Evaluation of CFVS Mitigative Effects in Level 2 PSA of Wolsong NPP 1

Se-Hoon Oh [a*], Ho-Chang Yang [a], Hyung-Jin Kim [a], Seong-Soo Choi [a]
[a]*ACT, #406, IT Venture Town, 35, Techno 9-ro, Yuseong-gu, Daejeon, 34027, Korea*
[*]*Corresponding author: shoh@actbest.com*

1. Introduction

According to the PSA results of the Wolsong NPP 1, an over-pressurization of the containment is one of the dominant modes of containment failure that could potentially lead to a large fission products release to the atmosphere. The Containment Filtered Venting System (CFVS) has been installed in Wolsong NPP 1 to keep the containment integrity against over-pressure and to carry out the filtered venting of radioactive materials to the environment. This system is considered as a mitigation measure during a severe accident in level 2 PSA. CFVS depressurizes the containment and prevents the radioactive material from releasing by using scrubbing water and filters.

The purpose of this paper is to evaluate the effects of the CFVS on containment failure modes and containment failure probability.

2. Methods and Results

The effects of the CFVS on containment failure modes and containment failure probability have been evaluated through sensitivity analysis based on level 2 PSA results.

In this section, the information used to model Level 2 PSA is described.

2.1 Operating of CFVS

The CFVS operates by passing the vented vapors and aerosols including radioactive materials released from the containment atmosphere through a scrubber/filter vessel. Figure 1 shows the conceptual diagram of the CFVS. This system is operated manually depending on the containment pressure.

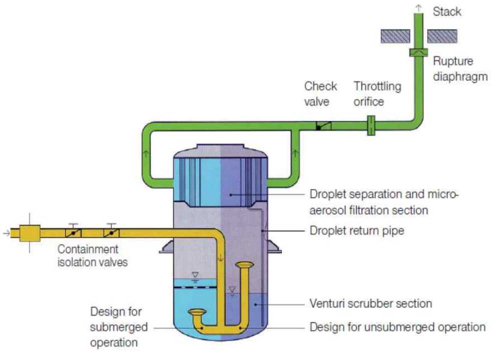

Fig. 1. Scrubber/filter vessel and piping of CFVS

2.2 CFVS depressurization capability analysis

ISAAC code (v. 4.0.3) calculates the variation of the pressure in the containment during a severe accident. The CFVS was modeled by considering the operating pressure and exhaust flow by using user-defined function in ISAAC code.

In order to evaluate the accident mitigating capability of the CFVS, an analysis was performed using representative accident scenarios. The analysis result of the CFVS depressurization capability is showed in Figure 2. While the CFVS is operating, it was found that the containment pressure did not rise up to containment failure pressure.

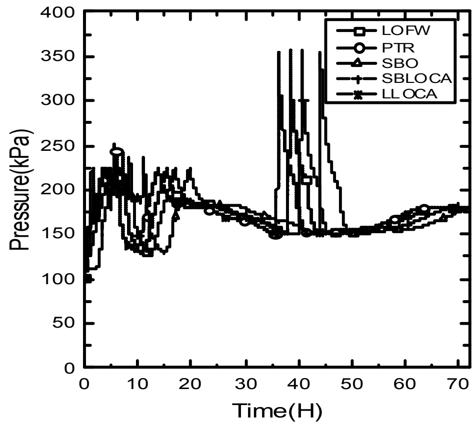

Fig. 2. CFVS depressurization capability on containment

2.3 CFVS modelling in Level 2 PSA

CFVS was added to the Level 2 PSA event tree. Level 2 PSA model includes PDSET, CET and DET.

The Plant Damage States (PDSs) are defined by developing all possible combinations of values for each of the PDS parameters. To bin core - damage sequences into PDSs systematically, the PDS Logic diagram(PDS LD) is used. A PDS logic diagram consists of PDS grouping parameters. These parameters define PDS characteristics. CFVS was added to the PDS LD as a PDS grouping parameter and these parameters as well as branch point considerations are shown in table I.

The Containment Event Tree (CET) is a logical framework for estimating the range of consequences associated with given accident sequences. It represents the sequence of events that could lead to failure of the containment pressure boundary and fission product release to the environment. CFVS was added to the CET as Top Event .The CET is illustrated in Figure 2.

The Decomposition Event Tree (DET) are “rolled up” to define the split fraction for the branch on CET. CFVS is reflected in DET to determine whether the event would occur(e.g., phenomena, accident conditions).

Table I: Grouping parameters and Branch point considerations of PDS LD

Grouping Parameters	Branch Point Consideration
Containment Bypass	No Bypass
	SG tube rupture
	Interfacing LOCA
Containment Isolation	Containment Isolation
	No Containment not Isolation
Initiating Event Type	Transient
	Loss of coolant
PHTS Loop Isolation	Loop Isolation
	Loop not Isolation
Secondary Heat Removal	Heat removed
	Heat not removed
RB Local air cooler	Containment cooled
	Containment not cooled
Containment Filtered venting	CFVS working
	CFVS not working
RB Dousing(Spray)	Spray working
	Spray not working
End Shield Cooling	Calandria cooled
	Calandria not cooled
PAR	Hydrogen controlled
	Hydrogen not controlled

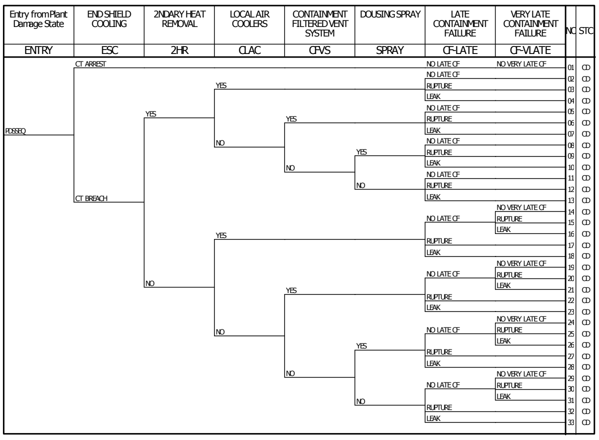

Fig. 2. Containment Event Tree including CFVS

2.4 Results

Sensitivity analysis was performed to consider the combined effects of CFVS, which was installed in Wolsong NPP 1. To evaluate the effects of CFVS on the containment failure modes and the containment failure probability, quantification for the presence and absence of CFVS was performed.

The results of CFVS sensitivity analysis are shown in table II. The results show that the containment integrity frequency was improved up to approximately 6.3% than the Reference Model within CDF.

In the Reference Model, the dominant failure modes of containment are Late Failure and Very Late Failure(the term “Late” is used to present a relatively late time compared with the first containment mode of the PWR).

Late Failure can result from over-pressurization generated by water vaporization process. As CFVS is intended to protect the containment integrity against over-pressurization generated by water vaporization, the Late Failure Frequency of the CFVS model was decreased from 13.38% to 1.68%.

Very Late Failure can result from hydrogen explosion. The CFVS can reduce the hydrogen concentration in the containment by venting hydrogen to the outside atmosphere. Steam generated continuously can reduce the possibility of hydrogen explosion. The Very Late Failure frequency of the CFVS model was increased form 16.55% to. 21.95%.

Some of the reduced Late Failure has been considered as Very Late Failure. Due to the operating of the CFVS, the Very Late Failure frequency is reduced approximately to 5.7% within CDF.

Table II: Containment failure mode and Frequency percentage according to CFVS in WS-1

Failure Mode	Ref. Model (No CFVS)	CFVS Model	Remarks
No Failure	68.59%	74.89%	9% increased
Isolation Failure	0.15%	0.15%	-
Bypass	1.32%	1.32%	-
Late Failure	13.38%	1.68%	87% decreased
Very Late Failure	16.55%	21.95%	32% increased
Total	100.00%	100.00%	-

3. Conclusions

PHWR is known for being more vulnerable to steam over-pressurization than PWR because PHWR plants have about twice the coolant inventory that can be released from the reactor vessel. As one of the post-Fukushima actions, Wolsong NPP 1 installed CFVS first.

This evaluation result showed that CFVS is effective to mitigate steam over-pressurization. In aspect to the Level 2 PSA, it also showed that the containment’s No Failure Frequency was improved as the Late Failure Frequency decreased.

REFERENCES

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