08/04/2016 Staff feedback on RAI 208-8245; Q 03.08.03-1

After reviewing the response to RAI 208-8245, Question 03.08.03-1, the staff have identified a need to review the below. We have some preliminary info we would like to see. Please see if you can put the below 2 items in the ERR:

1) background for the scaling factors for part (a) (see below), specifically, n-sub-g, n-sub-z, and n-sub-v.

2) We also need to confirm that the equation on page 5/9 refers to r>2r0 rather than just "0" (We have the background info that corroborates this, so this should just be a simple confirmation of a typo).

In RAI 8245, Question 03.08.03-1 (parts (a) and (b)), the staff requested the applicant to describe a) how the pressure transient for a single sparger activation was developed; and b) what cases of activation (of the spargers) may occur. The staff reviewed the structural aspect of the response to part (a) and found it to be acceptable. However, NRC also needs to review the other aspect of the response that describes the methodology for computing the PORSV spargers pressure transient for acceptance.

For part (b), the applicant stated that the criteria for determining the cases of activation of the spargers is the same as the criteria in the System 80+ application. The applicant further stated that "[a]ir bubble discharge loads from a particular sparger are considered to act only on the boundaries which can be "viewed" from the sparger bubble with direct line of sight…and [f]or multiple valve actuation events, where more than one bubble exists in the pool, the foregoing calculation procedure is first utilized independently for each bubble. The combined load is then obtained by SRSS (Square Root of the Sum of Square) addition of these individual loads at the location of interest."

KHNP INPUT

Item 1.

The equation in page 5/9 of the response to RAI 208-8245, Question 03.08.03-1 will be revised as follows:

$$\Delta P_r = 2 \cdot \Delta P_B (r_0/r) \; for \; r > 2r_0$$

Item 2.

The detailed design specifications for the sparger are referenced from the reference plant, Shin-Kori Units 3&4. All the APR1400 type reactors have the same sparger and IRWST design features. The request for uploading the calculation in the ERR is not necessary since the response to RAI 208-8245, Question 03.08.03-1 and this response below summarize the entire content of calculation.

1. **Steam Mass Flux**

Experiments have indicated that the maximum pressure amplitude in the pool is proportional to the steam mass flux if nothing else is changed. The Studsvik reference mass flux is 1300 kg/m^2-s. The scaling factor to account for differences in mass flux is 1.1 since the measured mass flux at the sparger header in the reference plant (Shin-Kori Units 3&4) is about 1420 kg/m^2-s.

$$\eta_G = \frac{(\Delta P_{gas\ cloud})_{APR1400}}{(\Delta P_{gas\ cloud})_{Studsvik}} = \frac{(G_{steam})_{APR1400}}{(G_{steam})_{Studsvik}} = \frac{1420}{1300} = 1.09 \approx 1.1$$

2. **Maximum Pressure in Discharge Pipe**

The inflow of non-condensable gas to the gas cloud in the condensation pool (the growth of the gas cloud) is essentially dependent on the pressure in the gas phase in the sparger during the last part of the "water clearing phase". The Studsvik reference maximum pressure is 1.6 MPa. The range of maximum pressure at the sparger tip in the reference plant is 1.24 - 1.65 MPa. Therefore, the scaling factor to account for differences in the maximum discharge pipe pressure is 1.0.

$$\eta_P = \frac{\left(P_{discharge\,pipe}^{max}\right)_{APR1400}}{\left(P_{discharge\,pipe}^{max}\right)_{Studsvik}} = \frac{1.65}{1.6} = 1.03 \approx 1.0$$

3. Submergence Depth of Sparger

Experiments have shown that the maximum pressure amplitude in a condensation pool decreases with decreasing submersion. This is, of course, due to a decreased pipe pressure as well as to the factor that the gas cloud will be closer to the water surface with decreasing inertial resistance of the pool water. The increase of the pressure amplitude will be of the order 10% per meter at the actual submergence depths based on the Studsvik tests (submergence depth 4.5 m and 5 m).

$$\frac{1}{\Delta P_{pool}^{max}} \frac{d\left(\Delta P_{pool}^{max}\right)}{d\left(z_{sparger}\right)} = 0.10m^{-1}$$

The Studsvik reference submergence depth is 4.5 m. The submergence depth in the reference plant is 93'- 81' = 12 ft = 2.75 m. Therefore, the scaling factor to account for differences in sparger submergence depth is conservatively determined as 0.9.

$$\frac{d\left(\Delta P_{pool}^{max}\right)}{\Delta P_{pool}^{max} d\left(z_{sparger}\right)} \Delta z_{sparger} = 0.1m^{-1} \times (4.5m - 2.75m) = 0.175 \approx 0.1$$

$$\eta_z \equiv 1 - \frac{d\left(\Delta P_{pool}^{max}\right)}{\Delta P_{pool}^{max} d\left(z_{sparger}\right)} = 1 - 0.1 = 0.9$$

4. Bubble Cloud Volume

Based on ABB-Atom's tests and analysis, ABB-Atom concludes that the bubble cloud peak pressure is in proportion to the radius of the bubble cloud. The Studsvik reference volume is 0.496 m^3 (17.52 ft^3). The mass of the air in the discharge line for the reference plant is about 24.04 lbm. Twelve spargers are installed in the discharge line. The mass of the air through one sparger is 24.04/12 = 2.0 lbm. Under the initial conditions (120 ^{o}F, 14.7 psia), the volume of the air is obtained to 29.54 ft^3 (0.836 m^3). Therefore, the scaling factor to account for gas cloud volume is 1.2.

$$\frac{(V_{gas\ cloud})_{APR1400}}{(V_{gas\ cloud})_{Studsvik}} = \frac{\frac{4}{3}\pi(R_{APR1400})^3}{\frac{4}{3}\pi(R_{Studsvik})^3} = \frac{29.54}{17.52} = 1.69$$

$$\eta_V \equiv \frac{R_{APR1400}}{R_{Studsvik}} = 1.69^{1/3} = 1.19 \approx 1.2$$

5. Initial Pool Water Temperature

The Studsvik tests have indicated that the maximum pressure amplitudes are increasing noticeably with increasing pool water temperature above a level of about 50-60 ^oC. The scaling factor to account for differences in initial pool water temperatures is shown in the Figure 1. The maximum initial IRWST temperature is 120 ^oF (48.9 ^oC). Therefore, the scaling factor to account for differences in the pool water temperature, η_T is 1.0.

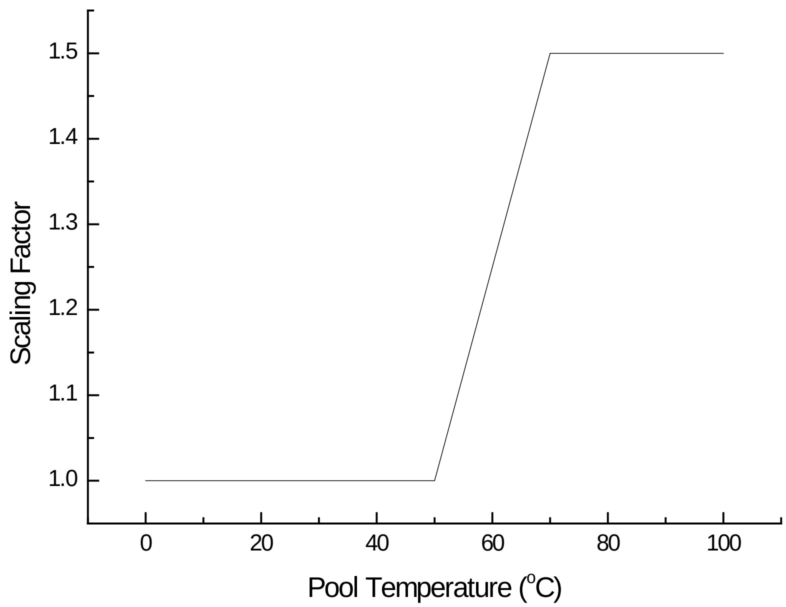

Figure 1. The Scaling Factor with Different Initial Pool Temperature

6. Bubble Cloud Location

Since the location of the APR1400 spargers from the pool walls (5 ft) is greater than that of the Studsvik or Formsmark tests (4.9 ft), a scale factor to account for differences in the bubble cloud location, η_r is estimated to 1.0.