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Analysis on Containment Response Following a LBLOCA of APR1400

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1. Introduction

A licensing application of Shin-Hanul Units 1&2 was submitted and is currently under KINS' review. These units are with 1400 MW capacity each and similar to Shin-Kori Units 3&4. However, the reactor containment and passive heat sinks are designed different from the preceding units. Therefore, Shin-Hanul Units 1&2 may possess different characteristics of peak pressure and temperature in containment following a large break loss-of-coolant-accident. To assess the important performance independently and to compare with prediction results presented in the final safety analysis report (FSAR) of Shin-Hanul Units 1&2 might be helpful to regulatory review for identifying validity of the FSAR. The end of blowdown (EOB) time during a LOCA could largely affect the peak pressure and temperature in the containment. This paper provides CONTEMPT-LT/028 prediction of the peak pressure and temperature of Shin-Hanul Units 1&2 following a large break loss-of-coolant-accident and compares with licensee's prediction results.

2. Modeling and input preparation

In this section, some of the methods used to model the Shin-Hanul Units 1&2 are described. The Shin-Hanul Units 1&2 reactor containment model includes passive heat sinks, drywell, liquid pool, spray, heat exchanger, etc.

2.1 Reactor containment design characteristics

The reactor containment of Shin-Hanul Units 1&2 is a large and dry one and pre-stressed concrete structure to maintain its integrity under the high internal pressure. The In-Containment Refueling Water Storage Tank (IRWST) installed inside the containment works as a source of water supply for emergency core cooling system or containment spray system. The reactor containment design pressure and temperature are 60 psig and 290˚F respectively, and cylindrical wall diameter and net free volume are 150ft and $3.128\times10^6 ft^3$ respectively. The design leakage rates are 0.1% free volume per day for the initial 24 hours but this was ignored in the calculation of pressure and temperature for conservatism.

2.2 Analysis methodology

A variety of computer programs are in use for the analysis of reactor containment pressure and temperature following a design basis accident. The CONTEMPT-LT/028 computer program developed by U.S. NRC is commonly used in Korea. The licensee, KHNP, has used CONTEMPT-LT/028 computer program to analyze reactor containment peak pressure and temperature described in chapter 6.2.1 of the final safety analysis report, and CONTEMPT4 computer program is used to predict back pressure for emergency core cooling system performance evaluation following a loss-of-coolant-accident. In this study, CONTEMPT-LT/028 computer program was used to compare reactor containment pressure and temperature prediction results of Shin-Hanul Units 1&2. The accident scenario for the analysis is the limiting loss-of-coolant-accident, double-ended suction line slot break with maximum safety injection, presented in the chapter 6.2.1 of the final safety analysis report. Fundamental input data were used from the final safety analysis report, and other variables which are not clearly stated in the final safety analysis report were decided based on the engineering judgement. The number of heat conducting structures is eighteen including containment cylindrical wall, containment dome, floor, steel reinforced concrete, containment concrete, steel reinforced spent fuel pool, upper plate of IRWST, polar crane and bridge and safety injection tank. The heat conducting structures are composed of six materials including carbon steel, stainless steel, concrete, epoxy paint, inorganic zinc paint and air, and representative thermal conductivities and volumetric heat capacities are given as input to the computer programs. Initial outside air temperature, absolute pressure and relative humidity are 120˚F, 14.7psia and 0.1, respectively. In the standard drywell, total compartment volume is $3.24\times10^6 ft^3$ and volume of liquid pool on floor is 83818 ft^3. Temperatures of vapor and liquid pool regions are 128 ˚F and total compartment absolute pressure is 16.9psia. Relative humidity of vapor region is 0.05 and horizontal cross-sectional area of compartment, used for liquid pool surface area and needed in evaporation model, is 12024.4 ft^2. The heat transfer coefficient to outside air is set as 2.0 Btu/ft^2-hr-˚F. The blowdown mass and energy addition table describing rates of water and energy addition to the drywell from blowdown of the primary system is set from 0 sec to 138 sec when the end of post-reflood (EOPR) takes place. This mass and energy table is generated from the realistic systems analysis program named RELAP5. The end of blowdown (EOB) time is estimated to be 19.403 sec, which determines long term condensation heat transfer coefficient and Tagami correlation is used until EOB time and Uchida one is used afterwards.

2.3 Prediction results

The most actual design values and parameters were used in the prediction of the containment response to the large break loss of coolant accident. The analysis results are given in Figures 1 and 2.

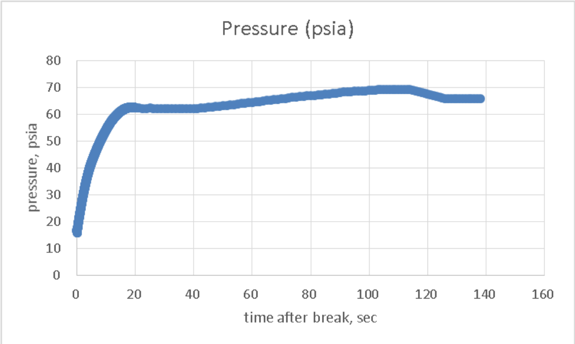

Figure 1. Containment pressure after break

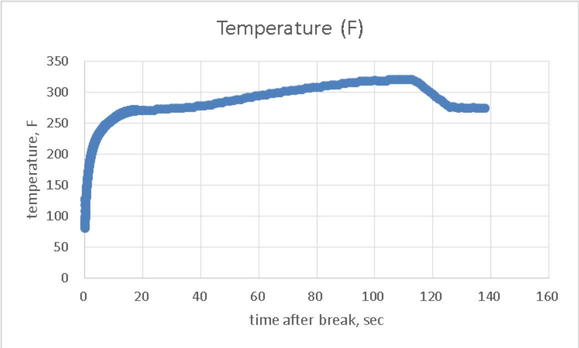

Figure 2. Containment temperature after break

The containment spray actuation signal is on at 3.85 sec and delay time of 110 sec is added. Therefore, containment spray is initiated at 113.86 sec as can be seen in the figures above. The peak pressure and temperature until the end of post-reflood are predicted as 69.44 psia and 320.01 ˚F , respectively. The difference of the predictions with the final safety analysis report values of peak pressure and temperature are 2.3% and 0.5%, respectively. Therefore, the predictions were almost identical to the final safety analysis report values. Also the peak timings agreed well with each other.

3. Conclusions

Simulation calculations using CONTEMPT-LT/028 can be useful for predicting peak pressure and temperature after a loss of coolant accident in APR1400 reactors. The predictions are in good agreements with the final safety analysis report, which implies the containment integrity is maintained during or after an accident like loss of coolant accident. In this study, the CONTEMPT-LT/028 was used to calculate the pressure and temperature, and in the follow-up study, CONTAIN 2.0 will be used for the pressure and temperature predictions in APR1400 reactors. The results shown in this paper do not represent the regulatory position of Korea Institute of Nuclear Safety.

REFERENCES

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