Sensitivity Analysis for the time of containment spray injection based on a SBLOCA scenario

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1. Introduction

To remove the heat in the containment atmosphere of a nuclear power plant (NPP) under a severe accident condition, a containment spray system has been installed in all NPPs on Korea. The containment spray system can reduce the pressure and temperature in a containment building by direct contact heat exchange between the atmosphere and sprayed droplets.

The containment spray system is very efficient to remove the heat in the containment. However, the containment spray system can increase hydrogen volume fraction due to condensing steam in the containment. [1]

It is possible that the operation of the containment spray system could be delayed, because a severe accident condition has various uncertainties.

In this study, a sensitivity analysis was performed to examine the influence from the delayed spray injection time. To perform the analysis, MAAP5.03 code was used, since the code includes a number of models to analyze severe accidents numerically [2]. A small break loss of coolant accident (SBLOCA) scenario in OPR-1000 was selected for the analysis with controlling time of spray injection.

2. Methods and Results

In this section, the analysis method and results are provided. The MAAP5.03 was selected as an analysis tool, since MAAP code can predict the trend severe accident progression well despite of the use of simplified models [3].

2.1 Base scenario

For this analysis, OPR-1000 was selected as a target NPP. A SBLOCA scenario with the operation of high pressure safety injection (HPSI) and safety injection tanks (SIT) was assumed. The reason why this scenario is selected is because the larger amount of hydrogen can be generated in the SBLOCA scenario than other scenarios.

When the water level of the refueling water storage tank (RWST) is too low to supply the water from the RWST, the sprayed water in the containment is supplied from the recirculation sump under the recirculation mode. [4, 5]

2.2 PAR model

PAR model was, also, included in all the cases, since the PAR can be operated automatically. NIS PAR model was selected, because the NIS PAR model has conservative performance in MAAP5.03 [6]. For the conservative analysis, the PAR operation time was delayed for 30 minute, after the PAR operation condition was reached.

2.3 Spray condition

For the analysis, spray performance was assumed as the design values of the NPP. The time of spray injection was controlled. The range of delay time was considered between 0 hours and 12 hours. Following Table I shows the time of spray injection after reaching spray set point.

Table I: The time delayed after reaching spray set point

	Time of spray injection (hour)
Case 1	0
Case 2	2
Case 3	4
Case 4	8
Case 5	12

2.4 Results and discussions

Following figure 1 shows the pressure in the containment. In Case 1, the pressure decreased sharply once reaching the set point. The more the time of spray injection is delayed, the more maximum pressure increases. The maximum pressure appeared in Case 5. The maximum pressure in Case 5 has a value of 1.14 times compared with the set point value. This value is not high enough to affect the containment integrity.

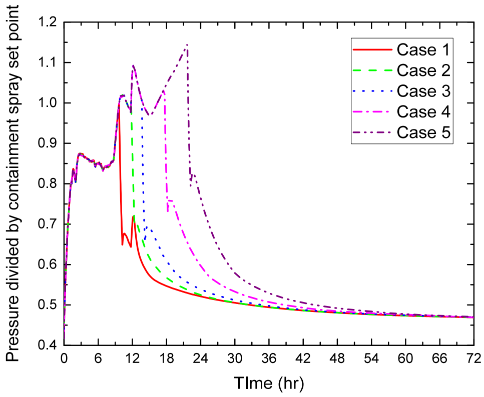

Fig. 1. Graph of pressure in containment dome along accident progress time

Following figure 2 represents the hydrogen volume fraction in the containment dome. In Case 1, the maximum hydrogen volume fraction is approximately 3.44%. The more time of spray injection is delayed, the more maximum value increases until Case 3. This may occur because PARs is opearted with the delayed time in this analysis and PARs have high performance under high hydrogen volume fraction.

The maximum hydrogen volume fraction in Case 3 has difference of 0.43% with Case 1. After 4 hours for the delay, the maximum value of the hydrogen volume fraction gradually decreases, as the delay time increases. This may be because the hydrogen is removed by the PARs in the containment bulinding during the delay time despite of low hydrogen volume fraction.

After 4 hours from the set point, the maximum hydrogen volume fraction is lower than Case 1, since the containment sprays sytem is operated after PARs remove much hydrogen in the containment.

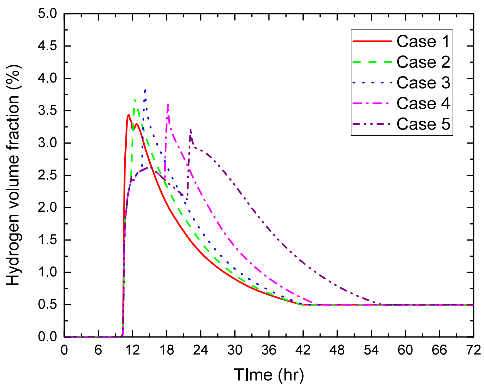

Fig. 2. Graph of hydrogen volume fraction in containment dome along accident progress time

3. Summary

In this analysis, the effect the spray operation time delayed after reaching pressure set point for the operation of the containment spray system was explored. For this, MAAP5.03 code was selected as the analysis tool. The spray operation time was controlled. The operation of PARs in the containment building was considered. The summary of this study is as follow:

1) If the containment spray system is operated with delayed time, the maximum pressure increases 1.14 times. This increase affects the containment integrity a little, because the containment integrity has enough margin to this value.
2) The hydrogen volume fraction can increase when the spray injection is delayed in some cases. However, the increase of hydrogen volume fraction is not threatening the containment integrity, since the maximum increases is approximately 0.43% and is lower than 4.0%.

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