Model Development and Evaluation of Containment Back Pressure by IRWST Damper of APR1400

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1. Introduction

The IRWST(In-Containment Refueling Water Storage Tank) of APR1400 is installed at the bottom of containment building to promote the plant safety functions during an accident. This design feature brings about uncertainty factors which may necessitate conventional prediction of temperature and pressure of containment building improved or revised when an accident occurs. The hot steam which is released from RCS break enters into the IRWST through four PRDs(Pressure Relief Damper). It is expected to be condensed with water stored in IRWST, colder than incoming steam.

The purpose of this study is to assess the influence of the IRWST and the PRD on back pressure and temperature in APR1400 containment building using the containment code, GOTHIC which can also predict the steam condensation on IRWST pool surface.

2. Basic Modeling of APR1400

2.1 Containment and IRWST

The APR1400 containment building is a pre-stressed cylindrical structure of concrete which has net free volume of 3.3×10^6 ft^3 as a maximum. The altitude of lower floor is 100 ft and maximum height of the upper part is 329.5 ft. IRWST is annular concrete structure located at the bottom of the containment and is connected to other containment compartments by four PRDs, and has nominal free volume of 117,416 ft^3. The altitudes of lower and upper floor are 81 ft and 97 ft, respectively. In this study, developed containment model does not have HVT(Holdup Volume Tank) because we only concern about early transients during 1,000 seconds from design basis accident.

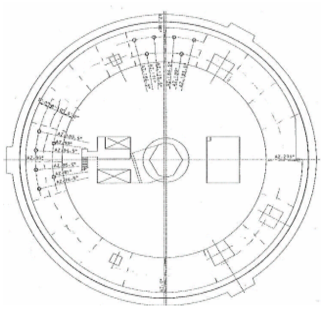

Figure 1. IRWST of APR1400

2.2 Pressure Relief Damper

The PRDs are located at the lowest floor of annular containment compartment and have a configuration of separation of approximately 90° between PRDs. The net flow area for each PRD is designed to be 36 ft^2. When pressure difference between containment and IRWST reaches 0.5 psia, PRD is opened, allowing steam and air flows on both sides.

2.3 Engeneered Safety Futures (ESFs)

The ESFs considered in this study are two trains of containment spray systems and safety injection systems, respectively. All these systems intake water of about 14,000 gpm from the sumps located at the bottom floor of IRWST during an accident. This suction flow can open the PRD by creating vacuum inside the IRWST over time interval of approximately 1 minute.

2.4 Passive Heat Sink

Passive heat sink is another factor that influences on pressure and temperature. For analysis purpose, maximum allowable passive heat sinks are applied in consistency with material properties.

2.5 RCS Mass and Energy Release

The data from accident analysis for design basis accident are used in this study.

2.6 Containment Initial Condition

In containment, it is assumed that temperature is 50 °F, pressure is 14.7 psia, and humidity is 90 %, consistent with other modelings. In IRWST, cooling water level is 11.5 ft.

3. Model Development

This study developed one-compartment (single) model, two-compartment (separated) model, and three-dimension (3-D) model, respectively. Two compartment model separates the IRWST from the other containment compartments. In 3-D model, only the IRWST is nodalized with Cartesian modeling.

The single model is developed for comparison with two-compartment model which can analyze PRD's infl-

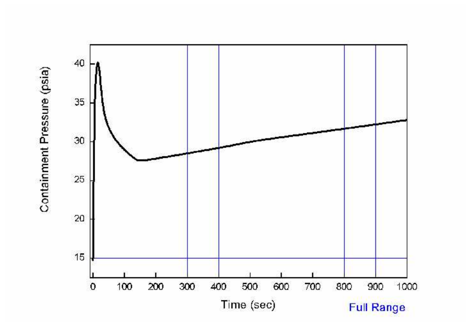

Fig. 2. Containment Pressure from Single Model

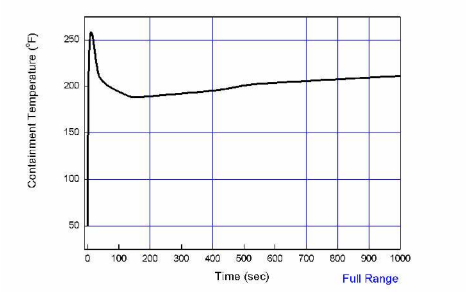

Fig. 3. Containment Temperature from Single Model

-ence. As seen in Fig. 2 and Fig. 3, initially pressure and temperature increase dramatically because of the RCS mass and energy release. And then, they decrease owing to containment spray system operation and gradually increase due to continuous addition of mass and energy.

The separated model for predicting PRD's influence divides the space between containment and IRWST. Four PRDs are modeled as pressure-difference flow paths in GOTHIC code. The distribution of pressure and temperature has a little difference on containment and IRWST. At initial time, as steam goes to IRWST press-

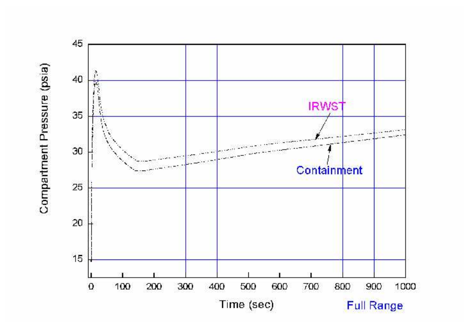

Fig. 4. Containment Pressure by Separated Model

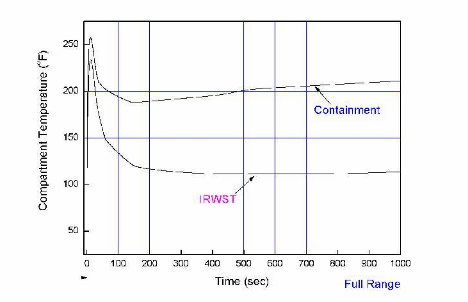

Fig. 5. Containment Temperature by Separated Model

-ure of IRWST increases. Finally, the state becomes thermally stratified and is maintained as equilibrium state.

3-D model for IRWST was generated because it is not symmetric considering location of sparger, pump, and suction sump. Therefore, IRWST is simulated with not only detailed three-dimensional behavior but also independent flow paths for four PRDs.

4. Conclusion

In this study, the detailed modeling of APR1400 containment building was performed by GOTHIC code. Initial pressure of IRWST increases higher than one of containment. A few seconds later, however, the state becomes thermally stratified and is maintained as equilibrium state. According to GOTHIC analysis result with various models, condensation between vapor and surface of water is predicted to be very small. The present models do not consider uncertainly factors such as geometrical and physical configuration and direct condensation over water pool surface. In next stage, detailed 3-D analysis will be performed considering APR1400-specific phenomena as stated in the previous sentence.

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