MEB-CQ-201505 10.3.5 Responses

Issue #1

The applicant has provided extensive detail about their water chemistry program. However, a combined license (COL) applicant will need to submit which revision of the EPRI PWR Secondary Water Chemistry Guidelines (EPRI Guidelines) it will use for the details not provided in the certified design.

Please revise APR1400 FSAR Section 10.3.5 to state that the COL applicant, for the details not provided in the certified design, will use the latest EPRI Guidelines revision at the time of COL submittal as the basis for their water chemistry program.

Response

KHNP will revise Section 10.3.5 to add COL 10.3(4) for the COL applicant to use the latest EPRI Guidelines revision at the time of COL submittal as the basis for their water chemistry program. Refer to the markup supplied as Attachment 1.

Issue #2

On page 10.3-30, the applicant includes in its reference list for Section 10.3 a reference for the EPRI PWR Secondary Water Chemistry Guidelines. However that reference identifies two revisions, when it seems that the information provided in the DCD comes from Revision 7.

Revise the reference in APR1400 FSAR Section 10.3 to cite only the applicable revision of EPRI PWR Secondary Water Chemistry Guidelines.

Response

KHNP will delete the reference in the DCD as shown in the supplied Attachment 2.

Issue #3

The applicant does not mention when the COL applicant must have the water chemistry program operational. Generally, the COL licensee will have its water chemistry program operational six months before fuel load.

Revise APR1400 FSAR Section 10.3.5 to include a COL Information Item requiring the COL applicant to state when its water chemistry program will be in operational.

Response

KHNP will include in COL 10.3 (4) for the COL applicant to establish the operational water chemistry program six months before fuel load as shown in Attachment 3.

Table 1.8-2 (16 of 29)

Item No.	Description
COL 9.5(7)	The COL applicant is to provide the fire brigade radio systems.
COL 9.5(8)	The COL applicant is to provide the LAN and VPN system.
COL 9.5(9)	The COL applicant is to provide the emergency offsite communication system including dedication hotline, local law enforcement radio equipment, and wireless communication system.
COL 9.5(10)	The COL applicant is to specify that adequate and acceptable sources of fuel oil are available, including the means of transporting and recharging the fuel storage tank, following a design basis accident.
COL 9.5(11)	The COL applicant is to provide a description of the offsite communication system that interfaces with the onsite communication system, including type of connectivity, radio frequency, normal and backup power supplies, and plant security system interface.
COL 9.5(12)	The COL applicant is to provide the security radio system that consists of a base unit, mobile units, and portable units.
COL 9.5(13)	The COL applicant is to provide the local law enforcement communications including dedicated conventional telephone and radio-transmitted two-way communication system.
COL 9.5(14)	The COL applicant is to provide electric power for the security lighting system.
COL 9.5(15)	The COL applicant is to provide the system design information of AAC GTG building HVAC system including flow diagram, if the AAC GTG building requires the HVAC system.
COL 10.2(1)	The COL applicant is to identify the turbine vendor and model.
COL 10.2(2)	The COL applicant is to identify how the functional requirements for the overspeed protection system are met and provide a schematic of the TGCS and protection systems from sensors through valve actuators.
COL 10.2(3)	The COL applicant is to provide a description of how the turbine missile probability analysis conforms with Subsection 10.2.3.6 to ensure that requirements for protection against turbine missiles (e.g., applicable material properties, method of calculating the fracture toughness properties per SRP Section 10.2.3 Acceptance Criteria, preservice inspections) will be met.
COL 10.3(1)	The COL applicant is to provide operating and maintenance procedures including adequate precautions to prevent water (steam) hammer and relief valve discharge loads and water entrainment effects in accordance with NUREG–0927 and a milestone schedule for implementation of the procedure.
COL 10.3(2)	The COL applicant is to establish operational procedures and maintenance programs as related to leak detection and contamination control.
COL 10.3(3)	The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202L-R3 and provide a milestone schedule for implementation of the program.
COL 10.3(4)	The COL applicant is to provide secondary side water chemistry threshold values and recommended operator actions for chemistry excursions in compliance with the latest version of the EPRI PWR Secondary Water Chemistry Guidelines in effect at the time of COLA submittal. The COL applicant is to establish the operational water chemistry program six months before fuel load.

Layup exists whenever the SGs are at a temperature of less than 99 °C (210 °F). The primary objective during any layup of the SG is to minimize corrosion by excluding and providing protection against oxygen, and maintaining a proper pH. In order to achieve this objective, the operator should prepare for layup as the plant is cooling down. The most effective means of excluding oxygen is to maintain an overpressure of steam or nitrogen in the SG. In order to provide reasonable assurance that oxygen is excluded, 0.35 kg/cm^{2}G (5 psig) is specified as the minimum SG pressure during normal layup. In addition, a positive nitrogen overpressure should be maintained during filling and draining operations to minimize oxygen ingress.

Sampling can be accomplished after pumping the contents from one SG to the other and back three times, assuming recirculation is available. The pumping operation should lower the water level in one SG from the can deck level to the low water level and raise the level in the other SG a corresponding amount. Adding chemicals, or reducing contaminant

operation.

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The COL applicant will provide secondary side water chemistry threshold values and recommended operator actions for chemistry excursions in compliance with the latest version of the EPRI PWR Secondary Water Chemistry Guidelines in effect at the time of COLA submittal. The COL applicant will establish the operational water chemistry program six months before fuel load. (COL 10.3(4))

The operating chemistry conditions for secondary side SG water, feedwater, and condensate are given in Tables 10.3.5-1, 10.3.5-2, and 10.3.5-3, respectively. Tables 10.3.5-4 and 10.3.5-5 show the recommended secondary sampling and laboratory analysis frequencies during normal operation and startup / wet layup, respectively.

Deleted

The chemistry limits are divided into four groups: normal, Action Level 1, Action Level 2, and Action Level 3. The limits provide high-quality chemistry control and permit operating flexibility. The normal chemistry conditions can be maintained by any plant operation with little or no condenser leakage. The normal values are based on what is routinely achievable and will minimize the corrosion environments to achieve system reliability for the life of the plant.

Monitored parameters that are confirmed to be outside the normal operating values are assigned one of the three action levels, which indicate the need for remedial corrective action. The actions increase in severity from Action Level 1 through Action Level 3.

Action levels and the associated chemistry limits are considered the minimum requirements for protection against secondary system and SG corrosion. Operating below Action Level 1 values permits achievement of a design lifetime while avoiding corrosive conditions. Action Level 2 is instituted for conditions that have been shown to result in SG corrosion during extended full power (100 percent) operation. Action Level 3 is implemented for conditions exist that result in rapid SG corrosion, and continued operation is not advisable.

Action Level 1

Deleted

Objective: To promptly identify and correct the cause of an out-of-normal value without power reduction.

Actions:

a. Corrective actions are implemented as soon as possible to return a parameter from the Action Level 1 condition.

b. If a parameter remains in the Action Level 1 condition for more than 21 days following confirmation of excursion, the parameters with Action Level 2 values go to Action Level 2. If the Action Level 1 condition was entered as a result of increasing power above 30 percent power while sodium, chloride, or sulfate was above the Action Level 1 value and remained above that value for more than 24 hours after increasing above 30 percent power, parameters are restored to normal values within 20 days. The lack of progressive action criteria for many parameters is not intended to imply that remaining outside the normal range is satisfactory. In these cases, other chemical parameters, specifically associated with known corrosion conditions, are utilized for control.

c. For the parameters that do not have an Action Level 2 value, an engineering justification is developed for operating above Action Level 1 for an extended period.

Action Level 2

Objective: To minimize corrosion by operating at reduced power while corrective actions are taken.

Actions: Deleted

a. Take immediate actions to reduce power to a plant-specific level at 30 percent power and achieve that power level within 24 hours of entering Action Level 2, or as quickly as safe plant operation permits. The power level is governed by safe, automatic plant operational concerns and the need to reduce the heat flux (i.e., impurity concentration rate). Power de-escalation can be terminated when the parameter value is no longer in the Action Level 2 condition. Escalation to full power can be resumed once the parameter is no longer in the Action Level 1 condition.

b. If the parameter remains in the Action Level 1 or Action Level 2 condition for more than 300 hours after entering the Action Level 2 condition, go to Action Level 3 for those parameters having Action Level 3 values. If Action Level 2 is entered as a result of being in Action Level 1 for more than the allotted time, and the parameter value has not entered the Action Level 2 condition, operation at 30 percent power may continue. Escalation to full power can be resumed once the parameter is no longer in the Action Level 1 condition.

c. After an Action Level 2 excursion, excluding dissolved oxygen, consideration should be given to further reductions in power, and low power or hot soak to promote removal of specific contaminant from the SG.

Action Level 3

Objective: To correct a condition that is expected to result in rapid SG corrosion during continued operation. Plant shutdown minimizes impurity ingress and eliminates further concentration of harmful impurities. Plant shutdown also reduces further damage to the SG by allowing cleanup of the impurities as a result of hideout return.

Actions:

Deleted

a. Regardless of the duration of the excursion into Action Level 3, the plant is taken to less than 5 percent power as quickly as safe plant operation permits. Cleanup by feed and bleed or drain and refill as appropriate until normal values are reached. The judgment on maintaining the SG in a hot condition or progressing to cold shutdown should be based on the corrosion concern imposed by the specific impurity and the most rapid means to effect cleanup.

10.3.5.2 Corrosion Control Effectiveness

Alkaline conditions in the feed train and the SG reduce general corrosion at elevated temperatures and tend to decrease the release of soluble corrosion products from metal surfaces. These conditions promote the formation of a protective metal oxide film and reduce the corrosion products released into the SG.

Hydrazine also promotes the formation of a metal oxide film by reducing ferric oxide to magnetite. Ferric oxide can be loosened from the metal surfaces and transported by the feedwater. Magnetite provides an adherent protective layer on carbon steel surfaces.

The removal of dissolved oxygen from secondary water is also essential in reducing corrosion. Oxygen dissolved in water causes general corrosion that can result in pitting of ferrous metals, particularly carbon steel. Dissolved oxygen is removed from the steam cycle condensate in the main condenser deaerating section and by the full-flow feedwater deaerator, which is located between the low-pressure and high-pressure feedwater trains. Additional oxygen protection is obtained by chemical injection of hydrazine into the condensate stream. Maintaining a residual level of hydrazine in the feedwater provides reasonable assurance that any dissolved oxygen that is not removed by the condensate system is scavenged before it can enter the SG.

The presence of free hydroxide (OH^-) can cause rapid corrosion if it is allowed to concentrate in a local area. Free hydroxide is avoided by maintaining proper pH control and by minimizing impurity ingress in the SG.

For the safety/non-safety carbon steel piping with relatively mild FAC degradation, the FAC monitoring program is prepared and implemented using knowledge acquired from experience in pipe wall thinning management of the operating nuclear power plants in Korea. The FAC monitoring program includes preservice thickness measurements of as-built piping considered susceptible to FAC and erosion/corrosion. By performing this preservice measurement, the piping thickness margin that is used as a wall thinning margin is known. By combining the measurement with regular inspections, the frequency of the pipe replacement can be predicted. Reasonable assurance of the integrity and safety of plants is provided by conducting inspection and maintenance during the service life of the plant and replacing piping if necessary. The type of fluid, flow rates, fluid temperatures, and pressure of ASME Class 2 and 3 piping for steam and feedwater system are given in Table 10.3.2-5.

The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202L-R3 and provide a milestone schedule for implementation of the program (COL 10.3(3)).

10.3.7 Combined License Information

COL 10.3(4)
The COL applicant is to provide secondary side water chemistry threshold values and recommended operator actions for chemistry excursions in compliance with the latest version of the EPRI PWR Secondary Water Chemistry Guidelines in effect at the time of COLA submittal.

COL 1 … procedure.

COL 10.3(2) The COL applicant is to establish operational procedures and maintenance programs as related to leak detection and contamination control.

COL 10.3(3) The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202L-R3 and provide a milestone schedule for implementation of the program.

Table 10.3.5-1 (Deleted)

Operating Chemistry Conditions for Secondary Steam Generator Water (1)

Variable	Wet Layup	Plant Startup (2)	Power Operation (4)			
			Normal (3) Specifications	Action Level		
				1	2	3
pH at 25 °C (77 °F)	≥ 9.8	-	-	-	-	-
Cation conductivity, µS/cm at 25 °C (77 °F)	-	≤ 2.0	≤ 1.0	-	> 1.0	> 4.0
Chloride, ppb	≤ 1,000	≤ 100	≤ 10	> 10	> 50	> 250
Sodium, ppb	≤ 1,000	≤ 100	≤ 5	> 5	> 50	> 250
Sulfate, ppb	≤ 1,000	≤ 100	≤ 10	> 10	> 50	> 250
Hydrazine, ppm	≥ 75	-	-	-	-	-
Dissolved oxygen, ppb	≤ 100 (5)	-	-	-	-	-

(1) The parameters and values are subject to change based on technical evaluation as water chemistry technology is developed.

(2) Plant startup values apply when the RCS temperature is greater than or equal to 99 °C (210 °F). The values are to be met prior to exceeding 5 percent reactor power.

(3) Normal specifications are those that are to be maintained by continuous SG blowdown during proper operation of secondary systems.

(4) This applies to greater than or equal to 30 percent reactor power.

(5) The oxygen value applies to SG fill source.

Table 10.3.5-2 (Deleted)

Operating Chemistry Conditions for Feedwater [(1)]

Variable	Plant Startup [(2)]	Power Operation [(4)]		
		Normal [(3)]	Action Level 1	Action Level 2
Conductivity (intensified cation), [(5)] µS/cm	-	≤ 0.2	-	-
Hydrazine, ppb	≥ 8 × CPD [(6)] O_2 and ≥ 20	≥ 8 × CPD [(6)] O_2 and ≥ 20	< 8 × CPD [(6)] O_2 or < 20	[(7)]
Dissolved oxygen, ppb	≤ 100 [(8)]	≤ 5	> 5	> 10 [(9)]
Iron, ppb	-	≤ 5	> 5	-
Suspended solids, ppb	< 10 [(10)]	-	-	-
Sodium, ppb	-	≤ 3	-	-

(1) The parameters and values are subject to change based on technical evaluation as water chemistry technology is developed.

(2) Plant startup values apply when the RCS temperature is greater than 99 °C (210 °F), but reactor power is less than or equal to 5 percent.

(3) Normal specifications are those that are to be maintained during proper operation of secondary system.

(4) This applies to greater than or equal to 30 percent thermal power.

(5) Conductivity is a diagnostic parameter. This value is set as a means of addressing steam purity concerns. Lower values are needed to meet blowdown limitations in Table 10.3.5-1. Cation conductivity values less than or equal to 0.2 µS/cm are generally required to meet SG water quality.

(6) CPD = condensate polisher discharge.

(7) If the ratio of feedwater hydrazine to feedwater oxygen decreases to a value less than 2 and is not restored to a value greater than or equal to 2 within 8 hours, commence shutdown as quickly as safe plant operation permits.

(8) It may not be possible to control dissolved oxygen at this value before turbine steam seals can be established. However, this value is to be met prior to reaching 30 percent power.

(9) Reduction to 30 percent power may not be a proper response to this Action Level 2 situation because of decreased steam seal integrity.

(10) During operational hot and cold shutdowns, the normal value of suspended solids is less than or equal to 100 ppb. The suspended solids concentration for the hot standby to less than 30 percent power is less than or equal to 10 ppb.

Table 10.3.5-3 (Deleted)

Operating Chemistry Conditions for Condensate

Variable	Normal [1]	Action Level
		1
Dissolved oxygen, ppb	≤ 10	> 10

(1) Normal specifications are those that are to be maintained during proper operation of secondary systems at greater than 5 percent power.

Table 10.3.5-4 (Deleted)

Secondary Sampling / Laboratory Analysis Frequencies During Normal Power Operation

Item	Sampling Frequency(1)		
	Steam Generator Secondary Water	Feedwater	Condensate
Cation conductivity	C	-	-
Specific conductivity	-	-	-
pH	C	C	C
Dissolved oxygen	-	C	C
Sodium	C	-	-
Hydrazine	-	C(2)	-
Chloride	D	-	-
Sulfate	D	-	-
Silica	-	-	-
Iron	-	W(3)	-
pH agent	-	D	-

(1) Frequencies:
C = Continuous
D = Daily
W = Weekly
Frequencies are to be increased if abnormal conditions are detected.

(2) Hydrazine analysis during normal operation is to be performed downstream of the normal chemical addition point.

(3) Analysis should be performed for the sample passed through filter and cation resin membrane.

Table 10.3.5-5 (Deleted)

Secondary Sampling / Laboratory Analysis Frequencies
During Plant Startup and Wet Layup

Item	Sampling Frequency (1)		
	Steam Generator Water		Feedwater
	Plant Startup	Wet Layup	Plant Startup
Cation conductivity	C	-	-
pH	C	(2)	D
Dissolved oxygen	-	(2)	D
Sodium	C	(2)	-
Hydrazine	D (3)	(2)	D (3)
Chloride	D	(2)	-
Sulfate	D	(2)	-
Suspended solids	-	-	D (4)

(1) Frequencies:
C = Continuous
D = Daily
Frequencies are to be increased if abnormal conditions are detected.
(2) Analyze every other day until stable, then weekly.
(3) Hydrazine feed rate may be verified during startup if actual sampling is not possible.
(4) More frequently during transient operation.

term plant and component integrity. The secondary water chemistry program is based on the Electric Power Research Institute (EPRI) Pressurized Water Reactor (PWR) Secondary Water Chemistry Guidelines ~~in Reference 10~~.

10.3.5.1 Chemistry Control Basis

SG secondary side water chemistry control is accomplished by the following:

a. Close control of the feedwater to limit the amount of impurities that can be introduced into the SG

b. Continuous blowdown of the SG to reduce the concentrating effects of the SG

c. Chemical addition to establish and maintain an environment that minimizes system corrosion

d. Preoperational cleaning of the feedwater system

e. Minimizing feedwater oxygen content prior to entry into the SG

Secondary water chemistry is based on the zero-solids treatment method. This method employs the AVT method to maintain system pH and to scavenge dissolved oxygen that may be present in the feedwater. A neutralizing amine is added to establish and maintain alkaline conditions in the feed train. Neutralizing amines that can be used for pH control are ammonia or ethanolamine.

Hydrazine is added to scavenge dissolved oxygen that is present in the feedwater. Hydrazine also tends to promote the formation of a protective oxide layer on metal surfaces by keeping these layers in a reduced chemical state.

Both the pH agent and hydrazine are injected continuously downstream of the condensate pumps or condensate demineralizers. These chemicals are added for chemistry control and can also be added to the upper SG feed line.

10.3.8 References

1. Regulatory Guide 1.155, "Station Blackout," U.S. Nuclear Regulatory Commission, August 1988.

2. 10 CFR 50.63, "Loss of All Alternating Current Power," U.S. Nuclear Regulatory Commission.

3. Regulatory Guide 1.115, "Protection Against Turbine Missiles," Rev. 2, U.S. Nuclear Regulatory Commission, January 2012.

4. Regulatory Guide 1.117, "Tornado Design Classification," Rev. 1, U.S. Nuclear Regulatory Commission, April 1978.

5. Regulatory Guide 1.29, "Seismic Design Classification," Rev. 4, U.S. Nuclear Regulatory Commission, March 2007.

6. ANSI/ASME B31.1, "Power Piping," The American Society of Mechanical Engineers, 2010.

7. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

8. 10 CFR 50.55a(f), "Inservice testing requirements," U.S. Nuclear Regulatory Commission.

9. Regulatory Guide 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-cycle Planning," U.S. Nuclear Regulatory Commission, June 2008.

10. ~~EPRI PWR Secondary Water Chemistry Guidelines: Rev. 6, EPRI 1008224, December 2004 and Rev. 7, EPRI 1016555, February 2009.~~ (Deleted)

11. ASME Boiler and Pressure Vessel Code, Section II, "Materials," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

12. Regulatory Guide 1.84, "Design and Fabrication Code Case Acceptability ASME Section III Division 1," Rev. 35, U.S. Nuclear Regulatory Commission, October 2010.

Layup exists whenever the SGs are at a temperature of less than 99 °C (210 °F). The primary objective during any layup of the SG is to minimize corrosion by excluding and providing protection against oxygen, and maintaining a proper pH. In order to achieve this objective, the operator should prepare for layup as the plant is cooling down. The most effective means of excluding oxygen is to maintain an overpressure of steam or nitrogen in the SG. In order to provide reasonable assurance that oxygen is excluded, 0.35 kg/cm^{2}G (5 psig) is specified as the minimum SG pressure during normal layup. In addition, a positive nitrogen overpressure should be maintained during filling and draining operations to minimize oxygen ingress.

Sampling can be accomplished after pumping the contents from one SG to the other and back three times, assuming recirculation is available. The pumping operation should lower the water level in one SG from the can deck level to the low water level and raise the level in contamina operation. Should th recirculati assurance that a representative sample is taken. Mixing should also be accomplished by sparging with nitrogen via the blowdown pipes.

The COL applicant will provide secondary side water chemistry threshold values and recommended operator actions for chemistry excursions in compliance with the latest version of the EPRI PWR Secondary Water Chemistry Guidelines in effect at the time of COLA submittal. The COL applicant will establish the operational water chemistry program six months before fuel load. (COL 10.3(4))

~~The operating chemistry conditions for secondary side SG water, feedwater, and condensate are given in Tables 10.3.5-1, 10.3.5-2, and 10.3.5-3, respectively. Tables 10.3.5-4 and 10.3.5-5 show the recommended secondary sampling and laboratory analysis frequencies during normal operation and startup / wet layup, respectively.~~

~~The chemistry limits are divided into four groups: normal, Action Level 1, Action Level 2, and Action Level 3. The limits provide high-quality chemistry control and permit operating flexibility. The normal chemistry conditions can be maintained by any plant operation with little or no condenser leakage. The normal values are based on what is routinely achievable and will minimize the corrosion environments to achieve system reliability for the life of the plant.~~

~~Monitored parameters that are confirmed to be outside the normal operating values are assigned one of the three action levels, which indicate the need for remedial corrective action. The actions increase in severity from Action Level 1 through Action Level 3.~~