MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

April 19, 2013

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-13095

Subject: **MHI's Amended Response to US-APWR DCD RAI No. 760-5576 Revision 0 (SRP Section 09.02.02)**

References:
1) "Request for Additional Information No. 760-5576 Revision 0, SRP Section: 09.02.02 – Reactor Auxiliary Cooling Water Systems – Application Section: 09.02.02" dated May 24, 2011.
2) MHI Letter No. UAP-HF-12043, "MHI's Response to US-APWR DCD RAI No. 760-5576 Revision 0 (SRPSection 09.02.02)", dated February 15, 2012 (ML12048A098).

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Amended Response to Request for Additional Information No. 760-5576 Revision 0". In Reference 2, MHI provided the original response to Question 09.02.02-82 contained in Reference 1.

Enclosed is the amended response to Question 09.02.02-82. This response is submitted to amend Table 5.4.1-2 in the DCD mark-up included in Attachment 2 of the response submitted in Reference 2. The other parts of the response are not changed. The amended response supersedes the previous response in its entirety.

As indicated in the enclosed materials, this document contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. A non-proprietary version of the document is also being submitted with the information identified as proprietary redacted and replaced by the designation "[ ]".

This letter includes a copy of the proprietary version (Enclosure 2), a copy of the non-proprietary version (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all materials designated as "Proprietary" in Enclosure 2 be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

Please contact Mr. Joseph Tapia, General Manager of Licensing Department, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

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NRO

Sincerely,

Y. Ogata

Yoshiki Ogata,
Executive Vice President
Mitsubishi Nuclear Energy Systems, Inc.
On behalf of Mitsubishi Heavy Industries, LTD.

Enclosures:

1. Affidavit of Yoshiki Ogata
2. Amended Response to Request for Additional Information No. 760-5576 Revision 0 (Proprietary version)
3. Amended Response to Request for Additional Information No. 760-5576 Revision 0 (Non-proprietary version)

CC: J. A. Ciocco
J. Tapia

Contact Information
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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-13095

MITSUBISHI HEAVY INDUSTRIES, LTD.
AFFIDAVIT

I, Yoshiki Ogata, state as follows:

1. I am Executive Vice President of Mitsubishi Nuclear Energy Systems, Inc., and have been delegated the function of reviewing MITSUBISHI HEAVY INDUSTRIES, LTD's ("MHI") US-APWR documentation to determine whether it contains information that should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4)as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled Amended Response to US-APWR DCD RAI No. 760-5576 Revision 0 (SRP Section 09.02.02) dated April 2013, and have determined that portions of the document contain proprietary information that should be withheld from public disclosure. Those pages containing proprietary information are identified with the label "Proprietary" on the top of the page and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The information identified as proprietary in the enclosed document has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the unique design of the RCP seal developed by MHI and not used in the exact form by any of MHI's competitors. This information was developed at significant cost to MHI, since it required the performance of Research and Development and detailed design for its software and hardware extending over several years.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market:

A. Loss of competitive advantage due to the costs associated with development and testing of the Reactor Coolant Pump. Providing public access to such information permits competitors to duplicate or mimic the Reactor Coolant Pump design without incurring the associated costs.

B. Loss of competitive advantage of the US-APWR created by benefits of enhanced plant safety, and reduced operation and maintenance costs associated with the Reactor Coolant Pump.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed on this 19th day of April, 2013.

Y. Ogata

Yoshiki Ogata,
Executive Vice President
Mitsubishi Nuclear Energy Systems, Inc.

Enclosure 3

UAP-HF-13095
Docket No. 52-021

Amended Response to Request for Additional Information
No. 760-5576 Revision 0

April 2013
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

4/19/2013

US-APWR Design Certification

Mitsubishi Heavy Industries, Ltd.

Docket No. 52-021

RAI NO.: **NO. 760-5576 REVISION 0**

SRP SECTION: **SRP SECTION: 09.02.02 - REACTOR AUXILIARY COOLING WATER SYSTEMS**

APPLICATION SECTION: 9.2.2

QUESTION FOR BALANCE OF PLANT BRANCH 1 (AP1000/EPR PROJECTS) (SBPA)

DATE OF RAI ISSUE: 5/24/2011

QUESTION NO.: 09.02.02-82

Follow-up to RAI 362-2278, question 09.02.02-34 and RAI 571-4365 question 09.02.02-58. This is also related to RAI 148-1700, question 19-273.
The staff is unable to perform an adequate review for several Standard Review Plan (SRP) sections related to the reactor cooling pump (RCP) seals which include:
· SRP 5.4 - Reactor Coolant System Component and Subsystem Design
· SRP 8.4 - Station Blackout (SBO)
· SRP 9.2.2 - Reactor Auxiliary Cooling Water Systems
· SRP 9.3.4 - Chemical and Volume Control System (PWR) (Including Boron Recovery System)
Information described in the US-APWR Design Control Document Revision 2 related to RCP seals states that:

- Tier 2, DCD 1.2.1.5.2.3, "Reactor Coolant Pumps," Leakage along the RCP shaft is normally controlled by three shaft seals, arranged in series so that any reactor coolant leakage to the containment is essentially zero.
- Tier 2, DCD 5.4.1.3.1, "Design Description," the seal section consists of three seals. The first is the hydrostatic seal; the second and third are mechanical seals. The No. 2 and No. 3 seals are assembled in a cartridge. These three seals prevent release of reactor coolant to the atmosphere.
- Tier 2, DCD 5.4.1.3.3, "Loss of Seal Injection," loss of injection water flow may be detected with a flow meter at the seal injection line. This condition will normally lead to an increase in seal and bearing inlet temperature and an increase in the No. 1 seal leak rate because reactor coolant flow into the RCP seals. Under these conditions, however, the CCW continues to provide flow to the thermal barrier heat exchanger; which cools the reactor coolant. The pump is therefore able to maintain safe operating temperatures and operate safely long enough for safe shutdown of the pump.
- Tier 2, DCD 5.4.1.3.4, "Loss of Component Cooling Water," if loss of CCW should occur, seal injection flow continues to be provided to the RCP. The pump is designed so that the seal injection flow is sufficient to prevent damage to the seals with a loss of thermal barrier

cooling.

- Tier 2, DCD 5.4.1.4.1, "Pump Performance," ....If LOOP occurs, injection flow to the pump seals and CCW to thermal barrier and motor stops. Standby power sources are automatically triggered by LOOP so that CCW flow and seal injection flow are automatically restored. The RCP seal integrity during station blackout (SBO) is discussed in Section 8.4. · Tier 2, DCD 8.4.2.1.2, "Station Blackout Coping Analysis," (2) RCP seal, RCP seal can keep its integrity for at least one hour without water cooling. There is no LOCA considered in this condition.
- Tier 2, DCD 9.2.2.3.5, RCP Seal Protection," even in the event that the CCW to RCP is isolated by a containment spray actuation signal and the seal water injection from the CVCS is also lost, the containment isolation valves on the CCW supply and return lines can be manually reopened from the MCR to restore RCP seal cooling. As shown in Table 9.2.2-3, the CCWS is designed to restore CCW supply to the RCP thermal barrier HX, assuming any single failure. To resupply water to the thermal barrier after the isolation of the containment vessel during an accident, the cooling water for the thermal barrier is ensured by opening NCS-MOV-445A/B, NCS-MOV-447A/B, and NCS-MOV-448A/B.
- Tier 2, DCD 9.3.4.1.2.4, "Reactor Coolant Pump Seal Water Injection," the CVCS continuously supplies seal water to the reactor coolant pump seals, as required by the reactor coolant pump design. The seal water flow requirement is specified in Table 9.3.4-2. During a SBO, the reactor coolant pumps seal integrity is maintained until the charging pumps are powered from an alternate power source and seal water injection restarts.
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Specifically, MHI should address the following items:

1. The guidance of SRP 9.2.2, Section II. "Acceptance Criteria", Item 4. D which states:
"Remote manual isolation of the RCP seal coolant water by the main control room operator for continued long-term pump operation in an actual event". In addition, SRP 9.2.2. Section III, "Review Procedure," Item 4.F. states: "Design provisions are made for isolation of component cooling water supply and return lines to the RCP by remote manual means only". Since the MHI CCWS design does not follow the guidance of this SRP, justification is needed in the DCD. This justification will need to be expanded to include other DCD sections as stated above.

2. Based on the November 29, 2010, Advisory Committee on Reactor Safeguards US-APWR Subcommittee Meeting, it was stated by MHI that testing has not occurred related the RCP seals during station blackout. MHI stated the since the #1 seal leak-off is stopped and the #2 seal becomes the reactor coolant boundary and the leakage is 0.2 gpm for the SBO case. Based on ACRS and MHI discussions, the assumed seal leakage based on NUMARK 87-00, "Guidance and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors," of 25 gpm is not exceeded; however, this leakage of 0.2 gpm is not described in the DCD. This information should be added to the DCD.

3. The details of the seal design are not described in the DCD and should be included in the DCD (various sections).

4. Operating experience has not been provided to the staff related to the proposed RCP seal design. If available, provide a summary of operating experience in the RAI response.

5. A Topical Report for the RCP seal design has not been provided to the staff regarding seal testing to support the three seal design and to support the 0.2 gpm seal flow rate during SBO. This information should be provided to the staff.

6. The applicant's response to RAI 148-1700, question 19-273 needs to be modified, as discussed below:
a. The portion of the response that states that each RCP seals leaks 0.17 gpm between 0 and 60 minutes during the SBO should be added to the DCD.
b. The portion of the response that states that each RCP seal will leak at 480 gpm post SBO should be added to the DCD.
c. RCP seal testing should be described in the topical report (in item 5 above) to confirm the heatup calculations described in this RAI response.
d. DCD Tier 1 should be revised to add a new ITAAC to verify the seal design and leakage requirements with no cooling water described in this RAI response.

ANSWER:

Question: 1)
In an amended response to RAI 571-4365 Q9.2.2-58, MHI will remove the automatic isolation feature of the RCP thermal barriers as described in DCD Revision 3. Affected DCD sections will be revised and DCD markups included in the amended RAI response. The amended response has been submitted as UAP-HF-11237.

Question: 2) A description of RCP leakage of 0.2 gpm during SBO will be added to DCD 5.4.1.4.9 and the cross-reference will be added to DCD 8.4.2.1.2 (2).

Question: 3) RCP seal design and function will be described in DCD 5.4.1.3.1, 5.4.1.4.1 and 5.4.1.4.9.

Question: 4) MHI has supplied RCP seals to over 30 RCPs in Japan continually for over 30 years. Some examples are provided in Tier 2, DCD 1.9.4.3. No. 1 seal leak-off rate, which shows the rate of seal water passing through the No. 1 seal, fluctuates within the allowable range, and the fluctuation range has drastically narrowed by seal improvements. The seal assembly keeps stable behaviour and good condition. Therefore, there have been no cases in Japanese operating experience of a plant shutdown caused by exceeding the seal water return flow alarm setpoint.

Question: 5) RCP seal design and behavior during SBO are described in response to Question 3 and a prior response to RAI 148-1700, Question 19-273.

The RCP No. 2 seal is designed to limit the leakage less than 0.2 gpm even in SBO condition as described in response to Question 3. To confirm the performance, unit tests were conducted in which the No. 2 seal was subjected to normal RCS operating pressure of 2235 psig and representative water temperature of 149 °F. The test apparatus did not include the No. 1 seal, so that the full fluid pressure was seen by the No. 2 seal. RCP motor rotation was slowed from design rated speed to zero in 5 minutes and held at zero for one hour in order to simulate SBO conditions. During these tests, No. 2 seal measured leak rate was less than 0.2 gpm when the rotor was at operating speed (shorter than 5 minutes) and less than 0.1 gpm at zero speed. The maximum water temperature of 223.2 °F comparing to the upper limit temperature of 235.4 °F of a heat non-resident O-ring was calculated based on the constant leakage of 0.2 gpm during one hour in the prior response to RAI 148-1700, Question 19-273. However, the measured leakage was much less especially after the rotation stopped. Moreover, the calculation in the prior response to RAI 148-1700 did not include heat release to the atmosphere. Therefore, the more realistic maximum temperature during the one hour is thought to be much lower than 223.2 °F. And the water temperature at the beginning of SBO is 130 °F. So the representative temperature during the one hour used in the test was set at 149 °F. Attachment 1 provides a brief description of seal testing. A separate Topical Report is not planned.

Additionally, MHI conducted RCP No. 2 seal leak rate tests for 30 minutes with production seals in use at Japanese PWR plants. During these tests, rotor speeds were kept at rated speeds and RCS normal operating pressure and seal water representative temperature were applied. The test apparatus also did not include the No. 1 seal. Leak rates were confirmed to keep almost constant values less than 0.2 gpm. The US-APWR reactor coolant pump is conservatively designed and seal flow is rated at 0.2 gpm based on these test results from Japanese PWR plants.

MHI will perform an RCP No.2 seal type-test under RCS normal operating pressure and simulated SBO conditions for each new production seal model, and confirm that the No. 2 seal can limit the leakage less than 0.2 gpm for 60 minutes. These test criteria will be added to DCD 5.4.1.4.9. Also, each RCP seal will be tested prior to shipment for use in an operating plant.

Question: 6a)

Statement that each RCP seals leaks 0.2 gpm between 0 and 60 minutes during the SBO will be added to the DCD Chapter 19.

Question: 6b)

Since the leak rate after the RCS seal has degraded is uncertain, PRA conservatively applies the maximum leak rate of the old O-ring model. The leak rate is 480 gpm per RCP after 60 minutes from the SBO. The leak rate will be described in DCD Chapter 19.

Question: 6c) Please see the response to Question 5.

Question: 6d) As described in response to Question 5, MHI will perform an RCP No. 2 seal type-test under RCS normal operating pressure and simulated SBO conditions for each production seal model. Seal type-tests will be prerequisite to "RCP Initial Operation Preoperational Test" described by DCD Subsection 14.2.12.1.3. This commitment assures that factory type-tests to verify RCP No. 2 seal performance will be completed prior to initial fuel loading. However, this performance feature is provided specifically to meet beyond design basis SBO conditions and, additionally, represents a level of detail inappropriate for Tier 1. Furthermore, RCP seal design is reasonably expected to change multiple times during US-APWR design life.

Since RCP seal design description and testing do not meet SRP 14.3 screening criteria and since seal design is expected to change during plant design life, US-APWR DCD Tier 1 will not describe RCP seal design and no ITAAC will be provided to verify RCP No. 2 seal leak rate.

Impact on DCD

Following chapters in the DCD Tier 2 will be revised with this RAI response. Concrete descriptions are shown in Attachment 2;

5.4.1.3.1 Design Description

5.4.1.4.1 Pump Performance

5.4.1.4.9 Shaft Seal Leakage

5.4.1.5 Test and Inspection

8.4.2.1.2 Station Blackout Coping Analysis

14.2.12.1.3 RCP Initial Operation Preoperational Test

19.1.4.1.1 Description of the Level 1 PRA for Operations at Power

Table 5.4.1-2 will be added. Table No. in Chapter 5.4 will be renumbered and the list of tables will be changed accordingly. Concrete descriptions are shown in Attachment 2.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical / Topical Report

There is no impact on a Technical / Topical Report.

Attachment1
Brief Description of No. 2 Seal Unit Test

1. Purpose of No. 2 Seal Unit Test

In the US-APWR Plant, the RCP No. 1 seal leak-off line is closed and the RCS total pressure is applied on the No. 2 seal during SBO. Therefore, No. 2 seal unit test was performed to confirm that the RCP seal assembly can limit the seal leak rate during SBO.

2. Test Condition

Pressure:	2235 psig
Temperature:	149 ^{o}F
Fluid:	Pure water

3. Test No. 2 Seal

The design values on the material and dimensions of the test No. 2 seal are exactly the same as those of production No. 2 seals. It is a mechanical seal whose faceplates are made of tungsten carbide for the seal runner and carbon for the seal ring. Representative materials and dimensions are shown in Table 1.

Table 1 Comparison between Test and Production Seal

		Test	Production
Representative Material	Seal Runner	F304 SS, Tungsten Carbide	F304 SS, Tungsten Carbide
	Seal Ring	403 SS, Titanium, Carbon	403 SS, Titanium, Carbon
Representative Dimension	Seal Runner		
	Seal Ring		

4. Apparatus

A schematic of the test apparatus is shown in Figure 1.
The No. 2 seal to be tested is attached on the upper side. No. 1 seal is not equipped at upstream of the No. 2 seal so the total pressure is applied to the No. 2 seal.
The apparatus has its own seal assembly at the lower side.

5. Measurement

No. 2 seal leakage is collected in a graduated cylinder and the leak rate was calculated from the quantity.
Rotation speed, differential pressure between the No. 2 seal and water temperature were also measured during the test.

6. Procedure

SBO condition was simulated in the test. Although AC supply to RCP motors immediately stops at the beginning of SBO, the rotation of the RCP shaft gradually stops because of inertia of a flywheel. In the test the shaft rotation speed was kept at 1200 rpm for the first 1 minute and it was gradually reduced to zero in 5 minutes and kept at zero for one hour.

7. Result

The test result is shown in Figure 2. It was confirmed that the leak rate is less than 0.2 gpm when the rotor is rotating and less than 0.1 gpm after rotor stop.

8. Estimation of Water Temperature at Inlet of No. 2 Seal

In Attachment to answer to RAI No. 148-1700, Question 19-273, the water temperature at the inlet of the No. 2 seal was calculated using the constant leak rate of 88.2 lbm/hr (40 L/hr). To estimate more realistic temperature, the same temperature calculation was conducted using the measured seal leak rate during the No. 2 seal unit test. The calculation method is described in Attachment to answer to RAI No. 148-1700, Question 19-273. The calculated water temperature history at the inlet of the No. 2 seal by mixing is shown in Figure 3. In this calculation, the effect of heat transfer is excluded. The resultant temperature during the first 1 hour is calculated to be 144 °F.

The temperature rise by heat transfer is not affected by the seal leak rate and the value is 22.9 °F as is calculated in Attachment to answer to RAI No. 148-1700, Question 19-273.

Therefore, more realistic water temperature at the inlet of the No. 2 seal is estimated to be 166.9 °F. The algebraic mean temperature of those at the beginning of and 1 hour after SBO is 148.5 °F, and the representative temperature of the No. 2 seal unit test is considered to be appropriate.

Figure 1 Schematic of Test Apparatus

Figure 2 Test Result

Figure 3 Estimated Water Temperature at No. 2 Seal Inlet

TABLES

DCD_09.02.02-82

5.4.1.3 Pump Assembly Description

5.4.1.3.1 Design Description

The RCP is a vertical shaft, single-stage, mixed flow pump with diffuser. The pump assembly is primarily composed of five sections, i.e., the hydraulics, thermal shield, rotating parts and bearing, the seals, and the motor sections. The pump and the motor are joined by rigid coupling.

The hydraulic section contains the casing, impeller, diffuser and suction adaptor. The casing has a suction nozzle at the bottom and a discharge nozzle on the side. The thermal shield section consists of a thermal barrier and heat exchanger. The rotating parts consist of a shaft, coupling, impeller, and spool piece.

The seal section consists of three seals. The first is the hydrostatic seal; the second and third are mechanical seals. The hydrostatic seal is used as the No. 1 seal because of its long life and capability to reduce seal water pressure. The No. 2 and No. 3 seals are assembled in a cartridge. These three seals prevent release of reactor coolant to the atmosphere. DCD_09.02.02-82

The motor section consists of a total enclosed squirrel cage induction motor with a vertical solid shaft, an oil-lubricated, double-acting Kingsbury type thrust bearing, upper and lower oil-lubricated radial guide bearings, and flywheel.

All parts of the pump in contact with the reactor coolant are austenitic stainless steel except for seals, bearings, and special parts. The reactor coolant pressure boundary (RCPB) materials of the RCP are given in Subsection 5.2.3.

5.4.1.3.2 Description of Operation

The impeller delivers the reactor coolant from the suction nozzle to the discharge nozzle and through the diffuser. A suction adapter is provided at the bottom of pump internal to limit leakage of reactor coolant between impeller and casing.

Injection water is supplied to the RCP through a connection on the main flange to help maintain proper operating temperatures. The injection water enters a plenum in the thermal barrier, and then flows in two directions. Downward flow goes to the thermal barrier/heat exchanger and into the RCS. The upward flow goes through the seal and is then bled-off and returned to the chemical and volume control system (CVCS).

The thermal barrier heat exchanger cools the reactor coolant that enters the RCP plenum in the event of loss of injection.

The RCP motor oil-lubricated bearings are of conventional design. The radial bearings are the segmented pad type, and the thrust bearing is a double-acting Kingsbury type.

Component cooling water (CCW) is supplied to the external upper bearing oil cooler and to the integral lower bearing oil cooler. The oil spillage protection system is attached to the RCP motor and is provided to contain and channel lubricating oil to a common collection point.

and/or motors. If CCW flow is lost and cannot be restored within the previously mentioned 10 minutes, the RCPs will be tripped following the reactor trip.

5.4.1.4 Design Evaluation

5.4.1.4.1 Pump Performance

The RCP is designed to maintain the required flow rate. The RCP is tested and hydraulic performance is checked. Initial plant testing confirms total delivery capability.

The RCP motor is tested, without mechanical damage, at over-speeds up to and including 125% of normal speed.

Controlled leakage shaft seals employ a well-established seal system that has been used in many operating plants. The primary components of No. 1 seal include the following: a runner, which rotates with the shaft and a non-rotating seal ring attached to the seal housing, and a seal ring and the seal runner, each of which is equipped with a silicone nitride faceplate clamped holder. The flow path is formed between the interface of the seal ring and seal runner. The seal insert mounted at the seal housing supports the seal ring. The seal ring can move axially on the seal insert to follow the seal runner. The No. 1 seal gap is controlled by the surrounding water pressure and the static pressure between the seal ring and runner. If the gap widens, the static pressure decreases and the gap is narrowed by the surrounding water pressure. If the gap narrows, the static pressure increases and the gap is widened by the static pressure. The controlled gap is thin and has a high spring ratio. The gap is constantly maintained. DCD_09.02.02-82

No.2 seal is designed and tested to maintain full system pressure for enough time to secure the pump. In the case of No. 1 seal failure, the No. 1 seal leak-off line is automatically closed. If the No. 1 seal fails during normal operation, the No. 2 seal minimizes leakage rates. No. 2 seal is able to withstand full system pressure and the No. 3 seal ensures the backup function. This ensures that leakage into atmosphere would not be excessive. Typical seal parameters are shown in Table 5.4.1-2. DCD_09.02.02-82

If LOOP occurs, injection flow to the pump seals and CCW to thermal barrier and motor stops. Standby power sources are automatically triggered by LOOP so that CCW flow and seal injection flow are automatically restored. The RCP seal integrity during station blackout (SBO) is discussed in Section 8.4.

5.4.1.4.2 Coastdown Capability

Should LOOP occur, the RCP is necessary to provide adequate flow to protect the reactor. The RCP has high rotation inertia due to the flywheel and rotating parts; and it continues to provide reactor coolant during coastdown period. Coastdown capability is maintained during in the worst case scenario, which is when safe shutdown due to earthquake and loss of offsite electrical power occur simultaneously. Coastdown flow and core flow transients are provided in Section 15.3.

The reactor trip system ensures that pump operation does not exceed assumptions used for analyzing loss of coolant flow and also ensures that adequate core cooling is provided to permit an orderly reduction in power if flow from a RCP is lost during operation.

flow leaves the pump via the No. 1 seal leak-off line. Minimal flow passes through the No. 2 seal to its leak-off line. Purge water from a purge water head tank is supplied between the No. 2 and the No. 3 seal to cool them. After cooling the No. 2 and the No. 3 seal, the water enters the CVDT with No. 2 seal leak-off via the standpipe.

Air operated valves are arranged on the No. 1 seal leak-off line. If SBO occurs, these valves close due to an undervoltage signal and the seal flow is limited to less than 0.2 gpm by the No. 2 seal. The seal water flow and CCW flow stops, and RCS water flows up toward the seal assembly. The limited seal flow prevents a sudden temperature rise around the seal assembly. The No. 2 seal performance to limit the leakage less than 0.2 gpm under RCS normal operating pressure and simulated SBO conditions for 60 minutes is confirmed at type-tests for each production seal model as described in Section 14.2.12.1.3. DCD_09.02.02-82

5.4.1.5 Test and Inspection

The design and construction of the RCP is made to comply with the ASME Code, Section III (Ref. 5.4-14). The RCP is designed to allow inspections as stipulated by ASME Code, Section XI (Ref. 5.4-15). Tests and inspections of the RCP are given in Table 5.4.1-~~2~~3. DCD_09.02.02-82

The pump casing with support feet is cast in one piece. Internal parts can be removed from the casing for visual access to the pump casing.

Table 5.4.1-2 Typical Parameters of RCP Seal DCD_09.02.02-82

		No. 1	No. 2	No. 3
Type		Hydrostatic	Mechanical	Mechanical
Differential Pressure during Normal Operation~~ng~~ (psi)		2290 ~ 23~~2~~35	8 ~53	determined by supplier
Representative Material	Seal Runner	~~SUS~~403SS, Silicone Nitride	~~SUS~~F304SS, Tungsten Carbide	Tungsten Carbid~~n~~e
	Seal Ring	~~SUS~~403SS, Silicone Nitride	~~SUS~~403SS, Titanium, Carbon	~~SUS~~F304SS, Carbon

DCD_09.02.02-82 S01

DCD_09.02.02-82 S01

(2) RCP seal

RCP seal can keep its integrity for at least one hour without water cooling as described in Chapter 5.4.1.4.9. There is no LOCA considered in this condition. DCD_09.02.02-82

(3) Integrity of electrical cabinets

Until AAC GTG restores power to the Class 1E power system within one hour after SBO occurs, Class 1E electrical room HVAC system cannot be operated. However, all Class 1E electrical cabinets and I&C cabinets are rated to keep their integrity up to 50°C temperature. The temperature of Class 1E electrical room and I&C room will not reach 50°C within one hour even without HVAC.

3. After AAC GTG has restored power to the Class 1E power system, the following operations will be performed and the plant will be in a safe shutdown condition for the long term:

Function	Action
Reactivity control	Supplying boric acid tank (BAT) water by using charging pump
RCS make up	Supplying water of refueling water auxiliary tank by using charging pump
RCS pressure control	Pressurizing by using pressurizer backup heater and depressurizing by using safety depressurization valve (SDV)
Decay heat removal	Supplying EFW pit water by using T/D EFW pump and Steam relieved by using Main Steam Relief Valve
Cooling of RCP seal	RCP seal injection by using charging pump (Water source is refueling water auxiliary Tank)
Supporting system	I&C, cooling system, HVAC

The plant can be kept in the safe shutdown condition by the above operations performed only on one Class 1E train.

8.4.2.2 Conformance with Regulatory Guidance

The offsite and onsite emergency power supply systems meet 10 CFR 50, Appendix A, GDC 17 and 18 (Reference 8.1-3).

14.2.12.1.3 RCP Initial Operation Preoperational Test

A. Objectives

1. To measure and record system and operating parameters of the RCPs, including seal parameters in the cold condition.

2. To measure and record pump operating parameters, including seal parameters, during hot functional testing.

3. To verify the operation of the associated oil lift pumps.

B. Prerequisites

1. Required construction testing including oil spillage protection system and the seal leakoff is completed.

2. Component testing and instrument calibration including RCP frame vibration, RTD, seal injection flow and CCW flow is completed.

3. Test instrumentation is available and calibrated.

4. Required support systems are available.

5. The CVCS is available to provide seal water to the RCPs.

6. The component cooling water (CCW) system is available for cooling.

7. The RCS is filled, vented, and pressurized.

8. RCP No. 2 seal type test was successfully completed. DCD_09.02.02-82

C. Test Method

1. The RCPs and associated oil lift pumps are operated in the cold condition, and operating data is recorded.

2. The RCPs and associated oil lift pumps are operated during hot functional testing, and operating data, including seal parameters and temperatures at the thermal barrier, motor, motor air cooler and oil coolers, are recorded at various temperature plateaus.

3. Alarms and Interlocks are verified.

D. Acceptance Criteria

1. Alarms and interlocks function as designed.

- Reliability of DAS is assumed to be equal or lower than 0.01 per demand. Complete dependency is assumed between different functions of DAS
- Probability of more than four control rods fail to insert into the core due to mechanical failure assumed as 1.0E-07 per demand
- Application software failure, which results in loss of all trains of signals and operator actions, is assumed to occur 1.0E-05 per demand. DAS is independent from application software failure
- Basic software failure, which is a failure of operation system and result in degradation of all application software, is assumed to occur 1.0E-07 per demand. Basic software failures degrade all signals and operator actions of the digital I&C system. DAS is independent from basic software failure
- US generic data are applied to component unavailability due to test and unplanned maintenance
- Surveillance test interval and refueling outages are consistent with Technical Specifications provided in Chapter 16
- Based on seal testing, RCP seal leakage is up to 0.2 gpm between 0 and 60 minutes after an SBO, but seal integrity is maintained. Thus, the RCP seal is assumed to keep its integrity for one hour without water cooling. An RCP seal LOCA with a leak rate of 480 gpm per RCP is assumed to occur one hour after both thermal barrier and RCP seal injection function is lost. Once RCP seal LOCA occurs, core will be uncovered if RCS makeup injection is absent DCD_09.02.02-82
- In loss of component cooling water events, non-essential chilled water system or FSS provide alternate component cooling water to charging pumps in order maintain RCP seal water injection. Operator action is necessary to supply alternate component cooling water to charging pumps
- If emergency feedwater pumps cannot feed water to two intact SGs, operators will attempt to open the cross tie-line of emergency feedwater pump discharge line in order to feed water to two SGs by one pump
- Motor-driven emergency feedwater pumps require room cooling for operation. On the other hand, turbine-driven emergency feedwater pumps are operable regardless of the availability of room cooling
- Loss of room cooling in ESF pump rooms (CS/RHR pumps and SI pumps) does not degrade the operability of the systems since room temperature increase within the mission time is tolerable
- Common cause failure between emergency power supply systems and alternate ac power supply systems (AAC) are minimized by their design characteristics. Common cause failure of gas turbine generators and circuit breakers do not occur across safety power system and AAC