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.:	**15-7896**
SRP Section:	**12.02 – Radiation Sources**
Application Section:	**12.2**
Date of RAI Issued:	**05/22/2015**

Question No. 12.02-4

REGULATORY BASIS

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.

10 CFR 50, Appendix A, Criterion 61, requires that the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions, with suitable shielding for radiation protection, and with appropriate containment, confinement, and filtering systems.

SRP Section 12.2 also indicates that source descriptions should include the methods, models and assumptions used as the bases for all values provided in SAR Section 12.2. The source terms provided in FSAR Section 12.2 are the basis for the shielding design for those components, provided in FSAR Section 12.3

ISSUE

As indicated within FSAR Section 12.2, the decontamination factors for some waste treatment components are based on NUREG-0017, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors,” Rev. 1 (1985). However, the decontamination factors for some other components are not based on the values provided in NUREG-0017 and the basis for the decontamination factors assumed for those components is not provided in the FSAR.

For example, the CVCS pre-holdup ion exchanger is identified as a mixed-bed ion exchangers in FSAR Section 9.3.4.2.8.4. While NUREG-0017, Table 1-4 “Decontamination Factors for PWR Liquid Waste Treatment Systems,” provides CVCS mixed bed ion exchanger decontamination factors of 100 for anions, 2 for Cesium (Cs) and Rubidium (Rb), and 50 for other nuclides, FSAR Section 12.2 indicates that the CVCS pre-holdup ion exchanger has a decontamination factor of 100 for Cs and Rb and a decontamination factor of 1 for Yttrium (Y).

Another example is in FSAR Table 11.1-5 (the assumptions in Table 11.1-5 are used in the Chapter 12 source term analysis), which uses a decontamination factor of 100 for Cs and Rb when NUREG-0017, Table 1-4 uses a value of 10.

The decontamination factors provided in NUREG-0017 represent the expected equipment performance averaged over the life of the plant, based on the time NUREG-0017 was developed. In general, the staff accepts the use of the decontamination factors provided in NUREG-0017 for developing radiation source terms. However, if the actual design of the systems and components in the plant would be expected to result in different decontamination factors than what is provided in NUREG-0017 then the more realistic values should be used in the calculation of radiation source terms in FSAR Section 12.2. For those components which use different decontamination factors than those provided in FSAR Section 12.2, the basis for the values chosen should be provided in the FSAR.

QUESTION

Staff does not intend to list all areas where inconsistencies exist within this question. Therefore, please review the source term information provided in FSAR Section 12.2 and update the FSAR to provide a basis for the use of all decontamination factors which are different than the decontamination factors provided in NUREG-0017.

Response

Decontamination factors used in CVCS are presented in Table 1. Though the decontamination factor (DF) of 2 for Cs and Rb is provided in NUREG-0017 for CVCS mixed bed ion exchanger, the DF of 100 for Cs and Rb is applied to CVCS pre-holdup ion exchanger. The use of DF 100 increases the removal efficiency (η=1-1/DF), thereby increasing the activity of Cs and Rb in the pre-holdup ion exchanger.

DF of Yttrium is assumed to 1 for all equipment of CVCS for conservatism and simplification. According to WASH-1258, Page A-10, DF of Cation for demineralizer does not include Yttrium. WASH-1258, page A-10 is provided as Attachment 1 of this response.

Table 1. Decontamination Factors Used in CVCS

Equipment	I, Br	Noble Gas	N-16	Cation	Anion	Cs, Rb	Crud	Mo, Tc	Y, H-3
Purification Ion Exchanger (IX)	100	1	1	50	100	2	50	50	1
Purification IX (Lithium Removal)	10	1	1	10	10	10	10	10	1
Deborating IX	10	1	1	1	10	1	10	1	1
Pre-holdup IX	10	1	1	10	10	100	10	10	1
Boric Acid Condensate IX	10	1	1	1	10	1	1	1	1
Gas Stripper	1	1000	1	1	1	1	1	1	1
CVCS Filter (upstream)	1	1	1	1	1	1	1	1	1
CVCS Filter (shielding)	1	1	1	1	1	1	10	1	1

Decontamination factors used for SGBDS, LWMS and CPS systems are presented in Table 2. These factors are consistent with the values provided in NUREG-0017. The SGBDS decontamination factor of 100 for Cs, Rb provided in Table 11.1-5 is a typographic error. In the SGBDS source term calculation, a decontamination factor 10 was used. This value will be corrected as indicated in the Attachment 2.

Table 2. Decontamination Factors Used for APR1400

Equipment		Anion	Cs, Rb	Cations
SGBDS		100	10	100
LWMS	RO Module	10	10	10
	Cation Bed	1	10	10
	Mixed bed 1	100	2	100
	Mixed bed 2	10	10	10
CPS		10	2	10

Impact on DCD

DCD Table 11.1-5 will be revised as indicated in the 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 Environmental Reports.

FINAL ENVIRONMENTAL STATEMENT CONCERNING

PROPOSED RULE MAKING ACTION:

ATOMIC ENERGY COMMISSION ★ UNITED STATES OF AMERICA ★

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 NUCLEAR
POWER REACTOR EFFLUENTS

VOLUME 2

ANALYTICAL MODELS AND CALCULATIONS

JULY 1973

	Partition Factor (PF)
Steam Generator, Internal Partition	
BWR – Reactor Vessel	0.01
PWR – Recirculating U-tube	0.01
PWR – Once-Through	1.0
Steam Generator Blowdown Vent (PWR)	0.05

Internal Cleanup System (Kidney) in PWR Containment Building. (Assume the internal recirculation system is operated for 16 hours prior to purging at a decontamination factor of 10 for iodine and a mixing efficiency of 70%).

10. Decontamination Factors for Demineralizers

Note: For two demineralizers in series, the DF for second demineralizer is given in parenthesis.

	Cation[a]	Anion	Cs, Rb
Mixed Bed (H^+ OH^-)			
Reactor Coolant	10	10	10
Condensate	10^3	10^3	10
Clean Waste	10^2(10)	10^2(10)	10(10)
Dirty Waste (Floor Drains)	10^2(10)	10^2(10)	1(10)
PWR Radwaste	10^2(10)	10^2(10)	2(10)
Mixed Bed ($LiBO_3$)	10	10	2
Cation Bed (H^+)	10^2(10)	1(1)	10(10)
Anion Bed (OH^-)	1(1)	10^2(10)	1(1)
Powdex (any system)	10(10)	10(10)	1(10)

[a]Does not include Cs, Mo, Y, Rb, Tc.

11. Removal
Nuclide
Mo and
Y
12. Decont
Miscel
Boric
Separa
Wast
13. Holdu
T = 0
Dynam
Opera
Dew I
Kr
Xe

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	100	~~100~~ 10	1	100
Condensate polishing	1	10	2	1	10

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Question No. 12.02-5

BASIS

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.

10 CFR 50, Appendix A, Criterion 61, requires that the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions, with suitable shielding for radiation protection, and with appropriate containment, confinement, and filtering systems.

SRP Section 12.2 indicates that sources should be based 0.25 percent fuel cladding defect and that the source term used for determining shielding and ventilation design of PWR components provided for purification of secondary coolant, should consider isotopic concentrations associated with operation at the technical specification allowed limits for primary-to-secondary leakage and/or the secondary coolant specific activity concentrations. Finally, SRP Section 12.2 indicates that source descriptions should include the methods, models and assumptions used as the bases for all values provided in SAR Section 12.2, and that the staff will review the descriptions of the sources. The source terms provided in FSAR Section 12.2 are the basis for the shielding design for those components, which is provided in FSAR Section 12.3.

As a result of the above regulations and guidance documents, staff has the following questions related to secondary side sources.

ISSUES AND QUESTIONS

1. FSAR Section 12.2.1.1.5.2 indicates that the blowdown rate for calculating the steam generator blowdown system source terms is assumed to be 0.2 percent of the maximum steaming rate. However, a review of FSAR Section 10.4.8.2.3 indicates that during startup the blowdown rate may be as high as 1 percent of the steam generators maximum steaming rate until the water quality is within the normal limits. It also indicates that the normal operation blowdown rate is 0.2 percent, but is 1 percent during abnormal blowdown. Please justify the use of 0.2 percent of the maximum steaming rate for calculating steam generator blowdown sources instead of 1 percent.

2. For the condensate polishing system, FSAR Section 12.2.1.1.5.3 indicates that, “It is assumed that 65 percent of the condensate flows through the CPS and that one out of six CPS demineralizers is used to process the condensate during normal operation.” However, FSAR Section 10.4.6.2.1 indicates that there are seven pairs of cation-bed ion exchanger vessels and mixed-bed ion exchanger vessels in the condensate polishing system (CPS) and that the CPS processes approximately 16 to 100 percent of the condensate flow during normal plant operation.

   a. Please provide the number of cation-bed and mixed-bed ion exchangers in the CPS system and ensure that the FSAR is updated so that FSAR Sections 10.4.6 and 12.2.1.1.5.3 are consistent regarding how many cation-bed and mixed-bed ion exchangers exist in the CPS system. In addition, please ensure that the FSAR is clear when it is discussing pairs of demineralizers versus single individual demineralizers.

   b. Please indicate if during normal operation condensate is expected to flow through only one pair of demineralizers at a time or if multiple pairs of demineralizers will be used at the same time.

   c. Please justify why 65 percent of the condensate was assumed to flow through a demineralizer when FSAR Section 10.4.6.2.1 indicates that the CPS can process as much as 100 percent of the condensate flow during normal plant operations.

<u>Response</u>

1. Radiation sources in the steam generator blowdown system presented in Table 12.2-18 were calculated by assuming a conservative continuous blowdown of 1 percent of the SG’s maximum steaming rate. The value of 0.2 percent in DCD Subsection 12.2.1.1.5.2 is a typographic error. This will be revised to correct the value as used in the source term calculations. Refer to Attachment for the DCD markups.

2.

   a. For the operation of CPS, the following is described in DCD Subsections 10.4.6.2.1 through 10.4.6.2.3:

      - The CPS consists of seven pairs of cation-bed ion exchanger vessels (CBVs) and mixed-bed ion exchanger vessels (MBVs). (Subsection 10.4.6.2.1)

- During the normal plant operation, the CPS has the capability to polish 100 percent of condensate through six CBVs and MBVs. (Subsection 10.4.6.2.2)
- One CBV - MBV pair processes 16-2/3 percent of the condensate flow. (Subsection 10.4.6.2.3)

As addressed above, the CPS is designed to have the capability to polish 100 percent of condensate by six out of seven pairs of CBVs and MBVs, where the seventh pair is isolated for standby service during normal operation. For clarity, the corresponding description in DCD Subsection 12.2.1.1.5.3 will be revised as indicated in the Attachment.

b. As illustrated in Figure 1 below, the CPS processes 16-2/3 to 100 percent of the condensate during normal plant operation depending on the three operating modes: 1) full flow mode, 2) partial flow mode, and 3) bypass mode. When the system is in operation in the full flow mode, 100 percent of condensate flows through six pairs of CBVs and MBVs. During partial flow operation, 16-2/3 to 83-1/3 percent of condensate flows through one to five pairs of CBVs and MBVs. On the other hand, during bypass mode where the condensate purification is not required, no condensate flow passes through the CPS.

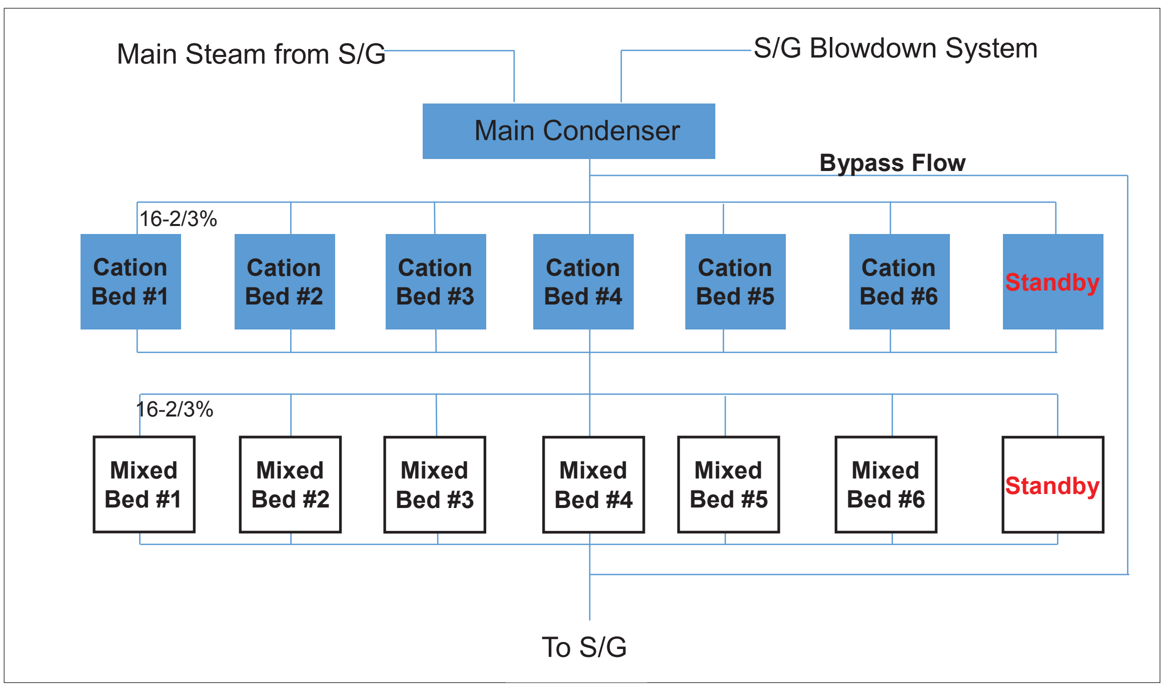

Figure 1. Flow Diagram of Condensate Polishing System

c. During normal operation, the condensate in the condenser contains 65 percent of the total main steam flow rate, and the blowdown flow rate from SGBDS. This flow is processed through one to six pairs of CPS demineralizers depending on the operating modes. DCD Subsection 12.1.1.1.5.3 states that 65 percent of the condensate is

processed through the CPS. This is not accurate and should say 65 percent of main steam flow is processed through the CPS. Therefore, this subsection will be revised to be consistent with Subsection 10.4.6.2 as indicated in the Attachment.

Impact on DCD

DCD Sections 12.2.1.1.5.2 and 12.2.1.1.5.3 will be revised as indicated in the 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 Reports.

e. Boric acid concentrator

The maximum values for BAC radionuclide inventories are presented in Table 12.2-14.

The total radioactivity inventories in the BAC package are based on a concentration factor of 100.

12.2.1.1.5.2 Steam Generator Blowdown System

Radiation sources in the steam generator blowdown system (SGBDS) are shown in Table 12.2-18. The sources are based on the assumed design basis primary-to-secondary (PTS) leakage rate and the assumed fuel defect percentage described in Subsection 12.2.1.1.3. The blowdown rate is assumed to be 0.2 percent of the maximum steaming rate.

1

12.2.1.1.5.3 Condensate Polishing System

total steam flow rate and the SGBDS blowdown flow

polishing system (CPS) are shown in Table 12.2-18. The sources are based on the design basis PTS leakage and the assumed fuel defect percentage described in Subsection 12.2.1.1.3. It is assumed that 65 percent of the condensate flows through the CPS and that one out of six CPS demineralizers is used to process the condensate during normal operation.

12.2.1.1.6 Gamma Sources of Irradiated Components

The components in the reactor vessel are irradiated by the fission neutrons during the core power operation and are activated. The in-core instrument (ICI) assembly, which consists of five rhodium detectors, one background detector, one core-exit thermocouple, and a central member assembly, is enclosed in a protective sheath. Activated gamma sources of the irradiated ICI assembly are estimated assuming 6 years of irradiation. The activated gamma sources of the irradiated control element assembly (CEA) and the irradiated neutron source assembly (NSA) are estimated assuming 10 years of irradiation. In CEA, the neutron absorbing material is B_4C and the cladding material is Inconel 625. The NSA contains the primary neutron source of Cf^{252} and the secondary neutron source of Sb-Be. The activated gamma source of the irradiated surveillance capsule assembly (SCA) is

one pair (16-2/3 percent of the condensate flow) out of total seven pairs of CPS demineralizers, of which one pair of demineralizers is in standby service,