# Sensitivity Study on Analysis of Reactor Containment Response to LOCA

Ku Young Chung* and Key Yong Sung
*Korea Institute of Nuclear Safety, 19 Gusung-dong, Yusung-gu, Daejeon, 305-338*
**Corresponding author: k479cky@kins.re.kr*

## 1. Introduction

As a reactor containment vessel is the final barrier to the release of radioactive material during design basis accidents (DBAs), its structural integrity must be maintained by withstanding the high pressure conditions resulting from DBAs. To verify the structural integrity of the containment, response analyses are performed to get the pressure transient inside the containment after DBAs, including loss of coolant accidents (LOCAs).

The purpose of this study is to give regulative insights into the importance of input variables in the analysis of containment responses to a large break LOCA (LBLOCA). For the sensitivity study, a LBLOCA in Kori 3&4 nuclear power plant (NPP) is analyzed by CONTEMPT-LT computer code[2].

## 2. Sensitivity Studies on Heat Removal Mechanisms in view of Containment Pressure Behavior

Kori 3&4 NPP has the containment spray system and the containment fan cooler system as the heat removal system. The structures inside the containment are also known to play a significant role to remove the energy inside the containment as the passive heat sink.

### *2.1 Containment Spray System*

The containment spray system depressurizes the pressure of the containment by cooling down the hot steam inside the containment. In the LBLOCA scenario of Kori 3&4 NPP, the Spray system is activated at 137 sec after the initiation of the accident. Fig. 1 shows the behavior of the containment pressure when the spray system is deactivated.

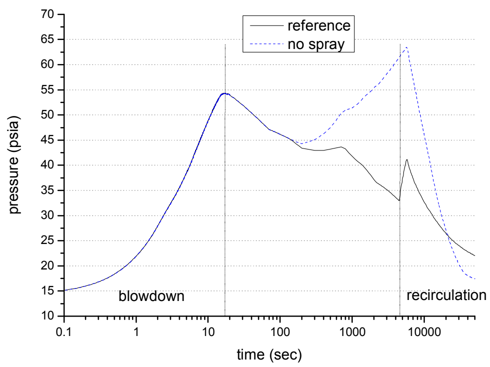


Fig. 1. Containment pressure behavior without spray system.

The result indicates that the second peak pressure occurs at about 5700 sec if the spray system is deactivated, and its value is much higher than the peak pressure of the reference case.

The key parameters of the spray system are a flow rate of spray water, efficiency, and the temperature of water source in the refueling water storage tank (RWST). It should be noticed that Fig. 1 indicates the spray system plays a main role in the time interval from the spray activation time (137 sec) to the recirculation initiation time (4500 sec). In the recirculation phase, the heat removal capability of the spray system drastically decreases because of the high temperature of the spray water obtained from the containment sump and the energy in the containment is removed by residual heat removal system. So the sensitivity results of the key parameters of the spray system are presented in the interval from 100 to 5000 sec in Fig. 2.

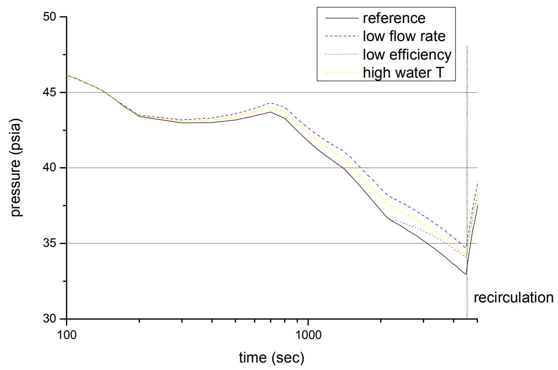


Fig. 2. Sensitivity results of key parameters of spray system.

In Fig. 2, the results of three cases are compared to that of reference, which are 10% reduced flow rate, 10% reduced spray efficiency and 10% increased water temperature (in Farenheit degree) of the RWST. The sensitivity results represent that 10% reduction of the flow rate increases the containment pressure mostly by about 5% and 10% reduction of the efficiency has the least effects on the containment pressure behavior.

### *2.2 Containment Fan Cooler System*

The reactor containment fan cooler system (RCFC) in Kori 3&4 NPP is designed to control the temperature and humidity inside the containment building in normal operation and to remove the energy of the air in the containment when accidents occur. In the LBLOCA scenario of Kori 3&4 NPP, RCFC is activated at 33 sec after the initiation of the accident. Fig. 3 shows the behavior of the containment pressure when the RCFC is deactivated.

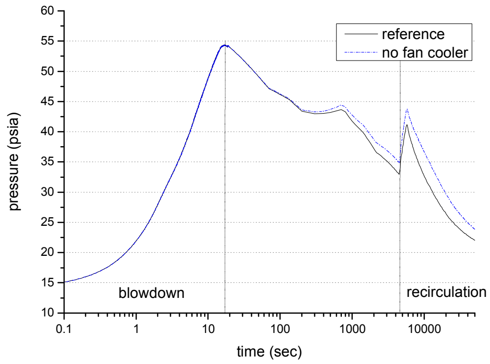


Fig. 3. Containment pressure behavior without RCFC.

Fig. 3 indicates that the deactivation of the RCFC causes about 10% increase of the containment pressure mainly in recirculation phase. As the heat removal capability of the RCFC is much less in comparison with that of the spray system, no sensitivity calculation is performed for the RCFC. But, it should be noted that the RCFC reduces the containment pressure to some degree in the recirculation phase while the spray system doesn't.

### *2.3 Heat Conducting Structures*

In the LBLOCA scenario of Kori 3&4 NPP, 18 heat conducting structures including concrete walls and steel liner plate are modeled. Fig. 4 shows the behavior of the containment pressure when the 18 structures are not modeled. At the end of blowdown phase (18.6 sec), the first pressure peak is about 10% higher than that of reference case, and after the blowdown the pressure continuously increases up to 68.5 psia which is 27% higher than the peak pressure of the reference case.

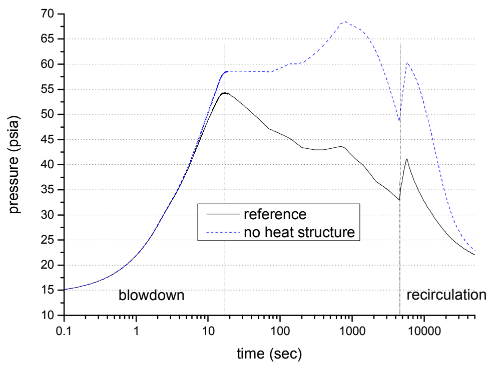


Fig. 4. Containment pressure behavior without heat conducting structures.

CONTEMPT-LT code solves the heat conduction equation for the structures with the appropriate boundary conditions including Tagami heat transfer coefficients given by Eq. (1) [2].

$$h_{\max} = 72.5\left(\frac{Q}{Vt_p}\right)^{0.62} \qquad (1)$$

CONTEMPT-LT assumes that the heat transfer coefficient of the surfaces of the structures interfacing the air inside the containment increases linearly from 0 to Tagami value given by Eq. (1) during the blowdown phase. $t_p$ in Eq. (1) stands for the time when the peak pressure occurs during the blowdown phase. In the reference case, $t_p$ is chosen as 15.9 sec and the pressure behavior is compared with the $t_p$ of 10.0 sec and 18.4 sec. Fig. 5 shows that the case of later peak time (18.4 sec) gives more conservative results with about 1% increase of the peak pressure.

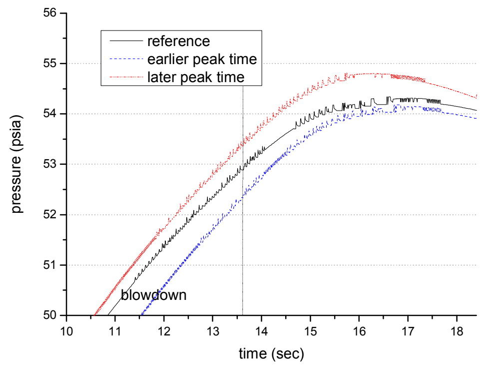


Fig. 5. Containment pressure behavior with the variation of peak time in Tagami correlation.

Sensitivities on the other parameters with regard to the structures like the heat transfer surface are not investigated, but it is obvious that the parameters should be carefully modeled and reasonably obtained to guarantee the appropriateness of the result of the containment analysis.

## 3. Conclusions

The sensitivity study suggested that the spray system and the heat conducting structures be the major means to remove the energy inside the containment during the LOCA, and the variations in the key parameters of the two means can result in substantial discrepancies of the results of the containment response analysis. To verify the results of containment response analyses, the appropriateness of the key parameters suggested in this paper should be carefully reviewed.

## REFERENCES

[1] U.S. NRC, NUREG-0800 Standard Review Plan 6.2.1 Containment Functional Design, Rev. 3, 2007

[2] Don W. Hargroves, Lawrence J. Metcalfe, CONTEMPT-LT.028-A Computer Program For Predicting Containment Pressure-Temperature Response to a Loss-Of-Coolant Accident, NUREG/CR-0255, Idaho National Engineering Laboratory, March 1979.