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.:	**343-8420**
SRP Section:	**12.02 - Radiation Sources**
Application Section:	**12.2**
Date of RAI Issue:	**12/22/2015**

Question No. 12.02-22

This is a follow-up to RAI 7856, Questions 12.02-2 and 12.02-3. (Note: this follow-up applies to Revision 1 of the response to these questions (ML15258A675)).

Requirements

10 CFR 52.47(a)(5) requires that the FSAR contain the kinds and quantities of radioactive materials expected to be produced in the operation and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in 10 CFR 20.

SRP 12.2 indicates that source descriptions should include all pertinent information required for (1) input to shielding codes used in the design process, (2) establishment of related facility design features, (3) development of plans and procedures, (4) assessment of occupational exposure and (5) determination of radiation dose to electrical equipment important to safety as described in 10 CFR 50.49.

SRP Section 12.3-12.4, indicates that the plant structures, as well as the general plant yard should be subdivided into radiation zones, with maximum design dose rate zones and the criteria used in selecting maximum dose rates identified. SRP Section 12.3-12.4 also indicates that doses to workers and members of the public should be ALARA.

Issues

1. In the response to Question 12.02-2 and 12.02-3, the applicant provided source term information for tanks containing liquid radioactive material. The source term information indicated that the source terms used for radiation shielding and zoning for many of the tanks was based on the tanks being filled to only a small fraction of the tanks' total volume. Since the SRP specifies that zoning (and therefore shielding) should be based on

the maximum dose rate, it isn't appropriate that the maximum designed dose rates would be based on a fraction of the total tank volume. Examples include the following:

a. Holdup Tank – 12.5% full (See response to Question 12.2-3, FSAR Table 12.2-25 markup).

b. Boric Acid Storage Tank - 50% full (See response to Question 12.2-3, FSAR Table 12.2-25 markup).

c. Reactor Makeup Water Tank – 80% full (See response to Question 12.2-3, FSAR Table 12.2-25 markup).

d. Reactor Drain Tank – 62% full (See response to Question 12.02-2, FSAR Table 12.2-25 markup)

e. Equipment Drain Tank – 37% full (See response to Question 12.02-2, FSAR Table 12.2-28 markup)

f. IRWST – 75% full (See response to Question 12.02-2, FSAR Table 12.2-25 markup)

Please revise the radiation source terms, shielding, and zoning for these tanks and all other liquid containing tanks in the FSAR (which are not currently based on the tanks being at or very near full capacity), so that they are based on tanks filled to their full capacity. The revised tank source terms should assume the additional liquid volume comes from input pathways that would result in the maximum source term for shielding and zoning as indicated in SRP 12.2 (i.e. the original radionuclide concentrations should not be decreasing with the increased liquid volume, except for additional decay time which may be appropriate, unless appropriate justification is provided for other assumptions resulting in diminished source term concentrations). The revisions should also consider the effects of source term changes made as part of responses to other Section 12.2 RAIs.

The above concern regarding tank volumes was initially discussed with the applicant during the Chapter 12 source term audit conducted during August 10 - 14, 2015, with the focus on the holdup tank and equipment drain tank, however, a subsequent review of the RAI responses reveals that the other tanks listed above were also only filled to a fraction of their total volume.

2. In the proposed FSAR addition of Table 12.2-28, it is unclear what the “low level fraction” and “high level fraction” values for the tanks represent and how they are associated with the source term calculations. Staff notes that the high and low level fractions presented in Table 12.2-28 do not correspond with the values in Table 12.2-25, which provides the water level for sources. For example, the proposed addition to Table 12.2-25 indicates that the boric acid storage tank is 50% full of liquid, but Table 12.2-28 indicates that the low level fraction is 40% and the high level fraction is 95%. Please explain what the “low level fraction” and “high level fraction” values for the tanks represent, the purpose for including the low level fraction and high level fraction in Table 12.2-28, and the reason for the differences between Tables 12.2-28 and 12.2-25.

3. In the proposed FSAR markup to FSAR Table 12.2-13, the staff noted that the total activity for the holdup tank changed, while the total activity in the other tanks in that table did not change. Please discuss why the activity values for the holdup tank changed from the values originally provided in the FSAR.

4. In part 5 of question 12.02-3, the staff requested that the applicant provide the methods, models, and assumptions used in calculating the source term for the holdup tank, in accordance with SRP Section 12.2. While the applicant provided the general methods, models, and assumptions used, they did not provide the quantity of material associated with each input path to the holdup tank. Therefore, it is unclear that the assumptions for input pathways to the holdup tank are conservative or reasonable for determining the maximum source term for zoning and shielding.

   In addition, the tank only being considered 12.5% full as indicated in question 1 above, and the questions regarding CVCS ion exchanger decontamination factors in RAI 8339, Question 12.02-19, would also affect the inventory of the holdup tank. Also, the contribution of radioactive daughter buildup is not included, as indicated in other RAIs (see the follow-up to RAI 8090, Question 12.02-13). It appears that the combination of all of these, may be resulting in a significantly underestimated CVCS holdup tank source term.

   With the response to all of the above questions taken into account, please provide the quantity of material (i.e. total volume from each input pathway and information regarding the activity concentration from each pathway) from each input pathway to the holdup tank with the tank filled to its full capacity, used in the source term calculation, with an explanation for why the assumptions are reasonable for determining the maximum plant shielding and zoning.

5. In the response to Question 12.02-3, the applicant indicates that the holdup tank and boric acid storage tank will be surrounded by concrete shielding on all sides, from the bottom to the top of the tanks, with no gap between the tank surface and the concrete, and that the dose rate outside the concrete will be less than 0.25 mrem/hour. However, there does not appear to be any shielding provided on the top of the tanks and the dose rate on the top of the tanks is not discussed. The Auxiliary Building is located near these tanks in FSAR Figure 1.2-1 and it is unclear if these tanks could result in elevated dose rates on the Auxiliary Building roof or other elevated areas that could result in dose to workers or members of the public.

   Since radiation exposure could result from accessing areas above the tanks please justify why no radiation shielding is needed for above the top of the tanks. In the response, indicate if there is expected to be a need for individuals to access the Auxiliary Building roof or other nearby areas above the tanks on a routine basis (e.g. security guard station). If so, please evaluate the dose rate to these areas and provide shielding, as appropriate, to ensure doses are ALARA. Update the FSAR, as appropriate.

6. In the response to Question 12.02-3, the applicant indicates that the holdup tank and BAST are surrounded by concrete from the bottom to the top of the tank with sufficient thickness to maintain dose rates outside the tanks to less than 2.5 micro Sieverts per hour. Please specify the minimum concrete thicknesses in the FSAR, for example in FSAR Table 12.3-4.

7. Regulatory Guide (RG) 8.8 specifies that station features and design should, to the extent practicable, permit inspections to be accomplished expeditiously and with minimal exposure of personnel and that maintaining doses ALARA can be added by a design that allows for prompt access. However, in the response to Question 12.02-3, the applicant indicates that the Holdup Tank and BAST are surrounded by concrete from the bottom to the top of the tank. Please specify how the above criteria from RG 8.8 is being met for these thanks and how tank inspections or repairs are to be performed on these tanks, while keeping worker dose ALARA.

8. In addition, there appear to be a number of editorial errors or inconsistencies associated with the response to RAI 7856. They are provided below. Please correct or explain them, as appropriate.

   a. The proposed FSAR addition on page 9 of 23 of the response to Question 12.02-2 states, “The liquid and vapor volumes are obtained from the low water level to maximize the VCT vapor source terms.” The staff believes that the intent of this sentence was to state that the vapor volumes were obtained from low water level and the sentence should therefore be reworded to state, “The vapor volumes are obtained from the low water level to maximize the VCT vapor source terms.”

      Please make this correction, if accurate. If the wording provided in the original response is correct (both the liquid and vapor source term are based on the minimum water level), then please provide additional explanation for why the current wording is accurate.

   b. In the response to Question 12.02-2, the applicant provides Table 5 on Page 8 of 13. The applicant indicates that “Case 2” in Table 5 provides assumptions used in the shielding calculations, however, in the proposed markup to FSAR Table 12.2-25, “Radioactive Source Dimensions and Parameters Used in Shielding Analysis,” the applicant provides a different liquid water volume for the Reactor Drain Tank than is provided in Case 2. Case 2 indicates the liquid volume fraction is 73% and the revised Table 12.2-25 indicates that it is 62%. Please correct this discrepancy.

   c. The revised Equipment Drain Tank dimensions provided in FSAR Table 12.2-25 indicate a significantly different volume than the volume provided in FSAR Table 9.3.4-2. Please correct this discrepancy.

   d. The revised Table 12.2-25 indicates that the volume control tank source term is based on being filled 40% with water, however, the response to question 2.b of Question 12.02-2, states that in the shielding calculations 60% of the water volume is used. Please correct this discrepancy.

   e. The IRWST volume provided in the revised FSAR Table 12.2-25 is different from the volume provided in the new FSAR Table 12.2-28. Please correct this discrepancy.

Response

1. The source terms are calculated based on normal plant operaton.
   For the shielding analyses of the CVCS tanks, the methodologies including the identification of source terms and the conditions for the analyses are summarized based on the various CVCS tank level as follows:

Holdup Tank (HUT)

The function of the holdup tank is to store recoverable reactor coolant generated during plant operation.

Tank Volume : 420,000 gal (1.590E+09 cm^3)

- The volume allows for holdup of total waste water generated by one cold shutdown and subsequent startup (see DCD Tier 2 Section 9.3.4.2.8.2, Item e).

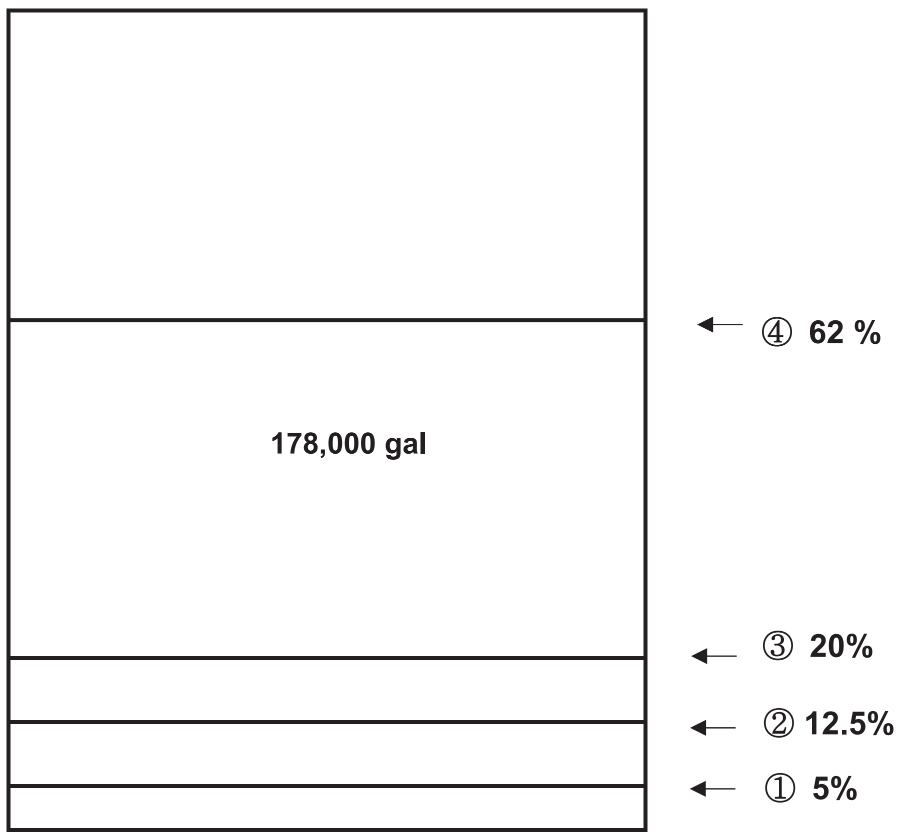

Figure 1. Tank Levels of the Holdup Tank.

<Tank Volume>

① Low Level Fraction (5%) : It is equal to the low level alarm setpoint which is based on the minimum tank volume required to supply the minimum NPSH to the holdup pumps with instrument channel accuracy.

③ High Level Fraction (20%) : It is equal to the high level alarm setpoint which is set to accommodate water volume for one cold shutdown and subsequent startup, and indicates that tank processing needs to be initiated. This level is the highest level for normal power operation from the beginning of fuel cycle except the shutdown operation.

③~④ Additional inflow volume (42%) from shutdown operation.

<Source Term>

For the activity calculation for the Holdup Tank,

1) To calculate HUT vapor activity, the low level fraction (5%) is used in order to maximize vapor space activities.
2) To calculate HUT liquid activity, the water level (62%) is used in order to maximize liquid space activities. This level (62%) includes the normal power operation volume (20%) and additional inflow volume (42%) from shutdown, refueling operation and startup operations for shutdown operation.

Calculation of Noble Gas Vapor Activities for the Holdup Tank

The noble gas activities of the vapor space for the Holdup Tank are determined initially by using Henry's law. Henry's law, however, is applied only if the tank is at equilibrium. If the tank is not at equilibrium and Henry's law is invalid, then partition factors are used to revaluate the vapor space activity.

The noble gas vapor activities are calculated by using the following equations:

For noble gas liquid activities,

$$A_{L-HUT,i} = \frac{Q_{HUT} * a_{i-HUT}}{\lambda_i + \frac{Q_{HUT}}{V_{L-HUT}}}\left(1 - e^{-\left(\lambda_i + \frac{Q_{HUT}}{V_{L-HUT}}\right)t}\right)$$

For noble gases at equilibrium condition,

$$A_{V-HUT,i} = \frac{(18)(H)(V_{V-HUT})(A_{L-HUT,i})}{(V_{L-HUT})(R)(T)} \qquad (1)$$

For noble gases at non-equilibrium condition,

$$A_{V-HUT,i} = \left(\frac{PF}{PF+1}\right)\left(\frac{Q_{HUT} * a_{i-HUT}}{\lambda_i}\right)\left(1 - e^{-\lambda_i t}\right) \qquad (2)$$

Where:

A_{L-HUT}, A_{V-HUT} = liquid and vapor activity, respectively, Bq

a_{i-HUT} = influent specific activities to Holdup Tank, Bq/cm^3

$$a_{i-HUT} = \frac{a_{i-PHIX}}{DF_{PHIX} * DF_{GS}}$$

a_{i-PHIX} = influent specific activity to Preholdup Ion Exchanger, Bq/cm^3

DF_{PHIX} = 1 (upstream Preholdup Ion Exchanger DF for noble gases)

DF_{GS} = 1,000 (upstream Gas Stripper DF noble gases)

$V_{L\text{-}HUT}$, $V_{V\text{-}HUT}$ = liquid and vapor volume, respectively, gallons

$V_{L\text{-}HUT}$ = 420,000 gallons * 5% = 21,000 gallons

$V_{V\text{-}HUT}$ = 420,000 gallons * 95% = 399,000 gallons

Q_{HUT} = influent flowrate, gallons per day ([ ]TS)

λ_i = decay constant of a nuclide, day^{-1}

PF = partition factor ([ ]TS for all noble gases)

t = transit time through tank (cycle), sec (480 day)

18 = molecular weight of water, gram/gram-mol

H = Henry's law constant, atm/mole fraction

Krypton : 2.43E+04 ([ ]TS), Xenon : 1.07E+04 ([ ]TS)

R = ideal gas constant, 82.06 atm-cm^3/K-gram-mol

T = temperature, K (([ ]TS)

The operability of Gas Stripper is described in DCD Tier1, Section 2.4.6.1 as Attachment 1

o Activities at Equilibrium Condition

The noble gas vapor activities at equilibrium condition are calculated initially by using Equation (1) with the following parameters.

The results ($A_{V\text{-}HUT}$) of calculation at equilibrium condition by using Equation (1) are shown in the following table.

[ ]TS

Henry's law, however, applies only if the tank is at equilibrium. To check this, the theoretical maximum activity of each nuclide that could possibly enter the vapor space with 100% partitioning and no credit for decay is calculated by using the following equation.

$$A_{V-HUT(Max)} = a_{i-HUT} * Q_{HUT} * t$$

The results of this calculation are shown in the last column of the above table. Comparing the theoretical maximum value ($A_{V\text{-}HUT(Max)}$) and the initially calculated vapor activity at equilibrium condition ($A_{V\text{-}HUT}$), Kr-85, Xe-131m and Xe-133 are not at equilibrium (that is, $A_{V\text{-}HUT}$ larger than $A_{V\text{-}HUT(Max)}$) and Henry's law is invalid. Therefore, the vapor activities of Kr-85, Xe-131m and Xe-133 for the Holdup Tank should be revaluated.

o Activities at Non-Equilibrium Condition

For noble gases at non-equilibrium condition, partition factors are used to revaluate the vapor activities as shown in the Equation (2).

The calculated vapor activities ($A_{V\text{-}HUT}$) of Kr-85, Xe-131m and Xe-133 at non-equilibrium condition are shown in the following table.

TS

o Final Vapor Activities of Noble Gases

Then the resulting vapor activities of the noble gases at equilibrium and non-equilibrium conditions are as follows.

TS

<Shielding Calculation>

② The shielding calculation of the Holdup Tank includes the use of liquid and vapor phase design basis source terms at 0.25% failed fuel fraction. The liquid phase volume uses 12.5% of the total tank volume, but the source term includes the radioactivity for the maximum water level 62%, concentrated to the 12.5% liquid volume. The shielding calculation also includes the vapor phase radioactivity at 87.5% tank volume, which is

based on that of noble gases. The radioactivity from the noble gases is higher than that of the liquid, contributing to about 90% of the shielding source terms. Hence the summation of these two source terms and calculation method results a more conservative shielding design for the Holdup Tank.
Please note that the 12.5% volume is an artificial assumption to adjust liquid and vapor phase volumes to 100% in order to maximize the vapor phase volume and source term. Even though that the liquid volume can be as high as 62%, the combined source terms for shielding calculation are based on a liquid volume of 12.5% and a vapor phase volume of 87.5% in order to make the conservative shielding source terms.

Boric Acid Storage Tank (BAST)

The BAST is a reservoir of boric acid to be used to make up the RCS during normal plant operation.

Tank Volume : 250,000 gal (9.464E+08 cm^3)

- The volume is enough to permit one shutdown operation to cold shutdown and startup, followed by a shutdown for refueling (see DCD Tier 2 Section 9.3.4.2.8.2, Item d).

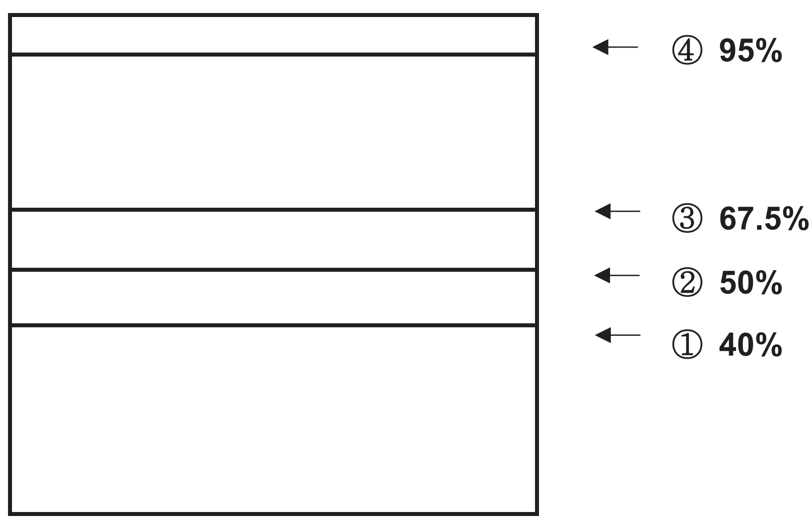

Figure 2. Tank Levels of the Boric Acid Storage Tank.

<Tank Volume>

① Low Level Fraction (40 %) : It is equal to the low level alarm setpoint which is based on the minimum tank volume required for one cold shutdown and subsequent startup, and indicates that filling of the tank needs to be initiated.

④ High Level Fraction (95 %) : It is equal to the high level alarm setpoint , which is used to warn of possible tank overflow and indicates that filling of the tank needs to be secured.

<Source Term>

Current Method

To calculate the BAST(liquid and vapor) activity, the average liquid level (67.5%) of ① and ④ has been used.

New Method

The calculation method for the BAST activity is changed to use the low and high level fraction instead of the average liquid level as follows;

① To calculate BAST vapor activity, the low level fraction (40 %) is used in order to maximize vapor space activity.

④ To calculate BAST liquid activity, the high level fraction (95 %) is used to maximize liquid space activity.

The results with the change in BAST water level, including the effects of the change in IRWST water level are given in the revised response of RAI 13-7856, Question 12.02-2_Rev.2 for Holdup Tank, BAST and IRWST and Attachment 2 of this response for boric acid filter. The activities of boric acid filter are affected because it is located at the downstream of BAST and the activities of holdup tank are affected due to the boric acid water recycle among the BAST, IRWST and RCS during refueling operation, heatup and power operation.

<Shielding Calculation>

Current Method

② The shielding calculation of the boric acid storage tank (BAST) includes the use of liquid and vapor phase design basis source terms at 0.25% failed fuel fraction. The source terms are modeled with a liquid phase volume of 50%, and a vapor phase of 50% for the shielding calculation. It is noted that the liquid phase volume uses 50% of the total tank volume, but the source term includes the radioactivity for the maximum water level 67.5%, concentrated to the 50% liquid volume. And the radioactivity from the liquid is much higher than that of the vapor, and contributes to more than 99% of the total dose rate. Hence the summation of these two source terms and calculation method results a more conservative shielding design for the BAST.

New Method

The shielding calculations for BAST and HUT were re-performed using the revised source terms determined based on the new method described above. As a result, the minimum required shield thicknesses for these components are increased due to the increase of the source terms. However, it is not required to change the structure design since the current structure thicknesses meet the increased minimum shield thicknesses.

Then, KHNP found that the 13 inches, presented in DCD Table 12.3-4, for the minimum thickness of the ceiling of the BA filter pit is calculation error. Hence, the shielding calculation for the ceiling was performed again for the ceiling. As a result, it was given that the right thickness is 20 inches. And, shielding calculation for the BA filter pit was re-performed based on the increased source term due to the BAST source term change, and resulted in only 2 inch increase for the ceiling of BA filter pit, however, this increase can meet the current structure thickness of 24 inches. In addition, for the other wall thicknesses around the BA filter, such as north, south, east, west walls, and floor, the sufficient margins in the previous shielding thickness analyses were applied already. Therefore, it is not required to increase the thickness more.

Based on above changes, DCD Table 12.3-4 will be revised as indicated in Attachment 3.

Reactor Makeup Water Tank (RMWT)

The RMWT is a reservoir of demineralized water to be used to make up the RCS during normal plant operation.

Tank Volume : 395,000 gal (1.495E+09 cm^3)

- The volume is based on providing dilution to allow total recycle and providing dilution for one cold shutdown and subsequent startup (see DCD Tier 2 Section 9.3.4.2.8.2, Item f).

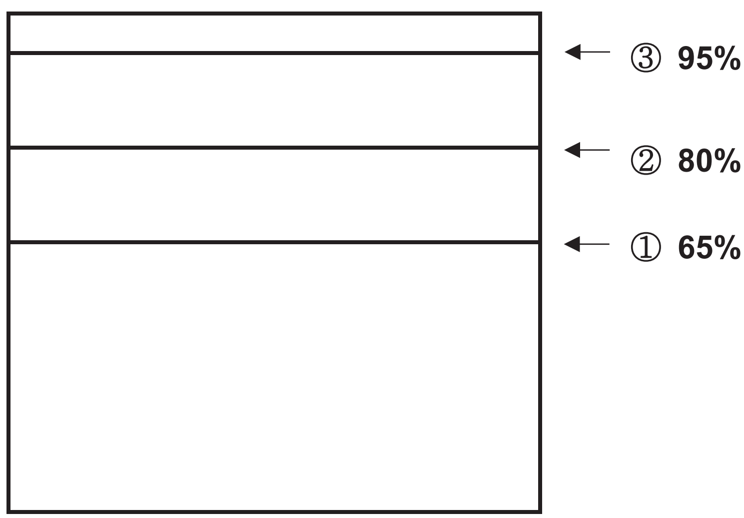

Figure 3. Tank Levels of the Reactor Makeup Water Tank.

<Tank Volume>

① Low Level Fraction (65 %) : It is equal to the low level alarm setpoint which is based on the minimum water volume required for one cold shutdown and subsequent startup and indicates that filling of the tank needs to be initiated.

③ High Level Fraction (95 %) : It is equal to the high level alarm setpoint, which is used to warn of possible tank overflow and indicates that filling of the tank needs to be secured.

<Source Term>

① To calculate RMWT vapor activity, the low level fraction (65 %) is used in order to maximize vapor space activity.

③ To calculate RMWT liquid activity, the high level fraction (95 %) is used to maximize liquid space activity.

<Shielding Calculation>

② The shielding calculation of the reactor makeup water tank (RMWT) includes the use of liquid and vapor phase design basis source terms at 0.25% failed fuel fraction. The liquid phase volume uses 80% of the total tank volume, but the source term is based on the radioactivity for the maximum water level at 95% and concentrated into the 80% liquid volume. The liquid source term is based on recycle of treated reactor makeup water. It is noted that the vapor phase volume uses 20% of the total tank volume, but the source term includes the radioactivity for the minimum water level 65%, 35% vapor source term inventory was concentrated to the 20% vapor volume. And the radioactivity from the vapor is much higher than that of the liquid, and contributes to more than 95% of the total dose rate. Hence the summation of these two source terms and the calculation method results a more conservative shielding design for the RMWT.

Reactor Drain Tank (RDT)

The function of the RDT is to receive various influxes from inside containment.

Tank Volume : 4,000 gal (1.514E+07 cm^3)

- The volume of RDT is based on the quantities as follows (see DCD Tier 2 Section 9.3.4.2.8.2, Item b):

  a. leakage from the pressurizer pilot operated safety relief valves (POSRVs)
  b. discharges from the thermal relief valves in the containment
  c. gravity drains and leakage of reactor grade water from components in the containment
  d. gravity drains from the RCS
  e. discharges from the reactor coolant gas vent system for a limited period
  f. a diversion of RCP controlled bleed-off for a limited period

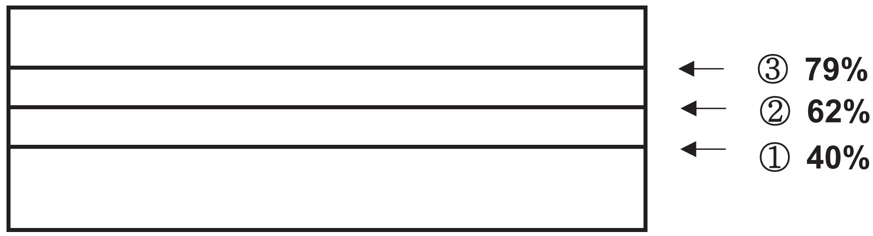

Figure 4. Tank Levels of the Reactor Drain Tank.

<Tank Volume>

① Low Level Fraction (40 %) : It is equal to the low level alarm setpoint which is set to be above the water level to prevent vortex formation at tank outlet and the minimum water volume to quench the high temperature leakage from POSRVs.

③ High Level Fraction (79 %) : It is equal to the high level alarm setpoint which is set to be above the collected volume of reactor grade leakage without any transient volume including the volume for the POSRV leakage and the bypass volume of the RCP controlled bleed-off flow for a limited period.

<Source Term>

① To calculate RDT vapor activity, the low level fraction (40 %) is used in order to maximize vapor space activities.

③ To calculate RDT liquid activity, the high level fraction (79 %) is used in order to maximize liquid space activities.

<Shielding Calculation>

② The shielding calculation of the reactor drain tank (RDT) includes the use of liquid and vapor phase design basis source terms at 0.25% failed fuel fraction. The liquid phase models a volume of 62% of the total tank volume (normal operation volume), but the source term is based on the radioactivity for the maximum water level at 79%, concentrated to the 62% liquid volume. The shielding calculation also includes a vapor phase radioactivity of noble gases at 38%, which is concentrated from 60% volume. The radioactivity from the noble gases is about 100 times higher than that of the liquid. The high contribution of noble gases activity increases the shielding requirement. Hence the summation of these two source terms and calculation method results a more conservative shielding design for the RDT.

Equipment Drain Tank (EDT)

The function of the EDT is to receive various gravity drains from outside containment.

Tank Volume : 9,500 gal (3.596E+07 cm^3)

- The volume is enough to accept gas stripper bypass flow and to accept discharges from miscellaneous relief valves (see DCD Tier 2 Section 9.3.4.2.8.2, Item c).

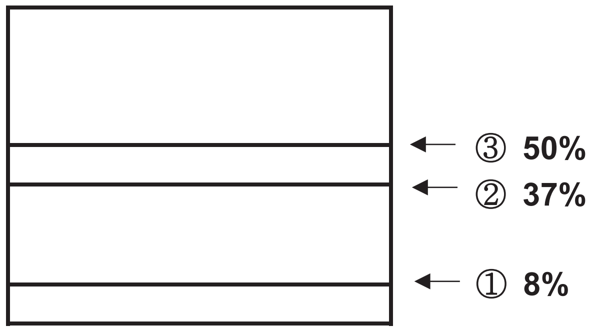

Figure 5. Tank Levels of the Equipment Drain Tank

<Tank Volume>

① Low Level Fraction (8 %) : It is equal to the low level alarm setpoint which is set considering the minimum height for vortex prevention.

② High Level Fraction (37 %) : It is equal to the high level alarm setpoint which is set to be above normal operating volume except gas volume and volume for gas stripper bypass. The normal operating volume is to accept flow from the ion exchanger sluicing volume which is greater than normal drain and sampling purge.

<Source Term>

① To calculate EDT vapor activity, the low level fraction (8 %) is used in order to maximize vapor space activities.

② To calculate EDT liquid activity, the high level fraction (37 %) is used in order to maximize liquid space activities.

<Shielding Calculation>

③ The shielding calculation of the equipment drain tank (EDT) includes the use of liquid and vapor phase design basis source terms at 0.25% failed fuel fraction. The liquid phase models a volume of 50% of the total tank volume. The shielding calculation also includes a vapor phase radioactivity of noble gases at 50%, which is concentrated from 92% volume. The radioactivity from the noble gases is about 50 times higher than that of the liquid and dominates the total dose rate. Hence the summation of these two source terms and calculation method results a more conservative shielding design for the EDT.

In-containment Refueling Water Storage Tank (IRWST)

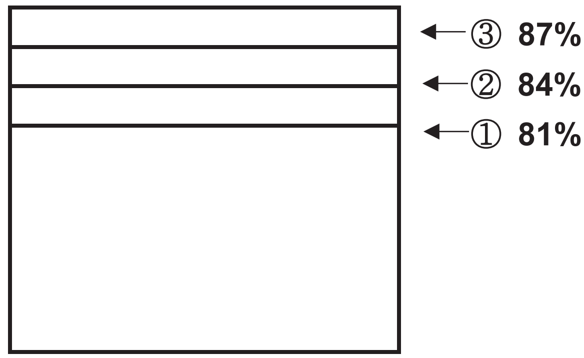

Figure 6. Tank Levels of the In-containment Refueling Water Storage Tank

<Tank Volume>

IRWST volume is sufficient for flooding the refueling pool during normal refueling operation assuming the initial RCS level is at the center of hot leg, and for providing the water for the ESF systems operation during LOCA.

① Low Level Fraction (81 %) : It is equal to the low level alarm setpoint which is based on the required water volume for providing adequate ESF pumps operation during accident operation.
③ High Level Fraction (87 %) : It is equal to the high level alarm setpoint which is based on the water level to prevent the reactor vessel breach from flooding caused by inadvertent operation of the cavity flooding system during normal operation.

<Source Term>
Current Method

② Midpoint of ① and ③ : The middle (84%) of low level fraction (81 %) and high level fraction (87%) is assumed as liquid volume and rest of this is assumed as vapor volume. The liquid and vapor source terms are identified at this level.

New Method
The calculation method for the IRWST activity is changed to use the low and high level fraction instead of the average liquid level as follows;

① To calculate IRWST vapor activity, the low level fraction (81 %) is used in order to maximize vapor space activity.
③ To calculate IRWST liquid activity, the high level fraction (87 %) is used to maximize liquid space activity.

The results with the change in IRWST water level, including the effects of the change in BAST water level are given in the revised response of RAI 13-7856, Question 12.02-2 for Holdup Tank, BAST and IRWST. The activities of holdup tank are affected due to the boric acid water recycle among the BAST, IRWST and RCS during refueling operation, heatup and power operation.

<Shielding Calculation>

Since the IRWST is located inside the containment and surrounded with the walls which have sufficient wall thickness for shielding, it is expected not to cause any significant impact on the plant structure design. Radiation zoning inside IRWST was determined based on the zoning for SFP since the source term of SFP is comparable to that of IRWST.

2. Low and high level fractions in Table 12.2-28 of the response to RAI 7856 Question 12.02-2 mean the low and high level alarm setpoints to control the tank level. The tank level is maintained between low and high level alarm setpoints during normal operation.

   The low level fraction is used in order to maximize vapor space activities. The high level fraction is used to maximize liquid space activities.

3. The activity for the holdup tank was changed because the concentration factor (CF) of boric acid concentrator was increased from 10 to 100. The deborating ion exchanger is operated to reduce the reactor coolant boron concentration when it reached 50 ppm near the end of core life. The feed-and-bleed operation is not used for RCS boron dilution below 50 ppm and there is no more excess coolant transferred to the holdup tank.

   The boron concentration of concentrated water from BAC package is about 4000 ~ 4400 ppm. Therefore, CF is assumed to be as follows:

   CF for non-noble gases = 100 (~ 4400 ppm/ 50 ppm)
   CF for noble gases and N-16 = 1

   The liquid activity of holdup tank (HUT) is calculated as follows (Cs-137) ;

$$A_{HUTL} = A_{HUTL1} + A_{HUTL2} + A_{HUTL3} + A_{HUTL4} + A_{HUTL5}$$

where

A_{HUTL1} = *normal power operation activity,*

A_{HUTL2} = *additional filling activity from low to high water level,*

A_{HUTL3} = *shutdown boration waste to HUT activity,*

A_{HUTL4} = *drain waste to HUT for Reactor Head removal activity, and*

A_{HUTL5} = *startup dilution waste to HUT activity.*

For conservatism, activities of shutdown (A_{HUTL3}), drain (A_{HUTL4}), and startup (A_{HUTL5}) are considered in calculation of total holdup tank activity. However, these activities ($A_{HUTL3} + A_{HUTL4} + A_{HUTL5}$) are not considered in holdup tank specific activity calculation. Because they are based on zero power condition, these specific activities are lower than those ($A_{HUTL1} + A_{HUTL2}$) of normal power operation. So, to calculate specific activity in holdup tank (a_{HUT}), only normal power operation activity (A_{HUTL1}) and additional filling activity (A_{HUTL2}) are considered and calculated as follows;

(1) The normal power operation activity of HUT is calculated based on following equation

$$A_L = \frac{Q_i a_i}{\lambda + \frac{Q_i}{V_L}} (1 - e^{-(\lambda + \frac{Q_i}{V_L})t})$$

In this case,

$A_L = A_{HUTL1}$

$Q_i = Q_{HUT}$

$a_i = a_{i,HUT}$

$t = T_{CYCLE}$

$V_L = V_{HUTL1} = V_{HUTL} f_{LOW}$

Where,

A_{HUTL1} = HUT liquid activity

$Q_i = Q_{HUT} = Q_{PHIX}$ = Pre-holdup Ion Exchanger flow rate

= $\frac{Total\ generated\ waste\ per\ one\ cycle}{Cycle} + Q_{RDT} + Q_{EDT}$

[ ]TS

a_i = HUT influent specific activity = [ ]TS (From SHIELD-APR output)

λ = decay constant = 7.27E-10 sec^{-1}

T_{CYCLE} = one cycle length = 480 days

V_{HUTL1} = HUT liquid volume = 420,000 gallons X 0.05 = 21,000 gallons

V_{HUT} = HUT total volume = 420,000 gallons

f_{LOW} = HUT low level fraction = 0.05

Therefore,

A_{HUTL1} = HUT liquid activity = [ ]TS

(2) The tank is filled from low level to high level with decay. The filled liquid activity(low level to high level) of HUT is calculated based on following equation

$$A = \frac{Q_i a_i}{\lambda}(1 - e^{-\lambda t_R})$$

In this case,

$$A = A_{HUTL2}$$

$$a_i = a_{i,HUT}$$

$$t_R = T_{F,HUT} = \frac{V_{F,HUT}}{Q_{HUT}}$$

$$V_{F,HUT} = (f_{HIGH} - f_{LOW})V_{HUT}$$

Where,

A_{HUTL2} = HUT filled liquid activity

[ ]TS

$a_{i,HUT}$ = HUT influent specific activity = 1.90E+01 Bq/cc (From SHIELD-APR output)

λ = decay constant = 7.27E-10 sec^{-1}

[ ]TS

$V_{F,HUT}$ = HUT filling liquid volume = 420,000 gallons X (0.2-0.05) = 63,000 gallons

f_{HIGH} = HUT high level fraction = 0.2

f_{LOW} = HUT low level fraction = 0.05

V_{HUT} = HUT total volume = 420,000 gallons

Therefore,

A_{HUTL2} = HUT filled liquid activity = [ ]TS

The specific activity of HUT is;

TS

The specific activity for Concentrate Pump of BAC components is calculated as follows (Cs-137) ;

TS

Same specific activity is applied to Concentrate Heater, Concentrate Transfer Pump, Concentrate Cooler, Flash Tank, and Vapor Separator ([ ]TS). The concentration ([ ]TS) of Cs-137 in the BAC package is 100 times more than the concentration ([ ]TS) in the Holdup Tank. In addition, the comparison of NRC and KHNP's HUT specific activity calculation is shown in following table.(NRC staff said in conference call that NRC applied 8.9E+09 Bq (DCD table 12.2-12, this should be revised to 1.0E+10 Bq according to RAI 13-7856 Question 12.02-2_Rev.1 Table 12.2-13) for HUT total activity and 52,500 gal for HUT volume. However, the application can't make the concentration factor (CF) of 35. So, to make the CF of 35, 1.0E+10 Bq and 50,000 gal seem to be assumed for NRC calculation.)

TS

4. Holdup tank receives the influent flow from pre-holdup ion exchanger during normal power operation, shutdown operation, and startup operation. The liquid activity of holdup tank is calculated as follows:

    1) Normal power operation at low water level by considering the decay and removal of the RCS activity.
    2) Normal power operation from low water level to high water level by considering the decay and removal of the RCS activity.
    3) Shutdown operation to borate the RCS for refueling by considering the decay and removal of the RCS activity and the boric acid storage tank activity. It is assumed that 46,000 gal of boric acid batching tank is required to borate the RCS. The flow path for shutdown operation is same as that for normal operation.
    4) Drain operation to remove the reactor vessel head. It is assumed that 42,680 gal of the RCS water is drained to remove the reactor vessel head. The coolant is drained to the reactor drain tank and sent to the holdup tank by passing the pre-holdup ion exchanger.
    5) Startup operation to dilute the RCS for startup by considering the decay and removal of the RCS activity and the reactor makeup water tank activity. It is assumed that 88,700 gal of reactor makeup water tank is required to dilute the RCS in order to remove the volume added during shutdown operation and drain operation. The flow path for startup operation is same as that for normal operation.

    The response regarding CVCS ion exchanger decontamination factors in RAI 8339, Question 12.02-19 is provided for justification.

5. The holdup tank (HT) and the boric acid storage tank (BAST) are located near the plant north wall of the auxiliary building (AB) at a distance about 56-feet away from the wall. The tank information is as follows:

	Holdup Tank	Boric Acid Storage Tank
Inside Diameter, feet	56’-0”	44’-0”
Height (tank bottom to top of wall), feet	25’-3”	28’-3”
Perpendicular Distance from AB Wall outside to Tank outside Insulation	About 56’-2”	About 54’-0”
Approximate Elevation of Top (Including Roof Top)	130’-10”	133”-0”
Elevation of AB with 6’-0” Parapet (4’-0” thick)	219’-6”	219’-6”

Based on the information in the above table, the tanks are located over 50 feet away, and with an elevation difference of about 86 feet, from the roof top to the top of parapet. The AB is designed with a parapet that is 6’-0” tall surrounding the roof. The section of the parapet near the tanks is about 4’-0” thick. Because of the parapet, individual on top of the roof is shielded from radiation shines from the HT and the BAST.

Access to the AB roof top is administratively controlled and is not expected to be accessed routinely.

KHNP also evaluated the dose rate in the AB roof area to be Radiation Zone 2 based on the radiation shines from the yard tanks but without consideration of parapet. It is noted that in this dose assessment, the tank roof is not credited.

6. In the response to RAI 7856, Question 12.02-3, KHNP provided an insert to Table 12.2-25 with the minimum shield wall thicknesses for the yard tanks. The minimum shield wall thicknesses for holdup tank (steel shell: 0.635 cm and concrete 37.465 cm) and boric acid storage tank (concrete: 40.64 cm) are designed to maintain a dose rate of less than 2.5 μSv/hr outside the tanks for Radiation Zone 1. Please refer to discussion and the insert for RAI 7856, Question 12.02-3 for more details.

7. (Later) The planned final submittal date is October 28th, 2016.

8.
   a. The sentence is correct. Both liquid and vapor source terms are initially calculated based on the low water level. This maximizes the vapor source term by using the maximum vapor volume. As for the liquid source term, the liquid volume between low and high water levels is considered. The liquid source term due to this volume is added to the liquid source term which is calculated at low water level.

   b. (Later) The planned final submittal date is October 28th, 2016.

   c. (Later) The planned final submittal date is October 28th, 2016.

   d. (Later) The planned final submittal date is October 28th, 2016.

   e. (Later) The planned final submittal date is October 28th, 2016.

Impact on DCD

DCD Tier 1, Section 2.4.6.1 will be revised as Attachment 1.
DCD Table 12.2-12 will be revised as Attachment 2.
DCD Table 12.3-4 will be revised as Attachment 3.

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.

2.4.6 Chemical and Volume Control System

2.4.6.1 Design Description

The chemical and volume control system (CVCS) controls the purity, volume, and chemistry of the reactor coolant. The portions of the CVCS which accomplish reactor normal makeup and normal reactivity control are classified at least safety Class 3.

The CVCS maintains the required volume of water in reactor coolant system (RCS) in conjunction with the pressurizer level control system. The CVCS also provides backup spray water to the pressurizer and cooling water to the RCP seals.

Major portion of CVCS is located in the auxiliary building and reactor containment building, except the holdup tank (HT), reactor makeup water tank (RMWT), and boric acid storage tank (BAST) are located in the yard and surrounded by a dike.

The gas stripper is operated as necessary to ensure that dose rate outside the HT remains less than the Zone 1 criteria.

1. The functional arrangement of the CVCS is as described in the Design Description of Subsection 2.4.6.1 and in Table 2.4.6-1 and as shown in Figure 2.4.6-1.

2.a The ASME Code components identified in Table 2.4.6-2 are designed and constructed in accordance with ASME Section III requirements.

2.b The ASME Code piping including supports identified in Table 2.4.6-1 is designed and constructed in accordance with ASME Section III requirements.

3.a Pressure boundary welds in ASME Code components identified in Table 2.4.6-2 meet ASME Section III requirements.

3.b Pressure boundary welds in ASME Code piping identified in Table 2.4.6-1 meet ASME Section III requirements.

4.a The ASME Code components identified in Table 2.4.6-2 retain their pressure boundary integrity at their design pressure.

4.b The ASME Code piping identified in Table 2.4.6-1 retains its pressure boundary integrity at its design pressure.

This table should be replaced with table on page 2 of Attachment 2.

Table 12.2-12 (1 of 2)

CVCS Filter Inventories, Maximum Values (Bq)

Nuclide	Seal Injection	Reactor Drain	Boric Acid	Purification	Reactor Makeup Water
H-3	9.8E+08	1.7E+09	9.7E+08	2.0E+09	1.9E+09
N-16	0.0E+00	0.0E+00	0.0E+00	1.8E+08	0.0E+00
Kr-85m	7.7E+07	6.9E+07	0.0E+00	1.6E+08	7.1E-03
Kr-85	3.4E+08	5.7E+08	2.1E+03	6.7E+08	1.7E+02
Kr-87	5.6E+07	5.3E+07	0.0E+00	1.2E+08	4.6E-04
Kr-88	1.6E+08	1.5E+08	0.0E+00	3.4E+08	6.2E-03
Xe-131m	3.4E+08	4.9E+08	2.3E+02	6.7E+08	4.8E+01
Xe-133m	2.0E+07	2.3E+07	1.6E-02	4.1E+07	2.5E-01
Xe-133	2.2E+10	2.9E+10	1.0E+03	4.4E+10	8.2E+02
Xe-135m	3.4E+07	3.8E+07	0.0E+00	9.0E+07	1.5E-05
Xe-135	4.4E+08	4.1E+08	0.0E+00	9.0E+08	1.7E-01
Xe-137	6.3E+06	8.8E+06	0.0E+00	2.1E+07	2.4E-07
Xe-138	2.9E+07	3.3E+07	0.0E+00	7.8E+07	1.0E-05
Br-84	1.2E+04	1.3E+06	0.0E+00	3.0E+06	1.3E-06
Rb-88	6.6E+07	1.5E+08	0.0E+00	3.5E+08	3.4E-04
Sr-89	4.9E+03	4.0E+05	3.7E+04	4.9E+05	2.3E+00
Sr-90	3.3E+02	2.8E+04	1.9E+04	3.3E+04	3.7E-01
Sr-91	7.2E+03	3.3E+05	1.1E-12	7.3E+05	1.2E-03
Y-91m	1.9E+05	1.8E+05	0.0E+00	4.3E+05	7.6E-04
Y-91	3.6E+04	6.0E+04	5.9E+05	7.3E+04	3.4E+01
Y-93	8.6E+03	8.0E+03	1.1E-11	1.7E+04	4.4E-03
Zr-95	2.3E+03	1.9E+05	2.4E+04	2.3E+05	1.3E+00
Nb-95	7.8E+02	6.3E+04	3.5E+03	7.8E+04	2.8E-01
Tc-99m	2.4E+05	1.1E+07	0.0E+00	2.5E+07	1.6E-02
Mo-99	4.2E+05	2.5E+07	5.5E+02	4.3E+07	3.5E+00
Ru-103	2.6E+02	2.1E+04	1.4E+03	2.6E+04	1.0E-01
Ru-106	1.1E+02	9.5E+03	4.3E+03	1.1E+04	1.1E-01
Ag-110m	7.8E+03	6.6E+05	2.5E+05	7.8E+05	6.9E+00

Nuclide	Seal Injection	Reactor Drain	Boric Acid	Purification	Reactor Makeup Water
H-3	9.8E+08	1.7E+09	1.6E+09	2.0E+09	1.9E+09
N-16	0.0E+00	0.0E+00	0.0E+00	1.8E+08	0.0E+00
Kr-85m	7.7E+07	6.9E+07	0.0E+00	1.6E+08	7.1E-03
Kr-85	3.4E+08	5.7E+08	2.7E+04	6.7E+08	1.7E+02
Kr-87	5.6E+07	5.3E+07	0.0E+00	1.2E+08	4.6E-04
Kr-88	1.6E+08	1.5E+08	0.0E+00	3.4E+08	6.2E-03
Xe-131m	3.4E+08	4.9E+08	3.3E+02	6.7E+08	4.8E+01
Xe-133m	2.0E+07	2.3E+07	2.2E-02	4.1E+07	2.5E-01
Xe-133	2.2E+10	2.9E+10	1.5E+03	4.4E+10	8.2E+02
Xe-135m	3.4E+07	3.8E+07	0.0E+00	9.0E+07	1.5E-05
Xe-135	4.4E+08	4.1E+08	0.0E+00	9.0E+08	1.7E-01
Xe-137	6.3E+06	8.8E+06	0.0E+00	2.1E+07	2.4E-07
Xe-138	2.9E+07	3.3E+07	0.0E+00	7.8E+07	1.0E-05
Br-84	1.2E+04	1.3E+06	0.0E+00	3.0E+06	1.3E-06
Rb-88	6.6E+07	1.5E+08	0.0E+00	3.5E+08	3.4E-04
Sr-89	4.9E+03	4.0E+05	5.4E+04	4.9E+05	2.3E+00
Sr-90	3.3E+02	2.8E+04	3.2E+04	3.3E+04	3.7E-01
Sr-91	7.2E+03	3.3E+05	1.6E-12	7.3E+05	1.2E-03
Y-91m	1.9E+05	1.8E+05	0.0E+00	4.3E+05	7.6E-04
Y-91	3.6E+04	6.0E+04	8.6E+05	7.3E+04	3.4E+01
Y-93	8.6E+03	8.0E+03	1.5E-11	1.7E+04	4.4E-03
Zr-95	2.3E+03	1.9E+05	3.5E+04	2.3E+05	1.3E+00
Nb-95	7.8E+02	6.3E+04	5.0E+03	7.8E+04	2.8E-01
Tc-99m	2.4E+05	1.1E+07	0.0E+00	2.5E+07	1.6E-02
Mo-99	4.2E+05	2.5E+07	7.8E+02	4.3E+07	3.5E+00
Ru-103	2.6E+02	2.1E+04	2.0E+03	2.6E+04	1.0E-01
Ru-106	1.1E+02	9.5E+03	6.9E+03	1.1E+04	1.1E-01
Ag-110m	7.8E+03	6.6E+05	4.0E+05	7.8E+05	6.9E+00

This table should be replaced with table on page 4 of Attachment 2.

Table 12.2-12 (2 of 2)

Nuclide	Seal Injection	Reactor Drain	Boric Acid	Purification	Reactor Makeup Water
Te-129m	4.5E+03	7.2E+05	3.5E+04	9.0E+05	2.9E-01
Te-129	4.3E+03	4.1E+05	0.0E+00	9.5E+05	1.9E-06
I-131	1.9E+06	2.6E+08	5.9E+05	3.8E+08	2.1E+01
Te-131m	2.1E+04	2.2E+06	2.9E-02	4.3E+06	5.9E-03
Te-131	6.8E+03	7.2E+05	0.0E+00	1.7E+06	4.6E-07
Te-132	1.5E+05	1.8E+07	9.1E+02	3.0E+07	3.1E-01
I-132	4.8E+05	4.4E+07	0.0E+00	1.0E+08	8.3E-04
I-133	2.6E+06	2.6E+08	3.7E-02	5.3E+08	3.8E-01
I-134	2.7E+05	2.6E+07	0.0E+00	6.2E+07	7.3E-05
Cs-134	1.3E+07	4.5E+07	1.0E+07	5.3E+07	2.2E+02
I-135	1.5E+06	1.4E+08	0.0E+00	3.0E+08	2.2E-02
Cs-136	1.8E+06	5.4E+06	2.1E+04	7.3E+06	4.0E+00
Cs-137	1.5E+07	5.2E+07	1.5E+07	6.2E+07	2.8E+02
Ba-140	6.2E+03	4.6E+05	3.9E+03	6.2E+05	7.5E-01
La-140	2.1E+03	1.1E+05	5.5E-02	2.1E+05	6.3E-03
Ce-141	2.3E+02	1.8E+04	9.1E+02	2.3E+04	7.8E-02
Ce-143	6.1E+02	3.2E+04	2.2E-03	6.2E+04	1.3E-03
Ce-144	6.7E+02	5.7E+04	2.3E+04	6.7E+04	6.1E-01
Na-24	2.7E+05	1.3E+07	4.6E-06	2.7E+07	1.1E-01
Cr-51	5.7E+10	1.8E+10	5.9E+08	8.6E+12	5.2E+05
Mn-54	4.9E+10	1.6E+10	6.0E+09	7.4E+12	1.4E+06
Fe-55	5.0E+10	1.7E+10	8.5E+09	7.6E+12	1.6E+06
Fe-59	2.0E+09	6.4E+08	4.3E+07	3.0E+11	2.7E+04
Co-58	4.8E+10	1.6E+10	1.9E+09	7.3E+12	8.5E+05
Co-60	2.4E+10	8.0E+09	4.4E+09	3.6E+12	8.0E+05
Zn-65	3.1E+03	2.6E+05	9.7E+04	3.1E+05	2.7E+00
Ba-137m	1.5E+07	5.2E+07	1.5E+07	6.2E+07	2.8E+02
W-187	1.5E+04	7.4E+05	9.4E-04	1.5E+06	1.6E-02
Np-239	1.3E+04	7.5E+05	5.5E+00	1.3E+06	7.8E-02

Nuclide	Seal Injection	Reactor Drain	Boric Acid	Purification	Reactor Makeup Water
Te-129m	4.5E+03	7.2E+05	5.1E+04	9.0E+05	2.9E-01
Te-129	4.3E+03	4.1E+05	0.0E+00	9.5E+05	1.9E-06
I-131	1.9E+06	2.6E+08	8.4E+05	3.8E+08	2.1E+01
Te-131m	2.1E+04	2.2E+06	4.1E-02	4.3E+06	5.9E-03
Te-131	6.8E+03	7.2E+05	0.0E+00	1.7E+06	4.6E-07
Te-132	1.5E+05	1.8E+07	1.3E+03	3.0E+07	3.1E-01
I-132	4.8E+05	4.4E+07	0.0E+00	1.0E+08	8.3E-04
I-133	2.6E+06	2.6E+08	5.3E-02	5.3E+08	3.8E-01
I-134	2.7E+05	2.6E+07	0.0E+00	6.2E+07	7.3E-05
Cs-134	1.3E+07	4.5E+07	1.7E+07	5.3E+07	2.2E+02
I-135	1.5E+06	1.4E+08	0.0E+00	3.0E+08	2.2E-02
Cs-136	1.8E+06	5.4E+06	3.0E+04	7.3E+06	4.0E+00
Cs-137	1.5E+07	5.2E+07	2.5E+07	6.2E+07	2.8E+02
Ba-140	6.2E+03	4.6E+05	5.5E+03	6.2E+05	7.5E-01
La-140	2.1E+03	1.1E+05	7.8E-02	2.1E+05	6.3E-03
Ce-141	2.3E+02	1.8E+04	1.3E+03	2.3E+04	7.8E-02
Ce-143	6.1E+02	3.2E+04	3.1E-03	6.2E+04	1.3E-03
Ce-144	6.7E+02	5.7E+04	3.7E+04	6.7E+04	6.1E-01
Na-24	2.7E+05	1.3E+07	6.5E-06	2.7E+07	1.1E-01
Cr-51	5.7E+10	1.8E+10	8.5E+08	8.6E+12	5.2E+05
Mn-54	4.9E+10	1.6E+10	9.5E+09	7.4E+12	1.4E+06
Fe-55	5.0E+10	1.7E+10	1.4E+10	7.6E+12	1.6E+06
Fe-59	2.0E+09	6.4E+08	6.3E+07	3.0E+11	2.7E+04
Co-58	4.8E+10	1.6E+10	2.7E+09	7.3E+12	8.5E+05
Co-60	2.4E+10	8.0E+09	7.4E+09	3.6E+12	8.0E+05
Zn-65	3.1E+03	2.6E+05	1.5E+05	3.1E+05	2.7E+00
Ba-137m	1.5E+07	5.2E+07	2.5E+07	6.2E+07	2.8E+02
W-187	1.5E+04	7.4E+05	1.3E-03	1.5E+06	1.6E-02
Np-239	1.3E+04	7.5E+05	7.8E+00	1.3E+06	7.8E-02

Table 12.3-4 (3 of 7)

RAI 141-8098 -Question 12.03-08

RAI 343-8420 -Question 12.02-22

Room Number	Room Name	Minimum Required Shield Thickness (inches)					
		North	South	East	West	Floor	Ceiling
Auxiliary Building (cont.)							
068-A06A	Gas Stripper Room	37	35	45	35	30	24
068-A07A	Hot Pipe Way	13	29	31	29	24	24
068-A08B	Hot Pipe Way	33	24	24	20	23	30
068-A09B	Valve Room	19	17	23	19	17	10
068-A10A	Filter and Demin. Valve Area	10	10	33	33	30	24
068-A11A	Filter and Demin. Valve Area	10	24	10	22	24	21
068-A12A	Filter and Demin. Valve Area	10	18	10	18	17	29
077-A01A	Reactor Drain Filter Pit	35	10	10	15	10	23
077-A02A	SFP Cleanup Filter Pit	10	10	10	10	23	23
077-A03A	SFP Demin Filter Pit	10	17	10	24	23	23
077-A04A	SFP Cleanup Filter Pit	10	10	10	10	23	23
077-A05A	SFP Demin. Filter Pit	10	10	10	10	23	23
077-A06A	Purification Filter Pit	10	10	10	10	10	39
077-A07A	Reactor Makeup Water Filter Pit	18	32	24	18	10	10
077-A08A	Purification Filter Pit	10	10	10	10	10	39
077-A09A	SGBD Filter Pit	10	10	10	10	22	23
077-A10A	Seal Injection Filter Pit	10	10	10	11	24	24
077-A11A	SGBD Filter Pit	10	10	10	10	22	23
077-A12A	Seal Injection Filter Pit	10	13	10	10	13	24
077-A13A	SGBD Filter Pit	35	10	10	10	22	23
077-A14A	Boric Acid Filter Pit	13	18	10	29	10	~~13~~ 22
077-A15A	Filter Cartridge Storage	32	39	39	39	25	39
078-A21A	Pipe Chase	10	36	48	48	10	24
078-A21B	Pipe Chase	36	10	48	48	10	10
078-A32A	SPF Cleanup Demin. Room	10	22	22	21	12	24
078-A33A	SG Blowdown Demin. Room	33	10	23	10	10	23
078-A34A	Pre-Holdup IX Room	33	15	15	33	15	24
078-A35A	Purification IX Room	12	24	29	43	29	42
078-A36A	Boric Acid IX Room	24	18	18	18	18	18

Table 12.3-4 (7 of 7)

Room Number	Room Name	Minimum Required Shield Thickness (inches)					
		North	South	East	West	Floor	Ceiling
Compound Building (cont.)							
085-P32	Primary Sampling Sink Room	10	13	12	12	14	18
085-P42	IX Module Room	10	30	30	27	14	28
085-P43	IX Module Room	30	10	30	30	14	28
085-P44	RO Feed Tank Room	10	27	32	22	19	25
085-P45	Drum Removal Chase	15	15	15	15	-	25
085-P46	MF Membrane Module Room	23	10	20	15	18	16
085-P47	MF Membrane Module Room	23	16	10	12	15	16
085-P48	RO Membrane Module and Valve Skid Room	43	24	43	34	32	36
096-P01	Charcoal Delay Bed Room	22	19	21	14	28	17
096-P02	Charcoal Delay Bed Room	47	44	14	38	36	42
100-P02	GRS Equipment Removal Area	13	11	38	10	23	10
100-P07	Future Extension Area	24	30	36	37	24	31
100-P08	Truck Bay	24	24	36	37	36	31
100-P09	Waste Drum Storage Area	28	24	36	26	34	31
100-P10	Spent Filter Drum Storage Area	36	28	48	37	36	43
120-P01	Gaseous Radwaste Sample Control Panel Room	10	10	10	11	17	25
120-P02	Gaseous Radwaste Sample Valve Rack Room	20	10	25	17	17	25
Yard							
-	Boric Acid Storage Tank	16	16	16	16	-	-
-	Holdup Tank	15[1)]	15[1)]	15[1)]	15[1)]	-	-

[1)] including the Tank wall of 0.25 inches