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Study on the containment external cooling effect for strategy of FSG-12 using GOTHIC 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 GOTHIC code and the OPR1000 type is selected to the reference plant.

2. Evaluation method

2.1 Modeling for analysis using GOTHIC 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 2,862,000 ft^3 which is specified in design document [2]. The containment wall is modeled using thermal conductor option of GOTHIC. This conductor is connected to containment node and imaginary volume for spray cooling.

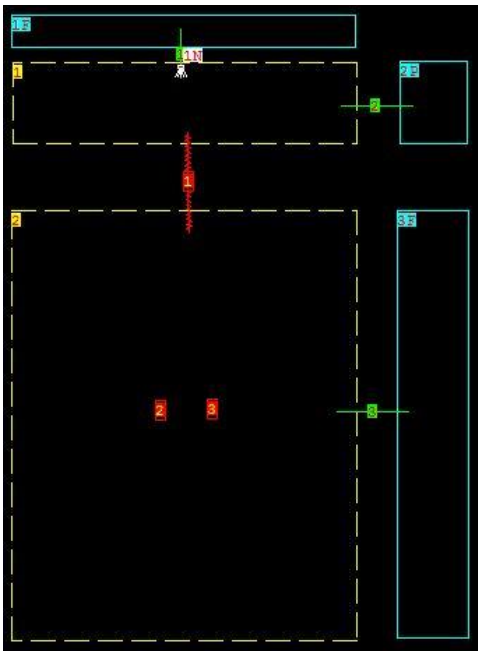

Fig. 1. GOTHIC view of nodding diagram for analysis

The wetted area of containment wall surface by the external spray cooling is 5,185 ft^2. It is assumed that this area is 1/4 of total cylindrical structure area. And, the containment wall thickness is 42 in. Additionally, the wall sub-regions are divided 26 regions as shown in figure 2. Total area of distributed heat sink on ceiling and cylindrical structure are 32,860 ft^3 and 107,260 ft^3, respectively. 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 [3]. It is also assumed that the containment inner pressure and temperature are 16.9 psia and 128 °F, respectively. And, the pressure and temperature of primary system are nominal condition. The input information for modeling is determined in accordance with design document [2].

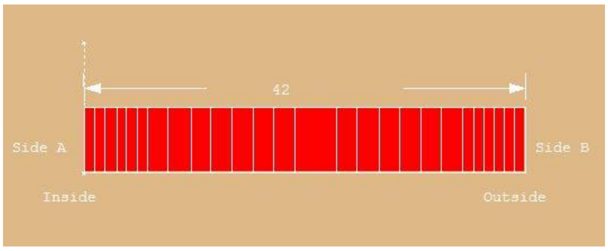

Fig. 2. GOTHIC view of containment wall thickness and detailed region

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. In fact, the entry condition of this strategy for Shin-kori units 1 and 2 is 20.13 psig. However, it is assumed that the initiation cooling action occurs at containment pressure of 18.0 psia to reduce GOTHIC run time.

3. Analysis results

The spray flow starts about 2,050 seconds only in case 2 as presented in figure 3. 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 decreased due to the low spray coolant temperature as shown in figure 4. However, the containment pressure and temperature behaviors are almost same both case 1 and case 2 as shown in figure 5 and 6, respectively. These results show that the thick concrete wall interrupts heat transfer from inside the containment surface to outside the containment wall surface.

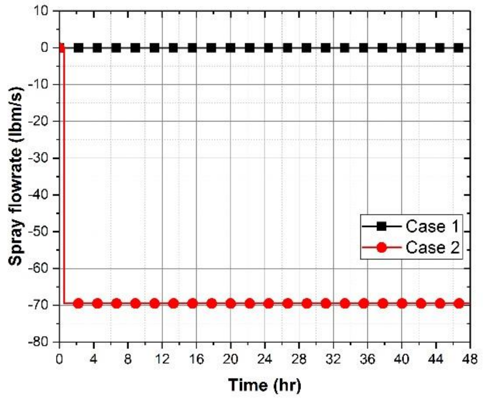

Fig. 3. Spray flowrate of cases 1 and 2

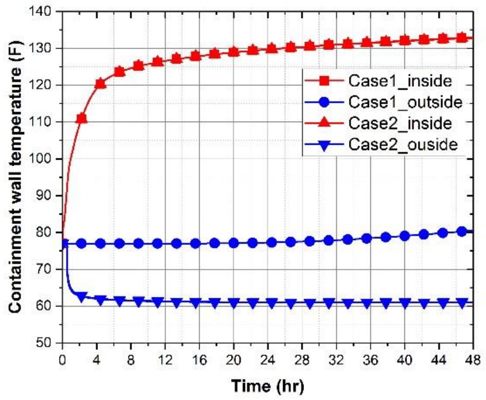

Fig. 4. Containment wall temperature of cases 1 and 2

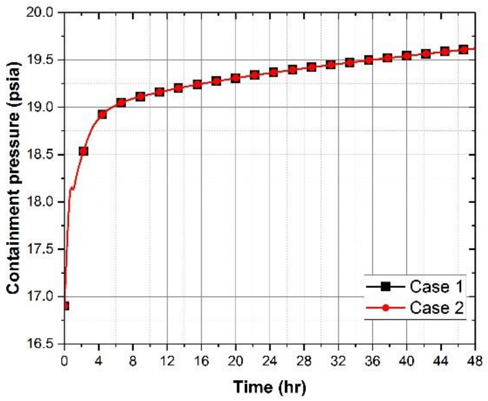

Fig. 5. Containment pressure behavior of cases 1 and 2

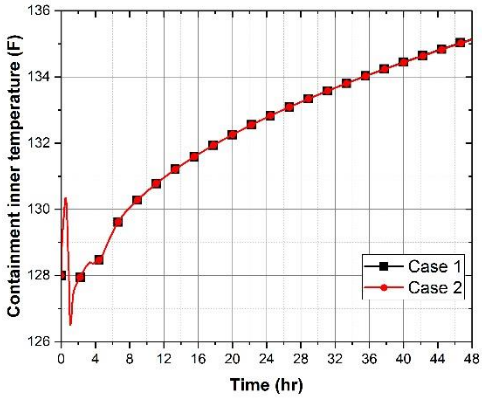

Fig. 6. Containment inner temperature of cases 1 and 2

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 first 48 hours. In other word, the external cooling strategy was not effective due to the thick, and low conductivity of concrete material during the early phase of ELAP condition.

ACKNOWLEDGEMENT

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[3] Nuclear Energy Institute, B.5.b Phase 2&3 Submittal Guideline, NEI 06-12, 2006.