Preliminary calculation on the containment external cooling effect during ELAP using CAP code

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1. Introduction

The external containment cooling strategy is involved in the step 9 of FLEX Support Guideline (FSG)-12 [1]. According to this document, the external containment cooling strategy will be most effective if the steel containment vessel itself can be sprayed with cool water. Additionally, this cooling strategy should be evaluated for plant-specific containment building design. In case of Korean nuclear power plant, the material of containment building is pre-stressed concrete. Therefore, it should be checked that the external cooling strategy which is specified in FSG-12 has an effect on the depressurization of containment.

In this paper, the containment external cooling effect was analyzed using CAP (Containment Analysis Package) code. The CAP code has been developed in Korean nuclear society for the analysis of nuclear containment thermal hydraulic behaviors including pressure and temperature trends and hydrogen concentration [2]. Additionally, the APR1400 is selected as the reference plant.

2. Evaluation method

2.1 Modeling for analysis using CAP code

In order to investigate the influence of external cooling, the containment building is simply modeled as shown in figure 1. The free volume of containment is about 88,600 m^3 which is specified in design document [3]. The containment wall is modeled using heat conductor option of CAP. These conductors are connected to containment node and imaginary volume for spray cooling.

The wetted area of containment wall surface by the external spray cooling is about 329 m^2. It is assumed that this area is 1/16 of total cylindrical structure area. And, the containment wall thickness is about 1.2 m which is divided 24 regions. The input information for heat sinks such as concrete, paint, carbon steel and so on is applied in accordance with design document [3]. It is assumed that the cooling water is sprayed by portable fire truck and flowrate of 500 gpm determined in accordance with the NEI document [4]. It is also assumed that the containment inner pressure and temperature are 110.6 kPa and 326.45 K, respectively. And, the pressure and temperature of primary system are nominal condition. The input information for modeling is determined in accordance with design document [3].

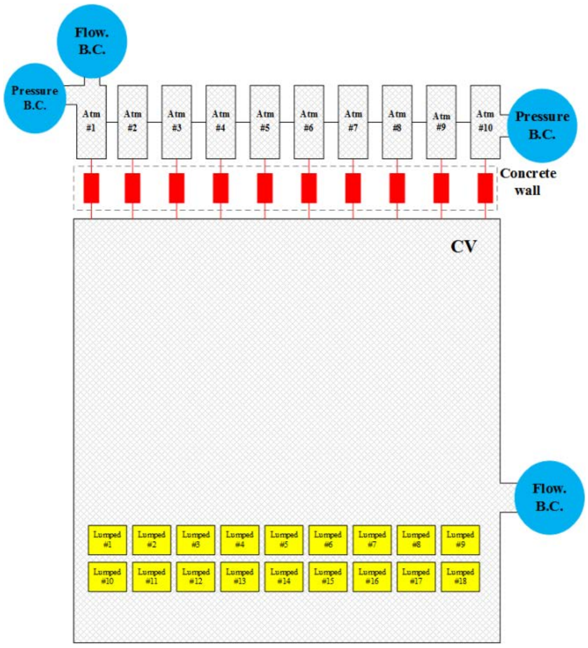

Fig. 1. Nodalization for analysis using CAP code

2.2 Scenario assumptions & Initial conditions

An Extended Loss of All AC Power (ELAP) event is one of the entry condition for FSG-12. Therefore, it is assumed that the scenario is started with ELAP event. Additionally, the RCP leakage rate of 100 gpm that is considered for the maximum leakage rate during an ELAP condition is also assumed. In this paper, the analysis was performed that the case 1 is no action scenario and case 2 has cooling strategy action. The entry condition of this strategy for Shin-kori units 3 and 4 is 139.47 kPa. It is assumed that the total run time for analysis is 2 days for ELAP period.

3. Analysis results

The spray flow starts about 2.5 hours only in case 2 as presented in figure 2. In case of case 1, the containment outer wall temperature slightly increased due to the no action. On the other hand, the containment outer wall temperature in case 2 decreased due to the low spray coolant temperature as shown in figure 3. The containment inside wall temperature are same both case 1 and case 2 as shown in figure 4. These results show that the thick concrete wall interrupts heat transfer from inside the containment surface to outside the containment wall surface. Therefore, the containment pressure trend is almost same both case 1 and case 2 as shown in figure 5.

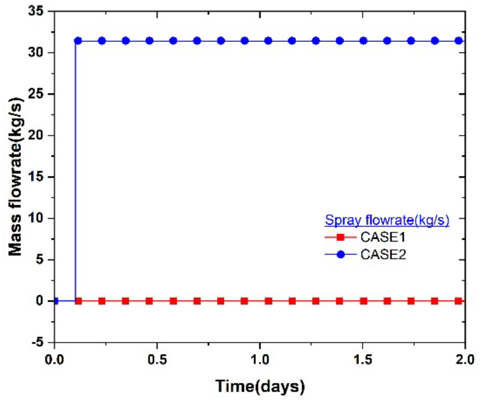

Fig. 2. Spray flowrate of cases 1 and 2

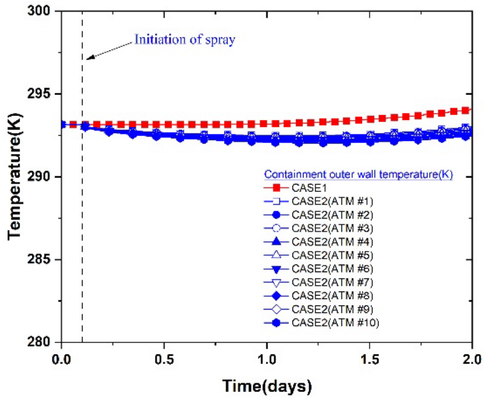

Fig. 3. Containment outside wall temperature of cases 1 and 2

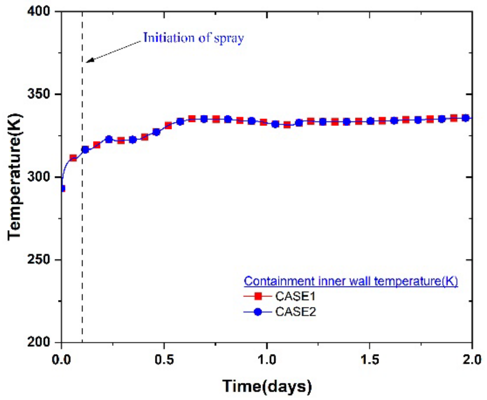

Fig. 4. Containment inside wall temperature of cases 1 and 2

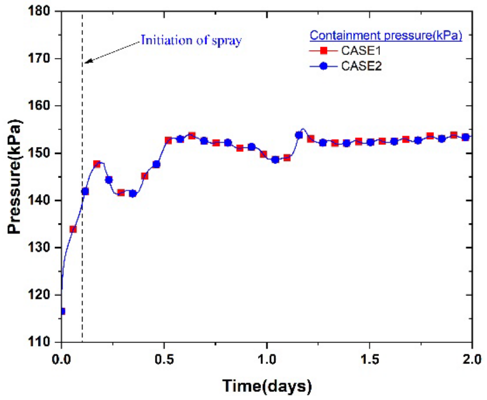

Fig. 5. Containment pressure behavior of cases 1 and 2

4. Conclusions

In this paper, preliminary calculation was performed to confirm the effect of external containment cooling strategy for ELAP case. The present calculation results show that the external spray cooling effect using fire pump truck have little effect on depressurization of containment during 2 days. In other word, the external cooling strategy was not effective due to the thick, and low conductivity of concrete material during the ELAP condition.

REFERENCES

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