
3	Operating Plant Power	Normal	98% - 102%	2815	
4	Decay Heat	Normal	93.4% - 106.6 %	ANS79-1	2σ(±6.6%)
5	Axial Power Distribution	Top/bottom	Assumption	8th node	±3 nodes
6	Fuel Thermal Conductivity	Normal	90% - 110 %	table	Function of temperature
7	Cladding Thermal Conductivity	Normal	88% - 112 %	table	Function of temperature
8	Pellet Heat Capacity	Normal	90% - 110 %	table	Function of temperature
9	Discharge Loss Coefficient	-	-	-	Not determined yet
10	Heat Transfer Coefficient	-	-	-	Not determined yet

Table 2: Operation Parameters

	Parameter	Distribution	Range	Nominal Value
1	RCP Trip	Uniform	10 – 15 K	trip signal from subcooled margin 12.5 K
			1 – 5 min	trip 3 min after trip signal
2	Feedwater Injection	Uniform	0.2 – 0.27	SG water level down : 23.5 %
3	HPSI Injection	Uniform	15 – 45	30 s after injection signal
	HPSI Flowrate	Uniform	-20 - +20 %	default value from input deck
4	Break Area	Uniform	0.0008 – 0.02 ft^2	0.0104 ft^2

scenario which was considered as cooling failure scenario can have the probability to end in safe state, not core melt. On the contrary to this, an accident scenario which was considered finally safe can head partially toward the core meltdown. Even if it is confirmed that the probability is zero, this kind of approach to evaluate the effect of uncertainty in thermal hydraulic analysis for PSA will be significant.

REFERENCES

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