Changes in the decontamination factor of cesium iodide on evaporation of a scrubbing solution in the Filtered Containment Venting System

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1. Introduction

The FCVS (Filtered Containment Venting System) has the main objectives of both the depressurization in the containment building and the decontamination of fission products generated under a severe accident. A general wet-type FCVS consists of a cylindrical pressure vessel including a scrubbing solution and filters [1]. A FCVS vessel can be installed on the outside of the containment building, and is connected with the containment through a pipe. When the pressure in the containment building approaches a setting value, the FCVS operates. The amount of steam and gas mixtures generated during a severe accident can be released into the FCVS. Non-condensable gases and fine aerosols can pass a scrubbing solution and the filters in the FCVS vessel. The decontaminated gases are finally discharged from the FCVS to the outside environment. Previous study [1] observed that a scrubbing solution in the FCVS vessel was constantly evaporating owing to high-temperature steam released continuously from the containment building. A scrubbing solution in the FCVS vessel was completely evaporated at about 31 hours after the FCVS operation. Pool evaporation in the FCVS vessel can negatively affect the decontamination feature of the FCVS because it reduces the scrubbing depth for fission products in an aerosol form. This study carefully evaluated the decontamination factor of metal iodide aerosols especially cesium iodide (CsI), on a scrubbing solution in the FCVS. This paper summarizes the calculated results on the decontamination factor of CsI in the FCVS vessel, which was presented at the international OECD-NEA/NUGENIA-SARNET workshop [2].

2. Methods

The MELCOR computer code (v. 1.8.6) simulated that a station blackout occurred in the OPR 1000. The reactor type is a pressurized water reactor with a thermal power of 2,815 MWt. It is assumed that the FCVS operates when the pressure in the containment building reaches 5 bars. In the summary of the FCVS modeling, a cylindrical vessel for the FCVS has a 3 m diameter and 6.5 m height, and it includes a scrubbing solution of 21 tons, i.e., the pool depth is 3 m. The inlet of the FCVS vessel is connected with the containment dome through a venting pipe with a 25 cm diameter. The exit of a venting pipe is submerged into a scrubbing solution in the FCVS vessel, and is located 2 m below the surface of a pool. A venting pipe includes a multi-hole sparger. The outlet of the FCVS vessel is linked to the outside environment through an exhaust pipe with a 25 cm diameter, where aerosol filters on this flow path were removed to estimate the decontamination factor on a scrubbing solution. The decontamination factor of a CsI aerosol on a scrubbing solution in the FCVS is defined by the ratio of the input mass of CsI aerosol to its output mass. The input mass of CsI aerosol into a scrubbing solution is the sum of CsI mass in a pool and its output mass from a scrubbing solution, where the output mass can be estimated by CsI aerosol in the FCVS vessel atmosphere plus that in the outside environment.

3. Results and discussion

To assess the thermal hydraulic effect on CsI aerosol scrubbing in the FCVS, the variation of CsI mass during the accident progress was calculated by the MELCOR computer code.

Figure 1 shows the accumulated mass of CsI aerosol in a scrubbing solution in the FCVS vessel. As soon as the FCVS operates at 33 hours after the start of SBO, the CsI aerosol mass increases continuously until 59 hours. The accumulated mass of the CsI aerosol in a scrubbing solution is unvaried from 59 hours to 64 hours. This indicates that there is no scrubbing of CsI aerosol in a pool. The accumulated mass of CsI aerosol in a scrubbing solution falls sharply at 64 hours in Fig. 1 because a pool in the FCVS vessel was completely evaporated at that time [1].

Figure 2 shows the accumulated mass of CsI aerosol in the FCVS vessel atmosphere. It was observed that there are no CsI aerosols in the atmosphere in the FCVS vessel from the start of the FCVS operation to about 59 hours. The accumulated mass of CsI aerosol in the FCVS vessel atmosphere increases from 59 hours to 72 hours, where the elevation of a scrubbing solution approached the venting pipe exit at 59 hours, and a pool was completely evaporated at 64 hours [1]. The first peak of the accumulated mass at 64 hours in Fig. 2 can occur because the remaining CsI aerosol in a pool can be released suddenly into the atmosphere in the FCVS vessel. The accumulated mass of CsI aerosol reaches the maximum value at 72 hours, and then decreases.

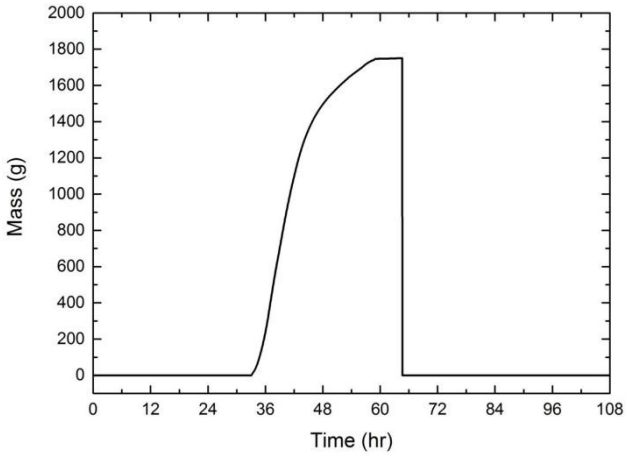

Fig. 1. Accumulated mass of CsI aerosol in a pool in the FCVS vessel [2].

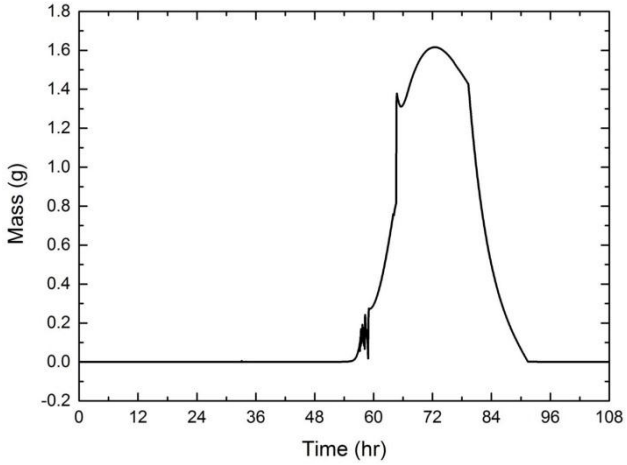

Fig. 2. Accumulated mass of CsI aerosol in the FCVS vessel atmosphere [2].

Figure 3 shows the input and output of the accumulated CsI aerosol mass on a scrubbing solution in the FCVS in the left axis, and the right axis shows the decontamination factor of CsI aerosol on a scrubbing solution. The input mass increases continuously from 33 hours to 64 hours. As soon as the pool level approaches the bottom of the FCVS vessel at 64 hours, the inlet mass falls sharply. The output mass starts to increase when the pool level is reduced by the level of a venting pipe exit. The accumulated output mass is unvaried from about 90 hours. The decontamination factor of CsI aerosol on a scrubbing solution starts to dramatically increase at 33 hours as soon as the FCVS operates. It peaks at 50 hours, and it then decreases sharply by unity, where a scrubbing solution was completely evaporated at 64 hours [1]. In the early FCVS operation, steam condensation can enhance the ability to capture particles in a scrubbing solution. In contrast to steam condensation, the evaporation negatively affects the particle scrubbing in a pool.

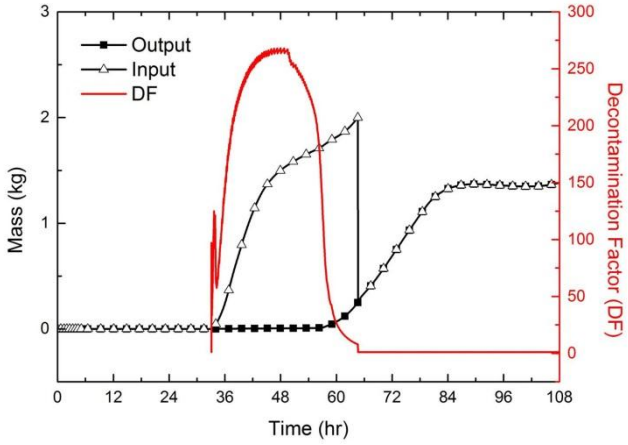

Fig. 3. Decontamination factor calculated by input and output of CsI aerosol mass on scrubbing solution [2].

3. Conclusions

This study estimated the decontamination factor of CsI on a scrubbing solution in the FCVS. The MELCOR computer code simulated that an SBO occurred in the OPR 1000. The FCVS consists of a cylindrical vessel with a 3 m diameter and 6.5 m height, and it includes a scrubbing solution of 21 tons. Accumulated mass of CsI aerosol was calculated in a scrubbing solution and the atmosphere in the FCVS vessel and the outside environment. In the early FCVS operation, the decontamination factor of CsI aerosol rapidly increased owing to steam condensation in a scrubbing solution. When the temperature of a pool approached its saturation temperature, the decontamination factor of CsI aerosol started to decrease. Particle capture in a scrubbing solution can be affected by both the steam condensation in the early FCVS operation and the pool evaporation. In this study, it is clearly observed that the decontamination factor of CsI aerosol on a scrubbing solution can be dependent on the thermal-hydraulic conditions in the FCVS.

Acknowledgments

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References

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