# RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**APR1400 Design Certification**

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

**Docket No. 52-046**

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| **RAI No.:** | **150-8144** |
| **SRP Section:** | **11.02 – Liquid Waste Management System** |
| **Application Section:** | **11.2 – Liquid Waste Management System** |
| **Date of RAI Issue:** | **08/10/2015** |

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## Question No. 11.02-1

SRP 11.2, and BTP 11-6 relates to the assessment of a potential release of radioactive liquids following:

- the postulated failure of a tank and,
- the tank components,
- located outside of containment, and

impacts of the release of radioactive materials at the nearest potable water supply, located in an unrestricted area, for direct human consumption or indirectly through animals, crops, and food processing.

The review of the consequences of a liquid tank failure having the potential to release radioactive materials to a potable water supply is performed under SRP Branch Technical Position (BTP) 11-6, using the requirements of Title 10 of the Code of Federal Regulations (CFR), Section 20.1302 and Table 2, Column 2, of Appendix B to 10 CFR Part 20.

The staff review of DCD section 11.2.3.2 and Table 11.2-9 that show the applicant's Liquid Waste Management System Failure Doses. These doses appear to be within the BTP 11-6 guidelines, however the staff requests a calculation package to verify the results provided in Table 11.2-9, specifically:

1. In the evaluation of this application, the staff requests the details as to how the applicant justifies the dilution of the source term to be 10% of the 10 CFR 20 Appendix B, Table 2 limits, in place of making assumptions on site specific parameters that limit release doses.

2. Staff is unable to determine the source term that is being referenced by the applicant for the presentation of results found in DCD Table 11.2-9. Current staff analysis observes that the source term is based on DCD Table 12.2-13, and a volume based on information found in DCD Figure 11.2-2 and DCD Table 9.3.4-2, of 420k gallons. Given the stated information staff is still unable to verify the holdup tank inventory provided in DCD Table 11.2-9.

3. Staff is attempting to verify the holdup tank inventory with the information provided in DCD section 11.2.3.2. Given that information, the staff requests information pertaining to additional tank volumes and tank inventories that were considered in identifying the tank for the BTP 11-6 analysis.

4. Staff requests the applicant provide information to support verification of calculations and details to follow the applicant's analysis. Include an analysis of the calculations performed to generate the Holdup Tank Inventory, and the Concentration at Nearest Potable Water for all radionuclides presented in Table 11.2-9. In addition:

    ◦ Provide the tank volume used with a reference DCD section,

    ◦ Provide the nuclide inventory used in this analysis with a reference DCD section,

5. Provide details of the other tanks considered in this analysis. Include DCD references to tank volumes and expected tank activity.

6. Provide a discussion that details how the DCD is following the guidance of BTP 11-6 as is described by text provided in DCD section 11.2.3.2, concerning:

    ◦ BTP 11-6 includes details about the use of 80% of the volume capacity of the tank and its components, but a discussion for this is not described in 11.2.3.2.

    ◦ BTP 11-6 describes that the inventory of the radioactive material is based on the expected failed fuel fraction of 0.12%, but this information is not discussed in DCD section 11.2.3.2.

7. To ensure clarity in the DCD the staff requests that DCD section 11.2.3.2 contain updated text based on the results of this RAI to include discussions that:

    a. Clearly state the basis for the source term. Currently there is no discussion provided as to if the source term is based on 0.12% fuel defect.

    b. A justification for whatever site-specific assumptions are taken. The current rational of calculating a dilution factor that would reduce the nuclide concentrations is unacceptable since there is no basis provided to review to understand this assumption.

    c. Provide a discussion in the DCD for how the values of Table 11.2-9 are obtained.

Please address the items above and provide a DCD mark-up on the proposed changes.

## Response

1. According to BTP 11-6, the radioactive concentrations in the nearest potable water supply due to failure of a tank containing radioactive liquid shall be below the limits specified in 10 CFR 20 Appendix B. In the analysis of a postulated failure of a liquid tank, it was determined that the holdup tank failure, based on its radionuclide inventory (concentration and volume), would result in the worst contamination release among the three yard tanks (including boric acid storage tank (BAST) and reactor makeup water tank (RMWT)). Hence the holdup tank content is used for the postulated tank failure analysis.

   The holdup tank content for the failed tank analysis is based on 20% of unmitigated reactor coolant (84,000 gallons) and other sources of inflow water: shutdown boration water (estimated to be 46,800 gallons), reactor head coolant drain for refueling operation (estimated to be 42,680 gallons), and reactor coolant letdown during startup operation (estimated to be 88,700 gallons). The accumulated volume, amounts to 262,180 gallons, of these sources amounts to 62% of the tank volume and is used to calculate the tank nuclide concentrations (Please see Table 1 attached to this response). This lower volume is used to conservatively calculate the higher nuclide concentrations. To further increase the safety margin, the analysis is performed with the objective to satisfy 10% of the 10 CFR 20 Appendix B limits. The dilution factor thus determined is about 2,762. This dilution factor is adjusted by the ratio of 80% to 62% to about 3,600, which is used as the minimum dilution factor yielding a receptor source concentration less than 10% of the 10 CFR 20 Appendix B limits. DCD Table 11.2-9 will be updated to provide the total tank inventory and the results of the revised dilution factor.

   Dilution water is generally available from normal plant operation from several sources, including blowdown from the cooling tower and wastewater treatment, circulating water, and other surplus plant water. Depending on the specific site hydrogeology, groundwater and surface runoffs are also available for dilution. Other nuclear power plants use dilution water, such as the San Onofre NPP, reported the use of a dilution factor of 59,000 [San Onofre 2&3 Updated FSAR, June 2005, Page 2.4-44]. The dilution factor determined for APR1400, i.e., 3,600, is therefore considered reasonable. A COL Item [11.2(14)] is included in the DCD for the COL applicant to perform a dilution water evaluation to ensure that the site-specific dilution factor is higher than 3,600 by using the site-specific plant water and hydrogeological data.

2. Based on the above discussion, DCD Table 11.2-9 will be updated to provide total tank inventory and the results of the revised calculation.

3. Information requested in this question is provided in the response Items No. 1 and 2 above.

4. Information requested in this question is provided in the response Item No. 1 above.

5. Expected tank inventory for the BAST and RMWT are also included in the attached Table 1, which will be included as a replacement to DCD Table 11.2-9. The volume of

the holdup tank, BAST and RMWT is 420,000 gal, 250,000 gal and 395,000 gal each and it is provided in DCD Table 5A-3.

6. The radionuclide inventory of the holdup tank is calculated using the expected RCS source term. The definition of the APR1400 expected source term is provided in DCD Section 11.1 Item b and is based on ANSI/ANS-18.1 (1999). It was the applicant's understanding that the primary coolant specific activities provided in ANSI/ANS-18.1 (1984) were equivalent to 0.12% fuel failure. The standard was updated to incorporate improved fuel performance, without clarification on the failed fuel basis. The expected source terms for APR1400 are derived from the same realistic model as described in ANSI/ANS-18.1 (1999), and is consistent with the "Expected" RCS conditions upon which the BTP 11-6 is based. Hence no change to the DCD is needed.

   However, the applicant agrees with staff's comment on adding details on following the guidance of BTP 11-6, and the following is added to the end of 2nd paragraph of DCD Subsection 11.2.3.2:

   > "…is not taken; and that 80% of the entire volume capacity of the tank is assumed to be released when the holdup tank fails."

7. a. Information requested in this question is provided in the response Items No. 1 and 6 above.

   b. Information requested in this question is provided in the response Item No. 1 above.

   c. Information requested in this question is provided in the response Item No. 1 above

Table 1. Expected Inventory of CVCS Yard Tanks

| Nuclide | HUT | BAST | RMWT | Nuclide | HUT | BAST | RMWT |
|---|---|---|---|---|---|---|---|
| H-3 | 7.20E+12 | 1.17E+13 | 3.97E+13 | Y-91 | 3.21E+07 | 9.66E+08 | 7.32E+04 |
| Br-84 | 1.41E+05 | 0.00E+00 | 2.00E-02 | Y-93 | 8.21E+08 | 4.92E-05 | 2.18E+04 |
| I-129 | 0.00E+00 | 0.00E+00 | 0.00E+00 | Zr-95 | 2.61E+07 | 8.79E+08 | 6.32E+04 |
| I-131 | 3.62E+07 | 4.51E+07 | 1.72E+03 | Nb-95 | 1.52E+07 | 2.50E+08 | 2.46E+04 |
| I-132 | 2.62E+06 | 0.00E+00 | 1.60E+00 | Mo-99 | 3.56E+07 | 8.67E+05 | 6.13E+03 |
| I-133 | 2.22E+07 | 1.08E+01 | 1.22E+02 | Tc-99 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| I-134 | 1.49E+06 | 0.00E+00 | 3.47E-01 | Tc-99m | 1.12E+06 | 1.39E-16 | 1.79E+01 |
| I-135 | 9.23E+06 | 2.07E-13 | 1.65E+01 | Ru-103 | 4.29E+08 | 8.22E+09 | 7.58E+05 |
| Rb-88 | 4.46E+06 | 0.00E+00 | 3.51E+00 | Ru-106 | 7.58E+09 | 8.54E+11 | 3.47E+07 |
| Cs-134 | 1.43E+06 | 1.95E+08 | 7.22E+03 | Ag-110m | 1.07E+08 | 1.02E+10 | 4.49E+05 |
| Cs-136 | 1.51E+07 | 5.32E+07 | 1.10E+04 | Te-129m | 9.41E+06 | 1.48E+08 | 1.49E+03 |
| Cs-137 | 2.08E+06 | 3.43E+08 | 1.16E+04 | Te-129 | 4.74E+05 | 0.00E+00 | 1.44E-01 |
| Na-24 | 3.50E+07 | 5.14E-02 | 1.39E+03 | Te-131m | 2.02E+06 | 6.75E+01 | 1.54E+01 |
| Cr-51 | 1.52E+08 | 1.82E+08 | 2.06E+05 | Te-131 | 5.29E+04 | 0.00E+00 | 5.88E-03 |
| Mn-54 | 1.33E+08 | 1.41E+09 | 5.92E+05 | Te-132 | 9.79E+06 | 5.31E+05 | 1.97E+02 |
| Fe-55 | 1.04E+08 | 1.50E+09 | 5.41E+05 | Ba-137m | 2.08E+06 | 3.43E+08 | 1.16E+04 |
| Fe-59 | 1.80E+07 | 3.99E+07 | 3.45E+04 | Ba-140 | 3.83E+08 | 1.31E+09 | 2.75E+05 |
| Co-58 | 3.15E+08 | 1.16E+09 | 8.02E+05 | La-140 | 7.07E+07 | 5.88E+04 | 7.45E+03 |
| Co-60 | 4.66E+07 | 7.20E+08 | 2.51E+05 | Ce-141 | 7.88E+06 | 1.17E+08 | 1.21E+04 |
| Zn-65 | 4.18E+07 | 3.93E+09 | 1.75E+05 | Ce-143 | 6.03E+06 | 8.38E+02 | 5.23E+02 |
| Sr-89 | 8.71E+06 | 2.23E+08 | 1.81E+04 | Ce-144 | 3.30E+08 | 3.35E+10 | 1.43E+06 |
| Sr-90 | 1.06E+06 | 1.76E+08 | 5.92E+03 | W-187 | 3.47E+06 | 1.20E+01 | 2.19E+02 |
| Sr-91 | 4.08E+05 | 8.73E-09 | 1.05E+01 | Np-239 | 9.81E+06 | 9.17E+04 | 1.44E+03 |
| Y-91m | 7.46E+06 | 0.00E+00 | 1.66E+01 | | | | |

**Impact on DCD**

DCD 11.2.3.2 and Table 11.2-9 will be updated as indicated in Attachment.

**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 Environmental Report.

11.2.3.2 Radioactive Effluent Release due to Failure of Radioactive Liquid Tank

For the assessment of the impacts of contamination levels on the nearest portable water supply located in an unrestricted area, a tank containing radioactive liquid is postulated to fail. The acceptance criteria and methods used for the assessment follow the guidance in BTP 11-6 (Reference 17) and the radionuclide concentration limits in 10 CFR 20, Appendix B (Reference 3). In addition, the Interim Staff Guidance (ISG) DC/COL-ISG-013 (Reference 34) stipulates that the COL applicant is to identify the site-specific parameters for the evaluation (COL 11.2(14)). In the absence of site-specific requirements, the minimum dilution factors are calculated using 10 percent of 10 CFR 20, Appendix B, Table 2 (Reference 3) concentration limits and compared with the corresponding expected release radionuclide concentration.

In evaluating the postulated liquid-containing tank failure, the CVCS holdup tank is selected because it contains the highest amount of radioactive inventory among the liquid waste collection tanks installed in the yard area. In accordance with Section B.3 of BTP 11-6 (Reference 17), credit for liquid retention by the tank house surrounding the holdup tank is not taken; and that 80% of the entire volume capacity of the tank is assumed to be released when the holdup tank fails.

The radionuclide inventory in the holdup tank is based on the expected fuel defect. The concentration of radioactive liquid after a liquid tank failure is assumed to be unmitigated and diluted by mixing in receiving water. The concentration after diluted in receiving water is divided by 10 CFR 20 Appendix B (Reference 3) limits. Table 11.2-9 summarizes the results of this evaluation and identifies the minimum dilution factor as ~~1.71~~ 3.60 $\times 10^3$ to sufficiently dilute the failed tank nuclides to 10 percent of the 10 CFR 20 Appendix B (Reference 3) concentration limits. Site-specific hydrologic characteristics related to dilution of liquid tank failure source terms are described in Subsection 2.4.13.

The COL applicant is to provide the site-specific volume of the mixing water and hydrogeological data for analysis; the results of the analysis are to demonstrate that the potential groundwater or surface water contamination concentration resulting from radioactive release due to liquid-containing tank failure meets the requirements in 10 CFR 20, Appendix B, Table 2 (Reference 3) (COL 11.2(14)).

Replace this table with "A" after this table

Table 11.2-9 (1 of 2)

Radioactive Concentrations in Nearest Portable Water Due to Liquid Waste Containing Tank Failure

| Nuclide | Holdup Tank Inventory (Bq/cm$^3$) | Concentration at Nearest Potable Water (1) (Bq/cm$^3$) | 10 CFR 20, Appendix B (Bq/cm$^3$) | Ratio |
|---|---|---|---|---|
| Br-84 | 8.81E-05 | 5.14E-08 | 1.48E+01 | 3.47E-09 |
| I-129(2) | 1.41E-09 | 8.23E-13 | 7.40E-03 | 1.11E-10 |
| I-131 | 2.26E-02 | 1.32E-05 | 3.70E-02 | 3.57E-04 |
| I-132 | 1.64E-03 | 9.54E-07 | 3.70E+00 | 2.58E-07 |
| I-133 | 1.38E-02 | 8.07E-06 | 2.59E-01 | 3.12E-05 |
| I-134 | 9.43E-04 | 5.51E-07 | 1.48E+01 | 3.72E-08 |
| I-135 | 5.79E-03 | 3.38E-06 | 1.11E+00 | 3.04E-06 |
| Rb-88 | 2.83E-03 | 1.65E-06 | 1.48E+01 | 1.12E-07 |
| Cs-134 | 8.81E-04 | 5.14E-07 | 3.33E-02 | 1.54E-05 |
| Cs-136 | 9.43E-03 | 5.51E-06 | 2.22E-01 | 2.48E-05 |
| Cs-137 | 1.32E-03 | 7.71E-07 | 3.70E-02 | 2.08E-05 |
| Na-24 | 2.20E-02 | 1.28E-05 | 1.85E+00 | 6.94E-06 |
| Cr-51 | 9.43E-02 | 5.51E-05 | 1.85E+01 | 2.98E-06 |
| Mn-54 | 8.18E-02 | 4.77E-05 | 1.11E+00 | 4.30E-05 |
| Fe-55 | 6.29E-02 | 3.67E-05 | 3.70E+00 | 9.92E-06 |
| Fe-59 | 1.13E-02 | 6.61E-06 | 3.70E-01 | 1.79E-05 |
| Co-58 | 1.95E-01 | 1.14E-04 | 7.40E-01 | 1.54E-04 |
| Co-60 | 2.96E-02 | 1.73E-05 | 1.11E-01 | 1.55E-04 |
| Zn-65 | 2.64E-02 | 1.54E-05 | 1.85E-02 | 8.33E-05 |
| Sr-89 | 5.47E-03 | 3.19E-06 | 2.96E-01 | 1.08E-05 |
| Sr-90 | 6.92E-04 | 4.04E-07 | 1.85E-02 | 2.18E-05 |
| Sr-91 | 2.58E-04 | 1.50E-07 | 7.40E-01 | 2.03E-07 |
| Y-91m | 4.72E-03 | 2.75E-06 | 7.40E+01 | 3.72E-08 |
| Y-91 | 2.01E-02 | 1.17E-05 | 2.96E-01 | 3.97E-05 |
| Y-93 | 5.16E-01 | 3.01E-04 | 7.40E-01 | 4.07E-04 |
| Zr-95 | 1.64E-02 | 9.54E-06 | 7.40E-01 | 1.29E-05 |
| Nb-95 | 9.43E-03 | 5.51E-06 | 1.11E+00 | 4.96E-06 |

Replace this table with "A" after this table

Table 11.2-9 (2 of 2)

| Nuclide | Holdup Tank Inventory ($Bq/cm^3$) | Concentration at Nearest Potable Water (1) ($Bq/cm^3$) | 10 CFR 20, Appendix B ($Bq/cm^3$) | Ratio |
|---|---|---|---|---|
| Mo-99 | 2.26E-02 | 1.32E+05 | 7.40E-01 | 1.79E-05 |
| TC-99m | 6.92E-04 | 4.04E-07 | 3.70E+01 | 1.09E-08 |
| Tc-99(2) | 1.65E-11 | 9.68E-15 | 2.22E+00 | 4.36E-15 |
| Ru-103 | 2.70E-01 | 1.58E-04 | 1.11E+00 | 1.42E-04 |
| Ru-106 | 4.78E+00 | 2.79E-03 | 1.11E-01 | 2.51E-02 |
| Ag-110m | 6.92E-02 | 4.04E-05 | 2.22E-01 | 1.82E-04 |
| Te-129m | 5.91E-03 | 3.45E-06 | 2.59E-01 | 1.33E-05 |
| Te-129 | 2.96E-04 | 1.73E-07 | 1.48E+01 | 1.17E-08 |
| Te-131m | 1.26E-03 | 7.34E-07 | 2.96E-01 | 2.48E-06 |
| Te-131 | 3.33E-05 | 1.95E-08 | 2.96E+00 | 6.57E-09 |
| Te-132 | 6.16E-03 | 3.60E-06 | 3.33E-01 | 1.08E-05 |
| Ba-137m | 1.32E-03 | 7.71E-07 | - | - |
| Ba-140 | 2.39E-01 | 1.39E-04 | 2.96E-01 | 4.71E-04 |
| La-140 | 4.47E-02 | 2.61E-05 | 3.33E-01 | 7.83E-05 |
| Ce-141 | 4.97E-03 | 2.90E-06 | 1.11E+00 | 2.61E-06 |
| Ce-143 | 3.77E-03 | 2.20E-06 | 7.40E-01 | 2.98E-06 |
| Ce-144 | 2.08E-01 | 1.21E-04 | 1.11E-01 | 1.09E-03 |
| W-187 | 2.20E-03 | 1.28E-06 | 1.11E+00 | 1.16E-06 |
| Np-239 | 6.16E-03 | 3.60E-06 | 7.40E-01 | 4.86E-06 |
| H-3 | 4.53E+03 | 2.79E-03 | 1.11E-01 | 2.51E-02 |
| | | | SUM | 1.00E-01 |

(1) Dilution factor of 1.71E+03 is assumed to meet the 10 % of 10 CFR 20, Appendix B limits.

(2) In accordance with NRC's position, two radionuclides of I-129 and Tc-99, which may cause significant potential exposure, are included in the liquid tank failure analysis. The inventories of I-129 and Tc-99 in the holdup tank are determined based on the assumption that they have the same RCS existence ratios to I-131 and Tc-99m with those for a similar PWR. As shown in the results, the impact of these nuclides on the dose contribution is negligible.

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Table 11.2-9 (1 of 3)

Radioactive Concentrations in Nearest Portable Water
Due to Liquid Waste Containing Tank Failure

| Nuclide | Expected Holdup Tank inventory | | Holdup Tank Concentraion (1) | | Concentration at Nearest Potable Water (2) | | 10 CFR 20, Appendix B | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | μCi | Bq | μCi/cm$^3$ | Bq/cm$^3$ | μCi/cm$^3$ | Bq/cm$^3$ | μCi/cm$^3$ | Bq/cm$^3$ | |
| Br-84 | 3.81E+00 | 1.41E+05 | 3.87E-09 | 1.43E-04 | 1.40E-12 | 5.18E-08 | 4.00E-04 | 1.48E+01 | 3.50E-09 |
| I-129(3) | 6.05E-05 | 2.24E+00 | 6.14E-14 | 2.27E-09 | 2.22E-17 | 8.22E-13 | 2.00E-07 | 7.40E-03 | 1.11E-10 |
| I-131 | 9.78E+02 | 3.62E+07 | 9.93E-07 | 3.67E-02 | 3.59E-10 | 1.33E-05 | 1.00E-06 | 3.70E-02 | 3.59E-04 |
| I-132 | 7.08E+01 | 2.62E+06 | 7.18E-08 | 2.66E-03 | 2.60E-11 | 9.62E-07 | 1.00E-04 | 3.70E+00 | 2.60E-07 |
| I-133 | 6.00E+02 | 2.22E+07 | 6.09E-07 | 2.25E-02 | 2.20E-10 | 8.15E-06 | 7.00E-06 | 2.59E-01 | 3.15E-05 |
| I-134 | 4.03E+01 | 1.49E+06 | 4.09E-08 | 1.51E-03 | 1.48E-11 | 5.47E-07 | 4.00E-04 | 1.48E+01 | 3.70E-08 |
| I-135 | 2.49E+02 | 9.23E+06 | 2.53E-07 | 9.36E-03 | 9.16E-11 | 3.39E-06 | 3.00E-05 | 1.11E+00 | 3.05E-06 |
| Rb-88 | 1.21E+02 | 4.46E+06 | 1.22E-07 | 4.52E-03 | 4.43E-11 | 1.64E-06 | 4.00E-04 | 1.48E+01 | 1.11E-07 |
| Cs-134 | 3.86E+01 | 1.43E+06 | 3.92E-08 | 1.45E-03 | 1.42E-11 | 5.25E-07 | 9.00E-07 | 3.33E-02 | 1.58E-05 |
| Cs-136 | 4.08E+02 | 1.51E+07 | 4.14E-07 | 1.53E-02 | 1.50E-10 | 5.55E-06 | 6.00E-06 | 2.22E-01 | 2.50E-05 |
| Cs-137 | 5.62E+01 | 2.08E+06 | 5.70E-08 | 2.11E-03 | 2.06E-11 | 7.64E-07 | 1.00E-06 | 3.70E-02 | 2.06E-05 |
| Na-24 | 9.46E+02 | 3.50E+07 | 9.60E-07 | 3.55E-02 | 3.47E-10 | 1.29E-05 | 5.00E-05 | 1.85E+00 | 6.95E-06 |
| Cr-51 | 4.11E+03 | 1.52E+08 | 4.17E-06 | 1.54E-01 | 1.51E-09 | 5.58E-05 | 5.00E-04 | 1.85E+01 | 3.02E-06 |
| Mn-54 | 3.59E+03 | 1.33E+08 | 3.65E-06 | 1.35E-01 | 1.32E-09 | 4.88E-05 | 3.00E-05 | 1.11E+00 | 4.40E-05 |
| Fe-55 | 2.81E+03 | 1.04E+08 | 2.85E-06 | 1.06E-01 | 1.03E-09 | 3.82E-05 | 1.00E-04 | 3.70E+00 | 1.03E-05 |
| Fe-59 | 4.86E+02 | 1.80E+07 | 4.94E-07 | 1.83E-02 | 1.79E-10 | 6.61E-06 | 1.00E-05 | 3.70E-01 | 1.79E-05 |

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Table 11.2-9 (2 of 3)

| Nuclide | Expected Holdup Tank inventory | | Holdup Tank Concentraion (1) | | Concentration at Nearest Potable Water (2) | | 10 CFR 20, Appendix B | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | μCi | Bq | $\mu Ci/cm^3$ | $Bq/cm^3$ | $\mu Ci/cm^3$ | $Bq/cm^3$ | $\mu Ci/cm^3$ | $Bq/cm^3$ | |
| Co-58 | 8.51E+03 | 3.15E+08 | 8.64E-06 | 3.20E-01 | 3.13E-09 | 1.16E-04 | 2.00E-05 | 7.40E-01 | 1.56E-04 |
| Co-60 | 1.26E+03 | 4.66E+07 | 1.28E-06 | 4.73E-02 | 4.63E-10 | 1.71E-05 | 3.00E-06 | 1.11E-01 | 1.54E-04 |
| Zn-65 | 1.13E+03 | 4.18E+07 | 1.15E-06 | 4.24E-02 | 4.15E-10 | 1.54E-05 | 5.00E-06 | 1.85E-02 | 8.30E-05 |
| Sr-89 | 2.35E+02 | 8.71E+06 | 2.39E-07 | 8.84E-03 | 8.65E-11 | 3.20E-06 | 8.00E-06 | 2.96E-01 | 1.08E-05 |
| Sr-90 | 2.86E+01 | 1.06E+06 | 2.91E-08 | 1.08E-03 | 1.05E-11 | 3.89E-07 | 5.00E-07 | 1.85E-02 | 2.10E-05 |
| Sr-91 | 1.10E+01 | 4.08E+05 | 1.12E-08 | 4.14E-04 | 4.05E-12 | 1.50E-07 | 2.00E-05 | 7.40E-01 | 2.02E-07 |
| Y-91m | 2.02E+02 | 7.46E+06 | 2.05E-07 | 7.57E-03 | 7.41E-11 | 2.74E-06 | 2.00E-03 | 7.40E+01 | 3.70E-08 |
| Y-91 | 8.68E+02 | 3.21E+07 | 8.80E-07 | 3.26E-02 | 3.19E-10 | 1.18E-05 | 8.00E-06 | 2.96E-01 | 3.98E-05 |
| Y-93 | 2.22E+04 | 8.21E+08 | 2.25E-05 | 8.33E-01 | 8.15E-09 | 3.02E-04 | 2.00E-05 | 7.40E-01 | 4.07E-04 |
| Zr-95 | 7.05E+02 | 2.61E+07 | 7.16E-07 | 2.65E-02 | 2.59E-10 | 9.59E-06 | 2.00E-05 | 7.40E-01 | 1.30E-05 |
| Nb-95 | 4.11E+02 | 1.52E+07 | 4.17E-07 | 1.54E-02 | 1.51E-10 | 5.58E-06 | 3.00E-05 | 1.11E+00 | 5.03E-06 |
| Mo-99 | 9.62E+02 | 3.56E+07 | 9.76E-07 | 3.61E-02 | 3.53E-10 | 1.31E-05 | 2.00E-05 | 7.40E-01 | 1.77E-05 |
| Tc-99(2) | 7.11E-07 | 2.63E-02 | 7.21E-16 | 2.67E-11 | 2.61E-19 | 9.66E-15 | 6.00E-05 | 3.70E+01 | 4.35E-15 |
| Tc-99m | 3.03E+01 | 1.12E+06 | 3.07E-08 | 1.14E-03 | 1.11E-11 | 4.11E-07 | 1.00E-03 | 2.22E+00 | 1.11E-08 |
| Ru-103 | 1.16E+04 | 4.29E+08 | 1.18E-05 | 4.35E-01 | 4.26E-09 | 1.58E-04 | 3.00E-05 | 1.11E+00 | 1.42E-04 |
| Ru-106 | 2.05E+05 | 7.58E+09 | 2.08E-04 | 7.69E+00 | 7.52E-08 | 2.78E-03 | 3.00E-06 | 1.11E-01 | 2.51E-02 |
| Ag-110m | 2.89E+03 | 1.07E+08 | 2.93E-06 | 1.09E-01 | 1.06E-09 | 3.93E-05 | 6.00E-06 | 2.22E-01 | 1.77E-04 |
| Te-129m | 2.54E+02 | 9.41E+06 | 2.58E-07 | 9.55E-03 | 9.34E-11 | 3.46E-06 | 7.00E-06 | 2.59E-01 | 1.33E-05 |
| Te-129 | 1.28E+01 | 4.74E+05 | 1.30E-08 | 4.81E-04 | 4.71E-12 | 1.74E-07 | 4.00E-04 | 1.48E+01 | 1.18E-08 |

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Table 11.2-9 (3 of 3)

| Nuclide | Expected Holdup Tank inventory | | Holdup Tank Concentraion (1) | | Concentration at Nearest Potable Water (2) | | 10 CFR 20, Appendix B | | Ratio |
|---|---|---|---|---|---|---|---|---|---|
| | μCi | Bq | μCi/cm$^3$ | Bq/cm$^3$ | μCi/cm$^3$ | Bq/cm$^3$ | μCi/cm$^3$ | Bq/cm$^3$ | |
| Te-131m | 5.46E+01 | 2.02E+06 | 5.54E-08 | 2.05E-03 | 2.01E-11 | 7.42E-07 | 8.00E-06 | 2.96E-01 | 2.51E-06 |
| Te-131 | 1.43E+00 | 5.29E+04 | 1.45E-09 | 5.37E-05 | 5.25E-13 | 1.94E-08 | 8.00E-05 | 2.96E+00 | 6.56E-09 |
| Te-132 | 2.65E+02 | 9.79E+06 | 2.68E-07 | 9.93E-03 | 9.72E-11 | 3.60E-06 | 9.00E-06 | 3.33E-01 | 1.08E-05 |
| Ba-137m | 5.62E+01 | 2.08E+06 | 5.70E-08 | 2.11E-03 | 2.06E-11 | 7.64E-07 | | | |
| Ba-140 | 1.04E+04 | 3.83E+08 | 1.05E-05 | 3.89E-01 | 3.80E-09 | 1.41E-04 | 8.00E-06 | 2.96E-01 | 4.75E-04 |
| La-140 | 1.91E+03 | 7.07E+07 | 1.94E-06 | 7.17E-02 | 7.02E-10 | 2.60E-05 | 9.00E-06 | 3.33E-01 | 7.80E-05 |
| Ce-141 | 2.13E+02 | 7.88E+06 | 2.16E-07 | 7.99E-03 | 7.82E-11 | 2.89E-06 | 3.00E-05 | 1.11E+00 | 2.61E-06 |
| Ce-143 | 1.63E+02 | 6.03E+06 | 1.65E-07 | 6.12E-03 | 5.99E-11 | 2.21E-06 | 2.00E-05 | 7.40E-01 | 2.99E-06 |
| Ce-144 | 8.92E+03 | 3.30E+08 | 9.05E-06 | 3.35E-01 | 3.28E-09 | 1.21E-04 | 3.00E-06 | 1.11E-01 | 1.09E-03 |
| W-187 | 9.38E+01 | 3.47E+06 | 9.51E-08 | 3.52E-03 | 3.44E-11 | 1.27E-06 | 3.00E-05 | 1.11E+00 | 1.15E-06 |
| Np-239 | 2.65E+02 | 9.81E+06 | 2.69E-07 | 9.95E-03 | 9.74E-11 | 3.60E-06 | 2.00E-05 | 7.40E-01 | 4.87E-06 |
| H-3 | 1.95E+08 | 7.20E+12 | 1.97E-01 | 7.30E+03 | 7.15E-05 | 2.64E+00 | 1.00E-03 | 3.70E+01 | 7.15E-02 |
| | | | | | | | | SUM | 1.00E-01 |

(1) 62 % of tank volume (262,180 gallons) is divided to calculate concentration.

(2) Dilution factor of 2.76E+03 is assumed to meet the 10 % of 10 CFR 20, Appendix B limits. This dilution factor is adjusted by the ratio of 80% to 62% to about 3.60E+03.

(3) In accordance with NRC's position, two radionuclides of I-129 and Tc-99, which may cause significant potential exposure, are included in the liquid tank failure analysis. The inventories of I-129 and Tc-99 in the holdup tank are determined based on the assumption that they have the same RCS existence ratios to I-131 and Tc-99m with those for a similar PWR. As shown in the results, the impact of these nuclides on the dose contribution is negligible.