Development of Trend Map on the Plant Initial Condition Using Sensitivity Study in the Non-LOCAs

Ilsuk Lee

Korea Institute of Nuclear Safety

Introduction

1. Determination of event scenario
2. Selection of plants
3. Making a PIRT

1 단계
규제검증평가 모델 정의

불확실도 평가 :
Physical Model, Calibration parameter, Unknown constant.
민감도 분석 :
경계/초기 조건, 독립변수

4. Specifying Codes
5. Codes Assessment
6. Defining NPP Modeling and Nodalization

2 단계
규제검증코드 검증 및 평가

불확실도 평가 : 실험자료(SET*, IET**)를 이용하여 범위와 분포 도출, 산업 전반적으로 널리 알려진 방법 이용

7. Base Calculation of the NPP
8. NPP Sensitivity Calculations
9. Final Assessment of the Events

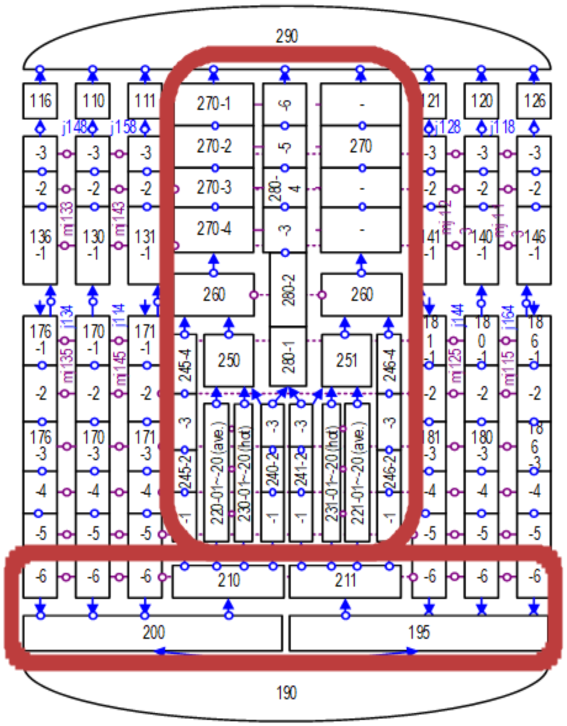
3 단계
원전 안전여유도 평가

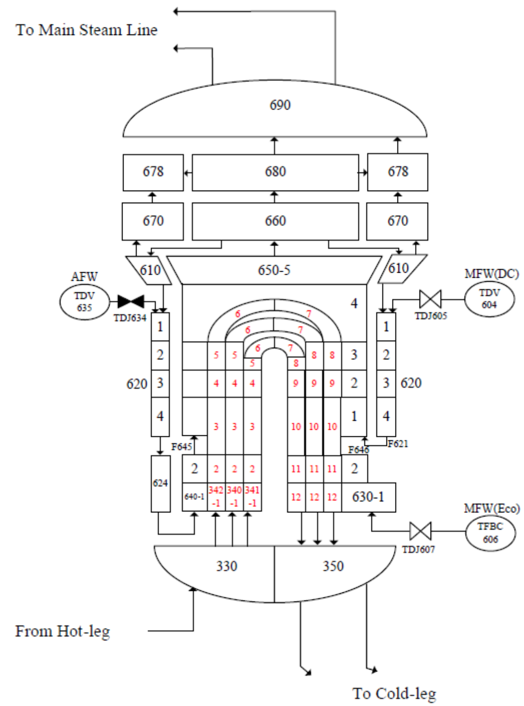
민감도 분석 :
Pearson 계수 또는 **Spearman** 순위 계수

정량화 :
Wilk's Formula (95/95)

In step 8 of Non-LOCA methodology by KINS, sensitivity study can be the best way to compensate on the bias and error for regulatory conservatism from the unknown parameters or methodology

Modeling applied to multiple channel

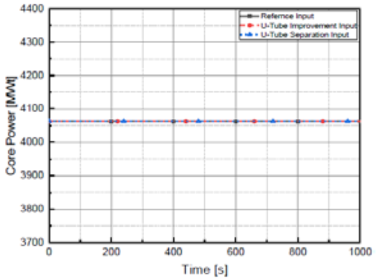


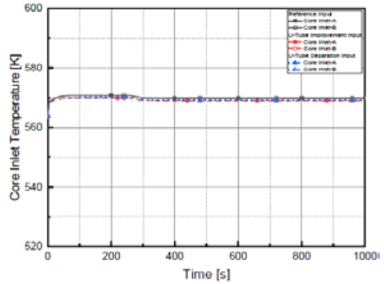


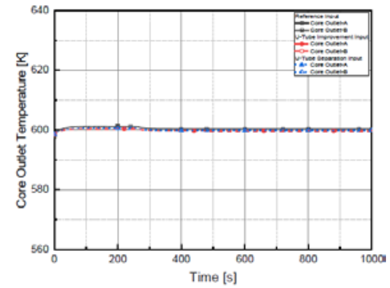
Reactor core : in order to analyze the core asymmetry, core is consist of 2 hottest channels, 2 hot channels and 2 average cores

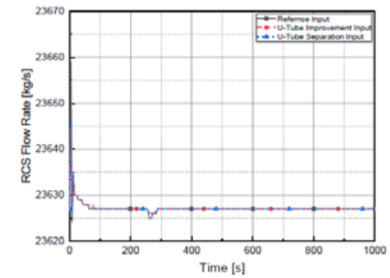
Steam Generator : U-tubes in the SG is divided into three-part considering the length of U-tubes with the latest design data

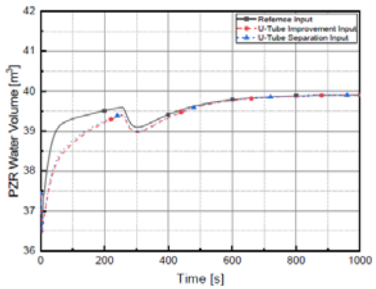
Steady state results of ARP1400

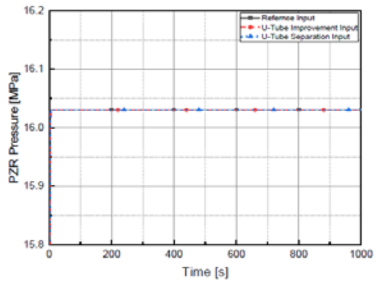


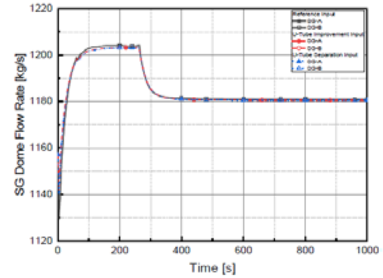


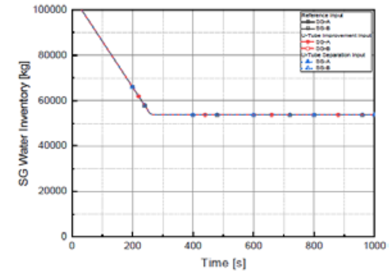


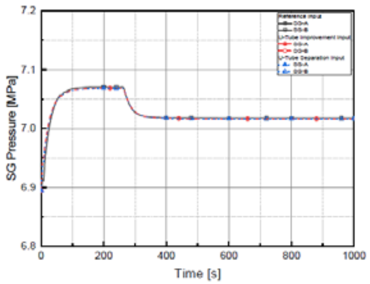


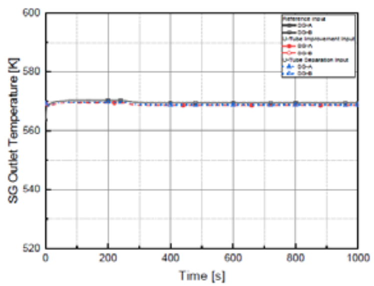


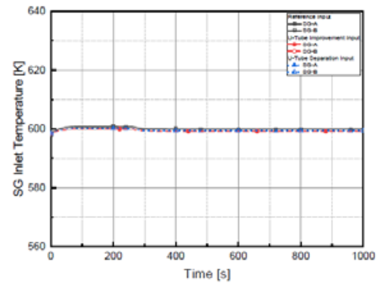


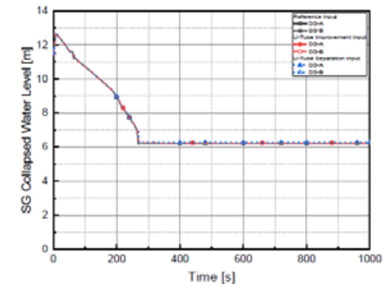












Sensitivity Matrix – MSLB

- **Initial condition focusing on fuel damage in the range of LCO**

TEST No.	Parameter			Remark
	RCS Flow (%)	Core inlet Temp. (K)	FTC	
Reference	**112.56**	**569.25**	**EOC**	**RCS flow-High / core inlet temp. -High**
Case 1	112.56	569.25	**BOC**	
Case 2	**95.0**	569.25	EOC	RCS flow – Low
Case 3	**97.5**	569.25	EOC	
Case 4	**100.0**	569.25	EOC	RCS flow – Normal
Case 5	**102.5**	569.25	EOC	
Case 6	**105.0**	569.25	EOC	
Case 7	**108.0**	569.25	EOC	RCS flow – High
Case 8	112.56	**560.95**	EOC	Core inlet temp. – Low
Case 9	112.56	**562.0**	EOC	
Case 10	112.56	**564.0**	EOC	
Case 11	112.56	**566.0**	EOC	
Case 12	112.56	**567.53**	EOC	Core inlet temp. – Normal

Sensitivity Matrix – MFLB

- **Initial condition focusing on fuel damage in the range of LCO**

TEST No.	Operating Parameters			MDNBR	
	RCS Flow (%)	PZR Pr.	Inlet Temp. (K)		
Case 1	92	15.65	569.11	1.3994	Reference
Case 2	**95**	**15.65**	569.36	**1.432**	RCS Flow
Case 3	**100**	**15.65**	569.78	**1.5089**	
Case 4	**105**	**15.65**	570.17	**1.5502**	
Case 5	**110**	**15.65**	570.54	**1.6058**	
Case 6	**115**	**15.65**	570.89	**1.6582**	
Case 7	92	15.0	569.25	**1.3214**	PZR Pr.
Case 8	**92**	**15.25**	**569.2**	**1.3399**	
Case 9	**92**	**15.5**	**569.14**	**1.3716**	
Case 10	**92**	**15.75**	**569.09**	**1.4113**	
Case 11	**92**	**16.0**	**569.04**	**1.436**	
Case 12	**92**	**15.65**	**560.83**	**1.5649**	Inlet Temp.
Case 13	**92**	**15.65**	**562.86**	**1.5258**	
Case 14	**92**	**15.65**	**564.91**	**1.5009**	
Case 15	**92**	**15.65**	**567.07**	**1.4469**	

Sensitivity Matrix – Seized RCP Rotor

- **Initial condition focusing on fuel damage in the range of LCO**

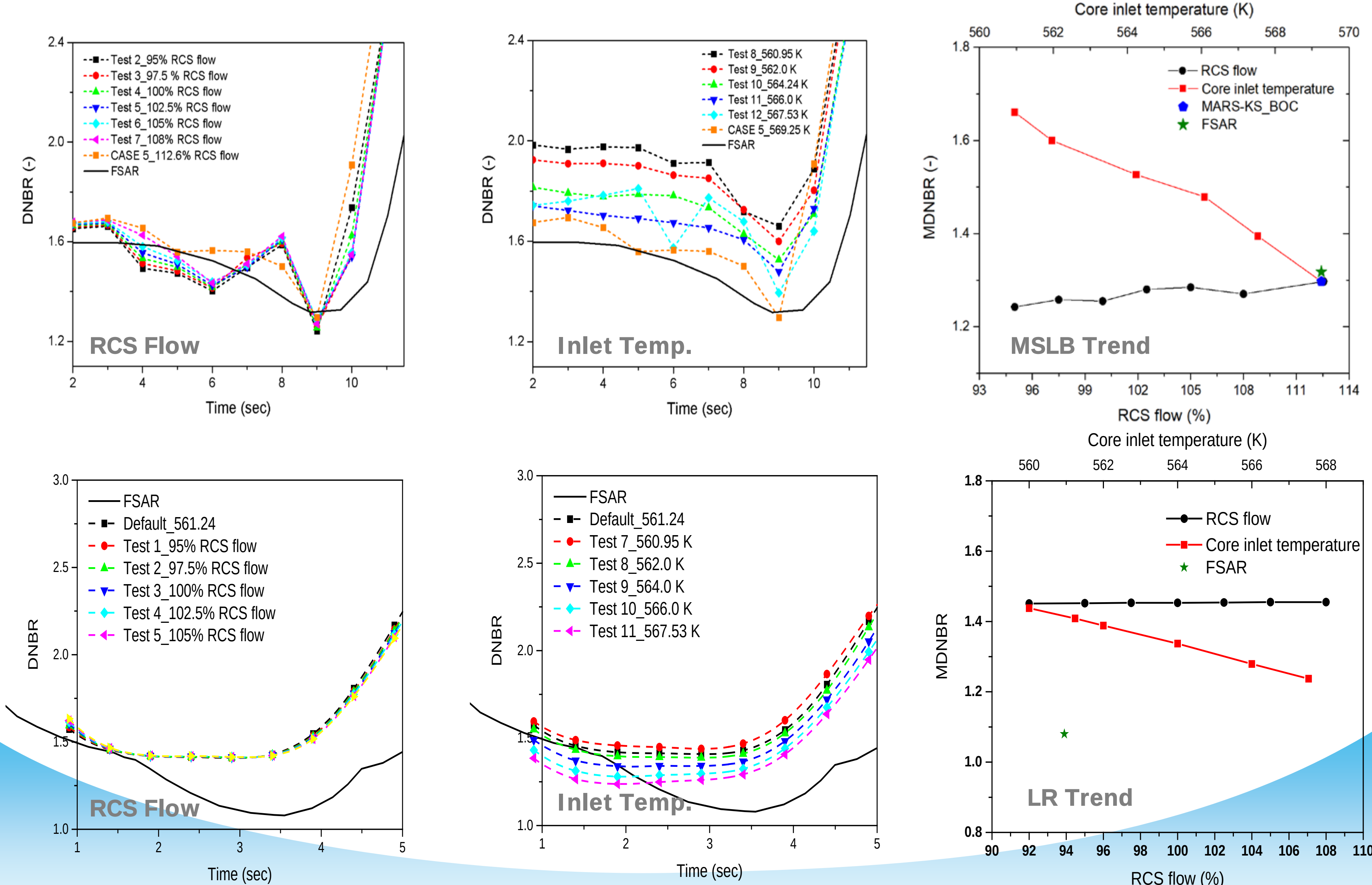
TEST No.	Parameter		Remark
	RCS flow (%)	Core inlet temp. (K)	
Reference	92.0	561.24	
Test 1	**95.0**	561.47	RCS flow – Low
Test 2	**97.5**	561.66	
Test 3	**100.0**	561.84	RCS flow – Normal
Test 4	**102.5**	562.02	
Test 5	**105.0**	562.19	
Test 6	**108.0**	562.39	RCS flow – High
Test 7	92.0	**560.95**	Core inlet temp. – Low
Test 8	92.0	**562.0**	
Test 9	92.0	**564.0**	
Test 10	92.0	**566.0**	
Test 11	92.0	**567.53**	Core inlet temp. – Normal

Sensitivity Matrix – SGTR

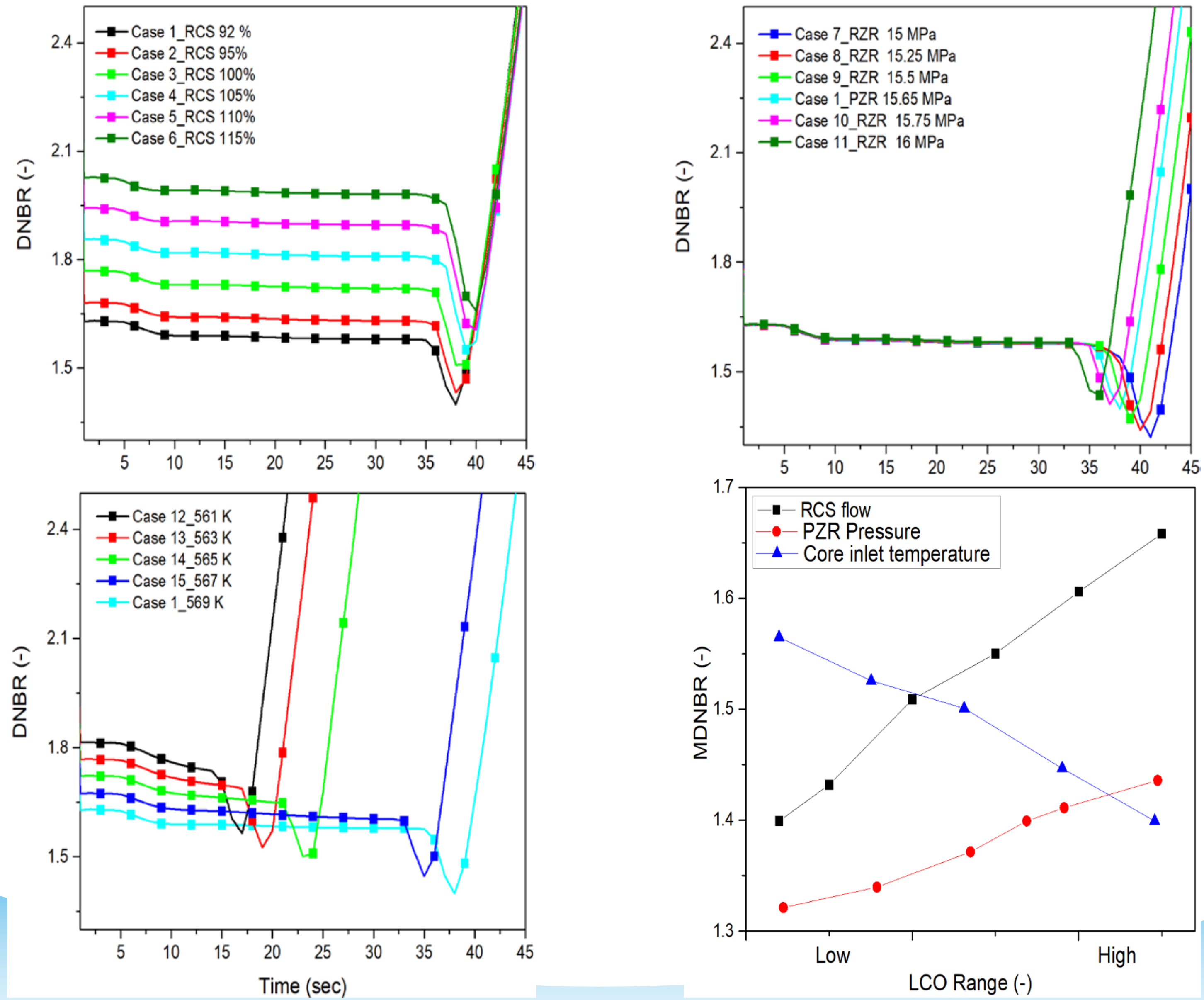
- **Initial condition focusing on fuel damage in the range of LCO**

TEST	Parameter						MDNBR (-)
	F_R (-)	P_{PRZ} (MPa)	$T_{c,i}$ (C)	$W_{c,i}$ (kg/sec)	M_{SG} (kg)	LOOP	
Default	1.8236	16.03	294.89	19344 (92%)	1.2E5	No	1.2053
2p1	-	15.80	294.94	-	-	-	1.2046
2p2	-	15.50	295.0	-	-	-	1.2035
2p3	-	15.30	295.05	-	-	-	1.2029
2t1	-	16.03	293.36	-	-	-	1.2300
2t2	-	-	292.11	-	-	-	1.2508
2t3	-	-	289.90	-	-	-	1.2868
2t4	-	-	286.94	-	-	-	1.3353
2w1	-	-	294.89	19942 (95%)	-	-	1.2428
2w2	-	-	-	20992 (100%)	-	-	1.3121
2w3	-	-	-	22041 (105%)	-	-	1.3861
2w4	-	-	-	23091 (110%)	-	-	1.4547
2m1	-	-	-	19344 (92%)	1.22E5	-	1.2020
2m2	-	-	-	-	1.18E5	-	1.2092
2l1	-	-	-	-	1.2E5	Yes	1.2053
3f1	1.50255	-	-	-	-	No	1.4629

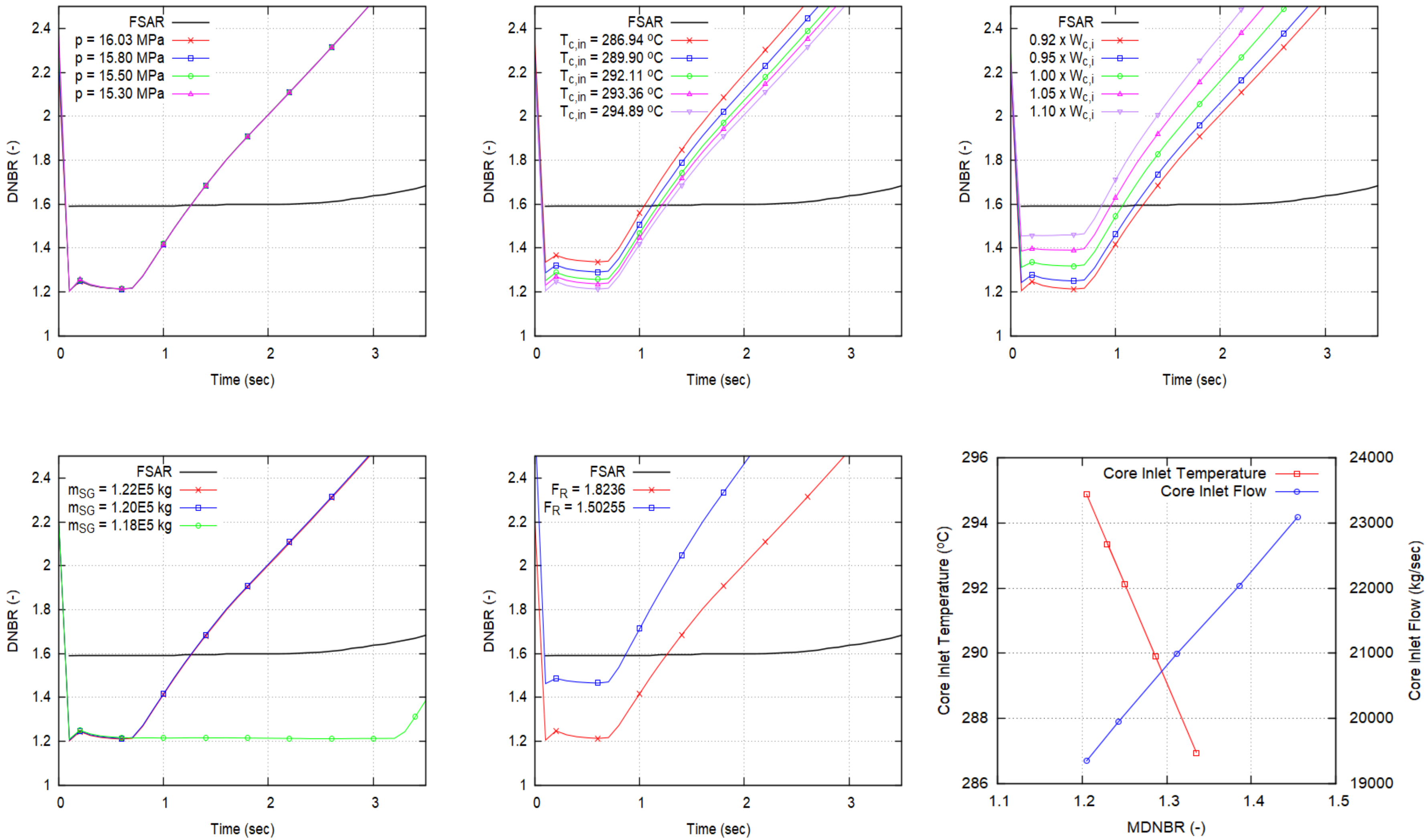
Results – MSLB, Seized RCP Rotor



Results – MFLB



Results – SGTR



Conclusion

- **System code was unable to show the effect in detail on the RCS flow deviation in the MSLB and seized RCP rotor**
- **Thus, system code was not partially suitable to analyze the DNBR**
- **It is crucial to make sure the conservative initial and assumption for a regulatory safety review**
- **Thus, this study needs to analyze more operating parameters in the initial conditions to finalize the trend map in the near future**

원자력 안전
KINS가 만들어 갑니다!

감사합니다

한국원자력안전기술원
KINS KOREA INSTITUTE OF NUCLEAR SAFETY