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.:	**86-8003**
SRP Section:	**10.04.09 – Auxiliary Feedwater System**
Application Section:	**10.04.09**
Date of RAI Issue:	**07/16/2015**

Question No. 10.04.09-1

In accordance with SRP 10.4.9 Section III, Item 3, the auxiliary feedwater system (AFWS) design should have features to meet the generic recommendations of NUREG-0611 and NUREG-0635. Also, Generic Short Term Recommendation No. 4 (GS-4) recommends emergency procedures be available for transferring to alternate sources of AFW supply.

DCD Tier 2, Section 10.4.9.5.4 states that level indication and low-level alarms for the auxiliary feedwater storage tanks (AFWSTs) are provided in the main control room (MCR) and remote shutdown room (RSR) by redundant level instrumentation on each tank. The low-level alarm is set to allow 30 minutes for alignment of the other AFWST or the non-safety backup makeup supply before the level decreases to a point where pump suction is lost. In the applicant's DCD the capability to use alternate water sources to supply the AFW system, and the alerting of the control room of when to begin alignment of alternate source are identified; however, the staff could not find a specific commitment to assure that the COL applicant specifically addresses the development of emergency procedures for transferring the AFWS to an alternate AFW supply source.

A. The applicant is requested to demonstrate how it will be assured that emergency procedures will be developed for switchover of water to the alternate source prior to time at which AFW pump suction will be lost

B. The applicant is requested to identify the AFWST level used to provide the alarm in the control room alerting operators that the AFWST level has fallen to the point where AFW suction will be lost if operator action to switchover to an alternate water source is not taken. The applicant is also requested to provide the basis for the selected AFWST water level assumed and the appropriate justification.

Response

A. DCD Tier 2, Subsection 13.5.2.1.3, “Emergency Operating Procedure Program” states that “The COL applicant is to provide a program for developing and implementing emergency operating procedures (COL 13.5(5)).”

Therefore, the emergency procedures for switchover of water to the alternate source prior to the time at which AFW pump suction will be lost are prepared by the COL applicant in accordance with Subsection 13.5.2.1.3, DCD Tier 2.

B. The AFWST level used to provide the alarm in the MCR alerting operators to switchover to an alternate water source is designed at a level of 4 ft 3 in from the bottom of tank and the AFW empty alarm is located at a level of 3 ft 1 in from the bottom of tank.

The reserved AFW volume from minimum AFW level to the empty alarm level of each AFWST is 421,911 gallons, even though the minimum dedicated AFW capacity is 400,000 gallons. The reserved volume from the level requiring operator action to empty is 22,063 gallons. Therefore, the level requiring operator action is appropriate to meet the minimum dedicated AFW capacity.

Impact on DCD

There is no impact on the DCD.

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 Report.

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Question No. 10.04.09-2

10 CFR 50.63, “Loss of all alternating current power,” requires that the design must be able to withstand for a specified duration and recover from a station blackout.

DCD Tier 2, Section 10.4.9.3 indicates that the turbine-driven auxiliary feedwater (TDAFW) pump is relied on in the event of a station blackout or an extended loss of AC power (ELAP). The TDAFW pumps are housed in the TDAFW pump rooms, along with their associated support and control systems. The TDAFW pumps are classified as safety-related; however the TDAFW pump room cooling system is not classified as safety-related. The AFW pump room is identified as being “mild” and is not an area serviced by safety-related cooling. Operation of the TDAFW pump may result in substantial heat generation in the room which would result in elevated room temperatures when room cooling is not available. Since the TDAFW pump rooms contain equipment used to respond to station blackout or ELAPs, there will be substantial heat generation in the AFW pump room, and no operational heat removal systems will be available during these events, reasonable assurance of TDAFW pump room equipment operability should be provided.

A. The applicant is requested to provide the EQ room temperature envelope for the TDAFW pump room, showing both the calculated transient room temperature, and the EQ envelope temperature.

B. The applicant is requested to provide documentation in the DCD to support the determination that, in the event of a station blackout, there is reasonable assurance of TDAFW pump room equipment operability for both mechanical and electrical equipment. The applicant is requested to also include documentation on the turbine control system environmental qualification that justifies why TDAFW pumps will

continue to operate stably for the duration for which they are credited after loss of all room cooling).

C. The applicant is requested to identify if access to the TDAFW pump room may be required by operators at the start or during TDAFW operation and, if so, discuss if any restriction to access the area will result due to room heatup during the loss of TDAFW room cooling.

Response

A. The EQ envelope temperature of the TDAFW pump room in an abnormal condition in which room cooling is not available is 160 ºF for 24 hours. This value will be used by the COL applicant as one of the environmental design requirements to purchase the TDAFW pump. The calculated transient room temperature is 133 ºF for 24 hours.

B. In the event of a station blackout, the EQ envelope temperature is 160℉ for 24 hours.

Therefore, TDAFWP operability may be assured for 24 hours, which is longer than the Class 1E battery power duration of 16 hours for the turbine governor speed control.

DCD Tier 2, Subsection 10.4.9.3 states that “An adequate safety-related water supply, designed to seismic Category I, is available to allow the plant to remain at hot standby for 8 hours followed by an orderly cooldown to shutdown cooling system entry condition within 6 hours, in conformance with BTP 5-4 (Reference 36)” and also states the basis for 400,000 gal of dedicated AFW in each mechanical division.

In addition, DCD Tier 2, Subsection 10.4.9.3 states that “In the event of a station blackout, the turbine-driven pump lines provided with battery-backed power are capable of providing auxiliary feedwater to the SGs coincident with a single failure for 16 hours. Battery-backed power is also available to the turbine governor speed control.” An AAC source of standby power is provided for the operation of the motor-driven AFW pump lines during an extended SBO.”

C. DCD Tier 2, Subsection 10.4.9.2.4 states that “At the low water level setpoint of the SG, the AFAS from the ESFAS and DPS actuates the AFWS as follows:

b. De-energizes the solenoid to open the associated turbine steam isolation bypass valve

c. Starts associated turbine-driven pump by de-energizing the solenoid to open the associated turbine steam isolation valve”

The TDAFW pump is automatically started on receipt of AFAS or DPS-AFAS. Therefore, operators will not need access to the TDAFW pump room at the start of or during TDAFW operation.

Impact on DCD

There is no impact on the DCD.

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 Report.

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Question No. 10.04.09-3

In accordance with SRP 10.4.9 Section III, Item 3, the AFWS design should have features to meet the generic recommendations of NUREG-0611 and NUREG-0635. Generic Short Term Recommendation No. 6 (GS-6) recommends confirmation of availability of an AFW flow path that has been taken out of service to perform periodic testing or maintenance, including Technical Specification requirements and procedures that require an operator to verify proper alignment of the flow path. These procedures should include an independent check by a second operator to verify the flow path alignment.

The staff could not find a specific commitment that the COL applicant would develop procedures that specifically require confirmation of the availability of an AFW flow path that has been previously taken out of service to perform periodic testing or maintenance, including independent verification by a second operator.

The applicant is requested to identify the procedure that demonstrates how the AFWS design meets Generic Short Term Recommendation No. 6 (GS-6) listed in NUREG-0611 and NUREG-0635. The applicant is to provide a DCD markup of this response.

Response

DCD Tier 2, Subsection 10.4.9.4.1 will be revised as follows:

Current description: N/A

Revised description: The COL applicant is to develop procedures to perform periodic testing or maintenance, including independent verification in accordance with NUREG-0635 (COL 10.4(10))

Impact on DCD

DCD Tier 2, Subsections 10.4.9.4.1 and 10.4.11 and Table 1.8-2 (17 of 29) will be revised as indicated on the attached markup.

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 Report.

designed and installed for inservice inspections and tests in accordance with ASME Section XI (Reference 23).

10.4.9.4.1 Auxiliary Feedwater Performance Tests

Testing of the AFWS is conducted in accordance with Subsection 14.2.12.

The COL applicant is to develop procedures to perform periodic testing or maintenance, including independent verification in accordance with NUREG-0635 (COL 10.4(10)).

10.4.9.4.2 Reliability Tests and Inspections

a. System-level tests

Following completion of installation, and prior to initial startup, the entire AFWS is hydrostatically tested in accordance with the requirements of ASME Section III. After the plant is brought into operation, periodic tests and inspections of the AFWS components and subsystems are performed in accordance with Technical Specifications to provide assurance of proper operation.

The scheduled tests and inspections are necessary to verify system operability, since during normal plant operation, the AFWS components are aligned for emergency operation and serve no other function. The tests defined permit a complete checking at the component level during normal plant operation. Satisfactory operability of the complete system can be verified during a normal scheduled refueling shutdown. The complete schedule of tests and inspections of the AFWS is detailed in Chapter 16.

b. Component tests

In addition to the system-level tests, tests to verify proper operation of the AFWS components are also conducted. These tests supplement the system-level tests by verifying acceptable performance of each active component in the AFWS. Pumps and valves are tested in accordance with ASME OM (Reference 25). A full-flow test line is provided so that the pumps can be performance-tested after maintenance at various flow rates up to and including the design point.

COL 10.4(9) The COL applicant is to determine the wet bulb temperature correction factor to account for potential interference and recirculation effects.

COL 10.4(10) The COL applicant is to develop procedures to perform periodic testing or maintenance, including independent verification in accordance with NUREG-0635.

10.4.12 References

1. HEI "Standards for Steam Surface Condensers," 9th Edition, Heat Exchanger Institute, 2006.

2. NRC RG 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," Rev. 4, U.S. Nuclear Regulatory Commission, March 2007.

3. NRC RG 1.28, "Quality Assurance Program Criteria (Design and Construction)," Rev. 4, U.S. Nuclear Regulatory Commission, June 2010.

4. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, the 2007 Edition with 2008 Addenda.

5. ASME B31.1, "Power Piping," The American Society of Mechanical Engineers, 2010.

6. NUREG-0800, Standard Review Plan, Section 10.4.2, "Main Condenser Evacuation System," Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

7. 10 CFR 20.1406, "Radiological Criteria for Unrestricted Use," U.S. Nuclear Regulatory Commission.

8. NRC RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning," U.S. Nuclear Regulatory Commission, June 2008.

9. HEI "Performance Standards for Liquid Ring Vacuum Pumps," 3rd Edition, Heat Exchange Institute, 2005.

10. ASME B16.34, "Valves-Flanged, Threaded, and Welding End," The American Society of Mechanical Engineers, 2009.

11. ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," The American Society of Mechanical Engineers, 2010.

Table 1.8-2 (17 of 29)

Item No.	Description
COL 10.4(1)	The COL applicant is to establish operational procedures and maintenance programs for leak detection and contamination control
COL 10.4(2)	The COL applicant is to maintain the complete documentation of system design, construction, design modifications, field changes, and operations
COL 10.4(3)	The COL applicant is to provide the location and design of the cooling tower, basin, and CW pump house
COL 10.4(4)	The COL applicant is to provide elevation drawings
COL 10.4(5)	The COL applicant is to address the design features for the prevention of contamination
COL 10.4(6)	The COL applicant is to provide operating and maintenance procedures for the following items in accordance with NUREG-0927 and a milestone schedule for implementation of the procedures.
COL 10.4(7)	The COL applicant is to describe the nitrogen or equivalent system design for SG drain
COL 10.4(8)	The COL applicant is to prepare the Site Radiological Environmental Monitoring Program
COL 10.4(9)	The COL applicant is to determine the wet bulb temperature correction factor to account for potential interference and recirculation effects
COL 11.2(1)	The COL applicant is to prepare the site-specific ODCM in accordance with NEI 07-09A.
COL 11.2(2)	The COL applicant is to prepare operational procedures and programs related to operations, inspection, calibration, and maintenance of the contamination control program.
COL 11.2(3)	The COL applicant is to determine whether contaminated laundry is sent to an offsite facility for cleaning or for disposal.
COL 11.2(4)	The COL applicant is to prepare and provide the P&IDs.
COL 11.2(5)	The COL applicant is to perform a site-specific cost-benefit analysis following the guidance in the regulatory requirements of NRC RG 1.110.
COL 11.2(6)	The COL applicant is to provide reasonable assurance that the mobile or temporary equipment and interconnections to plant systems conform with the regulatory requirements and guidance of 10 CFR 50.34a, 10 CFR 20.1406, NRC RG 1.143, and ANSI/ANS 40.37.
COL 11.2(7)	The COL applicant is to develop the procedure for the collection and shipment of mixed wastes, if and when they are generated, for offsite treatment. The generation of mixed liquid wastes is minimized by process control and the controlled use of hazardous chemicals.
COL 11.2(8)	The COL applicant is to develop the interface design and provide the site-specific information for the LWMS effluent discharge, including radioactive release points, effluent temperature, the design (type, shape, and size) of flow orifices, and the sampling requirements following the guidance of NRC RG 1.21 and RG 4.15 and the standards incorporated therein by reference.
COL 10.4(10)	The COL applicant is to develop procedures to perform periodic testing or maintenance, including independent verification in accordance with NUREG-0635.

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Question No. 10.04.09-5

NRC IE Bulletin IEB 88-04, “Potential Safety-Related Pump Loss,” discusses, in part, pump minimum flow requirements as they relate not only to pump cooling due to fluid temperature rise, but also to hydraulic instability due to insufficient minimum flow, resulting in pump cavitation and potential damage of the impeller. This bulletin recommends that the limitations associated with these hydraulic phenomena be considered when specifying minimum flow capacity.

The staff reviewed DCD Tier 2, Section 10.4.9.1.2 of the DCD and found that the design included provisions to provide recirculation flow for AFWS pumps. In DCD Section 10.4.9.1.2 it is stated that flow recirculation is provided downstream of each pump discharge to allow for (a) A continuous recirculation of the AFWST for pump, (b) Full or minimum recirculation flow testing of the pump. The pump recirculation lines discharge recirculation water back into the AFWSTs. There does not appear to be a discussion in DCD about pump minimum flow requirements as addressed in NRC IE Bulletin IEB 88-04.

The applicant is requested to demonstrate how the AFWS design meets the pump minimum flow requirements listed in NRC IE Bulletin IEB 88-04, “Potential Safety-Related Pump Loss.” The applicant is also requested to clarify item (a) on page 10.4-77 of the DCD. The applicant is to provide a DCD markup of this response.

Response

NRC IE Bulletin IEB 88-04, “Potential Safety-Related Pump Loss” describes two miniflow design concerns as follows:

- “The first concern involves the potential for the dead-heading of one or more pumps in safety-related systems that have a miniflow line common to two or more pumps or

other piping configurations that do not preclude pump-to-pump interaction during miniflow operation.

- A second concern is whether or not the installed miniflow capacity is adequate for even a single pump in operation."

DCD Tier 2, Figure 10.4.9-1 (1 & 2 of 3) shows that each AFW pump has an independent miniflow line. Therefore, the AFWS does not preclude pump-to-pump interaction during miniflow operation.

DCD Tier 2, Subsection 10.4.9.2.2.1 states that "The recirculation lines are adequately sized so that full pump flow can be recirculated through the bypass provided around the flow restrictive orifice for full flow pump testing during power operation."

DCD Tier 2, Subsection 10.4.9.2.1, item (a) on page 10.4-77 will be revised as follows:

Current description: a. A continuous recirculation to the AFWST for pump

Revised description: a. A continuous minimum recirculation flow to the AFWST for pump

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Impact on DCD

DCD Tier 2, Subsections 10.4.9.2.1 will be revised as indicated on the attached markup.

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 Report.

isolation valve is provided for each AFWST to provide separation. The line connected to non-safety sources can be manually aligned for gravity feed to either AFW pump suction if the AFWSTs reach low levels before shutdown cooling system entry conditions are reached.

A flow recirculation line is provided downstream of each pump discharge to allow for the following:

a. A continuous ~~recirculation~~ minimum recirculation flow to the AFWST for pump

b. Full or minimum recirculation flow testing of the pumps

A multi-stage flow-restrictive orifice restricts the flow to the minimum required for pump protection.

A non-condensing AFW pump turbine with an atmospheric discharge line is provided for each turbine-driven pump. Each turbine is supplied with the driving steam from its respective SG upstream of the main steam isolation valves (MSIVs) in the main steam system. Each supply line contains an air-operated steam isolation valve.

The turbine exhaust steam is discharged to atmosphere through a seismic Category I vent line routed through the roof.

Portable pump connections is provided at each turbine-driven pump suction and discharge line. The piping section connected at the AFW supply lines is designed as safety Class 3, seismic Category I. The piping section downstream of the isolation valve at the exterior of the auxiliary building up to the connector is designed as non-safety Class, seismic Category I.

10.4.9.2.2 Component Description

A summary of design parameters and codes for the major AFWS components is given in Table 10.4.9-1.