

1 RELAP5/MOD3/CANDU⁺ 가

Assessment of RELAP5/MOD3/CANDU⁺ to Wolsung-1 D₂O Leakage Event

150

19

RELAP5/MOD3/CANDU⁺

가 , '94 10 20 1

가 #4 가

, 가 1000

2

, RELAP5/MOD3/CANDU⁺

RELAP5/MOD3/CANDU⁺

가

MOV (Motor Operated Valve)

Abstract

In order to evaluate the integrated performance of RELAP5/MOD3/CANDU⁺ for CANDU operational transient analysis, we assessed the code to the D₂O leakage event occurred at Wolsung-I, 600 MW(e) CANDU reactor, on Oct. 20, '94. D₂O leakage event was initiated by stuck opening of liquid relief valve No. 4 in primary coolant pressure and level control system. Assessment calculation was performed for the plant transients up to 1000 seconds after the initiating event. Calculation results are compared with those measured in primary heat transport system, pressure and inventory control system and boiler secondary system. Comparison with the plant trip log shows that the RELAP5/CANDU⁺ is able to simulate the plant transients properly, from which we can conclude that the RELAP5/CANDU⁺ is validated for application to CANDU operational transient analysis. CANDU specific models used in the assessment are fuel bundle heat transfer model, decay heat model and MOV(Motor Operated Valve) model.

1.

USNRC RELAP5/MOD3
 , RELAP5/MOD3
 . RELAP5/MOD3
 RELAP5/MOD3/CANDU⁺ (RELAP5/CANDU⁺) 2000
 , , digital control
 sampling , MOV , , Henry-Fauske Moody ,
 가 [1].
 USNRC RELAP5/MOD3.3 Beta
 [2].
 RELAP5/CANDU⁺ 가
 , '94 10 20 1
 #4 가 가 ,
 , 2
 가 가
 , MOV (Motor
 Operated Valve) .

2. 1

1994 10 20 05 09 1
 Diaphragm 가 가
 [3,4]. , 가
 , 가
 가 가
 가 05 11
 , 가
 , 가
 , 05 25 가
 . 05 17 , 05 26
 가 , 가
 , 가
 ,

가 06 56

가

2~3

6.5 가

, 08 10

1

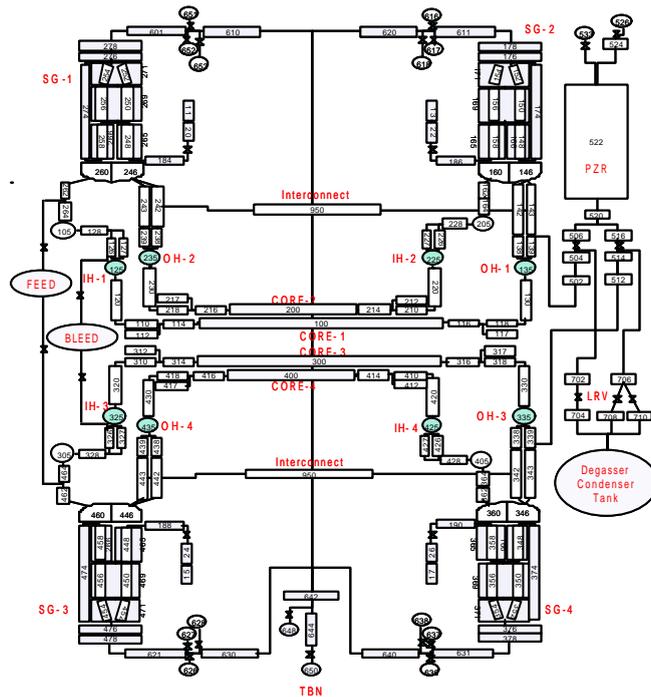
1. 1

Time	Event
0.0	LRV-4 Stuck Open
8.0	DCT Pressure High Alarm
56.0 ~ 59.0	DCT Spray PCV 24 Full Open, PCV 25 Open
79.0	PV 16, LCV 8, 15 Close
95.	DCT Level High Alarm
120.	Reactor Trip
157	PZR Heater Trip by PZR Low Level
266.	PHTS P less than 60 bar
291.	DCT P High Alarm
344.	D2O Storage Tank Low Level Alarm
406.	PZR Heater On by PZR Level Recovery
480.	Manual Turbine Trip
484.	PHTS P Recovery
571.	DCT PV 16, LCV 8, 15 Close Alarm Clear
884.	PZR Level Recovery
893.	PCV 24, 25 Auto Close
950.	DCT P Very High
1010.	PZR Level Setpoint Changed by Operator
1560.	BPC Hold -> Cooldown (CSDV Open)
2122.	PZR L Setpoint Change by Operator
2758.	PHTS Cooldown using BPC Program
4588.	PHTS P maintained at 94. bar
4828.	PHTS P increase up to 98.9 bar
6394.	RV 11 starts to Open & Close
6394.	RV 12 starts to Open & Close
6395.	DCT P Very High Alarm Clear
6411.	F/M Vault C-side Leak Alarm
6435.	RV 11 Close
6438.~6440.	FM High Temperature Alarm
6581.~6593.	CV High Pressure and Isolation
6601.	Heater Trip by DCT Low Level
~ 6878.	RV 12 Close
6990.	Feed Pump Trip by Low Inlet P
7008.	HT Recovery Pump Operation Mode
7086.	Emergency Cooldown by SG
7145.	PHT Pump Stop
7179.	Emergency Cooldown by SG
7196.	Shutdown Cooling System Operation
10828.	PHTS Safe Shutdown

3. 1

3.1

1 600MW(e) 가 “8” 2
 95
 2 , , ,
 가 1 (30%)
) , ,
 Interconnect Pipe 가 가 , 가
 #1 #3
 가 Nodalization 1
 , 2 “8”
 2 , 2 2 , 2 ,
 Interconnect . 2 가



1. 1 Nodalization

3.2

, 2 가 (Degasser Condenser Tank)
 , 가 (Feed) (Bleed) (D₂O
 Storage Tank) (Liquid)

1

가
Nodalization

4

1

가

3.3

1

2

1

2. 1

Plant Parameter	Desired*	Simulated
Reactor thermal power	2052 MW(th)	2052 MW(th)
Loop Flow	1900 kg/s**	2124.0 kg/s
Pressurizer pressure	97.53 bar	98.4 bar
Pressurizer level	9.149 m	9.145 m
Maximum ROH pressure	99.61 bar	99.8 bar
Degasser Condenser pressure	13.05 bar	12.42 bar
Degasser Condenser level	1.229 m	1.16 m
ROH Temperature	583.42 K	583.5 K
Core Temperature Increase	46.6 K	46.8 K
SG Pressure	47.56 bar	46.5 bar
Steam flow	256.33 kg/s	256.34 kg/s
Feedwater temperature	460.61 K	460.61 K

* 1 [7]

** [8]

3.4

1

#4

가

RELAP5/CANDU⁺

가

가

가

가

가

1000

1000

2

가

가

#4

[8]

120

ANS94-4

, 가

1

2

가

Orifice

4. 가

3 가

가 1

5 ~ 10

가

, 가

[7]

3. 1

가

Event	Trip Log (sec)	Simulation (sec)
LRV-4 Stuck Open	0.0	0.0
DCT Spray PCV 24 starts to Open (13. bar)	-	2.0
DCT Spray PCV 25 starts to Open (26. bar)	-	8.1
PV 16, LCV 8, 15 Close*	79.0	79.0
DCT P High (60 bar)	68.0	50.0
DCT Level High (2.5 m)	95.	100.
PHTS Pressure Low (95 bar)	65.0	66.0
Reactor Trip*	120.0	120.0
PZR Heater Trip by PZR Low Level (0.8 m)**	157.0	252.0
PZR Level Recovery**	937.0	838.0

* 1 [4]

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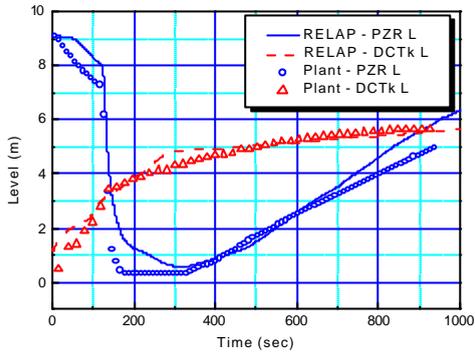
가 (6)

(6) (5)

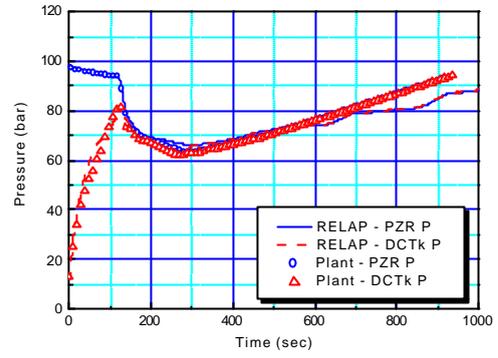
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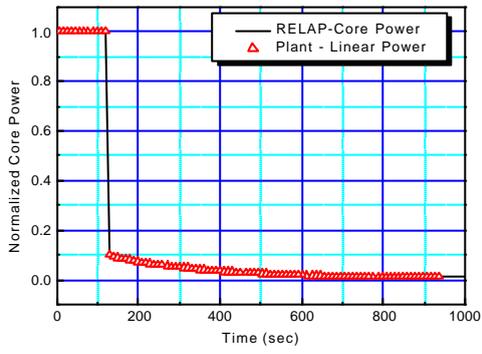
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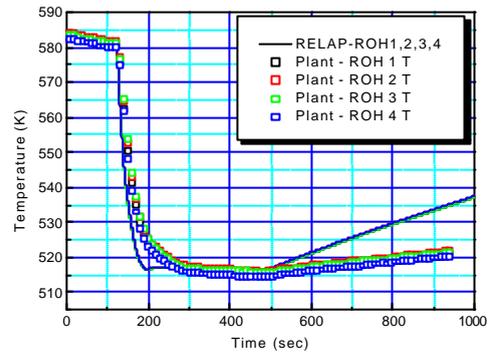
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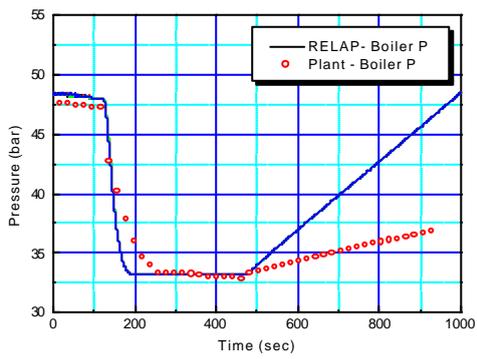
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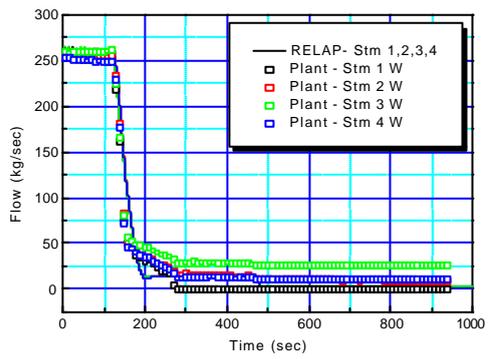
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