# Sensitivity Study for Coolant Void Reactivity Uncertainty Evaluation

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## 1. Introduction

During the large break loss of coolant accident(LBLOCA) for CANDU reactors, power pulse due to the positive coolant void reactivity(CVR) affects the peak sheath temperature and fuel integrity. In safety analysis for CANDU LBLOCA, energy deposition in cladding was considered but the amount of energy deposition might be underestimated because the CVR was underestimated significantly. Canadian utilities have been re-evaluated the CVR increase and safety margins in LBLOCA. However the efforts by Canadian utilities and regulatory bodies, the bias and uncertainty of CVR in LBLOCA situation were not explained clearly till now.

## 2. Safety Margin Evaluation Methodology

Regarding the safety issue related to CVR increase in LBLOCAs for CANDU reactors, safety margin evaluation methodology was proposed in reference 1. Figure 1 presented the schematic of the proposed methodology.

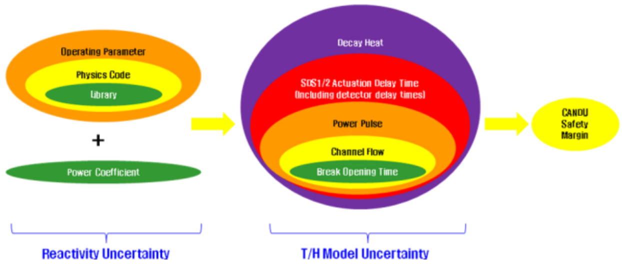


Fig. 1 The Impact of Uderestimated CVR in Safety Margin

In previous study, several comparisons and sensitivities were performed for libraries, computer codes and operating parameters related to LBLOCA situation.

As the next step, sensitivity study for thermal hydraulic parameters which can affects the phenomena in LBLOCA significantly. Parameters were chosen by referring the phenomena identification and ranking table(PIRT) result for CANDU LOCA. Chosen parameters were as bellow;

Distributions were selected based on the previous research results related the thermal hydraulic safety analysis uncertainty.

Table 1. Parameters for sensitivity analysis

| **Parameter** | **Distribution Range (Normalized)** |
|---|---|
| Core power | 0.98～102 |
| Initial temperature | 0.98～1.02 |
| UO2 Cp pellet | 0.845～1.15 |
| UO2 K pellet | 0.845～1.15 |
| Zircoly Cp pellet | 0.845～1.15 |
| Zircoly K pellet | 0.845～1.15 |
| Gap conductance | 0.67～1.5 |
| Critical heat flux (CHF) (Local boiling factor) | 0.17～1.8 |
| LOCA signal | 0.98～1.02 |

## 3. LBLOCA Sensitivity Analysis

To identify the range of peak sheath temperature during accident, 35% break of reactor inlet header(RIH) with loss of class 4 electric power was selected. With the loss of class 4 electric power, reactor coolant pumps were tripped earlier than the case of class 4 electric power available. This causes less peak sheath temperature.

To ensure the 95% of confidence, total number of cases were selected as 124 based on the Wilks formula as bellow;

$$q = 1 - [p^N + N(1-p)p^{N-1} + \frac{1}{2}N(N-1)(1-p)^2p^{N-2}] \quad (1)$$

For all parameters, random sampling using LHS code were performed and matrix for 124 calculation was generated.

### *3.1 MARS-CANDU for Wolsung 1*

For Wolsung nuclear unit 1, sensitivity study was performed using MARS-CANDU computer code. Based on the sensity scheme described, 124 calculations were performed and the results were presented in figure 2 to 3.

### *3.2 Comparison : MARS-CANDU vs. MARS-CANDU-SCAN for Wolsung 1*

SCAN is the computer code to calculate the neutron physics in CANDU core. For the exact estimation of CVR during LBLOCA, core physic calculation and

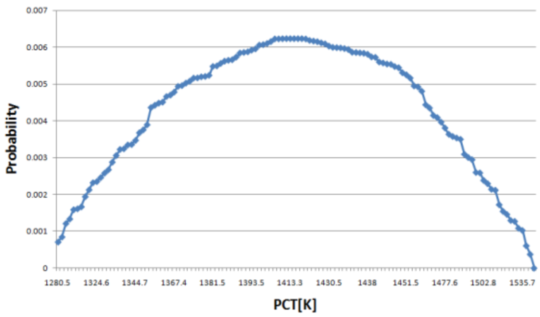


Figure 2. Probability Distribution of Peak Cladding Temperature in 35% RIH Break

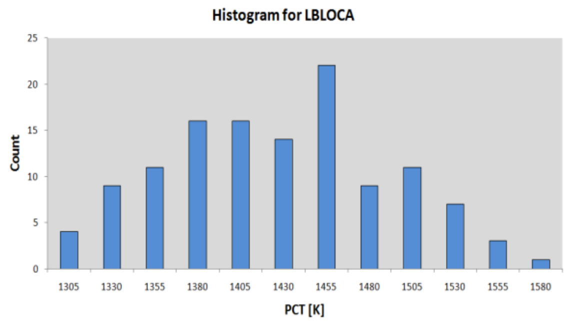


Figure 3. Histogram of Peak Cladding Temperature in 35% RIH Break

thermal hydraulic calculation were coupled. For this, MARS-CANDU and SCAN code were coupled. To verify the coupled code, same sensitivity calculations were performed using MARS-CANDU-SCAN and the results were compared.

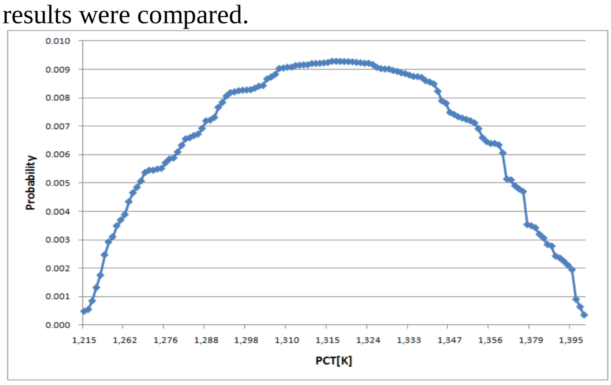


Figure 4. Probability Distribution of Peak Cladding Temperature in 35% RIH Break (MARS-SCAN)

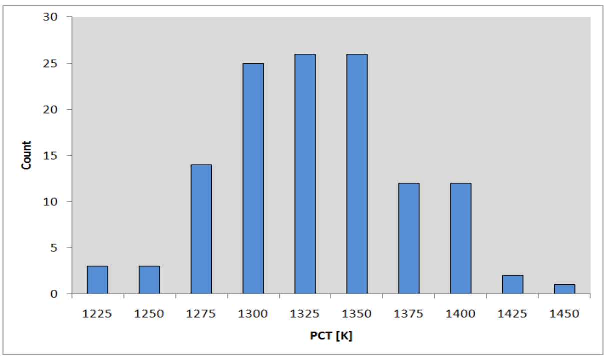


Figure 5. Histogram of Peak Cladding Temperature in 35% RIH Break (MARS-SCAN)

## 4. Conclusion

In 35% RIH break analysis using MARS-CANDU, the average peak sheath temperature was 1414.0K with standard deviation of 64.0K. The maximum temperature was 1565.8K.

In 35% RIH break analysis using MARS-CANDU-SCAN, the average peak sheath temperature was 1318.7K with standard deviation of 42.9K. The maximum temperature was 1428.1K.

Based on these results only, MARS-CANDU predicted peak sheath temperature higher than MARS-CANDU-SCAN up to 95K. For maximum temperature, MARS-CANDU predicted peak sheath temperature higher than MARS-CANDU-SCAN up to 138K. The reason for the underestimation of the coupled code should be found during the next research.

## REFERENCES

[1] Kap Kim et. al., Development of CANDU Void Reactivity Uncertainty Evaluation Methodology, Transactions of the Korean Nuclear Society Autumn Meeting, 2010

[2] Huichang Yang et. al., “Development of Regulatory Procedures for Evaluating the Uncertainties Identified in Void Reactivity Estimates for CANDU,” KINS/HR-1010, 2009