



Impact on the PSV Stuck Open according to the Henry-Fauske Model Modification in RELAP5/MOD3.3 (P05D03)

2014. 10. 30

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Introduction

Henry-Fauske Model Modification

- ❑ Modifications of Henry-Fauske (H-F) model in RELAP5/MOD3.3 are observed between patch 3 and patch 4 (Reference 1)
- ❑ Different flow areas are calculated at high pressure steam condition between two patches
- ❑ At low pressure condition or two phase discharge condition, H-F model shows different flow rate for the different flow areas

Purpose

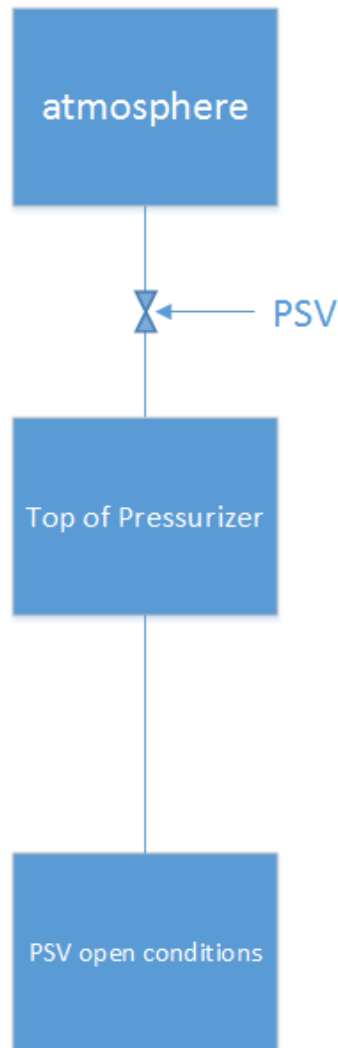
- ❑ Investigation about the impact on the PSV stuck open event according to the H-F modification in RELAP5/MOD3.3

Introduction

PSV Stuck Open Event

- ❑ Several POSs during the overhaul period
- ❑ PSV popping test is performed at POS2 for OPR1000 NPPs
- ❑ PSV stuck open is assumed at POS2 for LPSD PSA thermal-hydraulic (TH) analysis
- ❑ PSV area is calculated based on the design flow rate at high pressure setpoint
- ❑ PSV stuck open event provides two phase discharge
- ❑ Suitable to investigate the impact of H-F model modification

Method of PSV Area Determination



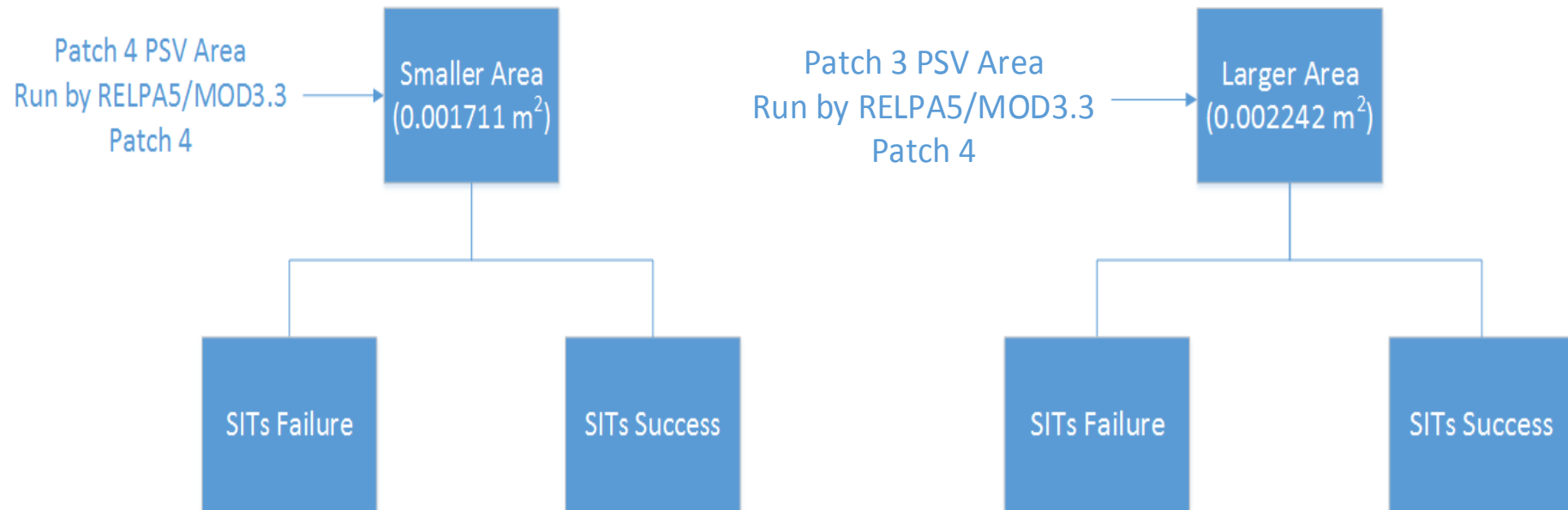
Parameter	Patch 4	Patch 3
PSV area (m ²)	0.001711	0.002242

- ❑ **PSV discharge flow rate (design) :
68.75 kg/s @ 17.237 MPa (2500 psia)**
- ❑ **Applying the Henry-Fauske (H-F) critical flow model, an iterative test is performed to get the PSV area at the design flow rate.**

Analysis Method

Case Analyzed

- ❑ Hanul Nuclear Power Units 3 and 4 (HUN 3&4)
- ❑ Run by RELAP5/MOD3.3 Patch 4
- ❑ PSV Area : 0.001711 m² and 0.002242 m²
- ❑ Cases : SITs injection success and failure



Analysis Method

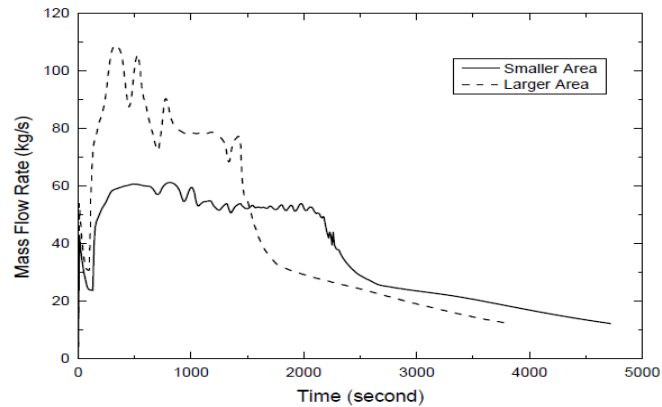
Major Assumptions and Initial Conditions

- Initial event : one PSV is opened during popping test
- HPSIPs : inoperable
- Fuel cladding failure criteria : 1477 K
- LPSIPs shutoff head : 1.45 MPa (success criteria)
- The SIT injection pressure : 4.31 MPa
- Initial conditions : PSV popping test conditions (Reference 2)

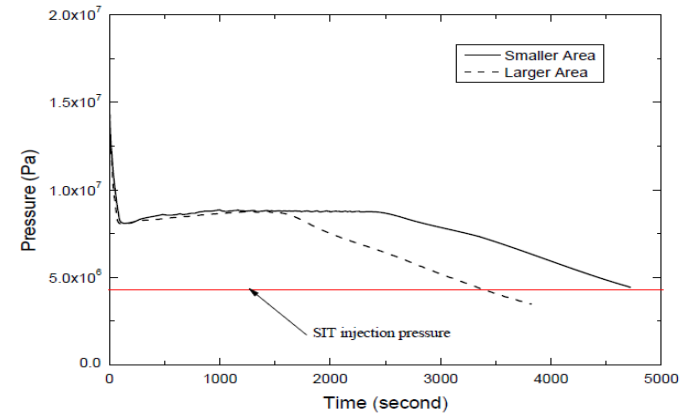
Analysis Results

Time to	SITs injection failure		SITs injection success	
	smaller area	larger area	smaller area	larger area
Core uncover	2882 sec.	2066 sec.	2882 sec.	2066 sec.
Fuel failure	4488 sec.	3605 sec.	4488 sec.	9263 sec.

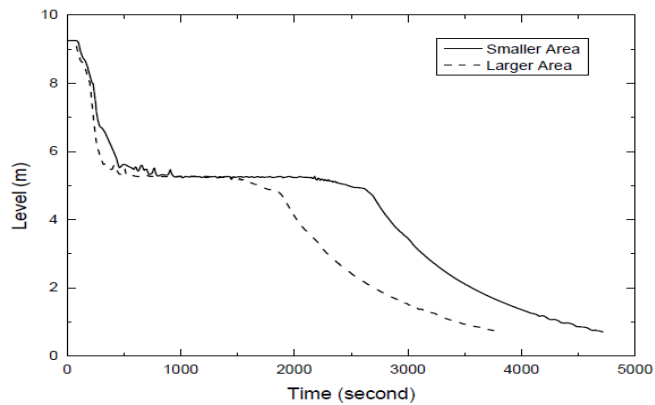
Analysis Results – SITs failure



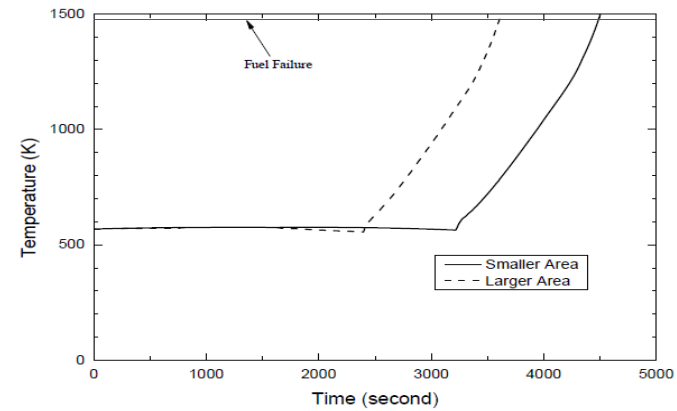
(a) PSV mass flow rate



(b) RCS pressure

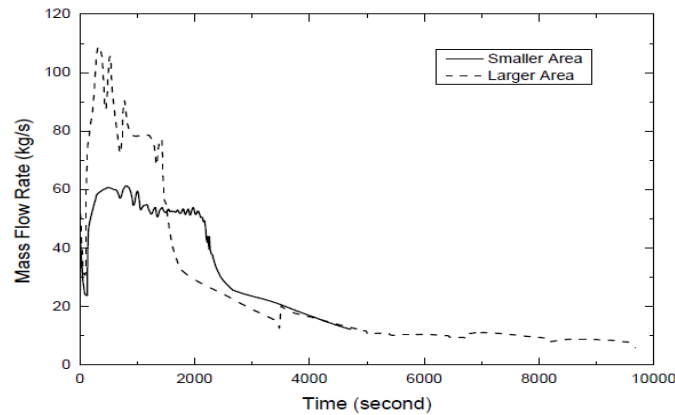


(c) Core level

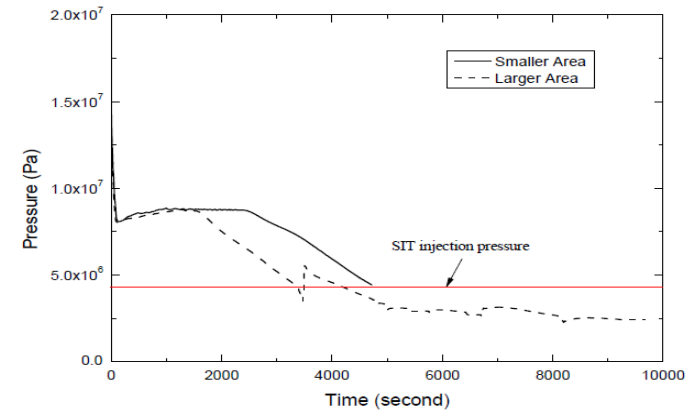


(d) Fuel cladding temperature

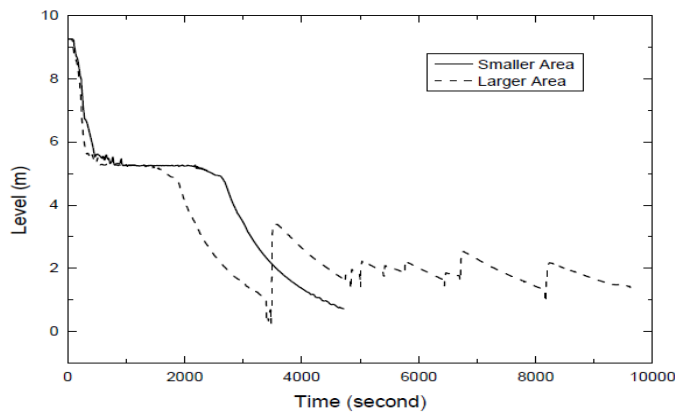
Analysis Results – SITs success



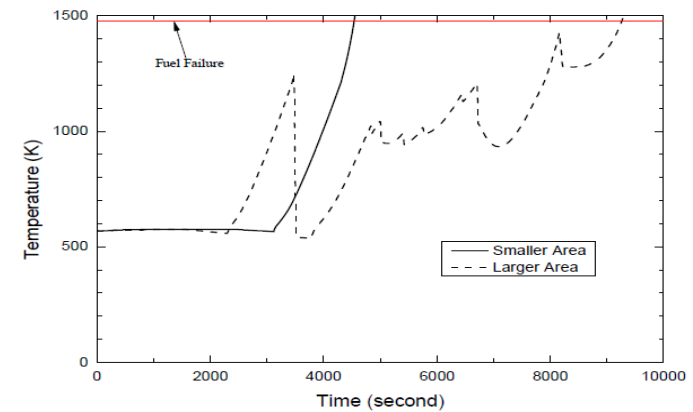
(a) PSV mass flow rate



(b) RCS pressure



(c) Core level

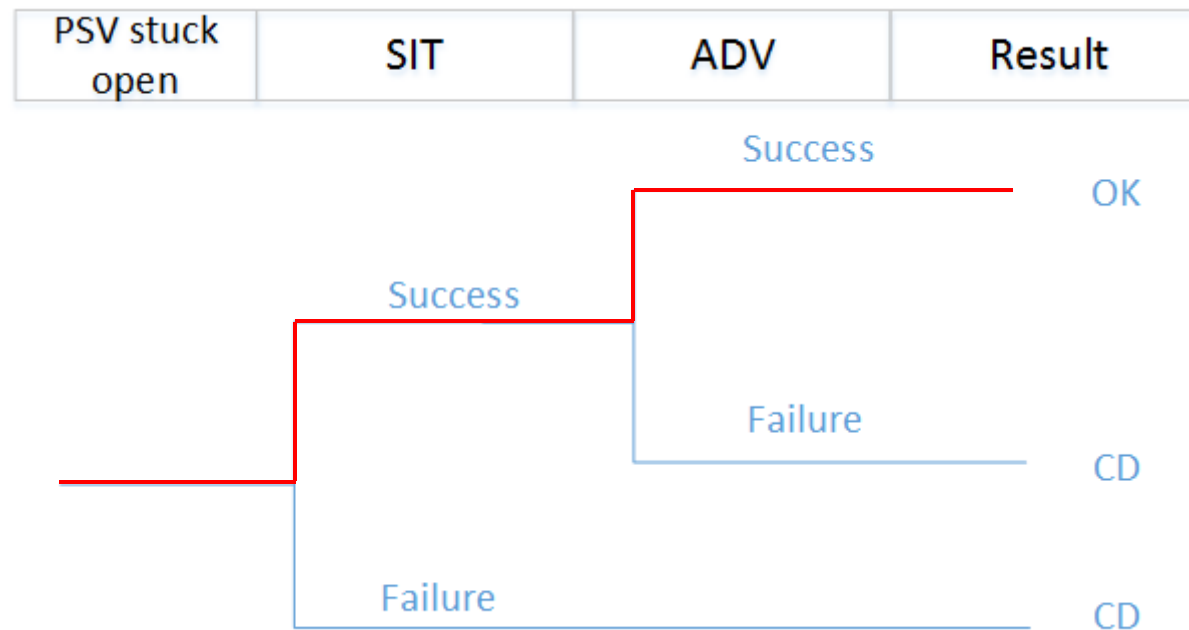


(d) Fuel cladding temperature

Impact on the LPSD PSA

Success Path of the PSV Stuck Open Event

- Opening ADV to cooldown RCS to LPSIP shutoff head



Impact on the LPSD PSA

Increasing Human Error Probability

- The time to open ADV becomes faster

Parameter	Patch 4	Patch 3
PSV area (m ²)	0.001711	0.002242
Time to open an ADV (second)	1800	6000

Operator Available Time	PSFs
equal or less than 20 minutes	X 3
equal or less than 40 minutes and more than 20 minutes	X 2
more than 40 minutes	X 1

Conclusion

Impact on the PSV Stuck Open Event

- ❑ The critical flow rate is increased at high pressure due to the modification of H-F model in RELAP5/MOD3.3 patch 4
- ❑ Simulated PSV area is decreased due to the modification of H-F model
- ❑ Change in PSV area impacts on the TH behaviors
- ❑ PSA modeling can be changed depending on the TH analysis results

Further Works

- ❑ Two phase discharge design data needs to be justified
- ❑ Analysis method to simulate discharge area at two phase discharge or low pressure conditions



References

1. Cheol Woo Kim “Comparison of Critical Flow in RELAP5/MOD3.3 Patches,” 2014 NuSTEP Summer Meeting, July 16th, 2014.
2. KHNP, “Operating Procedures of ULCHIN 3&4 Nuclear Power Plant”.

Abbreviation

- ❑ POS : Plant Operating States
- ❑ PSV : Pressurizer Safety Valve
- ❑ LPSD : Low Power and Shutdown
- ❑ SIT : Safety Injection Tank
- ❑ HPSIP : High Pressure Safety Injection Pump
- ❑ LPSIP : Low Pressure Safety Injection Pump
- ❑ RCS : Reactor Coolant System
- ❑ PSA : Probabilistic Safety Assessment
- ❑ ADV : Atmospheric Dump Valve
- ❑ CD : Core Damage
- ❑ CDF : Core Damage Frequency
- ❑ PSF : Performance Shaping Factor