Comparison of Containment Response by Model Difference between GOTHIC and CONTEMPT

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1. Introduction

GOTHIC and CONTEMPT are containment performance analysis codes, which are used in calculation of containment pressure and temperature for design basis accidents such as a loss of coolant accident(LOCA) and main steam line break(MSLB) accident. CONTEMPT models vapor and liquid phases, but GOTHIC has one more phase, drop phase. The containment responses between two codes are different each other during initial stage of accident due to this model difference. This paper evaluates the model difference between GOTHIC and CONTEMPT.

2. Model Characteristics

The CONTEMPT "pressure" and "temperature flash" models can be simulated by setting the source pressure to the blowdown compartment total pressure or steam partial pressures, respectively and specifying that the blowdown water go directly to the pool rather than enter the compartment as drops[1]. In the CONTEMPT temperature flash model it is assumed that the incremental mass and energy from the blowdown of the primary system enters the drywell and is uniformly and instantaneously mixed throughout the vapor region.

GOTHIC does not have the "pressure" and "temperature flash" models for blowdown mass and energy sources in CONTEMPT. The GOTHIC user specifies the enthalpy and pressure of incoming fluid and average drop diameter for typical blowdown sources. The pressure and enthalpy are used to calculate the incoming quality or steam and drop volume fractions[2].

3. Evaluation Model

Figure 1 shows GOTHIC containment model. The physical containment modelings(e.g., volumes and components) are basically unchanged for CONTEMPT. There are two volumes, containment atmosphere and annular region. All 13 heat conductors are modeled.

One containment fan cooler, 1C, is modeled with assumption of the single failure of one train diesel generator. The fan cooler is modeled to actuate on the containment Hi-1 pressure setpoint(18.7 psia) and to begin removing heat from the containment after time delay of 63 sec.

The boundary condition of 1F and 2F represent the mass and energy release and containment spray system from refueling water storage tank in this analysis, the mass and energy release is used for the double ended rupture of main steam line at 102% power under assumption of entrainment in the steam generator.

A circular flow path of 3 with a volumetric fan was added for sensitivity case to better simulate the temperature flash option in CONTEMPT. The fan flow rate was set to 6×10^7 CFM and the flow path drop deposition was set to -1(simulates 100% de-entrainment of drop). All of the liquid drops that enter the circular flow path are de-entrained and put into the sump.

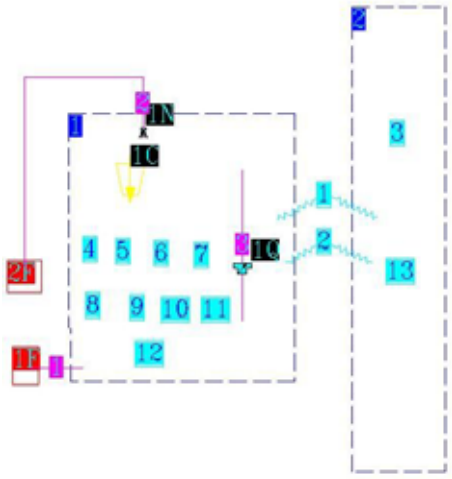

Figure 1 GOTHIC Model for MSLB of Kori Unit 2

4. Results

The containment pressure, temperature and sump temperature comparisons are shown in Figure 2 through Figure 4. For the reference case, GOTHIC predicts lower pressure than CONTEMPT. The containment temperature shows large difference between GOTHIC and CONTEMPT before the spray initiation about 100 sec. In this region, CONTEMPT predicts large superheated condition, but GOTHIC predicts the saturated state. After the spray initiation two codes show a good agreement. GOTHIC shows a bit higher sump temperature than CONTEMPT as seen in Figure 4. On the other hand, the containment pressure and temperature for the sensitivity case show reasonably good agreement between GOTHIC and CONTEMPT.

From this evaluation, it appears that there is a very different treatment between the codes in the treatment of latent heat of condensation. In GOTHIC, more of the latent heat appears to be distributed to the liquid phase than in CONTEMPT. Thus, because the vapor is superheated from the start in this event, GOTHIC is assuming that the latent heat released due to condensation (other than wall condensation) is released to the liquid phase, since that would bring the system into equilibrium. CONTEMPT appears to assume that the latent energy is absorbed by the vapor, resulting in greater vapor superheat, a higher peak vapor temperature, and a longer interval during which the containment vapor is superheated. This phenomenon can be seen in Figure 5. As seen in Figure 5, there is some phase change from drop to vapor for the reference case during 20 ~ 100 sec, but there is no phase change for the sensitivity case because volumetric fan removes droplets to sump.

GOTHIC is very good agreement with experimental data has been achieved for compartment pressures and temperatures for saturated steam blowdowns, whereas for superheated steam blowdowns, pressures and temperatures are calculated to be higher than experimental values[3].

Thus, while GOTHIC solutions give lower MSLB peak temperature and pressure than CONTEMPT, experimental data exists which indicates that the GOTHIC overpredicts the containment temperature and pressure response. This suggests that GOTHIC solutions are conservative, and that CONTEMPT solutions contain even greater conservatisms.

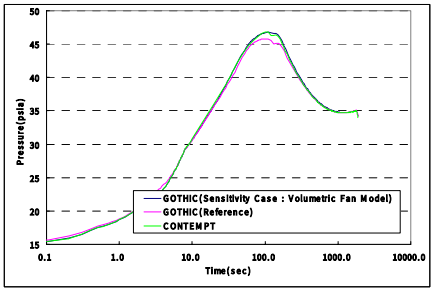

Figure 2 Containment pressure response for the double ended MSLB at 102% power with one diesel generator failure

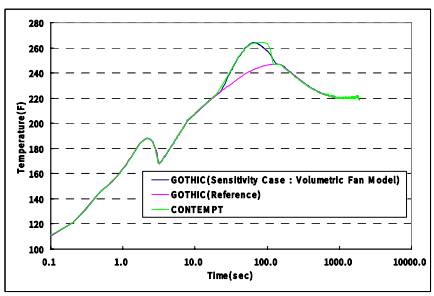

Figure 3 Containment temperature response for the double ended MSLB at 102% power with one diesel generator failure

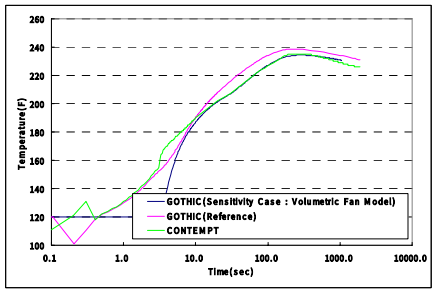

Figure 4 Sump temperature response for the double ended MSLB at 102% power with one diesel generator failure

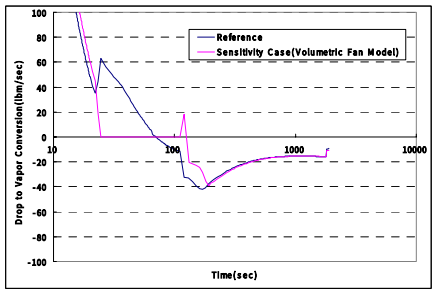

Figure 5 Drop to vapor phase change rate

5. Conclusion

In this paper, the containment responses for the GOTHIC and CONTEMPT are evaluated for the 102% MSLB case. GOTHIC predicts lower containment temperature than CONTEMPT does and CONTEMPT predicts the superheated state, but GOTHIC predicts the saturation state during the entire trend. This results from the difference of the treatment of droplet. GOTHIC is very good agreement with experimental data has been achieved for compartment pressures and temperatures for saturated steam blowdowns, whereas for superheated steam blowdowns, pressures and temperatures are calculated to be higher than experimental values. This suggests that GOTHIC solutions are conservative, and that CONTEMPT solutions contain even greater conservatisms.

REFERENCES

[1] D.W. Hargroves and L.J. Metcalfe, “CONTEMPT-LT/028 A computer program for predicting containment pressure-temperature response to a loss-of coolant accident”, NUREG/CR-0255, March 1979.

[2] T.L. George, et. al., “GOTHIC Containment Analysis Program, Version 7.2, Volume 1and 2”, NAI 8907-02, Rev. 16, Numerical Applications, Inc, Sept. 2004.

[3] T.L. George, et. al., “GOTHIC Containment Analysis Package-Qualification Report”, NAI 8907-09, Rev. 8, Numerical Applications, Inc, Sept. 2004.