# Minimum Containment Pressure and Its Effect on ECCS Performance of APR-1400

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## 1. Introduction

The containment pressure has a strong effect on the late reheat behavior for a large break LOCA, associated with the DVI issue[1]. The downcomer boiling, which occurs during the post-reflood phase, has a negative effect on core cooling for a LBLOCA. Because the downcomer boiling is enhanced as the containment pressure decreases, how to determine containment pressure is important to the evaluation of ECCS performance. In spite of its importance of containment pressure, there are few studies on the containment pressure and the interaction between RCS and containment thermal hydraulics. To have a better knowledge of the effect of containment pressure on APR-1400 ECCS performance, a parametric study for containment pressure has been carried out. Also, the interaction between RCS and containment behavior has been also investigated.

## 2. Results and Discussion

CONTEMPT4 code[2] is used to analyze containment thermal hydraulic behavior. In this section, the verification of code's input, a parametric study, and the interaction between RCS and containment are described.

### *2.1 Verification of Code's Input*

Necessary values for CONTEMPT4 input are taken from the Sinkori unit 3&4 PSAR[3]. For the verification of code's input, containment pressure calculated by CONTEMPT4 is compared with the minimum pressure presented in the PSAR. The comparison result is shown in Fig. 1.

The minimum containment pressure in the PSAR is calculated by COMPERC code[4]. Although codes are different, the differences in the containment pressures are small and acceptable. Therefore it is concluded that the code's input is verified to use for audit calculation.

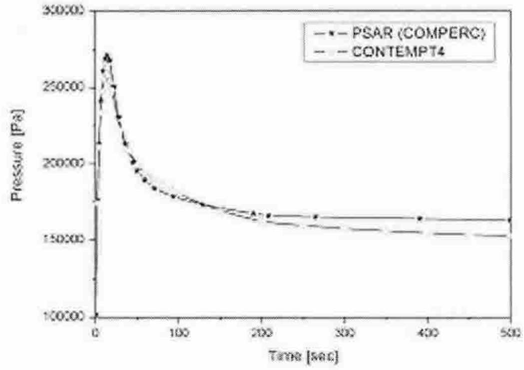


**Fig. 1 Comparison of Containment Pressures**

### *2.2 Parametric Study*

A comprehensive study for the effects of containment parameters on containment pressures is found in Ref. 5. Because the main focus of Ref. 5 is laid on the maximum pressure, little information is available for the minimum pressure used in evaluating the performance of ECCS.

In this study, four parameters were selected for a parametric study; 1) surface area, 2) spray flowrate, 3) fan coolers, 4) liquid pool. Brief description of each case is presented in Table 1.

**Table 1 Description of Case Study**

| Case | Parameter | Description |
|---|---|---|
| A | Heat Structure | 90% of the original |
| B | Surface Area | 110% of the original |
| C | Spray Flowrate | 1/2 Flowrate and 30 sec. Delay |
| D | Fan Coolers | Removed |
| E | Liquid Pool | Removed |

The calculation results of each case are shown in Fig. 2.

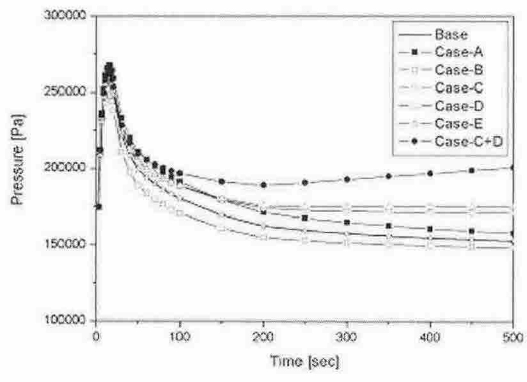


**Fig. 2 Containment Pressures from Case Calculations**

Because the downcomer boiling may occur after depletion of SIT water, containment pressures after about 200 sec. are important for ECCS performance.

The sensitivity of heat structure surface area to the minimum pressure would be ~ -1.2 kPa/% and nearly same as that for the maximum pressure[5]. The effect of fan coolers on the minimum pressure appears relatively large compared to the maximum pressure analysis. Total heat removal from fan coolers would be equivalent to that from the single train of the spray system. The way to treat liquid pool gives the negligible effect.

APR-1400 containment dose not have safety-related fan coolers and single failure criterion can be consistently applied for both RCS and containment analysis. If realistically conservative assumption, the combination of Case C and Case D, is applied to containment analysis, containment pressures after 200 sec. are calculated by ~30 kPa higher than those with the most conservative assumption. From the sensitivity calculations presented in Ref. 1, it is presumable that if realistically conservative assumption is applied to containment minimum pressure analysis, the late reheat would be significantly reduced in LBLOCA analyses.

### *2.3 Interaction between RCS and Containment Analysis*

The containment atmosphere is connected to RCS through a break point, and a simultaneous calculation for both RCS and containment thermal hydraulics is preferable for a more realistic analysis.

However, in the current ECCS EM, containment pressure is treated as a boundary condition and it is calculated by a separate containment analysis using the mass and energy discharge (M&E) data provided by a RCS analysis with a trial containment pressures. A new RCS analysis produces new M&E data different from the original data. If sufficient iteration process is taken, it is expected that the final containment pressure and M&E data are equivalent to the results obtained by a simultaneous calculation. This expectation is only valid when the containment pressures do not introduce new phenomena, like downcomer boiling, in RCS thermal hydraulic behavior.

To investigate the interaction between RCS and containment analysis, two LBLOCA analysis are carried out for APR-1400 by using RELAP5[6] code. For one calculation (Case 1), containment pressure is taken as same as the nominal one of Ref. 1, and 85% reduced pressure is used for the other calculation (Case 2).

Figure 3 shows mass flowrates discharged from the break. As the downcomer boiling is enhanced after the depletion of SIT water, mass flowrates for Case 2 is higher than those for Case 1. The increase in mass flowrates is resulted from the increase in ECCS bypass due to the higher upward flow of vapor in the downcomer.

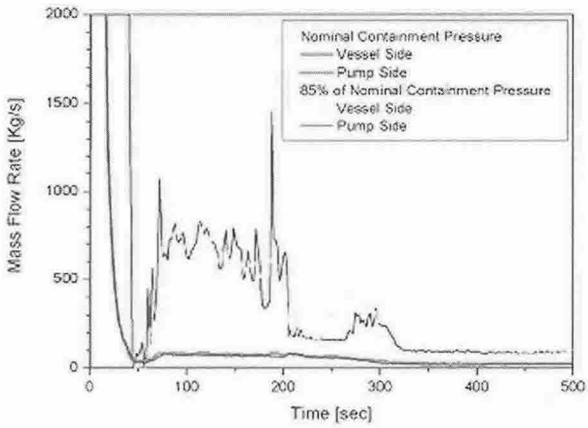


**Fig. 3 Discharge Mass Flowrates**

Larger mass releases with relatively low enthalpy make containment pressure decrease. Taking M&E data of each RELAP5 calculation for new containment analysis, resulted containment pressures with Case 2 data are lower than those using Case 1 data. This means that final containment pressure depends on how to assume containment pressure for the first trial, and iterated results would not be converged. Therefore, for the performance evaluation of APR-1400 ECCS, a simultaneous analysis for both RCS and containment thermal hydraulics is necessary.

## 3. Conclusion

Realistically conservative assumption may reduce the severity of the downcomer boiling for APR-1400 LBLOCA analysis. A simultaneous analysis for both RCS and containment thermal hydraulics is necessary to evaluate the performance of APR-1400 ECCS.

## REFERENCES


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