Validation of Ulchin Units 1, 2 CONTEMPT Model Prior to the Production of EQ Envelope Curve

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1. Introduction

The Ulchin Units 1, 2 will be refurbished with RSG (Replacement of Steam Generator) and PU (Power Uprate). The current EQ (Environmental Qualification) envelope curve should be modified according to RSG and PU. The containment P/T (Pressure/Temperature) analysis in Ulchin Units 1, 2 FSAR[1] was done using EDF computer program PAREO6. PAREO6 uses the same assumptions as the US NRC CONTEMPT[2] program, and the results given by both programs are in good agreement. It is utilized to determine pressure and temperature variations in a PWR containment subsequent to a reactor coolant or secondary system pipe break. But PAREO6 cannot be available to the production of EQ envelope curve, so CONTEMPT code should be used instead of PAREO6.

It is essential to validate the CONTEMPT OSG (Original Steam Generator) model prior to the production of EQ envelope curve considering RSG and PU. This study has been performed to validate the CONTEMPT model of Ulchin Units 1, 2 by comparing the CONTEMPT results with the PAERO6 results in Ulchin Units 1, 2 FSAR.

2. Validation of CONTEMPT Model

2.1 CONTEMPT-LT/028 Input Model

2.1.1 Control Volume and Initial Condition

The initial conditions for the containment P/T analysis are as follows:

- Pressure : 1.1 bar (15.95 psia)
- Temperature : 45°C (113°F)
- Humidity : 10%

The minimal net free volume of containment is $49400 m^3$ (1.744×10^6 ft^3).

2.1.2 Passive Heat Sink

The passive heat sinks in Ulchin Units 1, 2 CONTEMPT model are shown in Table 1.

2.1.3 Heat Transfer Model

Heat transfer between containment atmosphere and passive heat sinks is determined conservatively according to surface temperature of passive heat sinks, heat transfer coefficient, the arrangement of heat conductors, and thermal characteristics.

2.1.4 Re-evaporation Rate

When the containment atmosphere is at or below the saturation temperature, all condensate formed on the heat sinks should be transferred directly to the sump. When the atmosphere is superheated, some of the condensate may be assumed to remain in the vapor region. NUREG-0588 Appendix B[3] allows 8 % re-evaporation rate under superheated atmosphere for model of environmental qualification. But the methodology of PAREO6 used in Ulchin Units 1, 2 FSAR assumes that if the atmosphere is superheated, the total flow to sump is zero, since the water condensed on the cold walls is considered to evaporate instantly. In this study, the re-evaporation rate is assumed to be 100% to compare the CONTEMPT results with PAERO6 results.

Table 1. Passive Heat Sinks

Description	Material	Thickness [mm]	Surface area[m^2]
Part of the Containment above the ground	paint steel air concrete	0.4 7.4 3.0 900	6,995
Lower floor easily flooded	paint concrete steel concrete	3.6 1000 6.0 3500	830
Concrete Floors	paint concrete paint	3.6 830 0.87	2330
Concrete Walls	paint concrete paint	0.87 830 0.87	5470
Reactor Cavity	S/S air concrete paint	3.00 3.00 1000 0.37	765
Ventilation Ducts	S/S	1.6	3675
Thin Steel	paint steel paint	0.40 3.00 0.4	4250
Average Thickness Steel	paint steel paint	0.40 12.0 0.4	1450
Thick Steel	paint steel paint	0.40 40.0 0.4	2000
Tanks and Cold pipes, non-insulated and filled up with water	paint steel paint	0.40 12.0 0.2	1400
Motors	paint steel	0.40 0.172	52.5

2.2 LBLOCA-DEPSG P/T Analysis

The containment P/T Analysis for DEPSG (Double Ended Pump Suction Guillotine) break has been performed. The assumptions are as follows:

- 102% Full Power
- Maximum SI (2 RIS), Minimum Spray (1 EAS)
- Loss of Offsite Power Supply

The results are shown in Figure 1 and Figure 2. The pressure and temperature transients during blowdown (until 21.65 seconds) show good agreement between CONTEMPT and PAREO6 results. After the end of blowdown, the pressure and temperature of CONTEMPT begin to decrease faster than those of PAREO6 until 1800 seconds. At 1800 seconds, the spray source begins to change from RWST (Refueling Water Storage Tank) to recirculation sump. After about 3500 seconds, the pressure and temperature of CONTEMPT begin to decrease slower than those of PAREO6. The reasons for these differences are due to the heat transfer model and heat exchanger model of CONTEMPT and PAREO6.

After the end of blowdown, the CONTEMPT uses Uchida correlation with tabular form, but PAREO6 uses Tagami correlation as follows:

$$H = 11.356 + 283.9 \times \left(\frac{\text{steam mass}}{\text{air mass}} \right) \quad \text{for PAREO6}$$

Figure 3 shows the difference between CONTEMPT and PAREO6. The reason for the faster decrease of pressure and temperature of CONTEMPT after the end of blowdown is due to these differences.

The heat exchanger models in PAREO6 are composed of two models, one is the heat exchanger between EAS (Containment Spray System) and RRI (Component Cooling Water System) and the other is the heat exchanger between RRI and SEC (Essential Service Water System). But the heat exchanger model in CONTEMP considers only EAS-RRI heat exchanger. The RRI temperature in CONTEMPT is assumed to be 43^{o}C conservatively. The reason for the slower decrease of pressure and temperature of CONTEMPT during recirculation phase is due to these differences.

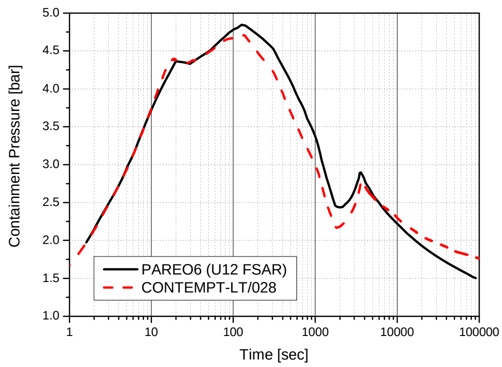

Figure 1. Pressure Transient of PAREO6 and CONTEMPT for DEPSG Break with 2 RIS and 1 EAS

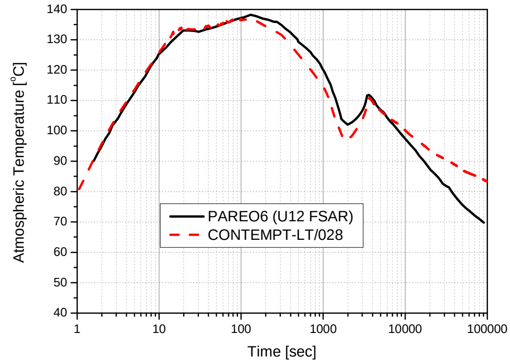

Figure 2. Temperature Transient of PAREO6 and CONTEMPT for DEPSG Break with 2 RIS and 1 EAS

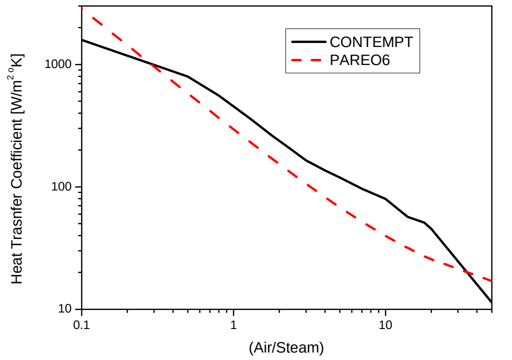

Figure 3. Heat Transfer Coefficients of PAREO6 and CONTEMPT After the End of Blowdown

3. Conclusion

The Ulchin Units 1, 2 CONTEMPT OSG model was validated by comparing the CONTEMPT results with PAERO6 results in Ulchin Units 1, 2 FSAR. The pressure and temperature behaviors between CONTEMPT and PAREO6 results are similar with each other. But there are some differences between CONTEMPT and PAREO6 results due to the differences of heat transfer model and heat exchanger model. The CONTEMPT model developed in this study will be utilized to the production of EQ envelope curve considering Ulchin Units 1, 2 RSG and PU.

REFERENCES

[1] KEPCO, Ulchin 1&2 Final Safety Analysis Report
[2] Idaho National Engineering Laboratory, NUREG/ CR-0255, March 1979, CONTEMPT-LT/028 - A Computer Program for Predicting Containment Pressure-Temperature Response to a Loss of Coolant Accident
[3] US NRC, NUREG-0588, Rev.1, July 1981, Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment, Appendix B