Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 29-30, 2014

Analysis of Depressurization Performance in Containment of Wolsong NPP Unit 1 through Containment Filtered Venting System

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1. Introduction

After the Fukushima accidents, it has been one of the key issues to keep the integrity of the containment under a severe accident. Currently, containment filtered venting system (CFVS) first installed at Wolsong unit 1 in Korea can be used to depressurize the containment during a severe accident such as station blackout (SBO). In addition, the key function of CFVS is to reduce the radioactive material releasing from the containment to the environment through a high-efficiency scrubber and filters. CFVS is designed to open and to close isolation valves passively by an operator. CFVS is operated when the containment pressure exceeds the design pressure (225 kPa(a)) and is closed when the containment pressure decreases below 151 kPa(a) [1].

The aim of this study is to analyze the depressurization performance of Wolsong unit1 through CFVS during SBO. The thermal-hydraulic behavior in containment of Wolsong unit 1 was evaluated using the MELCOR 1.8.6 code developed at Sandia National Laboratories (SNL) for the U.S. Nuclear Regulatory Commission (NRC). In addition, in order to evaluate the effects of the CFVS according to the venting area, a sensitivity study depending on different venting area of the CFVS was conducted. Finally, an analysis of the effects of filtering and scrubbing of radioactive material for CFVS is important but not treated in this paper.

2. Modeling

2.1 Accident Scenario

The SBO accident is chosen to evaluate the thermal-hydraulic behavior of Wolsong unit 1. In the case of SBO, the on-site and off-site electrical systems are not operating and also the active components including reactor coolant pumps (RCPs) cannot be used. As the accident begins, we assume that the reactor and the turbine are tripped, and then emergency core cooling system (ECCS), auxiliary feed water (AFW), local air cooler (LAC), moderator cooling and end shield cooling (ESC) are not available. However, passive high pressure injection, passive CFVS and dousing spray which automatically operates if the containment pressure exceeds 115 kPa(a) and stops if the containment pressure decreases below 108 kPa(a) are assumed to work for the SBO. When the containment pressure exceeds the design pressure of the containment building, 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 below 151 kPa(a).

2.2 MELCOR modeling

The MELCOR 1.8.6 code [2] was used for analysis of the containment pressure during SBO. The geometry of Wolsong unit 1 was modeled with one cell divided into 4 control volumes such as containment (CV820), CFVS (CV860), CFVS building (CV861) and environment (CV940). To simulate the venting area for the CFVS on the containment (CV820), the MELGEN user input for the CVs and flow paths were determined and the simulations were run up to 260,000 s (72 hr). Figure 1 shows the conceptual diagram for the structure of control volumes and flow paths of Wolsong unit 1.

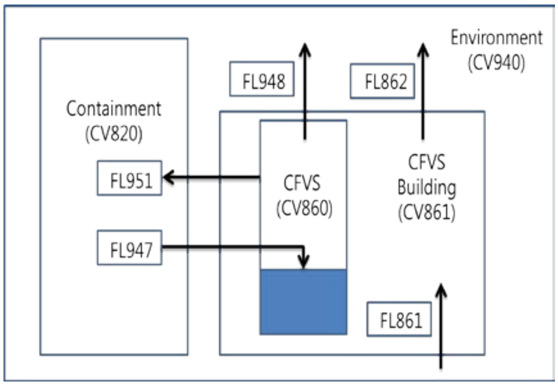

Fig. 1. Control volumes and Flow paths of Wolsong Unit 1

In order to carry out a sensitivity study, the flow path area as a variable parameter is chosen as 0.0065 m^2, 0.13 m^2 and 0.26 m^2, where this area indicates a venting diameter of the CFVS for 8 inch, 16 inch and 32 inch, respectively. The length of the flow path is specified as 5 m. Also, the segment parameters are defined, where the flow area, length, and hydraulic diameter of the segment are the same as the parameters of the flow path defined above.

3. Results

Using the developed MELCOR inputs, we have simulated the preliminary analysis like the pressure behavior in containment and CFVS. In addition, in order to check the feasibility of the inputs, a previous similar study [3] was examined to compare with MELCOR results calculated in this study.

Figure 2 shows the pressure behavior in the containment for SBO. In case of operating CFVS, the containment pressure is repeatedly rising and falling but it decreases gradually after 46 hrs. In contrast, the pressure continuously increases and then exceeds the containment failure pressure (427 kPa(a)) at 45.7 hrs without operating CFVS.

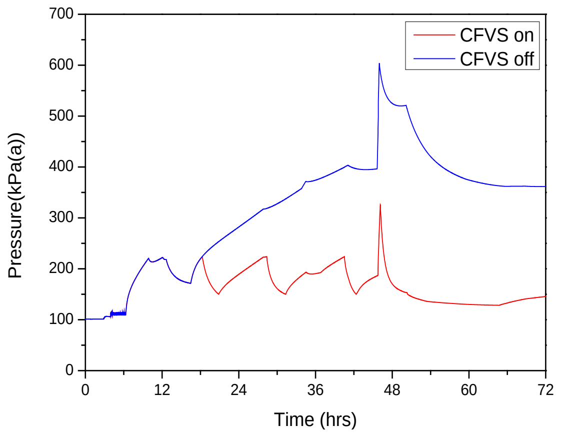

Fig. 2. Pressure behavior in the containment for SBO

To evaluate the effects of the pressure decrease through the CFVS operation, the containment pressure is calculated with the three different CFVS venting area defined above. Figure 3 shows the containment pressure depending on venting area. Here, base venting area is 16 inch (0.13 m^2) [1]. The pressure in the containment continuously increases from the start time of the accident, and then it decreases when CFVS is opened after 18hrs. There are large differences in the containment pressure depending on venting area. In case of the smallest venting area, it relatively takes a long time to depressurize the containment. Therefore, we can see that the decreasing rate of the pressure in the containment considerably depends on the venting area.

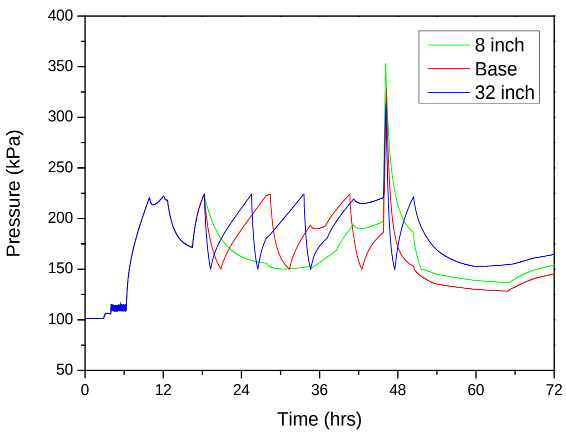

Fig. 3. Containmnet pressure depending on venting area

Figure 4 shows the CFVS water level depending on venting area. After CFVS is operated, the water level in CFVS is increases faster if the venting area is relatively small.

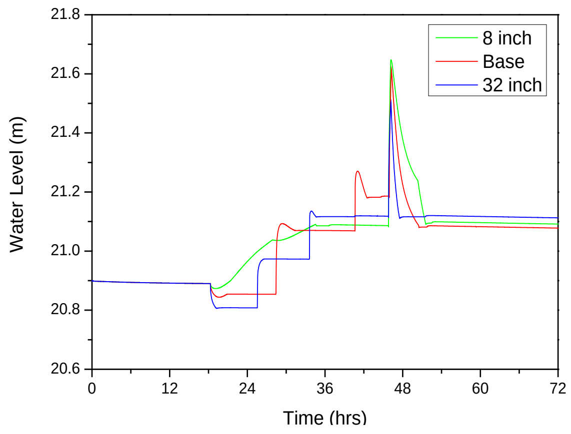

Fig. 4. CFVS water level depending on venting area

4. Conclusions

The SBO accident is chosen to analyze the thermal-hydraulic behavior of Wolsong unit 1. During SBO, the analysis of CFVS affecting on the depressurization of the containment was conducted using MELCOR 1.8.6 code. Also, a sensitivity study was carried out to evaluate the depressurization performance according to the venting area of CFVS.

The results show that the containment pressure is considerably decreased and the integrity of the containment could be maintained in case of CFVS operating. Therefore, CFVS has the capacity to keep the containment pressure below the design pressure during SBO. In addition, there are large differences in the containment pressure depending on venting area. We found that the decreasing rate of the pressure in the containment and water level in CFVS depends on the venting area.

In the future, a proper requirement for CFVS sizing criteria according to accident scenarios such as LBLOCA, SBLOCA and SGTR, etc. should be evaluated in order to review the licensing for CFVS. Finally, analyses of aerosols, fission product, and radioactive material behavior in containment and remove performance of radionuclide in CFVS are planning to be conducted.

REFERENCES

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