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.:	**308-8339**
SRP Section:	**12.02 – Radiation Sources**
Application Section:	**12.02**
Date of RAI Issue:	**11/16/2015**

Question No. 12.02-19

This is a follow-up to RAI 7896, Question 12.02-4 (26741).

SRP 12.2 indicates that RG 1.112 includes acceptable basis for developing source terms (if used appropriately). RG 1.112, references NUREG-0017 as the basis for the information in RG 1.112.

In the response to Question 12.02-4 the applicant provided a list of decontamination factors assumed for various plant components. Some of these decontamination factors are inconsistent with decontamination factors provided in NUREG-0017, and no justification is provided for the differences.

The differences are, 1) the use of a decontamination factor of 10 for crud for the deborating IX (NUREG-0017 would indicate the value should be 1). 2) All of the decontamination factor values associated with the pre-holdup ion exchanger are inconsistent with values from NUREG-0017 for a CVCS mixed bed ion exchanger except for noble gases and tritium. 3) The FSAR indicates that there are two steam generator blowdown ion exchangers which are generally aligned in series and while NUREG-0017 provides different values for the second steam generator blowdown ion exchanger in series, the applicant uses the decontamination values for the initial ion exchanger to apply to both demineralizers. 4) The applicant assumes that the CVCS system does not remove any Yttrium, based on WASH-1258, which is inconsistent with NUREG-0017. WASH-1258 is older than NUREG-0017 and is not referenced in the SRP or in RG 1.112.

Underestimating decontamination factors results in underestimating the source term and subsequently the shielding and zoning for that component. Overestimating the source term results in underestimating the source terms, shielding, and zoning for components downstream of the component with the overestimated decontamination factor. If the overestimation is only applied to the specific component but is not carried forward to downstream components, the overestimation is acceptable because all source terms are conservative or appropriate, but this does not appear to be the case in the above situations.

Therefore, for the differences from NUREG-0017 specified above, please do one or a combination of the following two options, as appropriate for the APR 1400 design;

1) Recalculate all effected source terms, including any effected airborne source terms, based on the values from NUREG-0017 and adjust the FSAR appropriately; or

2) Verify that the values which differ from NUREG-0017 are anticipated to represent the normal decontamination factors of the equipment, during normal operation; Indicate how and why the values selected were chosen; Specify how the COL applicant will ensure that the decontamination factors provided will be representative of the actual equipment selected during plant operation; and update the FSAR to provide additional information of how the values were chosen and how the COL applicant will ensure the decontamination factors are representative of the expected decontamination factors of the equipment used during operation.

Staff notes that if any of the assumed decontamination factors are not representative of what would be expected of the equipment during normal operation, the assumptions are not acceptable and must be revised to appropriate values, unless the applicant can demonstrate that the unrealistic assumptions do not result in any underestimation in plant shielding thicknesses, radiation zoning, effluent releases, waste generation rate source term and storage considerations (such as the potential generation of explosive gas in resins from radiological effects on the resin), or any other information or analysis in the FSAR or relevant to the design.

Response

1. Crud DF

It has been fairly common for other plants to assume a DF of 10 for crud in ion exchange resin beds. Although the resins in this case do not act chemically on the crud particles, they still serve as a mechanical filter. While it is true that an arrangement with a pre-filter, charcoal filter, and an ion exchanger could result in a lower volume of resin to replace, such an arrangement is not necessary to bring about this degree of reduction in crud concentration.

Three generations of Westinghouse plants include a statement to the following effect.

> For all isotopes except the isotopes of Kr, Xe, Br, I, Rb, Cs, Sr, and Ba, a removal DF of 10 was assumed. This assumption accounts for removal mechanisms other than ion exchange such as plateout or filtration. The DF is applied to the normal purification letdown flow.

This statement and approach lend strong support to the approach taken in the design of the System 80+ and APR1400 plants. This support is particularly compelling due to the fact that at the time of the plants' designs, Combustion Engineering and Westinghouse were two independent companies.

In summary, the assumption of a DF of 10 for crud has substantial historical support in addition to a strong and plausible basis.

2. Rb and Cs DF

Looking at the previous plant designs, it can be seen that there is a substantial history of the use of a DF of 100 for cesium and rubidium for the pre-holdup ion exchanger in Combustion Engineering plant designs (see References 1 and 2). These include System 80 plants as well as earlier, historical Combustion Engineering plants.

Each new plant in the Combustion Engineering design sequence has been based, to some extent, on the previous design. It is in this sense that the plant design can be regarded as evolutionary in its nature. The APR1400 is based on the System 80+ design, and that design was in turn based, prior to System 80, on plant designs from the early 1970s. Other plants in this evolutionary development chain include the System 80 design from the mid-to late 1970s, and the first C-E units in Korea – YGN 3 & 4 in the late 1980s to early 1990s. The System 80 design also includes Palo Verde, which began operating in the 1980s.

The use of a DF factor of 100 for the pre-holdup ion exchanger specifically ties to Combustion Engineering resin specifications dating back to the 1970s, which specified a 3:1 cation to anion bed resin volume for the CVCS pre-holdup ion exchanger (see References 3-5). Development Department laboratory tests performed from 1972 to 1973 established a cesium DF of ≥ 100 with the use of a 3:1 cation to anion bed. This requirement was specifically incorporated into the System 80 pre-holdup ion exchanger design in order to enhance removal of long-lived cesium nuclides and justify the use of outside storage tanks (Reference 6). A description of the same resin specification for the CVCS pre-holdup ion exchanger will be added in APR1400 DCD Tier 1, Section 2.4.6.1 and Tier 2, Section 12.2.1.1.5.1.

An extensive series of document searches has been conducted in order to identify specific reports related to this laboratory testing. The documents returned from these searches are presented in Table 1 below.

The documents in Table 1, and in particular those in the section titled, “CE and WCAP Topical Reports,” confirm that extensive testing was performed over a substantial period. These tests consistently demonstrated the following:

a. Cesium DFs in excess of 100 were consistently found.
b. Only for cumulative flows in excess of a value conservatively representing operation in load follow mode for the plant’s design life were cesium removal efficiencies observed to drop below this level.

This information was submitted in late 1973 or early 1974 as a topical report for regulatory review.

3. DF for the SG Blowdown IXs

Two steam generator blowdown ion exchangers are normally operated in series during continuous (normal) blowdown. However, the design also provides the flexibility for one S/G blowdown ion exchanger to be operated while the other is isolated in standby; or both ion exchangers to be operated in parallel.

In development of the S/G blowdown source terms, it is conservatively assumed that only one S/G blowdown ion exchanger is operating during normal blowdown mode using the decontamination factors for a single S/G blowdown ion exchanger in accordance with NUREG-0017, Table 1-4. Therefore, KHNP confirms that the source term analysis for the S/G blowdown system is performed in accordance with the guidance document. For purpose of clarity, a note is added to DCD Section 11.1, Table 11.1-5 to clarify the assumptions used in determination of the secondary system activity for the SGBDS.

4. Yttrium DF

Although there were early examples of the DF for this component being modeled as a higher value, it has been common in Westinghouse plants to make use of an assumed value of 1. In References 7, 8, and 9, for example, yttrium is not specifically called out in the DF listings and is therefore assigned a value of 1, which pertains to the “Other Isotopes” category. This is the most conservative assumption that can be made for the downstream components, and it is consistent with WASH-1258 (Reference 10), as stated in the response to RAI 7896. It appears that this practice was adopted due to a lack of definitive data demonstrating a higher DF for the purification ion exchanger. Statements were also found describing that the DF assumption for yttrium was being switched to 1 for both conservatism and simplification, since the DF for antimony species (Sb-122 and Sb-124) – in the same grouping as yttrium – had already been changed to 1.

Likewise, DF of 1 for yttrium is used for the APR1400 shielding design source terms. This would be consistent with the other historic and recent Westinghouse plants. Moreover, there is no evidence that a higher DF for yttrium would significantly increase either the source term for the purification ion exchanger or the required shielding.

References:

1. Westinghouse (Combustion Engineering) Document SP-PEC-061, Rev. 0, “System 80 Standard Plant Shielding Inventories,” December 27, 1976.

2. Westinghouse (Combustion Engineering) Document K-FS-C-082, Rev. 0, “Verification of YGN 3 & 4 RDG Shielding Inventories,” July 19, 1989.

3. Westinghouse (Combustion Engineering) Document 00000-PE-975, Rev. 3, “General Specification for Ion Exchange Resins,” April 1, 1976.

4. Westinghouse (Combustion Engineering) Document SYS 80-PE-CR20, Rev. 2, “Component Design Requirements for Chemical and Volume Control System for System 80,” October 7, 1977.

5. Westinghouse (Combustion Engineering) Document 10487-FS-975, Rev. 1, “Project Specification for Ion Exchange Resins for Yonggwang Nuclear Power Plant Units 3 and 4,” November 9, 1991.

6. Westinghouse (Combustion Engineering) Document SP-PSD-254, “Ion Exchange Resin Specifications,” February 24, 1976.

7. Westinghouse Report LTR-REA-00-632, “Radiation Analysis Manual [for a Representative 3-Loop Plant],” July 2000.

8. Westinghouse Standard Information Package, “Radiation Analysis Manual, 1000 MWe Plant (312/3-1),” Standard Information Package, SIP 3-1, Standard Plant 312, July 1984.

9. Westinghouse Report APP-GW-N1-021, Rev. 2, “AP1000 Radiation Analysis Design Manual” June 2015.

10. WASH-1258, “Final Environmental Statement Concerning Proposed Rule Making Action: Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion ‘As Low As Practicable’ for Radioactive Material in Light-Water-Cooled Power Reactor Effluents,” U.S. Atomic Energy Commission, July 1973.

Table 1 - Documents Relating to Testing of Cs and Rb DF

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
Test Report Logs & Test Report Documents				
Keywords_TASKS-302211-301131.pdf	Performance Testing of Ion Exchange Resins for the Removal of Impurities in a Chemical Shim Environment: Tasks 302211 and 301131	6/71	N	
TP-DT-XX Fuels Test Plans Log.pdf	TP-DT-30 and Addenda	~7/75	N	
Test Reports (TRP-DT-1 thru 00000-NLE-092).pdf	No citation evident.		N	The remainder of the searches in this section appear to have returned false positives.
Test Reports Log (TR-DT-1 through TR-DT-265).pdf	No citation evident.		N	“
Test Report Logs (TP-DT-1 thru TP-DT-98).pdf	No citation evident.		N	“
Test Reports (TR-ESE-001 thru TR-ESE-1030)_2.pdf	No citation evident.		N	“
TR-DT-X Test Reports Dept Log_2.pdf	No citation evident.		N	“
Test Reports (TR-ESE-001 thru TR-ESE-1030).pdf	No citation evident.		N	“
Specifications & Documents				
0000-PE-975.pdf	General Specification for Ion Exchange Resins, Specification No. 00000- PE-975, Rev. 03	3/76	Y	Gives detailed property requirements for resin bead physical configuration, composition, and performance. Both cation and anion resins are specified and characterized. For Type II resin, specifies that “the mixture shall be uniformly mixed to obtain a ratio of 3 volumes of cation resin to 1 volume of anion resin. (Types I and III, not used in the pre-holdup ion exchanger are specified as 1:1 ratios.) The specification also places requirements and limits on ion regeneration.

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
1370-PE-975.pdf	Project Specification for Ion Exchange Resins for Southern California Edison Company, Specification No. 1370-PE-975, Rev 01.	8/78	N	This document refers to three different types of ion exchange resin service. Does not list a “Pre-Holdup or Pre-Concentrator” mixed bed.
6370-PE-975.pdf	Project Specification for Ion Exchange Resins for Arkansas Power and Light Company Arkansas Nuclear One – Unit No 2, Specification No. 6370-PE-975, Rev 02.	7/76	Y	This document refers to seven different types of ion exchange resin service. Includes a “Pre-Concentrator” mixed bed and also a “Fuel Pool” mixed bed. Both are referenced to the Type II 3-to-1 paragraph in the 00000-PE-975 General Specification.
S-CE-2003.pdf	Letter S-CE-2003, “Ion Exchange Resins”	7/75	Pos.	Clarifies the requirements for conducting tests to verify that leachable chlorides are less than 0.1 ppm, in accordance with the 00000-PE-975 General Specification.
SP-PAC-014.pdf	Ion Exchangers – Transient Evaluation	5/77	Y	This calculation determines the suitability of the CVCS Ion Exchangers for the specified operating conditions involving cyclic application of loads and thermal conditions. Provides a fatigue analysis for the Pre-Holdup Ion Exchanger. Establishes that the requirements of ASME Code, Section III, Class 2 (NC-3300) requirements for ion exchangers are met. Concludes that the Pre-Holdup Ion Exchanger has no imposed pressure, temperature, or mechanical transients which require a fatigue analysis.
SYS80-PE-SD20-00.pdf	System Description, Chemical and Volume Control System for Standard Plant SYS80-PE-SD20-00	2/76	Y	Provides a mechanical component description for the Preholdup Ion Exchanger, stating that “The Preholdup ion exchanger is used to purify the process liquid from the reactor drain pump discharge and volume control tank diversion.” States that, “the ion exchanger is identical in size and detail to the purification ion exchanger.” In Section 7.3, states for the

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
				Preholdup ion exchanger that "the mixed resin consists of 3:1 cation to anion ratio." In Section 8.1, provides specific flow path and operation details associated with the Preholdup ion exchanger.
NFRCC Specification Log & Page Excerpts				
Page 6 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	Ion Exchange Resins Ion Exchange Resins	9/71 4/76	Pos. Pos.	Accession Number: 001454 Accession Number: 002125
Page 29 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	Ion Exchange Resins for Southern Cal Ed.	8/78	Pos.	Accession Number: 003387
Page 34 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	Mixed Bed Ion Exchange Resin Deborating Ion Exchange Resin	3/69 3/69	Pos. N	Accession Number: 001460
Page 41 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	Ion Exchange Resins Ion Exchange Resins	11/70 9/71	Pos. Pos.	Accession Number: 001461 Accession Number: 001462
Page 45 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	Ion Exchange Resins Ion Exchange Resins	12/71 1/75	Pos. Pos.	Accession Number: 001456 Accession Number: 001766
Page 109 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	No citation evident.		N	
Page 111 NFRCC Specification File Index Project Number Log (1966 - 1990)_5.pdf	CE Designed Ion Exchangers for System 80 Standard Design	8/76 11/76 5/77 12/83	Pos.	Accession Number: 002246, 002353, 002636, 004649
page 185 Director System 80 Project Files Log 1968-1983.pdf	Seal Injection Heat Exchanger Gen. Spec.: Comments	12/76	N	
page 200 Director System 80 Project Files Log 1968-	Ion Exchangers Ion Exchangers Ion Exchangers-Tanks-	12/75 12/75 12/75	Pos.	Accession Number: D000204, D000204-1, D000210

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
1983.pdf	Procurement			
Specifications Fuels Dept Log_2.pdf	No citation evident.		N	
CE and WCAP Topical Reports				
CENPD-109 Volume 1.pdf	Combustion Engineering, Inc. Pressurized Water Reactor Research and Development Quarterly Progress Report	7/73	Y	400-page quarterly progress report. Provides status showing that CE investigators were continually achieving a DF 100 value, even when they tested with flows greater than 10,000 bed volumes. The summary observation states that there is no evidence of cesium 137 breakthrough. Stated conclusion: “Ion Exchanger Removal Efficiency for Cesium: Removal efficiencies in excess of 99% (DF 100) have been consistently measured.” This strongly supports that the DF value is well- supported and that it does not simply represent an optimistic beginning of life value.
CENPD-110.pdf	Nuclear Power Department Product Engineering & Development, Summary Progress Report, First Quarter, 1973 Task 204020: Improvement in Plant Systems	8/73	Y	“Tests were performed with a pre-holdup ion exchanger for the chemical and volume control system. To date, about 4700 bed volumes of liquid have been processed which is equivalent to one full operating life for a pre-holdup ion exchanger resin bed. Neither lithium nor cesium breakthrough have been obtained. The decontamination factors for cesium have been consistently in excess of 100, compared to the current AEC assumption of 2. The high decontamination factor will permit inexpensive outside holdup and storage tanks without shielding. Testing will proceed until breakthrough for lithium and cesium is achieved to determine a design safety margin. The continued testing, however, is carried out with reduced bed sizes due to the high pressure losses across the bed resin.”
CENPD-119	Combustion	10/73	Y	pp 215, 227, 228:

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
Volume 1_2.pdf	Engineering, Inc., Pressurized Water Reactor Research and Development Quarterly Progress Report			Equivalent to 7/73 quarterly progress report presented below.
CENPD-121.pdf	Nuclear Power Department Product Engineering & Development, Summary Progress Report, Third Quarter, 1973 Task 204020: Improvement in Plant Systems	12/73	Y	"Ion Exchanger Removal Efficiency for Cesium: Ion exchanger testing is being performed to demonstrate the C-E position that a Cesium decontamination factor (DF) of 100 can be justified for the Chemical and Volume Control System (CVCS) preholdup ion exchanger and that the conservative AEC assumption of a DF of only 2 is unwarranted. The preholdup ion exchanger is in a hydrogen borate form and is changed when lithium breakthrough is detected, which precludes any loss in Cesium removal efficiency (DF 100). By making this assumption, resulting effluent activity levels allow relatively inexpensive outside holdup and storage tanks without shielding. Testing of the preholdup ion exchanger resin for cesium removal has been completed. Removal efficiencies in excess of 99% (DE I00) have been consistently measured. The data shows that lithium breakthrough was attained after approximately 7100 bed volumes were processed. Following processing of approximately 10,400 bed volumes of fluid, the decontaminated factor for cesium started to fall below 100. Processing 10,400 bed volumes of fluid through the preholdup ion exchanger would be equivalent to processing approximately 100% of the waste generated for a load follow 3817 MWt plant with an

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
				SGR core (i.e., ~2.4 x 10^6 gals). A topical report will be prepared for submittal to the AEC during the next report period.”
CENPD-123.pdf	Nuclear Power Department Product Engineering & Development, Summary Progress Report, Fourth Quarter, 1973 Task 204020: Improvement in Plant Systems	2/74	Y	“Ion Exchange Removal Efficiency for Cesium: Testing of the preholdup ion exchanger resin for Cesium removal was completed earlier in the year, demonstrating a decontamination factor DF larger than 100. A test report has been completed and is being reviewed.”
Keywords_ CENPD-109 Volume 1_2.pdf	Combustion Engineering, Inc., Pressurized Water Reactor Research and Development Quarterly Progress Report, April 1 – June 30, 1973	~7/73	Y	“Ion Exchanger Removal Efficiency for Cesium: Ion exchanger testing is being performed to demonstrate the C-E position that a Cesium DF of 100 can be justified for the CVCS pre-holdup ion exchanger and that the conservative AEC assumption of a DF of only 2 is unwarranted. The pre-holdup ion exchanger is in a hydrogen borate form and is changed when lithium breakthrough is detected, which precludes any loss in Cesium removal efficiency (DF 100). By making this assumption, resulting effluent activity levels allow relatively inexpensive outside holdup and storage tanks without shielding. The current testing is a repeat of work reported in the last quarterly report. The same chemistry was followed, as was the same basic testing apparatus. Minor changes in the physical layout, of the hardware were made. The major differences between the previous test and the current test were a reduction in resin volume from 24 inches to 8 inches and a corresponding reduction in bed flow rate from 2.86 gallons per hour to .95 gallons per hour. These changes were

File Name	Title	Date (m/yy)	Key Doc[1]?	Notes and Description
				implemented to try to achieve Cs-137 breakthrough within a reasonable testing time. The test is run eight to twelve hours a day five to six days a week, and samples are taken approximately every four hours of running time at the onset of testing. Two ion exchange columns are used, both loaded with eight inches of mixed bed resin. A 3/1 cation/anion ratio was used, using Amberlite IRN-77 and Amberlite IRN-78. "After 106 hours of testing, number one column showed lithium breakthrough, which is attributed to channeling. Both columns at this time had seen 2430 bed volumes. As of this writing the columns have seen 10,000 bed volumes each. There is no evidence of cesium 137 breakthrough. Effluent samples counted for 5 minutes are still essentially the same as background. Samples are now being taken once a day. Column #1 was lifted and the resin disturbed on 5/21/73 due to an improper shutdown sequence which resulted in backflow. The test results from Column #1 may show premature cesium 137 breakthrough due to this accident. The data from this column will not be considered in that event. Radiation levels in the area were getting excessive and a 4" lead shield was erected. Levels are now acceptable. Breakthrough should occur somewhere near 12,000 bed volumes for number 2 column. Testing will continue until the point of breakthrough is achieved.

File Name	Title	Date (m/yy)	Key Doc [1]?	Notes and Description
				Conclusions: Ion Exchanger Removal Efficiency for Cesium: Removal efficiencies in excess of 99% (DF 100) have been consistently measured.”
WCAP-7963.pdf	WCAP-7963, “Iodine and Cesium Decontamination Factors and Capacities for an Ion Exchange Processing System for Steam Generator Blowdown,” by M.J. Bell and J.R. Balavage, GAE-297	1/73	N	Not directly related to preholdup demineralizer work or conclusions.

[1] Y: Yes, N: No, Pos.: Possible

Impact on DCD

DCD Tier 1, Section 2.4.6.1 and Tier 2, Section 12.2.1.1.5.1 will be revised as indicated in Attachment 1.

DCD Tier 2, Table 11.1-5 will be revised as indicated in Attachment 2.

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.

8.d All displays and alarms required by the design exist in the RSR as defined in Tables 2.4.6-2 and 2.4.6-3.

9.a The CVCS provides makeup capability to maintain the RCS volume.

9.b The CVCS supplies seal water to the RCP seals.

9.c The CVCS provides pressurizer auxiliary spray water for depressurization.

10. The high-energy piping systems, including the protective features are reconciled with pipe rupture hazards analyses report to ensure that the safety-related SSCs are protected against or are qualified to withstand the dynamic effects associated with postulate failures of these piping systems.

11. A pre-holdup ion exchanger is used to limit radionuclide inventories stored in the holdup tank. A 3-to-1 cation to anion ratio provides a minimum cesium DF of 100.

2.4.6.2 Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.6-4 specifies the ITAAC for the CVCS.

The ITAAC associated with the CVCS equipment, components, and piping that comprise a portion of the containment isolation system are described in Table 2.11.3-2.

b. Ion exchangers

The maximum values for CVCS ion exchanger (IX) radionuclide inventories are presented in Table 12.2-11.

1) Purification ion exchanger

The total radioactivity inventory is based on resin buildup for the duration of 120 percent of one cycle of effective full-power days (EFPDs). This ion exchanger is used for removing lithium and purifying coolant water from RCS letdown. It is used for lithium removal for the first part of one-cycle EFPDs, which spans an average of 20 percent, and then it is put into service as a purification ion exchanger. The decontamination factor (DF) for anions is 100 with an efficiency of 99 percent. The DF for crud is 50 with an efficiency of 98 percent. The DF for all remaining nuclides except Xe, Kr, Y, Rb, and Cs is 50 with an efficiency of 98 percent. The DF for Xe, Kr, and Y is 1 with an efficiency of 0 percent. The DF for Rb and Cs is 2 with an efficiency of 50 percent. The radioactivity inventory in processed liquid is based on a normal letdown flow rate.

2) Deborating ion exchanger

The total radioactivity inventory is based on resin buildup during the end-of-cycle (EOC) deborating operation. This ion exchanger is used to reduce reactor coolant boron concentration at the EOC. Boron control in the CVCS is described in detail in Subsection 9.3.4. The DF for nuclides except anions and crud is 1 with an efficiency of 0 percent. The DF for anions and cruds is 10 with an efficiency of 90 percent. The radioactivity inventory in processed liquid is based on a normal letdown flow rate.

3) Pre-holdup ion exchanger

The total radioactivity inventory is based on resin buildup for the duration of one-cycle EFPDs. The DF for all nuclides except Xe, Kr, Y, Rb, and Cs is 10 with an efficiency of 90 percent. The DF for Rb and Cs is 100 with an efficiency of 99 percent. The DF for Xe, Kr, and Y is 1 with an efficiency of 0 percent. Liquid inputs processed by the pre-holdup ion exchanger include the letdown processed through the purification ion exchanger and the purification filter, and the inflow from the reactor drain tank (RDT) and the equipment drain tank (EDT).

; a 3-to-1 cation to anion ratio provides a minimum DF of 100.

4) Boric acid condensate ion exchanger

The total radioactivity inventory is based on resin buildup for the duration of one-cycle EFPDs. The DF for anions is 10 with an efficiency of 90 percent. The DF for other nuclides including crud is 1 with an efficiency of 0 percent. The radioactivity inventory is based on input from the letdown processed through the purification ion exchanger and the purification filter, the inflow from the RDT and the EDT, and the inflow from the boric acid concentrator (BAC) in consideration of the average condensation rate.

c. Filters

The maximum values for CVCS filter radionuclide inventories are presented in Table 12.2-12.

The total radioactivity inventories in the CVCS filters are based on crud buildup for the duration of one-cycle EFPDs. The DF assumed for crud buildup in the filter is 10 with an efficiency of 90 percent.

d. Tanks

The maximum values for CVCS tank radionuclide inventories are presented in Table 12.2-13.

The total radioactivity inventories in the CVCS tanks are based on buildup for the duration of one-cycle EFPDs.

Table 11.1-5

Assumptions Used in Determining Secondary System Activities

1. Primary coolant activities are described in Subsection 11.1.1.1 for the design basis case and in Subsection 11.1.2.1 for the expected case.

2. Primary-to-secondary leak rates:

   Design basis 3,270 L/day (0.6 gal/min)

   Expected 34 kg/day (75 lb/day)

3. Flow rates in the secondary system (based on the two steam generators):

   Steam flow rate, kg/hr (lb/hr) 8.14×10^6 (1.80×10^7)

   Continuous blowdown rate, kg/hr (lb/hr) 1.63×10^5 (3.59×10^5)

   High-capacity blowdown rate (hot leg), kg/sec (lb/sec) 8.18×10^1 (1.80×10^2)

4. Liquid masses in the secondary system of two steam generators, kg (lb): 2.41×10^5 (5.32×10^5)

5. Steam generator internal partition coefficients (Reference 7):

   H-3 1.0
   I, B 0.01
   Others 0.005

   All noble gases are assumed to be in the steam.

6. Fractions of radionuclide in the main steam reaching the main condenser (Reference 7):

   I, Br 0.2
   Noble gases 1.0
   Others 0.1

7. Decontamination factors of the blowdown demineralizer and condensate polishing demineralizer (Reference 7):

Demineralizer	Decontamination Factor				
	Noble Gases	I, Br	Cs, Rb	H-3	Others
Blowdown 1)	1	100	~~100~~ 10	1	100
Condensate polishing	1	10	2	1	10

1) In determining radioactive source terms for the secondary system, only one S/G blowdown demineralizer is assumed to be operating during normal blowdown mode.