Assessment of Mitigating Strategies using CFVS and CVWM at CANDU Plant under Severe Accident Conditions

G. E. Choi*, K. H. Lee, J. Y. Lee

FNC Technology Co. Ltd, Heungdeok IT Valley, Heungdeok 1-ro, Giheung-gu, Yongin-si, Gyeonggi-do, Korea

*Corresponding author: autumn94@fnctech.com

Introduction

❖ **Background**

- Challenge of containment integrity under severe accident
  - Gradual increase of containment pressure due to heat removal absence
  - Calandria Vessel (CV) failure → rapid steam generation
- Mitigation system
  - Containment Filtered Venting System (CFVS)
  - Calandria Vault Water Makeup (CVWM)

❖ **Purpose**

- Establishment of appropriate mitigating strategies to use CFVS and CVWM for reducing fission product releases

Analysis Cases

❖ **Accident Sequences**

- Scenario: Station Black-Out (SBO)
- Analysis code: MAAP-ISAAC 4.03

❖ **Sensitivity Analyses Condition for CVWM**

- SBO-NE case: CVWM does not operate (base case).
- SBO-CVF case: CVWM operates 1 hour after the CV failure.
- SBO-CVI case: CVWM operates when the water level of the calandria vault decreases below the top of calandria vault.

❖ **Sensitivity Analyses Condition for CFVS**

- Vent initiating pressure : 224, 324, 424, 524 kPa(a)
  - * Varying with 6 inch diameter of the vent line
- Vent line size : 6, 8, 10, 12 inch
  - * Varying with 224 kPa(a) vent initiating pressure
- The closure pressure of the CFVS: 150 kPa(a)

Analysis Results I

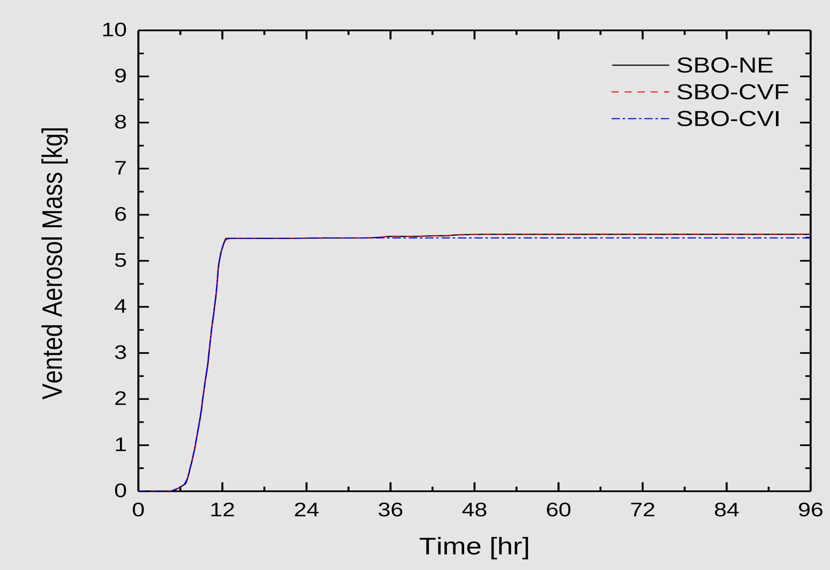
❖ **The Results of Sensitivity Analyses**

Accident Sequence	Vent Initiating Pressure (kPa(a))	Vent Line Size (inch)	Max. Venting Mass Flow Rate (kg/s)	Vented Radio-active Aerosol Mass (kg)
SBO-NE (Base)	224	6	7.7	5.57
		8	12.4	5.77
		10	20.4	4.81
		12	23.2	6.06
	324	6	8.9	6.24
	424	6	9.7	4.50
	524	6	11.4	1.05
SBO-CVF	224	6	7.7	5.57
		8	12.4	5.77
		10	20.4	4.81
		12	23.2	6.18
	324	6	8.9	6.31
	424	6	9.7	4.58
	524	6	11.4	1.05
SBO-CVI	224	6	6.1	5.50
		8	10.6	5.68
		10	16.5	4.71
		12	23.2	5.73
	324	6	7.8	5.88
	424	6	9.7	3.61
	524	6	11.4	0.37

Analysis Results II

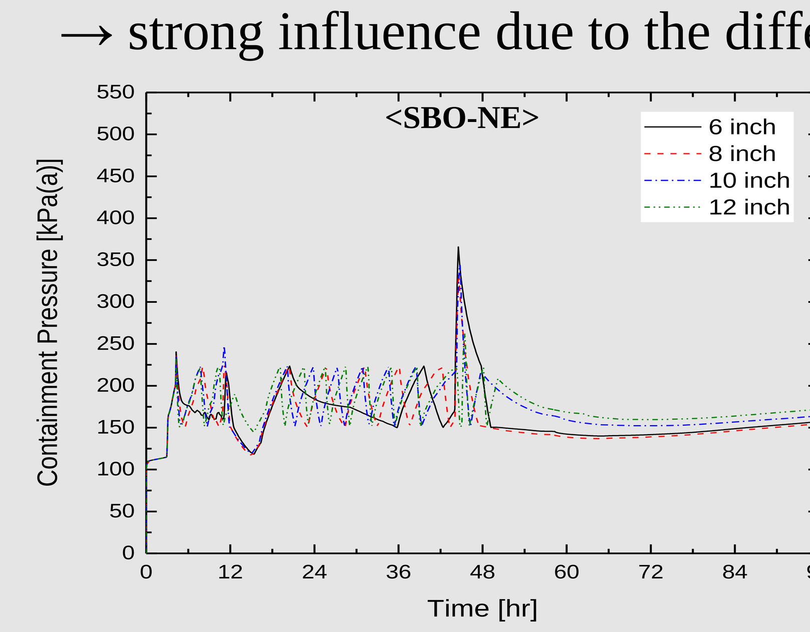
❖ **Sensitivity Analyses for CVWM**

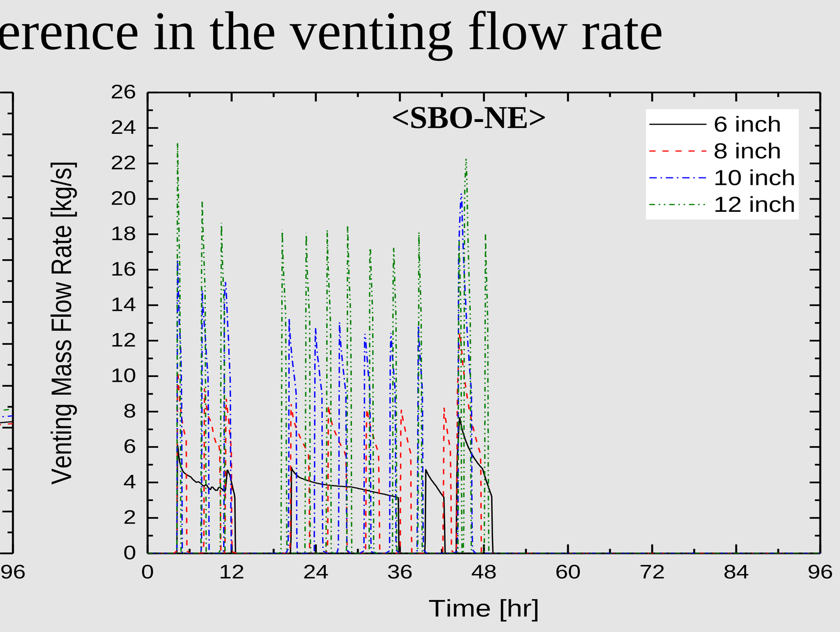
- **Operation of CVWM & Time of CVWM operation**
  - No remarkable difference of vented radioactive aerosol mass
    - ∴ Appropriateness of current mitigating strategies to operate CVWM before CV failure



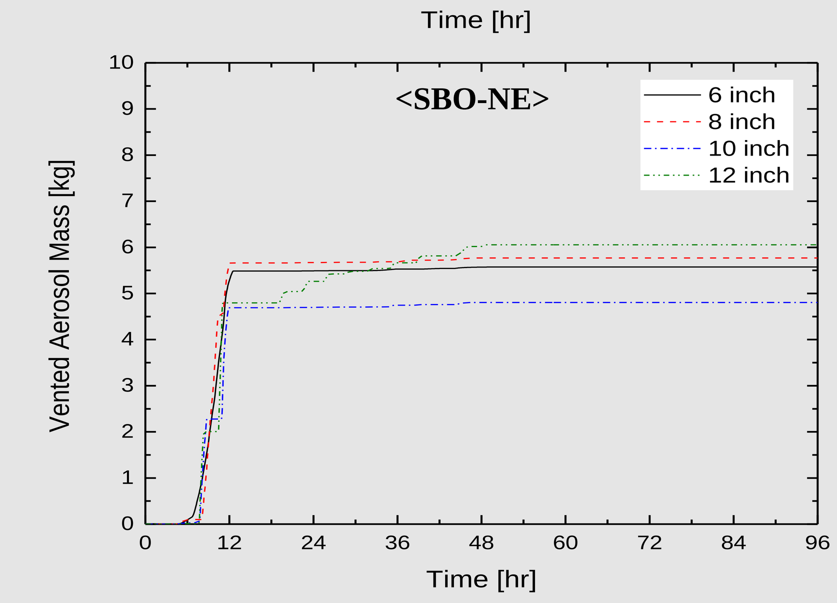
❖ **Sensitivity Analyses for CFVS**

- **Vent line size**
  - Behavior of the containment pressure
    → strong influence due to the difference in the venting flow rate

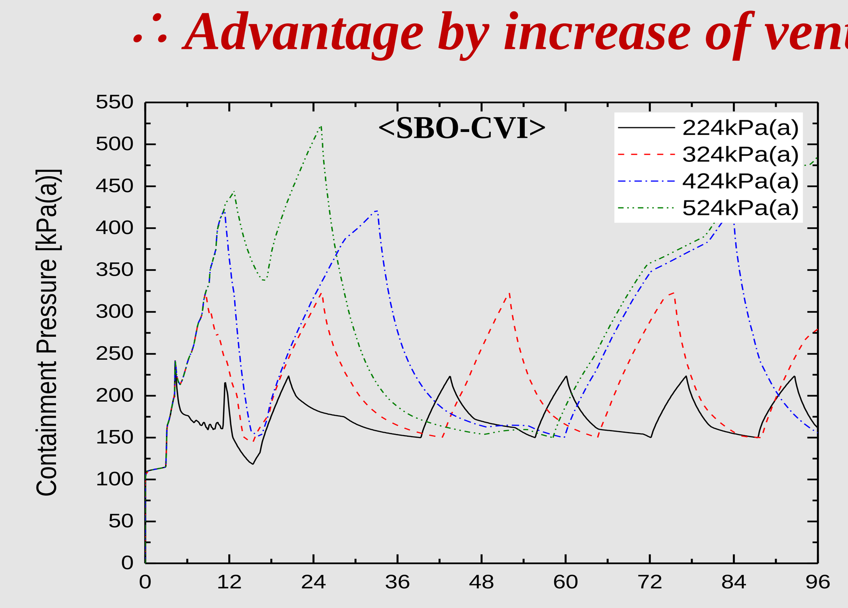


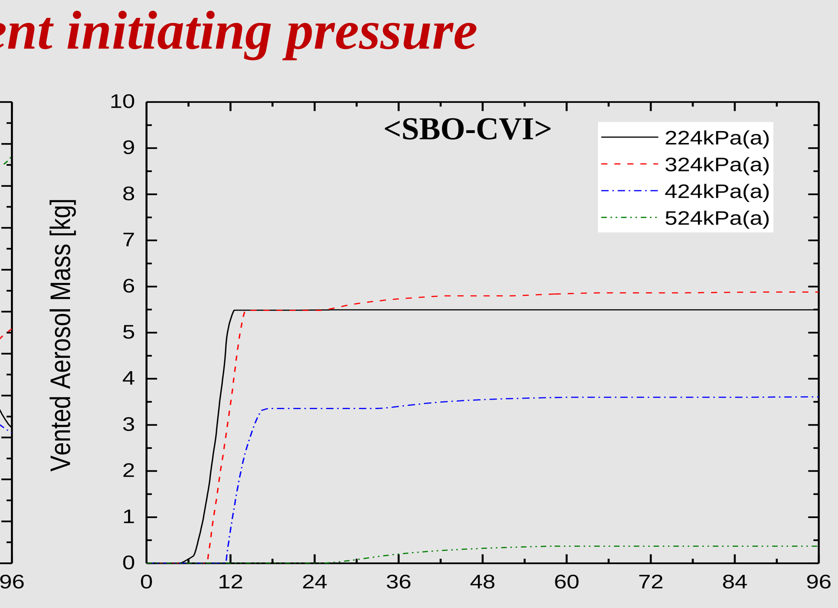


  - Behavior of vented aerosol mass
    → little influence
    - ∴ No need to modify the current vent line size of CFVS in the point of view to minimize fission product release



- **Vent initiating pressure**
  - Increase of vent initiating pressure
    → delay of venting
    → settlement and deposition of suspended particles (i.e. aerosol)
    → decrease of vented radioactive aerosol mass
    - *∴ Advantage by increase of vent initiating pressure*





Conclusion

❖ **CVWM operation in itself and the operation time do not contribute significantly in reducing the release of fission products.**

- Since the CV failure can cause various severe accident phenomena, current mitigating strategies using CVWM before CV failure is appropriate regardless of the fission products releases.

❖ **The vented aerosol mass is not affected by the vent line size strongly.**

- Therefore, it can be concluded that the current vent line size are appropriate to mitigate severe accidents.

❖ **Increase in vent initiating pressure gives positive effects to minimize the total releases of the fission products.**

- The current vent initiating pressure of CFVS in Wolsung NPP unit 1 is set to 224 kPa(a), the design pressure for Design Based Accident (DBA).
- Considering that CFVS is severe accident mitigating feature and there are positive effects by increasing the vent initiating pressure, it is required to re-evaluate the current set-point of CFVS operation carefully.