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The Effect of Containment Filtered Venting System on the Severe Accident Management Strategies of the CANDU6 Plant

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1. Introduction

In March, 2011, Fukushima daichi nuclear power plants experienced a long term station blackout and severe core damages and released a large amount of radioactive materials outside of the plants. After this accident Nuclear Safety and Security Commission (NSSC) decided to install a filtered containment venting system (CFVS) at all the operating nuclear power plants in Korean. To comply with NSSC's request, Wolsong Unit 1 has installed a CFVS. Current severe accident management guidance, which does not consider a CFVS has 6 severe accident management strategies for CANDU6 plant[1]. These strategies are 1) inject in to the primary heat transport system (PHTS), 2) inject in to the calandria, 3) inject into the calandria vault, 4) reduce fission product releases, 5) control containment conditions, 6) reduce containment hydrogen. The CFVS is designed to open and to close isolation valves by an operator. An operator opens the CFVS isolation valve when the containment pressure exceeds the design pressure (124 kPa(g)) and closes isolation valves when the containment pressure decreases below 50 kPa(g). The operation of the CFVS not only influences the current strategies (adds a means of controlling containment conditions) but also requires the new strategies. This paper discusses the necessity of the new strategies, such as the prevention of containment vacuum and the injection into the containment.

2. Prevention of Containment Vacuum

The station blackout accident is selected to examine the necessity of the prevention of containment vacuum strategy in CANDU6 plant. When the containment pressure exceeds the design pressure of the containment building, i.e. 124 kPa(g), the operator opens CFVS isolation valves. Then steam and air in the containment flows out to the environment through the CFVS and the containment pressure decreases. Operator closes CFVS isolation valves if the containment pressure drops below 50 kPa(g). The containment pressure oscillates between the open and the close set pressure of the CFVS as shown in Fig. 1. This oscillation continues until the containment fails by an over-pressurization after a reactor vault failure. During this pressure oscillation, the local air coolers (LACs) are assumed recovered and start an operation at 180,000 seconds (50 hours after SBO occurred). The operation of LACs condenses the steam in the containment atmosphere and decreases the containment pressure. A lot of air are expelled with steam from the containment atmosphere when the CFVS isolation valves are open. So the condense of steam by LACs results in the vacuum in the containment as shown Fig. 1. The containment for CANDU6 plant is not design to withstand against the negative pressure, but it may maintain its integrity up to the -15 kPa(g)[2]. The degree of the negative pressure depends on when LACs start to operate and how many LACs are operating. In Fig. 1 the containment pressure behavior are shown 12 LACs start to operate at 180,000 second. The negative pressure is almost -90 kPa(g). This negative pressure may results in the containment failure. To prevent containment failure by a negative pressure, a strategy which prevents a containment vacuum is required in the CANDU6 plant which has a CFVS. Containment pressure can be maintained near the atmospheric pressure by either LACs stop to operate or open the CFVS isolation valves when the containment pressure becomes negative.

3. Inject into Containment

After the corium penetrates the bottom concrete of the reactor vault, it reaches the basement. If the water does not exist in the basement, a core-concrete interaction occurs in the basement and the basemat melt-through occurs eventually. The previous study showed that the injection into the containment is not necessary for CANDU6 plant which does not install the CFVS[3]. When the CFVS operates, the steam generated in the basement flows out the containment and basement becomes dry out eventually. CANDU6 has a passive spray system. A spray operates automatically if the containment pressure exceeds 14 kPa(g) and stops automatically if the containment pressure reduces below 7 kPa(g). The basement is filled with enough water to cool the corium when a spray is operated successfully as shown Fig.2. The operation of a spray does not require an electrical power, but it may fail with very low probability. If a spray is not operated, then the water in the basement is not enough to prevent a core concrete interaction in the basement and the water supply to the basement is required to prevent a basemat melt-through. But this may happen at least 4 days after SBO occurrence and its probability is very low.

4. Conclusions

The necessity of the additional severe accident management strategies for CANDU6 plants which installed a CFVS is evaluated. During the operation of CFVS, a recovery of LACs results in the containment vacuum which may fail the containment integrity. So it is important to prevent a containment vacuum. A proper guidance is required to prevent a containment vacuum.

The water inventory in the basement depends on the operation of a spray, as shown Fig. 2. The operation of a CFVS affects the water inventory in the basement also, but not significantly. The SBO accident requires the water injection into the containment at least 4 days after an accident initiation if a passive spray system fails. If a spray system operates, then the injection into the containment is required more than 10 days after an accident initiation even though a CFVS operates.

REFERENCES

[1] Severe Accident Management Guidance for Wolsong Unit 1, KHNP
[2] Final Safety Analysis Report of Wolsong Unit 1, Chapter 6, KHNP
[3] Y. Jin, A study on Containment Flooding Strategy during Severe Accident in PHWR, Transaction of the Korean Nuclear Society Spring Meeting, 2009

Table 1. Important times for various accident sequences (unit : seconds)

	SBO w/ CFVS		SBO w/ CFVS, LAC recovery
	spray	No spray	spray
Reactor trip	0.0	0.0	0.0
SG dryout	10,065	10,065	10,065
Core uncover	13,050	13,016	13,050
SAMG Entry	14,268	14,241	14,268
First CFVS open	23,453	14,267	23,453
First CFVS close	27,216	16,453	27,216
Calandria fail	160,240	158,886	160,240
LAC recovery	-	-	180,000
Reactor vault fail	419,858	419,921	440,110
Containment fail by over pressure	424,715	421,810	-

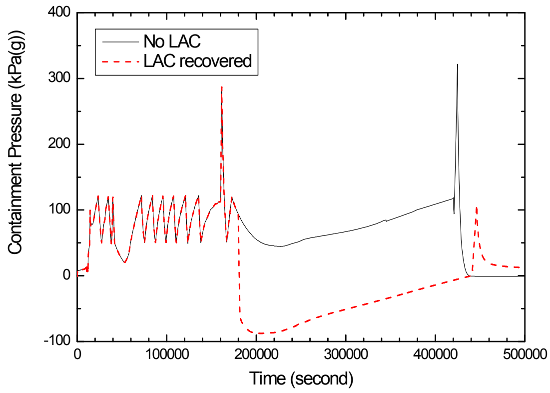

Fig. 1 Containment pressure behavior with CFVS operation

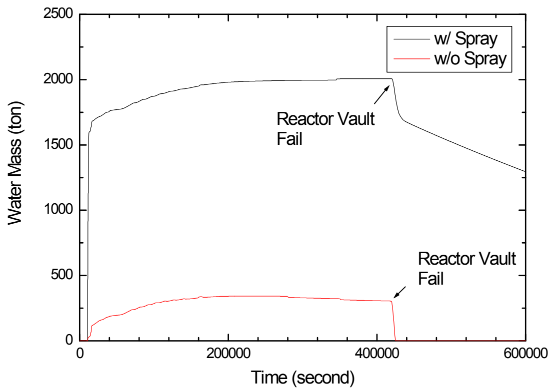

Fig. 2 Water mass in the basement