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.:	**443-8555**
SRP Section:	**05.04.01 – Reactor Coolant Pumps**
Application Section:	**5.4.1**
Date of RAI Issue:	**03/15/2016**

Question No. 05.04-2

This is a follow-up to RAI 307-7835, Question 5.4-1 based on the response letter dated 1/7/2016.

The staff considered the responses to Items 5 and 7 incomplete for the following reasons:

1. In RAI 307-7835, the staff raised, in part, the following issue for Item 5:

   DCD Subsection 5.4.1.2 states "If there is a simultaneous loss of CCW to all RCP and motor bearing assemblies but seal injection water is available to the seals, the RCP can operate for at least 30 minutes without bearing seizure, which could affect normal RCP coastdown."

   DCD Subsection 9.2.2 identifies RCP pump/motor oil coolers and the charging pump mini-flow heat exchanger as nonessential components supported by the Division I CCW pump.

   Based on the above descriptions, a failure of the Division I CCW pump will affect both the charging pump and the RCP pump/motor bearings. Therefore, the staff questions the availability of seal injection water during the stated 30-minute period. The applicant is requested to provide more detail on the following:

   a) Since the CCWS provides cooling water to both the CVCS (charging pump mini flow heat exchangers) and oil coolers for the RCP pump/motor bearings, explain what is meant by loss of CCW, and

   b) If "loss of CCW" includes cooling flow to CVCS, explain how seal injection flow to the RCPs will not be affected for "up to 30 minutes" to prevent seal damage.

In the response, the applicant stated "[T]he seal injection flow is provided by one of two charging pumps or an auxiliary charging pump of CVCS as described in DCD Subsections 5.4.1.2, 9.2.2.3, and 9.3.4.2. The auxiliary charging pump provides diverse means of seal injection when the normal means by the charging pump are unavailable. The operation of the auxiliary charging pump is not affected by loss of CCW whereas the charging pump is affected by improper function of the charging pump mini flow heat exchangers due to loss of CCW. If loss of CCW prevents the charging pump from proper operating, the seal injection flow to the RCP can be supplied by the auxiliary charging pump to prevent seal damage."

According to the CVCS description in DCD Subsection 9.3.4.2, the staff understands that the auxiliary charging pump can only be started manually by the plant operator, and therefore will not be able to provide the seal injection water to the RCPs within 30 minutes after a loss of CCW to all RCP coolers. The applicant is requested to provide further clarification regarding RCP seal injection during this 30-minute period, and revise the DCD accordingly.

2. In RAI 307-7835, the staff raised, in part, the following issue for Item 7:

   In DCD Subsection 5.4.1.2, the applicant states “As the seal is intended to withstand adverse SBO conditions, it is verified by a robust test program." The applicant is requested to provide a summary of the test results in DCD Section 5.4.1, and a reference to the document that describes this program.

   In the response, the applicant stated "[T]he planning and execution of the seal tests is now in progress so that any documented information for the tests is currently not available. Test results are considered proprietary for the seal supplier and inappropriate to be included or referred in DCD. However, after the tests have been completed, available information will be uploaded to ERR for NRC review. Incorporating a general summary of tests into DCD will be considered in the future."

   The applicant is requested to upload the above mentioned test results to ERR when they are available for the staff review and revise the DCD to incorporate a summary of these tests as stated in the response.

Response

1. Even in case of a loss of CCW to the reactor coolant pump and Chemical and Volume Control System (CVCS), the seal injection water is available and is precooled such that the controlled leakage seals can perform as designed without the further cooling capacity of the high pressure seal cooler. As indicated in the response to RAI 307-7835, the auxiliary charging pump that is not affected by loss of CCW can provide diverse means of seal injection when the normal means by the charging pump are unavailable.

   The operation of charging pump itself is not affected by CCW because the motor is air-cooling. The charging pumps are not required to be shut-down by loss of CCW. The heat load generated in the charging pump is cooled by mini-flow heat exchanger. The adverse effect of heat accumulation by the improper function of the charging pump mini-flow heat exchangers due to loss of CCW would be limited during the 30-minute period so that an immediate operator action is not required to manually switch over to the auxiliary charging pump.

In addition to losses of CCW to RCP high pressure seal cooler and the charging pump mini-flow heat exchanger, the loss of letdown may occur as a result of loss of CCW to the letdown heat exchanger and source for suction of charging pump is automatically changed to the boric acid storage tank (BAST) of which normal operating temperature is 60 ~ 120 °F.

2. The seal test has been completed and a summary of the test results is incorporated in the report, APR1400-A-M-NR-14002-P (WCAP-17925-P), “Extended Loss of AC Power Capability for APR1400 KSB RCP Seals”, Revision 1 (to be available at ERR by May 14 2016). The relevant paragraph in DCD Subsection 5.4.1.2 will be revised.

Impact on DCD

DCD Subsection 5.4.1.2 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

The Technical Report, APR1400-A-M-NR-14002-P, Revision 0, “Extended Loss of AC Power Capability for APR1400 KSB RCP Seals” is revised.

An acoustic leak sensor is provided on the shaft seal housing for use in detecting leakage coming through in the vapor seal of the pump. A description of the acoustic leak monitoring system (ALMS) is provided in Subsection 7.7.1.5

The need for improved station blackout (SBO) performance has led to selected improvements in the design of the seal. The seal uses an enhanced manufacturing process and improved composition of elastomer materials to provide high temperature seal performance at 300 ^{o}C (572 ^{o}F) and 163.1 kg/cm²G (2,320 psig). Key materials used in the seals are silicon carbide/graphite compound material for the glide rings (primary seals) and specially treated (high-temperature-resistant) ethylene propylene diene monomer (EPDM) elastomers (secondary seals). Both materials are capable of withstanding long-term exposure to a high temperature and pressure environment. Seal dimensions and normal operational characteristics are basically unchanged from those in pump assemblies in existing operating plants. As the seal is intended to withstand adverse SBO conditions, it is verified by a robust test program.

which focuses on demonstrating the ability of the seal to survive a long term SBO event and represents simulation of a SBO event lasting up to 72 hours with and without isolation of the controlled leakage and a test regimen to investigate seal performance under low subcooling conditions. The test results are summarized in "Extended Loss of AC Power Capability for APR1400 KSB RCP Seals" (Reference 6).

The motor is sized fo[r] ... pump operation with ... start and accelerate t... voltage at the motor t...

Each RCP motor is equipped with two air-to-water heat exchangers such that the temperature of motor cooling outlet air discharged to the containment is less than the maximum containment ambient temperature. Electrical insulation of the motor is suitable for a high humidity and high radiation environment.

Each motor is provided with an anti-reverse rotation device. The device is designed to prevent impeller rotation in the reverse direction, assuming each of the following two conditions: (1) motor starting torque if the motor was incorrectly wired for reverse rotation and (2) reactor coolant flow through the pump in the reverse direction due to the largest pipe break remaining after the application of leak before break as described in Subsection 3.6.3.

The RCP assembly is equipped with an oil collection system to collect oil leakage. The oil collection system is capable of collecting lube oil from all potential pressurized and

COL 5.4(5) The COL applicant is to verify the as-built RV support material properties and 60-year neutron fluence.

5.4.17 References

1. 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 the 2008 Addenda.

2. 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants." U.S. Nuclear Regulatory Commission.

3. Regulatory Guide 1.14, "Reactor Coolant Pump Flywheel Integrity," Rev. 1, U.S. Nuclear Regulatory Commission, August 1975.

4. APR1400-A-M-NR-14001-P, "KHNP APR1400 Flywheel Integrity Report," KHNP, November 2014.

5. 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.

6. APR1400-A-M-NR-14002-P , "Extended Loss of AC Power Capability for APR1400 KSB RCP Seals", Rev. 1, KHNP, May 2016.

7. ~~6.~~ ASME PTC 8.2, "Centrifugal Pumps," The American Society of Mechanical Engineers, 1990.

8. ~~7.~~ NEMA MG-1, "Motors and Generators," National Electrical Manufacturers Association, 2009 (with 2010 Revision 1).

9. ~~8.~~ Regulatory Guide 1.121, "Bases for Plugging Degraded PWR Steam Generator Tubes," Revision 0, U.S. Nuclear Regulatory Commission, August 1976.

10. ~~9.~~ ASME Section III, Appendix N, "Dynamic Analysis Methods," The American Society of Mechanical Engineers, the 2007 Edition with the 2008 Addenda.

11. ~~10.~~ Bulletin 79-13, "Cracking in Feedwater System Piping," Rev. 1, U.S. Nuclear Regulatory Commission, August 30, 1979.

12. ~~11.~~ NEI 97-06, "Steam Generator Program Guidelines," Rev. 3, Nuclear Energy Institute, January 2011.

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