REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power

Docket No. 52-046

RAI No.:	**232-7864**
SRP Section:	
Application Section:	**19.2.2.2.c –Mid-Loop Operation**
Date of RAI Issue:	**09/30/2015**

Question No. 19-6

a. The risk significant operational assumptions regarding SG nozzle dam integrity, SG nozzle dam installation, and SG nozzle dam removal documented in DCD Section 19.2.2.2.c., should be included in the Risk Insights Table or a justification should be provided documenting why inclusion in the risk insight table is not necessary.

b. The following statement in DCD Section 19.2.2.2.c , “The installation procedure requires that the pressurizer manway be opened so that a hot side vent pathway exists prior to blocking both RCS hot legs with nozzle dams” seems to be inconsistent with the statement in DCD Section 19.2.2.2, "In order to provide reasonable assurance that nozzle dam design pressures are not exceeded during reduced inventory operations with boiling conditions in the reactor vessel, the APR 1400 design requires that a mid-loop vent pathway is opened via the pressurizer manway prior to reduced inventory operation." Please resolve the inconsistency in the DCD and the Risk Insights table.

c. In GL 88-17, Section 2.1.1, Pressurization, it states, “cold leg openings can allow water to be ejected from the vessel following a loss of DHR until sufficient water is lost that steam is relieved by clearing of the crossover pipes.” Information Notice 88-36 also discusses the potential for a rapid loss of RCS inventory through cold leg penetrations. IN 88-36 states, “The possibility of ejecting coolant by this mechanism can be eliminated by ensuring that a steam generator hot leg plenum manway and its associated hot leg pipe are kept open to provide an adequate vent path whenever any cold leg openings are made. This can be accomplished by ensuring that a hot leg manway is the first manway to be opened, and a hot leg nozzle dam is the last dam to be installed.” Please update the nozzle dam installation and removal procedures in the Risk Insights Table and DCD Section 19.2.2.2.c. to be consistent with the guidance from IN 88-36 or please justify why this change is not necessary.

d. Regarding overpressure protection of the SG nozzle dams as described in GL 88-17, the

Shutdown Evaluation Report states, "An acceptable, conservative RCS equilibrium pressure that is below the assumed SG nozzle dam abnormal design pressure limit has been calculated when mid-loop operation is assumed to start at 4 days after shutdown. Therefore, the recommended earliest time after shutdown (from full power) for operating at mid-loop level is 4 days. It fixes the time to boil [

]TS

e. Concerning the differential pressure capability of the SG nozzle dams, DCD Section 19.2.2.2 states, "In the APR1400 design, the ability of the RCS to withstand abnormal pressurization during reduced inventory operations with the nozzle dams installed is limited by the design pressure of the nozzle dams. Based on overpressure tests performed on nozzle dams, the design pressure is estimated to be 3.52 kg/cm^2 (50 psia). The design pressure is sufficient to withstand an abnormal pressurization transient." The staff understands these statements in this paragraph to mean that mid-loop operation initiated earlier than 4 days could result in an RCS re-pressurization beyond the differential pressure capability of the SG nozzle dams of 50 psid, if the DHR function is lost. Loss of a nozzle dam due to RCS pressurization could result in rapid RCS inventory loss and is risk significant. The staff has two questions:

i) In section 19.2.2.2 of the DCD, the staff is requesting the applicant to discuss the results of an analysis that evaluates RCS peak pressure given an RCS re-pressurization following a loss of decay heat removal, 96 hours post shutdown. This discussion is needed to document that the steam generator nozzle dams will remain intact given an abnormal pressurization transient.

ii) According to SRP 14.3, the differential pressure capability of the nozzle dams is risk significant and should be considered for ITAAC.

Response – (Rev. 1)

a. The risk insights and key assumption for SG nozzle dam integrity will be added in the Table 19.1-4 in DCD section 19.1 as shown in the Attachment 1.

b. The statement in DCD Section 19.2.2.2.c, "The installation procedure requires ...", is to describe the operation procedure for installation of nozzle dams. The other statement in DCD Section 19.2.2.2, "In order to provide reasonable assurance ...", is to provide the design verification that operation pressure of nozzle dams during reduced inventory operation with core boiling condition is less than the design pressure of nozzle dams when the pressurizer manway is open. Therefore, there is no inconsistency between these statements.

But key assumption for SG nozzle dam integrity such as "Pressurizer manway is opened before mid-loop conditions are reached" will be added in the Risk Insight Table (Table 19.1-4) as shown in the Attachment 1.

c. Based on the evaluation of APR1400 for the hot side vent path, the pressurizer (PZR) manway is determined to be enough to limit the over-pressurization of hot leg. The reduced inventory operation including mid-loop operation is performed after PZR manway is opened. When the nozzle dam is not installed, the analysis results of loss of residual heat removal (LORHR) with SG outlet plenum manway opened showed that a little larger RCS inventory loss during a short time period after saturation and less severe core uncovery time than the case with SG inlet plenum manway opened.

So, unlike SG nozzle dam installation, the procedure for SG manway opening is not important for the APR1400 design since the APR1400 has a sufficient PZR manway vent path. Therefore, the DCD does not require a revision.

Nozzle dams in the cold legs shall be installed first; and second in the hot legs to prevent overflow from the cold leg to the SG plenum due to overpressure in the hot leg during LORHR. Reversely, nozzle dams in the hot legs shall be removed first; and second in the cold legs to prevent overflow due to overpressure in the hot leg during LORHR. The above mentioned installation and removal procedures (in response to question b) have been incorporated in the DCD.

d. Table 19.1-4 in DCD section 19.1 and TS LCO 3.4.8/ B3.4.8 will be revised as shown in the Attachments 1&2.

e. The responses on two questions are as follows;

   i) The sentence "RCS peak pressure at nozzle dam during LORHR initiated from the reduced inventory operation at [ ]TS, which is well below the nozzle dam design pressure." will be added as indicated in the Attachment 3.

   ii) The nozzle dam capability and verification during mid-loop operation will be incorporated in Tier 1, Section 2.4.1.1 and Table 2.4.1-4 as indicated in Attachment 4.

Impact on DCD

The risk insights and key assumption for SG nozzle dam integrity will be added in the Table 19.1-4 in DCD Section 19.1 as shown in the Attachment 1.

DCD Section 19.2.2.2 will be revised as shown in the Attachment 3.

Tier 1 Section 2.4.1.1 and Table 2.4.1-4 will be revised as shown in the Attachment 4.

Impact on PRA

There is no impact on the PRA

Impact on Technical Specifications

TS 3.4.8 and B3.4.8 will be revised as shown in Attachment 2.

Impact on Technical/Topical/Environmental Reports

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

APR1400 DCD TIER 2

Table 19.1-4 (25 of 25)

No.	Insight	Disposition
	Risk Insights from PRA Models	
58	The fire PRA assumes that the fire barrier management procedures used during LPSD will include directions to provide reasonable assurance that breached risk-significant fire barriers can be closed in sufficient time to prevent the spread of fire across the barrier. The procedural direction is to include the use of a fire watch whose duties are commensurate with the risk associated with the barrier. For example, for fire barriers that separate two fire compartments that both contain no equipment or cables necessary to prevent core damage or large early release during LPSD conditions, or have been demonstrated to have low risk significance, there will at least be a roving fire watch to check the barrier during rounds. For fire barriers separating fire compartments that contain equipment or cables necessary to prevent core damage or large early release during LPSD conditions, and have been demonstrated to be risk significant with respect to fire, a permanent fire watch will be established until the barrier is reclosed. In the latter case, the fire barrier management procedure is to direct that hoses or cables that pass through a fire barrier use isolation devices on both sides of a quick-disconnect mechanism that allow for reclosure of the barrier in a timely fashion to re-establish the barrier prior to fire spread across the barrier.	Subsection 19.1.6.3.1.2 COL 19.1(11)
59	The LPSD PRA assumes that Pressurizer manway is opened before midloop conditions are reached. In order to assure that the nozzle dam design pressure limit is not exceeded during reduced inventory operations with boiling conditions in the reactor vessel, the APR1400 design includes a requirement that will be imposed to establish a mid-loop vent pathway via the pressurizer manway before operating in reduced inventory. The Nozzle dams are installed in the cold legs first and in the hot legs second. The Nozzle dams are removed in the hot legs first and in the cold legs second.When the manway is opened to the containment atmosphere, the surge line provides sufficient venting capacity to prevent RCS pressurization and subsequent nozzle dam failure.	Subsection 19.2.2.2
60	Mid-loop operation should be started [ ]TS	TS 3.4.8

3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.8 RCS Loops – MODE 5 (Loops Not Filled)

LCO 3.4.8 Two shutdown cooling (SC) trains shall be OPERABLE and one SC train shall be in operation.

------------------------------------ NOTE ------------------------------------

1. All SC pumps may be de-energized for ≤ 15 minutes when switching from one train to another provided:
   a. Core outlet temperature is maintained at least 5.6 °C (10 °F) below saturation temperature.
   b. No operations are permitted that would cause a reduction of RCS boron concentration required to meet the SDM of LCO 3.1.1; and
   c. No draining operations to further reduce RCS water volume are permitted.
2. One SC train may be inoperable for ≤ 2 hours for surveillance testing provided the other SC train is OPERABLE and in operation.
3. A containment spray pump can be manually realigned to meet the requirement of a SC pump.

APPLICABILITY: MODE 5 with RCS loops not filled.

(Mid-loop operation shall be started [

]TS)

BASES

LCO (continued)

An OPERABLE SC train is composed of an OPERABLE SC pump capable of providing forced flow to an OPERABLE SC heat exchanger, along with the appropriate flow and temperature instrumentation for control, protection, and indication. SC pumps are OPERABLE if they are capable of being powered and are able to provide flow if required. Management of gas voids is important to SCS OPERABILITY.

Note 3 permits the alignment of a containment spray pump if an SC pump is not available or becomes inoperable. These pumps are designed to be interchangeable for operational flexibility.

APPLICABILITY

In MODE 5 with loops not filled, this LCO requires core heat removal and coolant circulation by the SCS.

Operation in other MODES is covered by:

LCO 3.4.4, “RCS Loops – MODES 1 and 2”

LCO 3.4.5, “RCS Loops – MODE 3”

LCO 3.4.6, “RCS Loops – MODE 4”

LCO 3.4.7, “RCS Loops – MODE 5 (Loops Filled)”

LCO 3.9.4, “Shutdown Cooling System (SCS) and Coolant Circulation – High Water Level”, and

LCO 3.9.5, “Shutdown Cooling System (SCS) and Coolant Circulation – Low Water Level”

ACTIONS

<u>A.1</u>

If one required SC train is inoperable, redundancy for heat removal is lost. Action must be initiated immediately to restore a second train to

The typical initial conditions of LORHR event are the reduced inventory or the mid-loop operation. The pressurizer manway opening configuration is selected as a representative case because the pressurizer manway will be always open during the reduced inventory operation. Several calculations are performed for the LORHR events with various RCS openings in addition to the pressurizer manway opening.

[ ]TS are used for the analyses. The initial steady state calculation is performed considering one train of the shutdown cooling system (SCS) operation based on the normal SCS operation. The coolant injection of SCS to the RCS is performed through the DVI nozzle and the SCS suction is considered from the hot leg. The SCS flow rate is assumed as approximate average value of 1 train SCS flow.

19.2.2.2 Mid-Loop Operation

1) The shutdown cooling suction lines do not contain loop seals, thereby minimizing the potential to trap gas. The suction piping layout allows self-venting of accumulated gas (or air).

2) The two redundant shutdown cooling suction lines are completely independent.

3) There are no auto-closure interlocks on the shutdown cooling suction piping valves, minimizing the potential for shutdown cooling isolation events.

c. Steam generator nozzle dam integrity

The APR1400 design addresses the regulatory concern of preventing significant pressurization in the upper plenum of the reactor vessel during core boiling scenarios. The APR1400 procedural guidance recommends a nozzle dam installation and removal sequence, which consists of the following:

1) Installation: The nozzle dams are installed in the cold legs first and in the hot legs second.

2) Removal: The nozzle dams in the hot legs are removed first and in the cold legs second.

The installation procedure requires that the pressurizer manway be opened so that a hot side vent pathway exists prior to blocking both RCS hot legs with nozzle dams.

In the APR1400 design, the ability of the RCS to withstand abnormal pressurization during reduced-inventory operations with the nozzle dams installed is limited by the design pressure of the nozzle dams. Based on overpressure tests performed on nozzle dams, the design pressure is estimated to be 3.52 kg/cm^2 (50 ~~psia~~ psig). The design pressure is sufficient to withstand an abnormal pressurization transient.

RCS peak pressure at nozzle dam during LORHR initiated from the reduced inventory operation [ ]TS is analyzed as 0.3 MPa (28.8 psia, 2.03 kg/cm^2), which is well below the nozzle dam design pressure.

In order to provide reasonable assurance that the nozzle dam design pressure is not exceeded during reduced-inventory operations with boiling conditions in the reactor vessel, the APR1400 design requires that a mid-loop vent pathway is

10. The RV is equipped with holders for at least six capsules for accommodating material surveillance specimens.

11. RV material specimens taken from materials actually used in fabrication of the beltline region are inserted in the capsules and include Charpy V-notch specimens of base metal, weld metal and heat-affected zone material and tensile and 1/2T compact tension specimens from base metal and weld metal.

12. CEDMs release the CEAs upon termination of electrical power to the CEDM.

13. The piping system qualified for LBB identified in Table 2.4.1-1 meets the LBB criteria

14. During mid-loop operation, the nozzle dam withstands its design pressure of 50 psig.

2.4.1.2 Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.1-4 specifies the inspections, tests, analyses, and associated acceptance criteria for the reactor coolant system.

Table 2.4.1-4 (7 of 7)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
12. CEDMs release the CEAs upon termination of electrical power to the CEDMs.	12. Tests are performed on the as-built CEDMs to confirm scramability.	12. Maximum drop time for 90 % insertion of the CEA is 4.0 seconds.
13. The piping system qualified for LBB identified in Table 2.4.1-1 meets the LBB criteria.	13. Inspections and analyses of the as-built piping system qualified for LBB identified in Table 2.4.1-1 will be performed.	13. For piping system qualified for LBB identified in Table 2.4.1-1, an LBB evaluation report exists which documents that the LBB acceptance criteria are met by the as-built piping system including the final detailed design parameters.
14. During mid-loop operation, the nozzle dam withstands its design pressure of 50 psig.	14. Test or type test will be performed that demonstrate the capability of the nozzle dam to operate under the design conditions.	14. A test report exists and concludes that nozzle dam is capable of being operated under design condition of mid-loop.