RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**363-8446**
SRP Section:	**06.05.02 - Containment Spray as a Fission Product Cleanup System**
Application Section:	**6.5.2**
Date of RAI Issue:	**1/11/2016**

Question No. 06.05.02-2

The staff reviewed FSAR Section 6.5.2, Table 6.5-4 and compared these parameters to the ones used in the pH calculation report (Calc. No. 1-035-N387-008). There are discrepancies in the parameters provided in the FSAR and the pH calculation report, i.e., max volume, TSP mass, etc.

Explain which parameters are correct and revise Table 6.5-4 with the accurate numbers and correct labeling.

Response

Parameters listed in Table 6.5-4 in DCD Section 6.5.2 are correct. The pH calculation has been revised, as indicated in the attachment associated with this response. It is noted that the final result, time to reach pH = 7, is not changed. The revised calculation is available for review if requested.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

CALCULATION SHEET

- M_{Pipe}= 5,000 ft^3 / 0.016032 ft^3/lbm = 311,876 lbm

- Max. boron concentration : 4,400 ppm [DID 3]

1-6) Total Water Mass and Volume

The total water mass is

$M_{Total} = M_{IRWST} + M_{RCS} + M_{PZR} + M_{SIT} + M_{Pipe}$

= 5,596,366 + 731,494 + 61,704 + 505,453 + 311,876 = 7,206,893 lbm

The total water volume (liquid) at 120 $^{\circ}F$ is

V_{Total} = 7,206,893 lbm x 0.016204 ft^3/lbm = 116,780 ft^3

Therefore, the total water volume available in containment water source is

V_{Total} = 116,780 ft^3 x 28.3168 $liter/ft^3$ = 3,306,850 $liter$ (*at* 120 $^{\circ}F$)

2) Maximum Allowable Boron Concentration

The average boron concentration can be calculated using the following equation.

$$C_{B.AVG} = \frac{(M \cdot C_B)_{RCS} + (M \cdot C_B)_{SIT} + (M \cdot C_B)_{PZR} + (M \cdot C_B)_{IRWST} + (M \cdot C_B)_{PIPING}}{M_{RCS} + M_{SIT} + M_{PZR} + M_{IRWST} + M_{PIPING}}$$

where,

$C_{B,AVG}$ = average boron concentration in mixed water source (ppm)

M = water mass (lbm)

C_B = initial boron concentration in water source (ppm)

$C_{B,AVG}$= (5,596,366×4,400 + 731,494×2,500 + 61,704×2,500 + 505,453×4,400 + 311,876×4,400) / (5,596,366 + 731,494 + 61,704 + 505,453 + 311,876) = 4,191 ppm

CALCULATION SHEET

$$[PO_4] = \frac{\left(\frac{MW_{PO_4}}{MW_{TSP}}\right)(required\ weight\ of\ TSP)}{water\ volume}$$

$$= \frac{\left(\frac{94.9714}{380.12}\right)(21{,}645{,}723\ g)\left(\frac{1000\ mg}{1\ g}\right)}{3{,}306{,}850\ liter}$$

$$\cong 1{,}635 ppm$$

where, MW_{PO4}= molecular weight of PO_4 (= 94.9714 *grams/mole*)

MW_{TSP} = molecular weight of TSP (= 380.12 *grams/mole*)

3-2). TSP amount to increase 2000 *ppm* PO_4

For conservatism, the PO_4 concentration will be increased to 2000 *ppm*. The amount of TSP required to produce a 2000 *ppm* PO_4 is calculated as follows from above equation;

Required weight of TSP

= 2000 *ppm (mg/liter)* x 3,306,850 *liter* x (380.12/94.9714) x(1 *g*/1000 *mg*)

= 26,471,123 *gram*

Required mass of TSP = 26,471,123 *gram* x 0.0022046 *lbm/gram* = 58,358 *lbm*

From assumption, the bulk density of TSP is 56 lbm/ft^3.

The required volume of TSP is : TSP volume = 58,358 *lbm* /56 lbm/ft^3 = 1,042 ft^3

4) Minimum pH Calculation

4-1) Molarity of TSP in Recirculating Water

At initial boron concentration, TSP [$Na_3PO_4.12H_2O$] volume is assumed to be dissolved into the recirculated spray solution uniformly and constantly during the time required to pump the water volume using one containment spray system (CS) pump.

CALCULATION SHEET

1-5) SI and CS Pipings

The min. water mass within these pipings are assumed to be 3,000 ft^3 at 120 ^oF, 14.6 *psia*. [See Assumptions 7]

- M_{Pipe}= 3,000 ft^3 / 0.016204 ft^3/lbm = 185,139 *lbm*

- Min. boron concentration : 4,000 *ppm* ([DID 3]

1-6) Non-Recirculated Water

It is conservatively assumed that the water at reactor cavity is not recirculated after LOCA. The volume of water within reactor cavity is 114,732 *gallons* at 120 ^oF. [DID 8]

For conservatism, the volume of the non-recirculated water is assumed as follows;

- Reactor cavity water volume @120 ^oF = 180,000 *gallons*

= 180,000 *gallons* x 0.13368 $ft^3/gallons$ = 24,062 ft^3

From the data above, reactor cavity water mass is

- Specific volume of IRWST water @120 ^oF, 14.6 *psia*

= 0.016204 ft^3/lbm [Ref. 6]

- M_{cavity} = 24,062 ft^3 / 0.016204 ft^3/lbm = 1,484,967 *lbm*

1-7) Total Minimum Water Mass and Volume

The total minimum water mass is

$M_{Total} = M_{IRWST} + M_{RCS} + M_{PZR} + M_{SIT} + M_{Pipe} - M_{cavity}$

= 5,171,634 + 598,495 + 50,485 + 413,553 + 185,139 - 1,484,967 = 4,935,340 *lbm*

CALCULATION SHEET

The total minimum water volume (liquid) at 300 $^{\circ}F$ is

V_{Total} = 4,935,340 *lbm* x 0.017453 ft^3/lbm = 86,136 ft^3

Therefore, the total minimum water volume available in containment water source 300 $^{\circ}F$ is

V_{Total} = 86,136 ft^3 x 28.3168 $liter/ft^3$ = 2,439,110 *liter*

2) Minimum Allowable Boron Concentration

The average boron concentration can be calculated using the following equation.

$$C_{B.AVG} = \frac{(M \cdot C_B)_{RCS} + (M \cdot C_B)_{SIT} + (M \cdot C_B)_{PZR} + (M \cdot C_B)_{IRWST} + (M \cdot C_B)_{PIPING}}{M_{RCS} + M_{SIT} + M_{PZR} + M_{IRWST} + M_{PIPING}}$$

where,

$C_{B,AVG}$ = average boron concentration in mixed water source (*ppm*)

M = water mass (*lbm*)

C_B = initial boron concentration in water source (*ppm*)

$C_{B,AVG}$= (5,171,634 ×4,000 + 598,495 ×0 + 50,485 ×0 + 413,553 ×4,000 + 185,139 ×4,000) / (5,171,634 + 598,495 + 50,485 + 413,553 + 185,139) = 3,596 ppm

Therefore,

Boron molarity

= 3,596 *ppm (mg/liter)* x (1 *g* /1000 *mg*)/(10.81 *g/mole*)

= 0.3326 *mole/liter*