REVISED 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.:	**496-8630**
SRP Section:	**06.03 – Emergency Core Cooling System**
Application Section:	**6.3**
Date of RAI Issue:	**06/17/2016**

Question No. 06.03-10

As required by 10 CFR 50.36(c)(3), the design must have surveillance requirements to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met.

As mentioned in RAI 158-7997, Question 06.03-7, the applicant stated “boron recycling operations are not used for the APR1400.” However, the staff noted that in DCD Tier 2, Section 9.3.4, the CVCS provides for the capability of recycling boron. The staff determined that it is unclear whether the APR1400 uses boron recycling for water contained in the SIS (IRWST and SITs). As documented in RAI 158-7997, Question 06.03-7, the staff determined the need for a technical specification and associated surveillance requirement if boron recycling is to be used in the APR1400. If boron recycling is not to be used in the APR1400, the DCD should clearly reflect that since there is currently no technical specification and surveillance requirement that verifies the boron-10 atom percent of the SIS water when that water is recycled.

The staff needs the applicant to update DCD Tier 2, Section 6.3 and Section 9.3.4 to clearly specify whether or not boron recycling will be used for SIS water (IRWST and SITs) in the APR1400. If boron recycling is to be used, the applicant shall provide a discussion in the DCD about how the current proposed technical specifications and surveillance requirements ensure a minimum boron-10 atom percent when that water is recycled, or provide an additional technical specification and surveillance requirement as laid out in RAI 158-7997, Question 06.03-7. If boron recycling is not to be used, the applicant shall provide a clear discussion in the DCD detailing that boron-10 atom percent surveillance verification of the SIS water is not necessary since boron recycling will not be used for the APR1400. The staff must ensure that for a COL applicant incorporating the APR1400 by design, who wishes to utilize the APR1400's capability of boron recycling, a technical specification and surveillance requirement must be added to the applicant's technical specifications to ensure boron-10 atom percent is greater than some minimum limit after recycling.

Response – (Rev. 1)

The boron recovery system, described in DCD Tier 2 Section 9.3.4, is used to recover excess boron from the RCS and to store for later use such as to correct boron concentration of the SITs or IRWST. Thus, the B-10 atom percent of the SITs and IRWST can be decreased gradually.

Surveillance Requirement 3.5.1.6 and B 3.5.1.6 will be added to verify the isotopic concentration of B-10 in each SIT every 24 months. Surveillance Requirement 3.5.4.4 and B 3.5.4.4 will be added to verify the isotopic concentration of B-10 in the IRWST every 24 months as indicated in attachment.

During reactor operation, the B-10 isotopic concentration of the reactor coolant in the RCS is gradually depleted, caused by the neutron flux in the core. The reactor coolant in the RCS is mixed with the refueling water in the IRWST during refueling outages. The B-10 isotopic concentration of the refueling water in the IRWST can be decreased over time whenever the mixture process is repeated. The B-10 isotopic concentration in the SITs also can decrease over a long time, because the IRWST water may be utilized in order to add water inventory to the SITs.

Since B-10 in the IRWST and SITs is not directly exposed to a significant neutron flux and the IRWST water used as inventory for the SITs is only mixed with the reactor coolant during refueling outages, 24 months is considered conservative. The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk.

Since the B-10 isotopic concentration of the water in the SFP is gradually depleted caused by the neutron flux in the SFP, Surveillance Requirement 3.7.15.2 and B 3.7.15.2 will be added to verify the isotopic concentration of B-10 in the SFP every 24 months as indicated in attachment. The 24 months Frequency is appropriate because the boron in the spent fuel pool is not exposed to a significant neutron flux.

As stated in the response to RAI 158-7997, Question 06.03-7 (ref. KHNP submittal MKD/NW-16-0014L), the reduction of B-10 atom percent during 15 years is 0.2 a/o (to 19.6 a/o from 19.8 a/o of initial atom percent) according to the operating experience of OPR1000 Units. This reduction is equivalent to 0.02 a/o per fuel cycle of 18-month. Since the minimum boron concentration in IRWST is 4,000 ppm, the corresponding difference in boron concentration is about 4 ppm (= $4000 \times 0.02 / 19.8$) between cycles. The boron concentration in the IRWST to maintain APR1400 core subcritical (0.99 k_{eff}) for post-LOCA is estimated to be less than 3,000 ppm, while the required minimum boron concentration for the IRWST is 4,000 ppm.

As described in B 3.5.1, the LCO established the minimum conditions required to ensure the SITs are available to accomplish their core cooling safety function following the LOCA. For a SIT to be considered OPERABLE, the motor operated isolation valve must be fully open with power removed (SR 3.5.1.1, SR 3.5.1.5) and the limits established in the SR for contained volume (SR 3.5.1.2), boron concentration (SR 3.5.1.4, SR 3.5.1.6) and nitrogen cover gas pressure (SR 3.5.1.3) must be met.

Therefore, by verifying the Surveillance Requirements from 3.5.1.1 to 3.5.1.6, we can ensure that the LCO 3.5.1 (four SITs shall be operable) is met.

DCD Tier 2 Subsection 9.3.4.2.2 will be revised to clarify boron recycling operation as indicated in attachment.

Impact on DCD

DCD Tier 2 Subsection 9.3.4.2.2 will be revised as indicated in attachment.

Same as changes described in the Impact on Technical Specifications section.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Technical Specification Surveillance Requirements 3.5.1.6, 3.5.4.4, and 3.7.15.2 and B 3.5.1.6, B 3.5.4.4, and B 3.7.15.2 will be added and B 3.5.4 will be changed as indicated in attachment.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical or Environmental Report.

9.3.4.2.1.4 Shutdown Purification

When the SCS is operational, a flow path through the CVCS can be established for purification. This is accomplished by diverting a portion of the flow from the shutdown cooling HX to the letdown line upstream of the letdown HX or upstream of the letdown control valves. The flow then passes through the purification filter, process radiation monitor and boronometer, purification ion exchanger, and the letdown strainer to the VCT. The fluid is returned to the RCS by the charging pump.

9.3.4.2.2 Boron Recovery Subsystem

The boron recovery subsystem can be used under the normal operation conditions.

The boron recovery portion of the CVCS accepts letdown flow diverted from the VCT as a result of feed-and-bleed operations for shutdowns, startups, and boron dilution over core life. The diverted letdown flow, which has passed through a purification filter and the purification ion exchanger, also passes through the pre-holdup ion exchanger. The pre-holdup ion exchanger retains cesium, lithium, and other ionic radionuclides with high efficiency. The process flow then passes through the gas stripper, where hydrogen and fission gases are removed with high efficiency, thus (1) precluding the buildup of explosive gas mixtures in the holdup tank and (2) minimizing the release of radioactive fission product gases in aerated vents or liquid discharges. The degassed liquid is discharged from the gas stripper to the holdup tank.

Reactor coolant quality water from valve and equipment leak-offs, drains, and reliefs within the containment is collected in the reactor drain tank (RDT) and scheduled for batch processing. Recoverable reactor coolant quality water outside the containment from various equipment and valve leak-offs, reliefs, and drains is collected in the equipment drain tank (EDT) and scheduled for batch processing. Reactor coolant collected in either of these tanks is periodically discharged by the reactor drain pumps through the reactor drain filter and pre-holdup ion exchanger and processed in the same manner as the flow diverted from the VCT, as described above. This liquid is also discharged to the holdup tank.

When a sufficient volume accumulates in the holdup tank, it is pumped by a holdup pump to the boric acid concentrator, where the bottoms are concentrated to 4,000 to 4,400 ppm boron. The boric acid concentrator bottoms are continuously monitored for proper boron concentration and are normally discharged to the BAST. In the event that abnormal

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.5.1.1	Verify each SIT isolation valve is fully open.	12 hours
SR 3.5.1.2	Verify borated water volume in each SIT is ≥ 29% and ≤ 69% (% narrow range).	12 hours
SR 3.5.1.3	Verify nitrogen cover-pressure in each SIT is ≥ 40.6 kg/cm^{2}G (578 psig) and ≤ 43.9 kg/cm^{2}G (624 psig).	12 hours
SR 3.5.1.4	Verify boron concentration in each SIT is ≥ 2,300 ppm and ≤ 4,400 ppm.	31 days AND ---------- NOTE ---------- Only required to be performed for affected SIT. ---------- Once within 6 hours after each solution volume increase of ≥ 1% of tank volume that is not the result of addition from the in-containment refueling water tank
SR 3.5.1.5	Verify power is removed from each SIT isolation valve operator when pressurizer pressure is ≥ 50.3 kg/cm^{2}A (715 psia).	31 days
SR 3.5.1.6	Verify isotopic concentration of B-10 in each SIT is within the limit specified in the COLR.	24 months

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.1.5

Verification every 31 days that power is removed from each SIT isolation valve operator when the pressurizer pressure is ≥ 50.3 kg/cm^{2}A (715 psia) ensures that an active failure could not result in the undetected closure of an SIT motor operated isolation valve. If this were to occur, only three SITs would be available for injection during a LOCA. Since installation and removal of power to the SIT isolation valve operators is conducted under administrative control, the 31 day Frequency was chosen to provide additional assurance that power is removed.

This SR allows power to be supplied to the motor operated isolation valves when pressurizer pressure is < 50.3 kg/cm^{2}A (715 psia), thus allowing operational flexibility by avoiding unnecessary delays to manipulate the breakers during unit startups or shutdowns. Even with power supplied to the valves, inadvertent closure is prevented by the RCS pressure interlock associated with the valves. Should closure of a valve occur in spite of the interlock, the SI signal provided to the valves would open a closed valve in the event of a LOCA.

REFERENCES

1. IEEE Standard 603-1991.
2. FSAR, Subsection 6.3.
3. 10 CFR 50.46.
4. FSAR, Chapter 15.
5. NUREG-1366, February 1990.

SR 3.5.1.6

Periodic verification that the isotopic concentration of B-10 in each SIT is within the limit specified in the COLR ensures that the B-10 isotopic concentration assumed in the safety analysis is available. Since B-10 in the SITs is not directly exposed to a significant neutron flux and the IRWST water used as inventory for the SITs is only mixed with the reactor coolant during refueling outages, 24 months is considered conservative. The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk.

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.5.4.1	Verify IRWST water temperature is ≥ 10°C (50°F) and ≤ 49°C (120°F).	24 hours
SR 3.5.4.2	Verify IRWST water volume is ≥ [2,373.5 m^3 (627,000 gal)] and ≤ [2,540.6 m^3 (671,162 gal)] (i.e., ≥ 74.43% and ≤ 79.67%).	7 days
SR 3.5.4.3	Verify IRWST boron concentration is ≥ 4,000 ppm and ≤ 4,400 ppm.	7 days
SR 3.5.4.4	Verify isotopic concentration of B-10 in the IRWST is within the limit specified in the COLR.	24 months

3.7 PLANT SYSTEMS

3.7.15 Spent Fuel Pool Boron Concentration

LCO 3.7.15 The spent fuel pool boron concentration shall be ≥ 2,150 ppm.

APPLICABILITY: When fuel assemblies are stored in the spent fuel pool and spent fuel pool verification has not been performed since the last movement of fuel assemblies in the spent fuel pool.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Spent fuel pool boron concentration not within limit.	NOTE LCO 3.0.3 is not applicable.	
	A.1 Suspend movement of fuel assemblies in spent fuel pool.	Immediately
	AND	
	A.2.1 Initiate action to restore spent fuel pool boron concentration to within limit.	Immediately
	OR	
	A.2.2 Initiate action to perform a fuel storage pool verification.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.15.1	Verify spent fuel pool boron concentration is within limit.	7 days
SR 3.7.15.2	Verify isotopic concentration of B-10 in the SFP is ≥ 19.9% (atomic percent).	24 months

BASES

APPLICABLE SAFETY ANALYSES (continued)

The LOCA dose analyses assumes a volume of at least (2,370 m^3 (627,000 gal)) for dilution of radionuclide in water. The 4,000 ppm limit for minimum boron concentration was established to ensure that, following a LOCA with a minimum IRWST level, the reactor will remain subcritical in the cold condition following mixing of the IRWST and RCS water volumes. Small break LOCAs assume that all control rods are inserted, except for the control element assembly (CEA) of highest worth, which is withdrawn from the core. Large break LOCAs assume that all CEAs remain withdrawn from the core. The most limiting case occurs at f life.

The safety analysis assumes that the boron has the minimum B-10 isotopic concentration limit specified in the COLR.

um boron limit of 4,400 ppm in the IRWST is based on boron in the core following a LOCA. With the reactor vessel at saturated conditions, the core dissipates heat by pool nucleate boiling. Because of this boiling phenomenon in the core, the boric acid concentration will increase in this region. If allowed to proceed in this manner, boron precipitation will occur in the core. Post-LOCA emergency procedure directs the operator to establish simultaneous hot leg/DVI nozzle injection to prevent this condition by a forced flow through the core regardless of break location.

This procedure is based upon the minimum time in which precipitation could occur, assuming the maximum LCO limit of the IRWST boron concentration. Boron concentrations in the IRWST in excess of the limit could result in precipitation earlier than assumed in the analysis.

The safety analyses assumes the minimum allowed IRWST water temperature is 10°C (50°F) and the maximum temperature of the IRWST is 49°C (120°F).

The IRWST satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii).

BASES

ACTIONS (continued)

Therefore, the reactor flange water level above the reactor vessel flange with head off in MODE 6 does not require one safety injection pump after loss of coolant accident at low power shutdown risk. In addition, if RCS water level is below the flange of the reactor vessel, there is a potential of evaporation of the coolant. The reduction of RCS cold leg temperature to < 57.2°C (135°F) will provide a reduction in clad temperature. If RCS cold leg temperature reaches above 57.2°C (135°F), there is a potential to evaporate. The 24 hour Completion Time limits the time the plant is subject to conditions where the LCO is applicable.

SURVEILLANCE REQUIREMENTS

SR 3.5.4.1

IRWST water temperature shall be verified every 24 hours to be within the limits assumed in the accident analysis. This Frequency has been shown to be sufficient to identify temperature changes that approach either acceptable limit.

SR 3.5.4.2

The IRWST water volume must be maintained equal to or more than the required minimum value and equal to or less than the maximum value. IRWST water volume shall be verified every 7 days. Since the IRWST
w level alarm, a
be acceptable

SR 3.5.4.4

Periodic verification that the isotopic concentration of B-10 in the IRWST is within the limit specified in the COLR ensures that the B-10 isotopic concentration assumed in the safety analysis is available. Since B-10 in the IRWSTs is not directly exposed to a significant neutron flux and the IRWST water is only mixed with the reactor coolant during refueling outages, 24 months is considered conservative. The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk.

l every 7 days to
s that the reactor
nsures that the
ge such that boron
precipitation in the core will not occur earlier than predicted and the effect of chloride and caustic stress corrosion on mechanical systems and components will be minimized. Since the IRWST volume is normally stable, a 7 day sampling Frequency is appropriate and has been shown through operating experience to be acceptable.

REFERENCES 1. 10 CFR Part 50, Appendix A, GDC 35.

BASES

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel pool until a complete spent fuel pool verification has been performed following the last movement of fuel assemblies in the spent fuel pool. This LCO does not apply following the verification since the verification would confirm that there are no misloaded fuel assemblies. With no further fuel assembly movements in progress, there is no potential for a misloaded fuel assembly or a dropped fuel assembly.

ACTIONS

A.1, A.2.1, and A.2.2

The Required Actions are modified by a Note indicating that LCO 3.0.3 does not apply.

When the concentration of boron in the spent fuel pool is less than required, immediate action must be taken to preclude an accident from happening or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement fuel of assemblies. This does not preclude the movement of fuel assemblies to a safe position. In addition, action must be immediately initiated to restore boron concentration to within limit.

SR 3.7.15.2

Periodic verification that the isotopic concentration of B-10 in the SFP is ≥ 19.9% (atomic percent) ensures that the B-10 isotopic concentration assumed in the safety analysis is available. The 24 month Frequency is appropriate because the boron in the SFP is not exposed to a significant neutron flux.

operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.15.1

This SR verifies that the concentration of boron in the spent fuel pool is within the required limit. As long as this SR is met, the analyzed incidents are fully addressed. The 7 day Frequency is appropriate because no major replenishment of pool water is expected to take place over a short period of time.

REFERENCES

None.