The Effect of the Venting Area for CFVS on the Containment

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1. Introduction

It is important to keep the integrity of the containment building under a severe accident. One of the mechanisms of a containment failure is the increment of the pressure from the steam generation induced by the interaction between the melted core and the coolant, as well as a Molten Core Concrete Interaction (MCCI) without a working Containment Spray System (CSS) [1]. To mitigate this situation, the Containment Filtered Venting System (CFVS) depressurizes the containment. In addition, CFVS prevents the radioactive material releasing from the containment from entering the environment using scrubbing water and filters. Figure 1 shows the concept of the CFVS. The objective of this study is to evaluate the effects of the venting area for the CFVS on the containment as one of the important design considerations for depressurization.

2. Methods and Results

The MELCOR (v. 1.8.6) code calculates the variation of the pressure in the containment during a severe Large Break Loss Of Coolant Accident (LBLOCA) and Station Blackout (SBO). The variable parameter in the MELCOR user input is the venting area for CFVS on the containment. The OPR 1000 was chosen as the target nuclear power plant, which has a thermal power of 2,815 MWt and its reactor coolant system consists of two steam generators and four reactor coolant pumps (RCP).

2.1 Accident Scenarios

LBLOCA and SBO were chosen as severe accidents to simulate the increment of the pressure in the containment.

During the LBLOCA, coolant discharges from a break of 0.04667 m^2 (= 24 cm in diameter) at a cold leg. This uncovers the core for a short time. When the pressure in the pressurizer reaches 12.59 MPa, the reactor and turbine are tripped, the Main Feed Water (MFWs) and Auxiliary Feed Water (AFWs) are stopped, and Main Steam Isolation Valve (MSIV) is closed.

During the SBO, the on-site and off-site electrical systems are not operating. The RCPs are stopped, and the capacity of the reactor cooling becomes insufficient. At time zero, i.e., the start time of the accident, the reactor and the turbine are tripped, the MFWs and AFWs are stopped, and the MSIV is closed. Here, High Pressure Safety Injection (HPSI), Low Pressure Safety Injection (LPSI) and spray do not work for either the LBLOCA or the SBO.

2.2 Modeling

MELCOR was used to simulate the severe accident scenarios mentioned above. Figure 2 shows the control volumes in a cross section of the OPR 1000 [2], where the control volumes of 810, 820, 830, and 840 are for the cavity, inner shell, annulus and dome, respectively. To simulate the venting area for the CFVS on the containment (840), the MELGEN user input for the

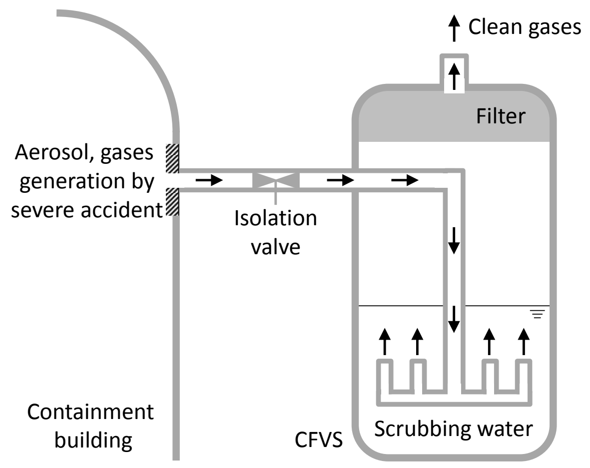

Fig. 1. CFVS connected with the containment

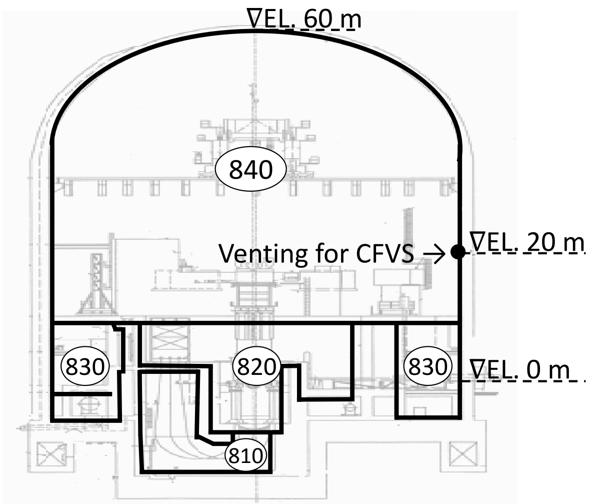

Fig. 2. Control volumes in the cross section of the containment and the elevation of the venting for CFVS

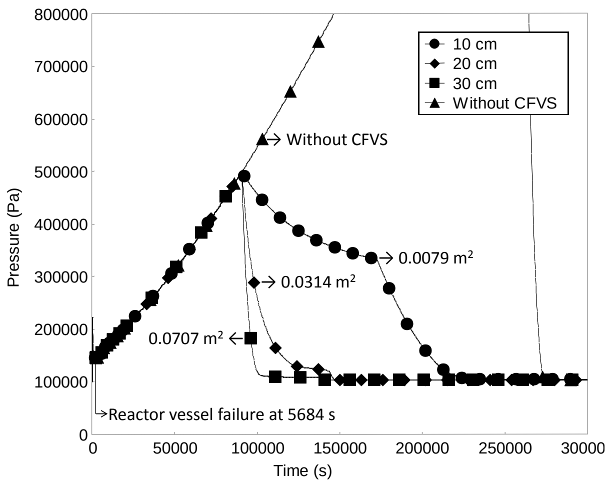

Fig. 3. Pressure in the containment for LBLOCA

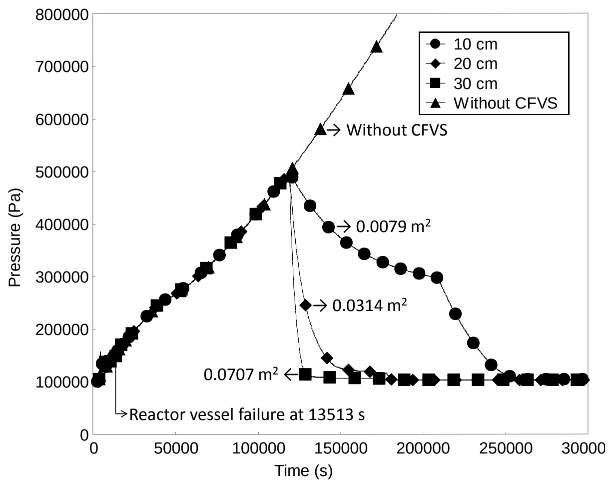

Fig. 4. Pressure in the containment for SBO

flow path package [3] was modified as follows:

(1) In FLnnn00, a flow path from the upper plenum (840) to the environment is defined, and the altitude of the junction, i.e., the elevation of the venting area on the containment, is specified as 20 m from the center line of a hot leg.

(2) In FLnnn01, the flow path area as a variable parameter is determined as 0.0079 m^2, 0.0314 m^2 and 0.0707 m^2, where this area indicates a venting diameter for the CFVS of 10 cm, 20 cm and 30 cm, respectively. The length of the flow path is specified as 1 m.

(3) In FLnnn03, the forward and reverse loss coefficients are defined as a default value of 1, which present the frictional pressure drop across the flow path.

(4) In FLnnnSk, 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.

The venting area for the CFVS on the containment will open when the pressure in the containment reaches 5 bar, which is lower than the design pressure of 6.4 bar of the containment of the OPR 1000.

2.3 Results

Figures 3 and 4 show the calculation results of the pressure in the containment for the LBLOCA and SBO, respectively. The circle, diamond and square present a venting area of 0.0079 m^2, 0.0314 m^2 and 0.0707 m^2, respectively, and the triangle indicates the pressure in the containment without operating the CFVS. The pressure in the containment continuously increases from the start time of the accident, and then it decreases after reaching the setting pressure of 5 bar, i.e. the venting area for CFVS on the containment is opened by a valve. In Figs. 3 and 4, the decrement rate of the pressure in the containment strongly depends on the venting area. For 0.0314 m^2 and 0.0707 m^2, the pressure in the containment dramatically decreases, while it takes a long time to depressurize for 0.0079 m^2, i.e. the smallest venting size. It would be induced by the balance difference between the amount of steam generation by a severe accident and the releasing amount through a venting area for CFVS on the containment.

3. Conclusion

This study showed the effect of the venting area for the CFVS on the containment for depressurization under severe accidents, especially an LBLOCA and SBO. MELCOR (v. 1.8.6) calculated that the operating of the venting area (0.0079 m^2, 0.0314 m^2 and 0.0707 m^2) depressurized the containment, and the large venting area of 0.0314 m^2 and 0.0707 m^2 showed a depressurization in a short time.

Although other parameters such as the loss coefficient and the segment hydraulic diameter are fixed in this study, they could affect the depressurization in the containment. In the future, a sensitivity analysis on the various parameters should be conducted to design a CFVS for a particular nuclear power plant.

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