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.:	**481-8546**
SRP Section:	**16 – Technical Specifications**
Application Section:	**16.3.4, 16.3.5, 16.3.6, 16.3.7, 16.3.9**
Date of RAI Issue:	**05/12/2016**

Question No. 16-151

Follow-up to the response dated 2/5/2016, to RAI 133-7978, Question 16-31 (26973), Subquestion 12.

The staff found the response to Subquestion 12 unacceptable for the following reason.

In the original RAI, the staff raised the Subquestion 12 issue as follows:

> SR 3.9.5.1 does not state the minimum reactor coolant circulating flow of 4150 gpm as in SR 3.9.4.1. The applicant is requested to add this acceptance criterion to SR 3.9.5.1.

In the response, the applicant stated

> [A]ccording to STS NUREG-1432 Rev.4, SR 3.9.5.1 does not state the minimum reactor coolant circulating flow. The minimum reactor coolant circulating flow in low water level operation including REDUCED RCS INVENTORY operation can be provided in operational procedures rather than the TS.

It should be noted that requirements for an explicit numerical value for SC pump flow in the STS SRs 3.4.7.1, 3.4.8.1, 3.9.5.1 and 3.9.6.1 are dependent on specific safety/accident analyses described in FSAR Chapter 5/Chapter 15 to ensure adequate decay heat removal and/or boron mixing, during shutdown modes where no RCP is running, and the SC pump is used to provide coolant circulation through the reactor core. In addition, based on operating experiences during Mid-Loop operations as documented in generic letter (GL) 88-17, “Loss of Decay Heat Removal - 10 CFR 50.54(f),” a flow requirement should also be established to address the air ingestion condition in the hot leg when the RCS water inventory is maintained at the lowest permitted level for SC operation.

DCD Subsection 5.4.7.2, “System Design,” states, in part, “[R]educed inventory including midloop operation is necessary for increasing the plant availability. During this operation, the RCS water level is lowered to below the reactor vessel flange. When the RCS water level abnormally decreases, air may be ingested into the shutdown cooling system with the

possibility of affecting the SCS. The RCS level is maintained higher than the RCS low water level of 8.3 cm (3.28 inch) above the loop center, and a SCS flow rate of 14,385 to 15,710 L/min (3,800 to 4,150 gpm) is maintained for decay heat removal and prevention of an air ingestion.“

In Appendix A, “Procedural Guidance to Support Reduced Reactor Coolant System Inventory Operations,” of Technical Report (TeR) APR1400-E-N-NR-14005-P, “Shutdown Evaluation Report,” a minimum SCS cooling flow of "3000 gpm" is specified to ensure adequate decay heat removal during Mid-Loop operations.

The applicant is requested to include in the above listed SRs a minimum flow of “3000 gpm” for the SC pump to ensure adequate decay heat removal and/or boron mixing, and a maximum flow of “4150 gpm” to ensure no occurrence of vortexing in the hot leg or provide justification for not doing so.

In addition, correct the DCD and TeR to reconcile the difference between the above minimum SC flow values of 3800 gpm and 3000 gpm.

Response - (Rev.1)

An explicit numerical value for SC pump flow is added in the TS SR 3.4.7.1, 3.9.5.1. This value is to ensure adequate decay heat removal and to prevent boron mixing based on safety/accident analyses. An explicit numerical value for SC pump flow is added in the TS SRs 3.4.8.1 and 3.9.5.1 as documented in generic letter (GL) 88-17. This value is established to ensure adequate decay heat removal and to prevent boron mixing and also to address the air ingestion in the hot leg when the RCS water inventory is maintained at the lowest permitted level on safety/accident analyses. However, because TS 3.9.6 is about refueling water level during movement of irradiated fuel assemblies within containment the flow requirement of SC pump is not required. TeR is corrected to reconcile the difference between the minimum SC flow values of 3800 gpm and 3000 gpm as indicated in the Attachment 1. TS 3.4.7, 3.4.8, 3.9.5, Bases 3.4.7, 3.4.8 and 3.9.5 will be revised as indicated in the Attachment 2. In addition, Instead of using “REDUCED RCS INVENTORY,” the associated elevation threshold value of 127' ¼" is used and “EL” is deleted in response to 16-149(RAI 481-8546).

1. LCO 3.4.7 is applicable to Mode 5 with RCS loop filled. In this condition concern for vortexing in the hot leg does not exist. A flow rate of ≥ 15,710 L/min (4,150 gpm) ensures adequade decay heat removal and/or boron mixing. Therefore proposed markup is appropriate.

   Also, LCO 3.9.4 is applicable to Mode 6 with the water level ≥ 7.0 m(23 ft) above the top of the reactor vessel flange. Decreased SCS flow rate to address the air ingestion in the hot leg is controlled to nearly rated flow rate of ≥ 15,710 L/min (4,150 gpm) normally. Therefore proposed markup is appropriate.

2. LCO 3.4.8 is applicable to Mode 5 with RCS loop not filled. In this condition concern for vortexing in the hot leg exists and requirement for a maximum flow is needed. Therefore, the SR 3.4.8.1 will be changed as recommended:

Verify one SC train is in operation with circulating reactor coolant at a flow rate of ≥ 14,385 L/min (3,800 gpm) and < 15,710 L/min (4,150 gpm). | 12 hours

In Mode 5 with reduced RCS water volume a flow rate of ≥ 14,385 L/min (3,800 gpm) ensures adequade decay heat removal and/or boron mixing and < 15,710 L/min (4,150 gpm) prevents vortexing in the hot leg.

3. LCO 3.9.5 is applicable to Mode 6 with the water level < 7.0 m(23 ft) above the top of the reactor vessel flange. At RCS level < 38.72 m (127 ft-1/4 in) including mid-loop operation vortexing in the hot leg exists and requirement for a maximum flow is needed. Therefore, the SR 3.9.5.1 will be changed as follows:

   Verify required SCS trains are OPERABLE and one SCS train is in operation with circulating reactor coolant at a flow rate of ≥ 15,709 L/min (4,150 gpm) at RCS level ≥ 38.72 m (127 ft-1/4 in) or ≥ 14,385 L/min (3,800 gpm) and < 15,710 L/min (4,150 gpm) at RCS level < 38.72 m (127 ft-1/4 in). | 12 hours

At RCS level ≥ 38.72 m (127 ft-1/4 in) and the water level < 7.0 m(23 ft) above the top of the reactor vessel flange decreased SCS flow rate to address the air ingestion in the hot leg is controlled to nearly rated flow rate of ≥ 15,710 L/min (4,150 gpm) normally

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Impact on DCD

Same as changes described in Impact on Technical Specifications section.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

TS 3.4.7, 3.4.8, 3.9.5, Bases 3.4.7, 3.4.8 and 3.9.5 will be revised as indicated in the Attachment 2.

Impact on Technical/Topical/Environmental Reports

TeR(APR1400-E-N-NR-14005-P, Rev.0), Appendix A will be revised as indicated in the Attachment 1.

A.4.3 Perform the RCS drain procedure to lower the RCS level to the desired reduced inventory elevation identified below:

Scheduled Maintenance Activity RCS	Elevation
S/G cold leg nozzle dams	[ ]
S/G hot leg nozzle dams	[ ]
RCP seal housing removal	[ ]
DVI nozzle 2A or 2B valve maintenance	[ ]

A.4.4 Monitor the following RCS/SCS system parameters during reduced inventory operations.

RCS core exit temperature	[List instruments]
SCS system flow rate	[ ]
RCS boron concentration	[ ]
SCS system temperature	[ ]
RCS pressure	[ ]
RCS level	[ ]

NOTE

Decay heat production decreases steadily with time after shutdown. SCS flow rate should be throttled to match heat removal requirements to reduce the possibility of vortexing.

A.4.5 Adjust SCS flow rate to match DHR requirements. Minimum flow must be maintained at greater than (11.4 m^3/min (3,000 gpm)).

A.4.6 Perform the scheduled maintenance activities while in the reduced inventory mode.

If reduced inventory maintenance requires the installation of SG nozzle dams, the cold leg dams shall be installed first, prior to the hot leg dams and removed last, after hot leg nozzle dam removal.

A.4.7 After the completion of the desired maintenance activities, restore RCS level to greater than elevation [119 ft 1in] per the applicable RCS makeup procedure.

A.5.0 ABNORMAL OPERATING CONDITIONS

A.5.1 Loss of shutdown cooling flow.

with circulating reactor coolant at a flow rate of ≥ 15,710 L/min (4,150 gpm)

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.4.7.1	Verify one SC train is in operation.	12 hours
SR 3.4.7.2	Verify required SG secondary side water level is ≥ 25 % wide range indication.	12 hours
SR 3.4.7.3	---------- NOTE ---------- Not required to be performed until 24 hours after a required pump is not in operation. ---------- Verify correct breaker alignment and indicated power available to required SC pump.	7 days
SR 3.4.7.4	Verify required SCS train locations susceptible to gas accumulation are sufficiently filled with water.	31 days

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One SC train inoperable.	A.1 Initiate action to restore SC train to OPERABLE status.	Immediately
B. Required SC trains inoperable. OR No SC train in operation.	B.1 Suspend all operations involving reduction of RCS boron concentration. AND B.2 Initiate action to restore one SC train to OPERABLE status and operation. AND B.3 Initiate action to raise RCS level to > EL. 38.72 m (127 ft-1/4 in).	Immediately Immediately Immediately

DELETED

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.4.8.1	Verify one SC train is in operation.	12 hours
SR 3.4.8.2	---------- NOTE ---------- Not required to be performed until 24 hours after a required pump is not in operation. ---------- Verify correct breaker alignment and indicated power available to required SC pump.	7 days
SR 3.4.8.3	Verify required SCS train locations susceptible to gas accumulation are sufficiently filled with water.	31 days

with circulating reactor coolant at a flow rate ≥ 14,385 L/min (3,800 gpm) and < 15,710 L/min (4,150 gpm)

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with circulating reactor coolant at a flow rate of ≥ 15,709 L/min (4,150 gpm) at RCS level ≥ 38.72 m (127 ft-1/4 in) or ≥ 14,385 L/min (3,800 gpm) and < 15,710 L/min (4,150 gpm) at RCS level < 38.72 m (127 ft-1/4 in)

	SURVEILLANCE	FREQUENCY
SR 3.9.5.1	Verify required SCS trains are OPERABLE and one SCS train is in operation.	12 hours
SR 3.9.5.2	Verify correct breaker alignment and indicated power available to the required SCS pump that is not in operation.	7 days
SR 3.9.5.3	Verify correct breaker alignment and indicated power available to the required CS pump.	24 hours when in REDUCED RCS INVENTORY
SR 3.9.5.4	Verify required SCS train piping locations susceptible to gas accumulation are sufficiently filled with water.	31 days

at RCS level < 38.72 m (127 ft-1/4 in)

and circulating reactor coolant.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.4.7.1

This SR requires verification every 12 hours that one SC train is in operation. Verification includes flow rate, temperature, or pump status monitoring, which help ensure that forced flow is providing decay heat removal. The 12-hour Frequency has been shown by operating practice to be sufficient to regularly assess degradation and verify operation is within safety analyses assumptions. In addition, MCR indication and alarms will normally indicate loop status.

The flow rate is determined by the flow rate necessary to provide sufficient decay heat removal capability and to prevent thermal and boron stratification.

The SC flow is established to ensure that core outlet temperature is maintained sufficiently below saturation to allow time for swap over to the standby SC train should the operating train be lost.

SR 3.4.7.2

Verifying the SGs are OPERABLE by ensuring their secondary side water levels are greater than or equal to 25 % wide range ensures that redundant heat removal paths are available if the second SC train is inoperable.

The Surveillance is required to be performed when the LCO requirement is being met by use of the SGs. If both SC trains are OPERABLE, this SR is not needed. The 12-hour Frequency has been shown by operating practice to be sufficient to regularly assess degradation and verify operation within safety analyses assumptions.

SR 3.4.7.3

Verification that the second SC train is OPERABLE ensures that redundant paths for decay heat removal are available. The requirement also ensures that the additional train can be placed in operation, if needed, to maintain decay heat removal and reactor coolant circulation. Verification is performed by verifying proper breaker alignment and power available to the required pump. The Surveillance is required to be performed when the LCO requirement is being met by one of two SC trains (e.g., SGs have less than 25 % wide range water level). The 7-day Frequency is considered reasonable in view of other administrative controls available and has been shown to be acceptable by operating experience.

This SR is modified by a Note that states the SR is not required to be performed until 24 hours after a required pump is not in operation.

BASES

ACTIONS (continued)

B.1, B.2 and B.3

If required SC trains are inoperable or no train is in operation, the action requires immediate suspension of any operation for boron concentration reduction, initiating action to raise RCS level to greater than EL 38.72 m (127 ft 1/4 in) and requires action to immediately start restoration of one SC train to OPERABLE status. Boron dilution requires forced circulation for proper mixing and margin to criticality must not be reduced in this type of operation. The immediate Completion Time reflects the importance of maintaining operation for decay heat removal.

and circulating reactor coolant.

SURVEILLANCE REQUIREMENTS

SR 3.4.8.1

This SR requires verification of the required SC train is in operation every 12 hours.

The flow rate is determined to provide sufficient decay heat removal capability and to prevent thermal and boron stratification and also to address air ingestion in the hot leg when the RCS water inventory is maintained at the lowest permitted level.

Verification includes flow rate, temperature, or pump status monitoring, which help ensure forced flow is providing decay heat removal.

The 12-hour Frequency has been shown by operating practice to be sufficient to regularly assess degradation and verify operation within safety analyses assumptions.

SR 3.4.8.2

Verification that the required number of trains are OPERABLE ensures that redundant paths for heat removal are available and additional trains can be placed in operation, if needed, to maintain decay heat removal and reactor coolant circulation. Verification is performed by verifying proper breaker alignment and indicated power available to the required pumps.

The 7-day Frequency is considered reasonable in view of other administrative controls available and has been shown to be acceptable by operating experience.

This SR is modified by a Note that states the SR is not required to be performed until 24 hours after a required pump is not in operation.

SURVEILLANCE REQUIREMENTS

SR 3.9.5.1

This Surveillance verifies that the SCS train is operating and circulating reactor coolant. The flow rate is determined by the flow rate necessary to provide sufficient decay heat removal and to prevent thermal and boron stratification in the core. In addition, this surveillance demonstrates that the other SCS train is OPERABLE.

and at RCS level < 38.72 m (127 ft-1/4 in) the flow rate is determined to provide sufficient decay heat removal capability and to prevent thermal and boron stratification and also to address air ingestion in the hot leg when the RCS water inventory is maintained at the lowest permitted level.

In addition, during operation of the SCS train with the water level in the vicinity of the reactor vessel nozzles, the SCS train flow rate determination must also consider the SCS pump suction requirements. The 12-hour Frequency is sufficient considering the flow, temperature, pump control, and alarm indications available to the operator to monitor the SCS system in the MCR. This Frequency ensures that flow is checked and temperature monitored at adequate intervals.

Verification that the required trains are OPERABLE and in operation ensures that trains can be placed in operation as needed, to maintain decay heat and retain forced circulation. The 12-hour Frequency is considered reasonable, since other administrative controls are available and have proven to be acceptable by operating experience.

SR 3.9.5.2

Verification that the required pump is OPERABLE ensures that an additional SCS pump can be placed in operation, if needed, to maintain decay heat removal and reactor coolant circulation.

Verification is performed by ensuring correct breaker alignment and indicated power available to the required pumps. The 7-day Frequency is considered reasonable in view of other administrative controls available and has been shown to be acceptable by operating experience.

SR 3.9.5.3

Verification of the correct breaker alignment and indicated power available to the operable CS pump ensures that the CS pump will be able to remove heat from the RCS in the event of a power failure to the operating SCS train. The 24-hour Frequency is based on operating experience.