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Pressure/Temperature Analysis using GOTHIC Computer Code for Kori 3&4 Auxiliary Building Environmental Qualification

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1. Introduction

Before late 1970's Regulatory Body (US NRC and/or KINS in Korea) did not impose strict regulatory requirements for Environmental Qualification (EQ) on safety-related equipments or components. To resolve this, NRC incorporated the requirement into 10CFR50.49 in 1983. As a result, from the early of 1980's most of utilities had to update their plants by re-qualification of modification to meet the newly issued regulatory requirements for EQ.

As a part of a BOP EQ for Kori 3&4 Project, KOPEC investigated High Energy Line Break (HELB) in the Auxiliary Building (AB). A modeling of the HELB analysis has been developed using GOTHIC computer code [1]. This model is described herein and representative results of the model calculations are presented.

2. Methods and Results

In this section some of the techniques and assumptions used to model the HELB analyses in auxiliary building are described.

2.1. GOTHIC Computer Code Modeling

The KOPEC has developed GOTHIC input model that is be used in the HELB analyses in the Kori 3&4 AB. All rooms at three floors (EL. 64' & 74', EL. 88', EL. 100' & 115') in AB are modeled as control volumes. The methodology utilized to develop the Lumped Volume GOTHIC model of the Kori 3&4 AB is as follows:

The model inputs are developed using the guidance of the applicable section of the GOTHIC User's Manual [1] and the GOTHIC Technical Manual [2].

GOTHIC Control Volumes, Boundary Conditions, Flow Paths, Thermal Conductors, Components (Doors), Trips, Functions, Initial Conditions, and Run Control Parameters are used to develop the model. This model is developed using current plant configuration drawings and design input information. A typical nodes and flow paths diagram of the resultant GOTHIC AB HELB EQ model is shown in Figure 1.

2.1.1. Control Volume

1) For control volume calculations of volumes having ceilings composed of multiple floor slabs that are not all of uniform thickness, a representative composite (may be a minimum or average based upon review of floor slab thickness variation within the HELB volume) room height may be assumed.

2) To account for internal structures and equipment, a volume reduction fraction was determined through the plant walk-down.

3) For wetted surface area calculations, large openings are subtracted from the total surface areas. This is a minor adjustment on the volume's hydraulic diameter and will not significantly impact volume flow calculations.

2.1.2. Flow Path

1) To account for buoyancy effects, wall penetrations , doors and large flow areas (labyrinths, hallways, etc.) are modeled as two flow paths, upper half and lower half each with 50% of the doorway flow area. K values (flow resistance) for door pathways are modeled such that the K value calculated for the door as a single flow pathway is applied to both flow pathways in the GOTHIC model. Thus, when flow is in the same direction through the upper and lower modeled door pathway, the modeled door flow area and K value equates to that of the door modeled as a single pathway.

2) Friction length and Inertia Lengths for flow paths corresponding to open areas on the same level are assumed to be zero as these friction losses are already accounted by volume friction losses. All Inertia Lengths assume volume widths based on the entire volume or to the nearest wall along the flow path or "effective volume width" as applicable.

3) Stairwell flow path junctions are modeled as floor and ceiling orifices.

4) AB external penetrations (pipe & electrical, doors, HVAC) are conservatively assumed to remain sealed throughout all HELB transients.

5) Hatch covers, plates, etc. are assumed to remain in place throughout all HELB transients.

6) The K forward/reverse losses are input as sharp-edge entrance and exit losses (K = 1.5).

2.1.3. Thermal Conductors

1) The volume's conductor surface areas are conservatively defined based on inside wall area.

2) Radiation heat transfer (surface to surface or surface to vapor for the internal structures) is conservatively ignored in the GOTHIC model.

3) For internal AB surfaces, condensation heat transfer is modeled using the Uchida correlation.

4) For internal AB surfaces, a natural convection correlation is incorporated with a minimum HTC of 0.25 BTU/Hr.-Ft^2-°F assumed.

5) Areas outside the AB are not modeled. For thermal conductors facing these areas, the wall is assumed insulated.

6) Containment wall assumed as a half thickness heat structure of 2.0’ thickness.

2.1.4. Components (Doors)

1) The only Kori 3&4 AB pathways that are assumed to fail open as a result of the HELB transient pressure response within the AB are internal AB doors.

2) A “minimum” opening pressure for doors opening against the latch of 1.0 psid is assumed.

3) A “minimum” opening pressure of 2 psid is assumed for doors failing against the door frame.

4) Watertight doors are assumed to withstand any postulated HELB break without damage.

2.1.5. Boundary Conditions

1) Mass & Energy (M&E) releases due to HELB are calculated by Moody [3] and Henry-Fauske [4] Critical Flow Models for saturated and subcooled water, respectively. The break flows was inserted into a control volume for the room containing broken pipe via boundary conditions.

2) For liquid M&E releases where a portion of the released fluid will flash to steam and based on experimental evidence for blowdown analysis, the GOTHIC User’s Manual[1] recommends that the liquid be injected in droplet form with a diameter on the order of 0.01 cm (equal 100 microns, equal 0.00394 inches).

3) Outside environmental conditions assumed at 14.7 psia and 97°F.

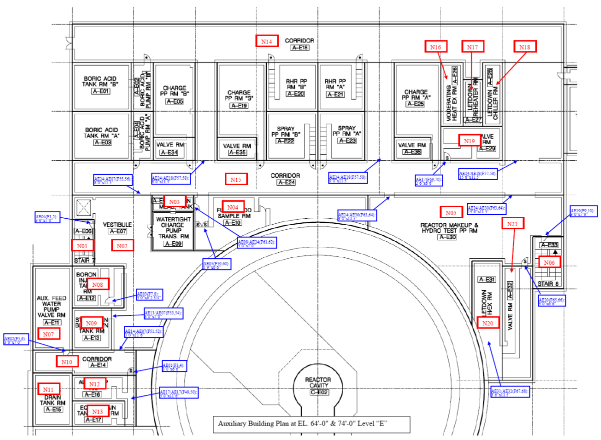

Figure 1. Nodalization of Kori 3&4 AB EL. 64’&74’

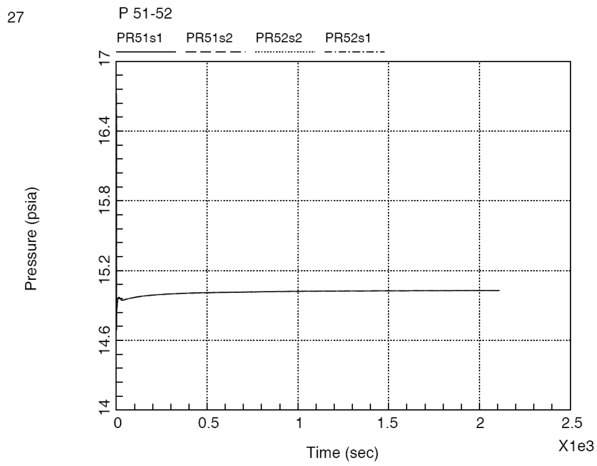

Figure 2. Pressure Transients for 4” Steam Supply Line to TD-AFWP in AB

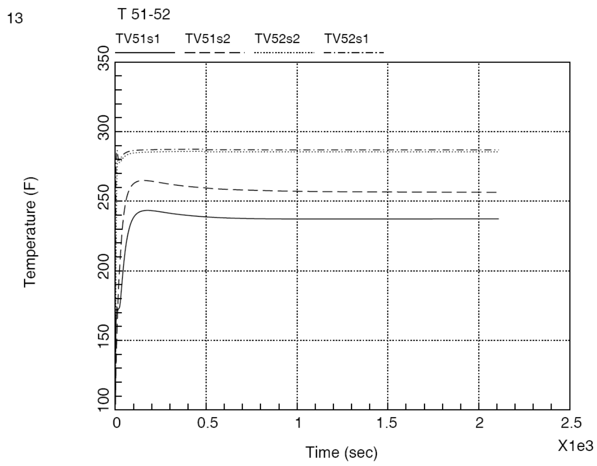

Figure 3. Temperature Transients for 4” Steam Supply Line to TD-AFWP in AB

3. Conclusion

The lumped volume GOTHIC model for Kori 3&4 AB was developed for the generation of pressure and temperature profile during HELB in AB. Figures 2 and 3 show the results for the 4” Steam Supply Line Break to Turbine-Driven Auxiliary Feedwater Pump. These P/T curves will be used in the EQ analysis for safety-related equipments or components in Kori 3&4 AB.

REFERENCES

[1] GOTHIC Containment Analysis Package, Users Manual, Version 7.2, NAI 8907-02, Rev. 16.

[2] GOTHIC Containment Analysis Package, Technical Manual, Version 7.1, NAI 8907-06, Revision 15.

[3] F.J. Moody, “Maximum Flow Rate of a Single Component, Two-Phase Mixture,” Journal of Heat Transfer, Trans. ASME, 87, Feb. 1965.

[4] R.E. Henry and H.K. Fauske, “The Two-Phase Critical Flow of One Component Mixtures in Nozzles, Orifices, and Short Tubes,” Journal of Heat Transfer, Trans. ASME, 93, May 1971.