APR1400 Containment Simulation with CONTAIN code

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1. Introduction

The more realistic containment pressure variation predicted by the CONTAIN code through the coupled analysis during a large break loss of coolant accident in the nuclear power plant is expected to provide more accurate prediction for the plant behavior than a standalone MARS-KS calculation. The input deck has been generated based on the already available ARP-1400 input for CONTEMPT code. Similarly to the CONTEMPT input deck, a simple two-cell model was adopted to model the containment behavior, one cell for the containment inner volume and another cell for the environment condition. The developed input for the CONTAIN code is to be eventually applied for the coupled code calculation of MARS-KS/CONTAIN.

2. Methods and Results

Input deck for the CONTAIN code has been prepare based on the CONTEMPT containment modeling data. Due to the fundamental discrepancy in containment modeling between CONTAIN and CONTEMPT codes, it was necessary to interpret and adapt a large portion of COMTEMPT input deck for the CONTAIN code. Geometry data, however, was rather a direct conversion of the physical unit.

2.1 Fan-cooler modeling

Fig. 1 illustrates heat removal rate of the fan cooler of APR-1400 type plant [1]. It is seen that approximately 62500 Btu/sec of heat removal is expected at 140 ^{o}F. The additional parameters required by the CONTAIN code for the fan-cooler modeling were coolant inlet temperature and mass flow rate. Code default values were adopted for these data. Separate sensitivity tests showed the effects of these parameters were not significant.

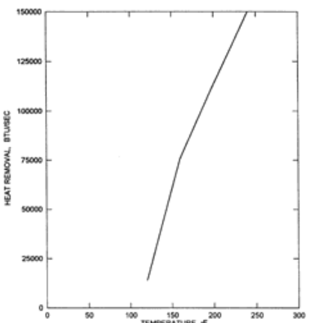

Fig. 1. Fan Cooler Heat Removal Rate [1]

2.2 Spray modeling

When a spray system functions as one of ESF(Engineered Safety Feature), CONTAIN code requires modeling data for SOURCE and SPRAY.

An alternative method would be to provide TANK, PUMP, HEX, and SPRAY input values. In this study the later method was chosen. Initial inventory of TANK (irwst) was set to a value which is large enough that a recirculation is not activated for the spray operation. The effect of PUMP and HEX values, thereby, were removed. Also, the pressure threshold was set to low enough for the immediate engagement of the spray.

2.3 Wall Heat Transfer Modeling

Wall heat transfer modeling in the CONTAIN code is practically based on a diffusion layer theory proposed by Peterson [2]. The model, as seen in Fig. 2 [3], is in good agreement with the Uchida test date [4], especially when the initial air pressure is 1 bar, which is widely applied for the containment wall heat transfer. For the minimum containment pressure model which is required for the evaluation of ECCS performance capability, separate models are used for the blowdown phase and thereafter. Normally four times Tagami model is used for the blowdown phase, while 1.2 times of Uchida model for the rest of the event (See Fig. 3)[5]. In this study, regardless of the different phases of the event, a single multiplication factor (hmxmul) of 4 was set to the Nusselt parameter in the CONTAIN code. The containment outside wall heat transfer was treated normally without any modification. The geometry of the containment was similarly configured as the CONTEMPT input.

2.4 Simulation Results

The simulation results for the CONTEMPT and CONTAIN codes are discussed, along with a best estimate analysis performed with the multiplication factor for the Nusselt number of 1. Fig 4 depicts the containment pressure variation during the postulated LBLOCA accident. The transient during the initial 50 seconds is shown in Fig 5, separately. As seen in these figures, the conservative analysis of CONTAIN code prediction shows a very similar transient behavior with the CONTEMPT code. Initially (see Fig. 5), the pressure increases among the three different calculations were essentially same. The peak pressure in the conservative CONTAIN analysis rises up to 2.86 bar, which is nearly 11% higher than 2.57 bar predicted by the CONTEMPT code. The best estimate values by the CONTAIN code is found to be 3.31bar, which is around 29% higher that the CONTEMPT reference calculation. The gas temperature transient in the containment building is seen in Fig 6. The trend of the temperature variation is found to be very similar with that of the pressure. The peak value of the gas temperature, for the conservative analysis, by the CONTAIN code is 386K which is approximately 5K higher that the CONTEMP code prediction. The effect on the reactor coolant system transient is expected to be minor, however. It is noted that the peak value by the best estimate analysis is a little higher (7K) than the conservative calculation.

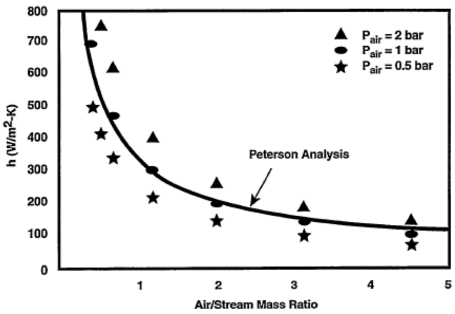

Fig. 2. Heat Transfer Coeff. for the condensing air/steam [3]

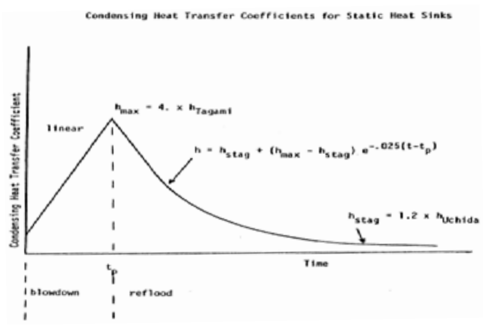

Fig. 3 Heat Transfer Coeff. for min. Containment Pressure

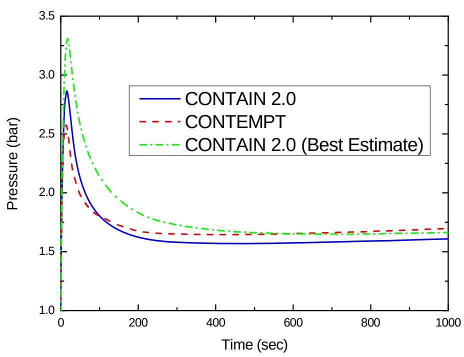

Fig. 4. Containment Pressure

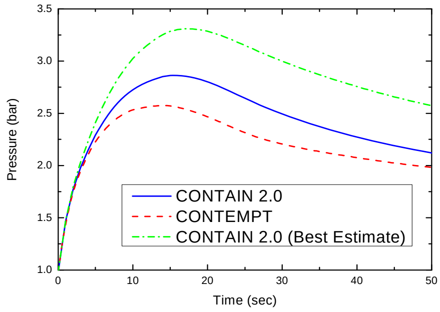

Fig. 5. Containment Pressure (early phase)

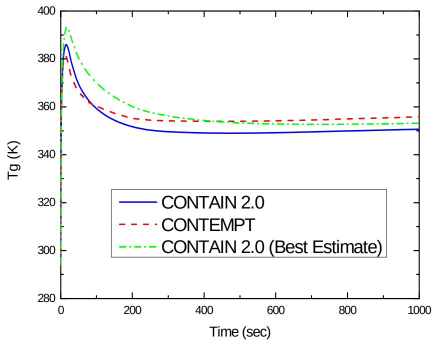

Fig. 6. Containment Gas Temperature

3. Conclusions

An input data for the CONTAIN code has been developed for APR-1400 type containment building. The LBLOCA accident was simulated with the input deck and results were compared with the reference COMTEMPT code prediction. When compared to the results of the CONTEMPT code calculation, the newly generated CONTAIN code input was found to provide very similar trends in containment pressure and gas temperature variations. The peak pressure predicted by CONTAIN code was approximately 11% higher than the CONTEMPT calculation. The developed input deck is expected to provide a more realistic containment behavior, especially when a coupled code calculation of MARS-SK and CONTAIN code is performed.

REFERENCES

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[5] NRC Standard Review Plan- Minimum Containment Pressure Model for PWR ECCS Performance Evaluation – NUREG-008 (Branch Technical Position 6-2)