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August 6, 2012

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-12223

Subject: **MHI's 2nd Amended Response to US-APWR DCD RAI No. 464-3520 Revision 0 (SRP 05.04.07)**

Reference: 1) "Request for Additional Information 464-3520 REVISION 0, SRP Section: 05.04.07 – Residual Heat Removal (RHR) System Application Section: 5.4.7, Questions for Reactor System, Nuclear Performance and Code Review (SRSB)" dated October 6, 2009.
2) MHI Letter UAP-HF-09511, "MHI's Response to US-APWR DCD RAI No.464-3520 Revision 0", dated November 4, 2009.
3) MHI Letter UAP-HF-11353, "Amended MHI's Response to US-APWR DCD RAI No.464-3520 Revision 0", dated October 12, 2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "2nd Amended Response to Request for Additional Information No. 464-3520 Revision 0".

Enclosed is the amended response to Question 05.04.07-11 that is contained within Reference 1. This amended response is submitted to address design features, surveillance requirements, and ITAAC to prevent gas accumulation.

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

Sincerely,

Yoshiki Ogata,
Director - APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

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NRD

Enclosure:

1. 2nd Amended Response to Request for Additional Information No. 464-3520 Revision 0

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Docket No. 52-021
MHI Ref: UAP-HF-12223

Enclosure 1

UAP-HF-12223
Docket No. 52-021

2nd Amended Response to Request for Additional Information No. 464-3520 Revision 0

August 2012

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

8/6/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: NO. 464-3520 REVISION 0

SRP SECTION: 05.04.07 – RESIDUAL HEAT REMOVAL SYSTEM

APPLICATION SECTION: 5.4.7

DATE OF RAI ISSUE: 10/6/2009

QUESTION NO.: 05.04.07-11

Gas accumulation can cause water hammer, gas binding in pumps, and inadvertent relief valve actuation that may damage pumps, valves, piping, and supports and may lead to loss of system operability. Recently, GL 2008-01 (ML080110126) provided past instances of gas accumulation in operating plants and discussed the regulatory requirements related to gas accumulation prevention.

Have potential pathways for gas intrusion in the CS/RHR system been evaluated? If so, identify the pathways. What features are present in the US-APWR design which prevent gas accumulation to ensure CS/RHR system operability? What design features and operating procedures include means for detecting and controlling gas accumulation?

Describe the ITAAC test conditions for the CS/RHR pumps, NPSH (Tier 1, Table 2.4.5-5, 8f) test. Explain why these test conditions are conservative especially with regard to gas entrainment and its effect on NPSH.

ANSWER:

This response revises and replaces MHI's amended response to RAI 464-3520, Question 05.04.07-11 submitted in MHI Letter UAP-HF-11353 dated October 12, 2011.

MHI has considered Generic Letter 2008-01 (Reference 1), as well as Nuclear Energy Institute (NEI) and the Institute of Nuclear Power Operations (INPO) recommendations, in the design of the US-APWR. The US-APWR design includes gas accumulation counter-measures that prevent or significantly mitigate gas accumulation in primary fluid systems as identified in industry documents (Reference 1, 2, and 3). This response also discusses surveillance and venting procedures to prevent gas accumulation. The surveillance and venting procedures are consistent with the recommendations of Final Interim Staff Guidance ISG-019, item 3.

US-APWR GAS ACCUMULATION PREVENTION AND MITIGATION DESIGN FEATURES

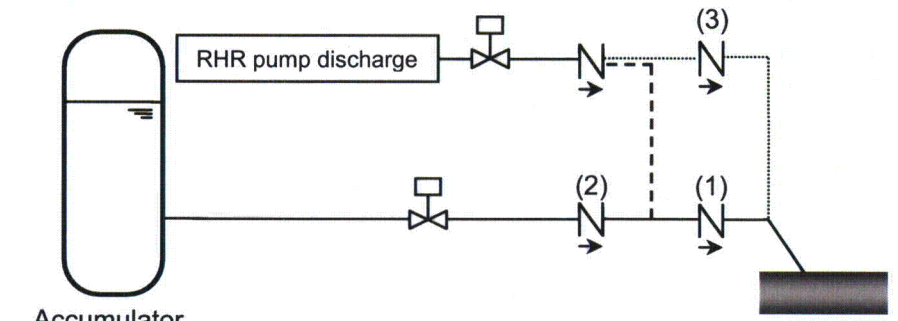
Review of industry documents (Reference 1, 2, and 3) and the US-APWR design have identified the following potential US-APWR sources of gas accumulation for the Containment Spray / Residual Heat Removal (CS/RHR) system and the Emergency Core Cooling (ECCS) system:

1) Nitrogen evolution from accumulator leakage (RHR)
2) Air ingestion due to vortex formation during mid-loop operation (RHR)
3) Inadequate venting during maintenance evolutions (CS/RHR and ECCS)
4) Air ingestion due to vortex formation at the ECCS strainers during accident conditions (CS and ECCS)
5) Air ingress due to piping or equipment leakage (CS/RHR and ECCS)

1. Accumulator Leakage

With regard to nitrogen evolution from accumulator leakage, the US-APWR design prevents this issue through the following features:

- In current PWR plants, the primary check valve (1) for the RHR and Accumulator system is shared, as shown by the dashed line in Figure 05.04.07-11A. If the water in the accumulator leaks through the secondary check valve (2) during normal power operation, gas accumulation from evolution of dissolved nitrogen in the accumulator fluid can occur in the upstream pipe of the check valve (2).
- In the US-APWR, the nozzles from the RHR pump discharge line to the RCS are separated from the accumulator injection line, as shown by the dotted line in Figure 05.04.07-11A. By this design, there are two check valves between the accumulator system and the RHR system, so potential accumulator leakage into the RHR system is decreased. (Ref: DCD Table 6.3-4, Sheet 10 of 11)
- The US-APWR uses independent primary check valves for the accumulator injection line (1) and RHR return line (3). In addition, there is a normally closed valve between the accumulator system and the RHR system because the RHR system is not used as a low head injection system.
- This configuration ensures that the primary check valves for the accumulator (1) and RHR return line (3) are held closed by RCS pressure during normal operation, and that any leakage would be from the RCS system. The dissolved gas content of the RCS coolant is maintained very low compared to the accumulator inventory, such that no significant gas accumulation from deaeration of RCS leakage occurs.



Note: The dashed line shows the typical arrangement in operating plants.
The dotted line shows the US-APWR configuration.

Figure 05.04.07-11A

Accumulator system functional arrangement will be verified by US-APWR DCD Revision 3 Tier 1 Table 2.4.4-5, ITAAC 1.a.

2. Mid-Loop Operation

The RHR system is designed to prevent vortex creation in all modes of operation. Mid-loop operation considerations are discussed in DCD Tier 2 Section 5.4.7.1. Air ingestion caused by vortex creation during mid-loop operation is addressed by DCD Tier 2 Section 5.4.7.2.3.6, which describes mid-loop operation and operating parameter limits that prevent air ingestion during this mode. RHR pump operation will be verified by DCD Tier 1 Table 2.4.5-5 ITAAC #8.a and by preoperational testing described in DCD Tier 2 Section 14.2.12.1.22, which includes demonstration that vortex creation is prevented during mid-loop operation. This test is performed with the CS/RHR pump suction aligned to the RCS hot leg and the RCS water level at the minimum level for mid-loop operation. This is the bounding operating condition for vortex creation.

CS/RHR pump NPSH is verified by DCD Tier 1 Table 2.4.5-5 ITAAC #8.f and Table 2.11.3-5 ITAAC #7.c.

3. Inadequate Venting

GL 2008-01 describes gas voids caused by inadequate venting. Inadequate venting is attributed in GL 2008-01 to one or more of the following causes:

1) Inadequate Vent Capability – Vent valves were either not included in the design or were in the design but were not installed during construction.

2) Incorrect Vent Valve Location – Vent valve locations were either not properly designed or were properly designed but not installed in the correct location during construction.

3) Inadequate Human Interface – Adequate venting could not be accomplished due to vent valve locations that prevented access. For example, vent valves were inaccessible due to piping configurations, were located in high radiation areas, or could not be located.

4) Inadequate Venting Procedure – Vents were properly designed and constructed but the procedurally required venting process left gas voids in the system.

5) Human Performance Failure – Inadequate venting was caused by human error. Vent design, construction, and procedures were adequate but operators did not follow procedure.

US-APWR detailed piping design will include venting design features that adequately consider design inadequacies described by GL 2008-01. Adequate venting requirements, procedures, and adherence to procedures must be addressed by licensees.

4. Strainer Vortex Formation

The CS/RHR and ECCS pumps draw suction from the in-containment Refueling Water Storage Pit (RWSP) through the ECCS strainers. MHI Technical Report MUAP-08001 evaluates the air ingestion performance of the ECCS strainers during accident conditions. As described in MUAP-08001, the minimum RWSP water level during accident conditions remains above the strainers and is sufficient to prevent air ingestion due to vortex formation.

5. Piping or Equipment Leakage

The CS/RHR and ECCS pumps draw suction from the RWSP, which is located at the bottom floor of containment. Because of the location of the RWSP, the CS/RHR and ECCS systems include piping which is at a higher elevation than the normal RWSP water level, and therefore is at a negative pressure during standby conditions. The CS/RHR and ECCS systems include check valves to ensure that these piping sections remain full of water. However, piping or fitting leakage may result in air ingress (e.g., air in-leakage from valve stems or bonnets, or through the open discharge piping of the full-flow test line).

However, Japanese PWR operating experience has not indicated piping or equipment leakage to be a significant source of gas accumulation. This is consistent with a review of operating experience discussed in GL 2008-01, which indicates that elevation concerns for gas accumulation are mainly focused on large elevations resulting in column separation, such as in BWR keep-full systems. In comparison, the maximum elevation of US-APWR piping above the normal RWSP water level is much smaller (approx. 24 feet), thereby limiting the negative pressure during standby conditions, and is not sufficient to cause column separation. Therefore, piping or equipment leakage is not considered to be a significant source of gas accumulation considering the dynamic venting performed every 90-days during pump surveillance testing and the 30-day surveillance to ensure piping is adequately full of water.

US-APWR VENT & PIPING DESIGN REQUIREMENTS

The US-APWR includes design features to eliminate or mitigate sources of gas accumulation as described above. In addition, the US-APWR also includes vent and piping design features to facilitate static and dynamic venting.

A simplified CS/RHR system diagram is shown in Figure 05.04.07-11B. This figure shows the CS/RHR system configuration and features provided to allow adequate venting (similar features apply to the ECCS system). For example, CS/RHR piping is designed with a continuous slope to provide continuous venting during standby conditions. Dynamic venting procedures will sweep non-condensable gases from piping sections that are difficult to vent using static vent procedures, such as gas accumulation downstream of check valves.

US-APWR detailed design will appropriately consider vent valves and piping layout to prevent gas accumulation voids and ensure adequate venting can be performed. CS/RHR and ECCS vent valve placement and piping layouts avoid gas accumulation in the following manner:

1) Vents will be located at piping high points. (Figure 05.04.07-11B)
2) Vents will be installed on upper pipe surfaces, not sides or bottom. (Figure 05.04.07-11C)
3) Horizontal piping runs will be sloped upward in the direction of flow on the discharge side of pumps and downward in the direction of flow on the suction side of pumps. (Figure 05.04.07-11B, -11D)
4) Vents will be installed at high points of inverted-U piping sections. (Figure 05.04.07-11E)
5) Pump suction piping will be connected on lower sides of inlet headers. (Figure 05.04.07-11F)
6) Vent accessibility will be assured by provision of adequate space, ladders, platforms, etc.
7) Vent areas will be thermally shielded to protect operators during venting operations.
8) Vent areas will be radiation shielded to protect operators during venting operations in accordance with ALARA principles.
9) Vent valves will be clearly identified by tagging.
10) Vent areas will be adequately lighted.

MHI 10CFR50 Appendix B qualified engineering design controls will verify vent design conformance with these requirements during detailed design. Construction inspections will verify that as-built vents are fabricated and constructed in accordance with approved design.

US-APWR VENTING AND SURVEILLANCE PROCEDURES

The US-APWR eliminates sources of significant gas accumulation through design features as described above. In addition, the vent and piping design features discussed above will facilitate static and dynamic venting to further prevent the likelihood of significant gas accumulation.

The vent location and accessibility design requirements described above will ensure that static venting can be performed during maintenance evolutions. Venting procedures will be developed as part of the maintenance and operating procedures discussed in DCD Subsection 13.5.2.

The US-APWR also includes periodic surveillance testing of the CS/RHR and ECCS pumps as required by the technical specifications (DCD Chapter 16 SR 3.6.6.2 and 3.5.2.3, respectively). The Inservice Testing Program is described in DCD Subsection 3.9.6.2. CS/RHR and ECCS pump testing is performed every 90 days in accordance with the requirements of the ASME OM Code.

In addition to providing continuous venting of the piping, the pipe slope requirements described above facilitate dynamic venting during pump surveillance testing through the full-flow test line located at the highest elevation to discharge any potential voids, minimize unacceptable dynamic effects such as water hammer, and ensure operability of the suction and discharge lines.

In addition, DCD Chapter 16 is revised to add surveillance requirements to verify that ECCS and RHR piping is adequately full of water, based on Owner's Group recommended technical specification improvements (Ref. 5), as shown in the attached mark-ups.

The following surveillance requirements (and bases) from Reference 5 will be added to DCD Ch. 16 (Note: Numbering from Ref. 5 is listed below. Numbering for DCD Ch. 16 may differ.)

RHR Piping Surveillance Requirements:

- SR 3.4.6.4 – RCS Loops – Mode 4
- SR 3.4.7.4 – RCS Loops – Mode 5
- SR 3.4.8.3 – RCS Loops – Mode 5, Loops Not Filled
- SR 3.9.5.2 – RHR and Coolant Circulation – High Water Level
- SR 3.9.6.3 – RHR and Coolant Circulation – Low Water Level

ECCS Piping Surveillance Requirements:

- SR 3.5.2.3 – ECCS - Operating
- SR 3.4.7.4 – RCS Loops – Mode 5
- SR 3.4.8.3 – RCS Loops – Mode 5, Loops Not Filled

CS Piping Surveillance Requirements:

- Not applicable (see discussion of susceptible locations below)

RHR Bases:

- B 3.4.6 – RCS Loops – Mode 4
- B 3.4.7 – RCS Loops – Mode 5
- B 3.4.8 – RCS Loops – Mode 5, Loops Not Filled
- B 3.9.5 – RHR and Coolant Circulation – High Water Level
- B 3.9.6 – RHR and Coolant Circulation – Low Water Level

ECCS Bases:

- B 3.5.2 – ECCS - Operating
- B 3.4.7 – RCS Loops – Mode 5
- B 3.4.8 – RCS Loops – Mode 5, Loops Not Filled

CS Bases:

- Not applicable (see discussion of susceptible locations below)

Surveillance procedures will be developed, as discussed in DCD Subsection 13.5.2, to describe locations susceptible to gas accumulation and requiring surveillance, surveillance methods, acceptance criteria, and venting requirements to minimize gas accumulation when identified.

Surveillance locations will be chosen during detailed design considering details such as piping layout and accessibility. The effects of the maximum undetectable void, based on detailed piping layout and surveillance location, will be evaluated as part of detailed design.

Locations Susceptible to Gas Accumulation

Based on the design features, slope and vent requirements, and gas accumulation mechanisms described above, locations susceptible to gas accumulation are identified in Figures 5.04.07-G and 5.04.07-H and discussed below:

A) RHR Suction Line – Downstream of RHR-MOV-002

Gas may accumulate due to piping drain-down, deaeration, and/or small amounts of air ingestion during mid-loop operation.

This location is swept during RHR operation, but not during RHR pump surveillance testing. This location will be surveilled every 30 days to verify the piping is sufficiently full of water.

B) RHR Discharge Line – Upstream of RHR-MOV-021

Gas may accumulate at this normally closed valve due to piping drain-down.

This location is swept during RHR pump surveillance testing. This location will be surveilled every 30 days to verify the piping is sufficiently full of water.

C) SIS Discharge Line – Upstream of SIS-VLV-010

Gas may accumulate at this check valve due to piping drain-down.

This location is swept during SI pump surveillance testing. This location will be surveilled every 30 days to verify the piping is sufficiently full of water.

Locations not susceptible to gas accumulation, or otherwise not requiring surveillance, are also shown in Figures 5.04.07-G and 5.04.07-H and discussed below:

D) RHR Full-Flow Test Line

Pipe slope provides continuous venting to the full-flow test line, which is routed back the the RWSP and is open to the atmosphere above the RWSP surface. That is, gas is vented to the RWSP and does not accumulate at the full-flow test line. Upstream piping (i.e., Location B) is surveilled every 30-days to detect potential gas accumulation, and this portion of the line is swept during pump surveillance testing. Therefore, this location does not require additional surveillance.

E) SI Full-Flow Test Line

Pipe slope provides continuous venting to the full-flow test line, which is routed back the the RWSP and is open to the atmosphere above the RWSP surface. That is, gas is vented to the RWSP and does not accumulate at the full-flow test line. Upstream piping (i.e., Location C) is surveilled every 30-days to detect potential gas accumulation, and this portion of the line is swept during pump surveillance testing. Therefore, this location does not require additional surveillance.

F) CS Branch Line – Upstream of CSS-MOV-004

Gas may accumulate due to piping drain-down or deaeration.

The spray headers are normally not filled with water. Therefore, the impact of gas accumulation in the containment spray branch lines will be within typical design-basis loads for this piping. No further surveillance or monitoring for gas accumulation is considered necessary.

G) SI Injection Line – Upstream of SIS-VLV-012

Gas may accumulate at this check valve due to insufficient fill and venting during maintenance. Gas accumulation from piping drain down is not possible due to pipe elevations. Temperature indication is provided to monitor for RCS leakage.

Sufficient fill and venting is controlled through maintenance procedures and provision of local vents. No additional surveillance is required during normal operation.

US-APWR ITAAC

MHI will revise ASME Code Section III piping ITAAC in Section 2.4.4, Emergency Core Cooling System, Section 2.4.5, Residual Heat Removal System, and Section 2.11.3, Containment Spray System to require verification of design features described in the design basis to limit potential gas accumulation.

References

1. USNRC Generic Letter GL 2008-01, Managing Gas Accumulation In Emergency Core Cooling, Decay Heat Removal, And Containment Spray Systems, January 11, 2008
2. INPO 06-001, "Operating Experience to Apply to Advanced Light Water Reactor Designs," March 2006
3. NEI 09-10, Rev. 0, "Guidelines for Effective Prevention and Management of System Gas Accumulation," October 2009
4. USNRC Final Interim Staff Guidance Review of Evaluation to Address Gas Accumulation Issues in Safety Related Systems and Systems Important to Safety DC/COL-ISG-019
5. PWR Owner's Group / BWR Owner's Group, Technical Specification Task Force, Improved Standard Technical Specifications Change Traveler, "Generic Letter 2008-01, Managing Gas Accumulation, TSTF-523 Rev. 1.

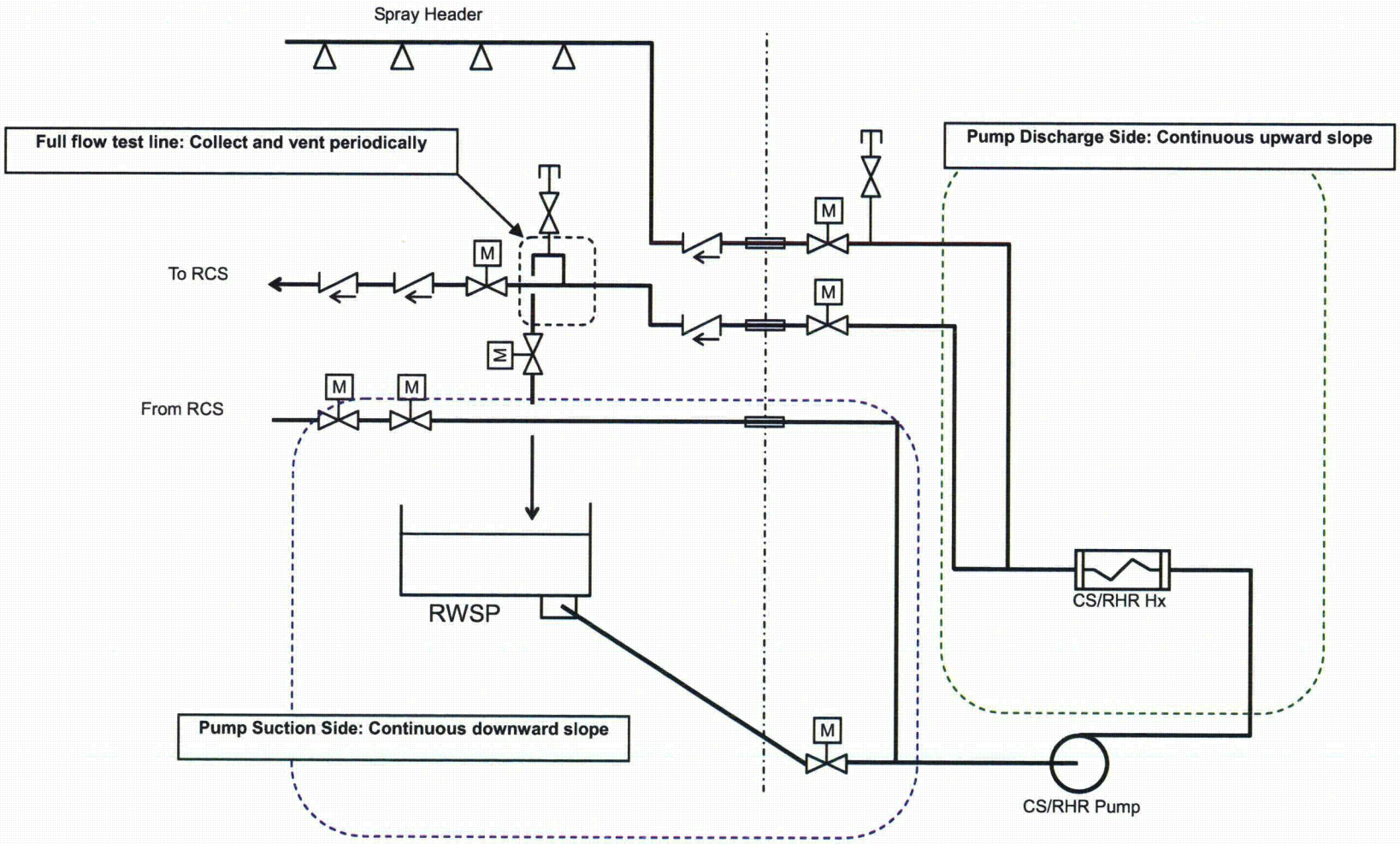


Figure 05.04.07-11B Simplified CS/RHR system diagram

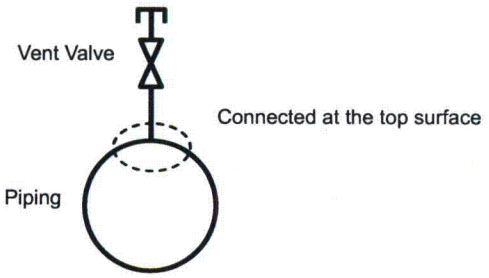


Figure 05.04.07-11C

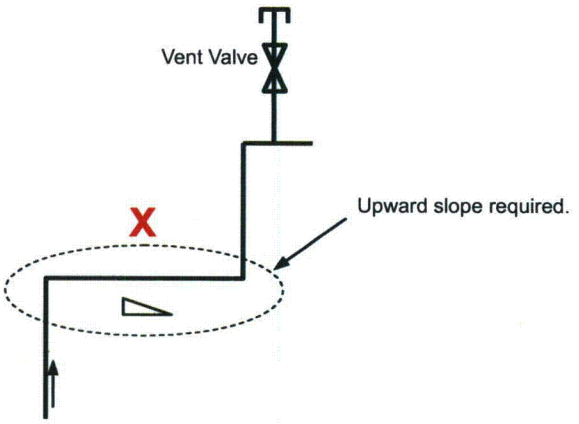


Figure 05.04.07-11D

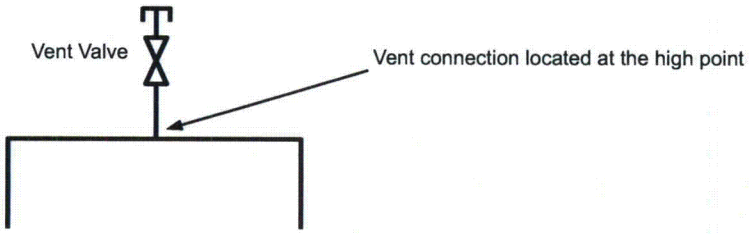


Figure 05.04.07-11E

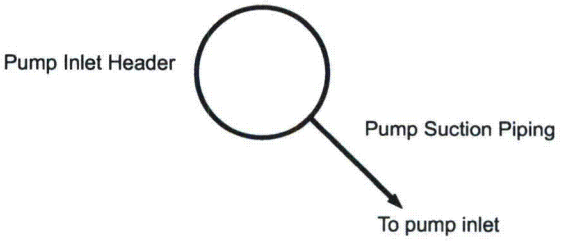


Figure 05.04.07-11F

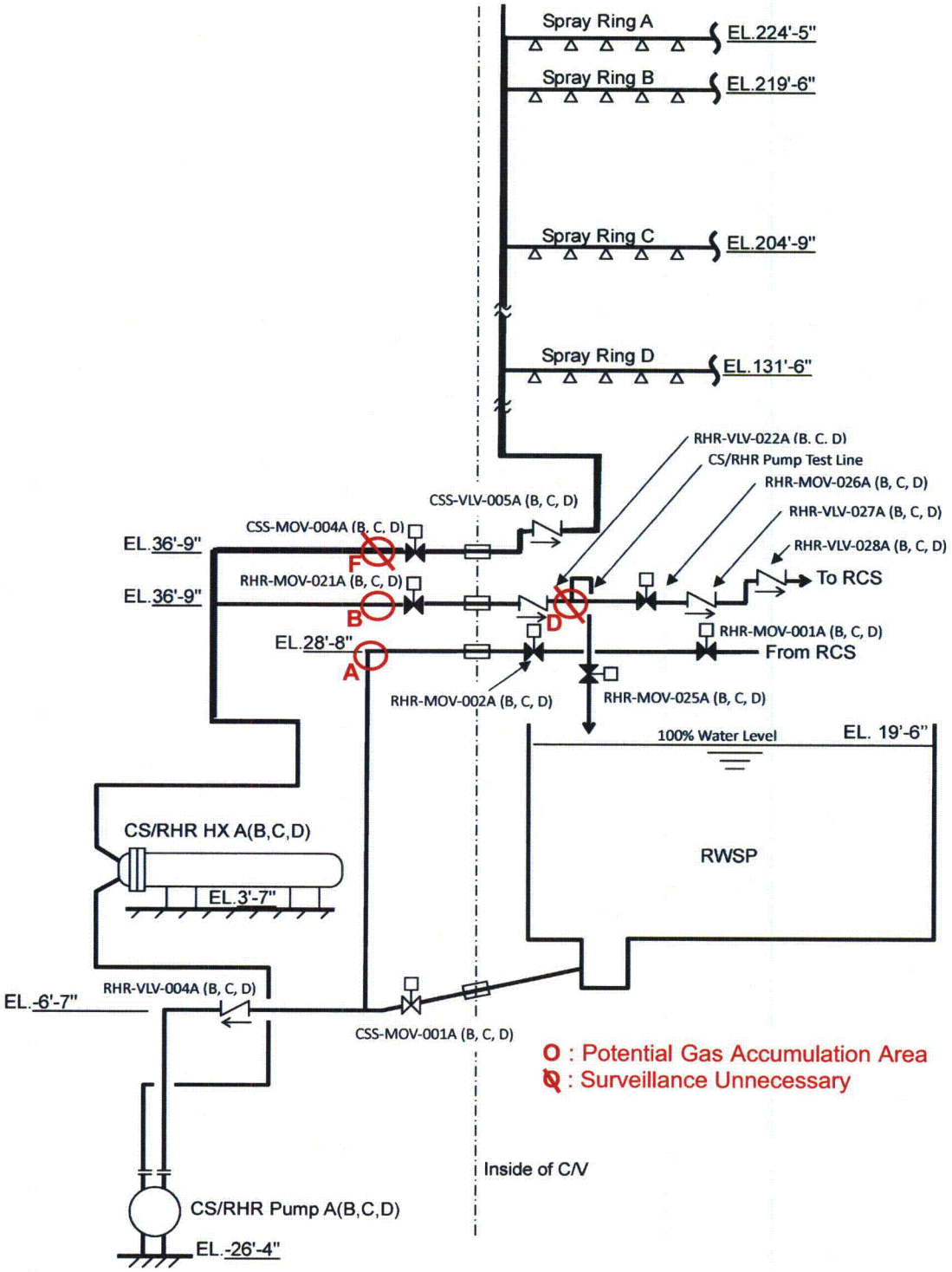


Figure 05.04.07-G

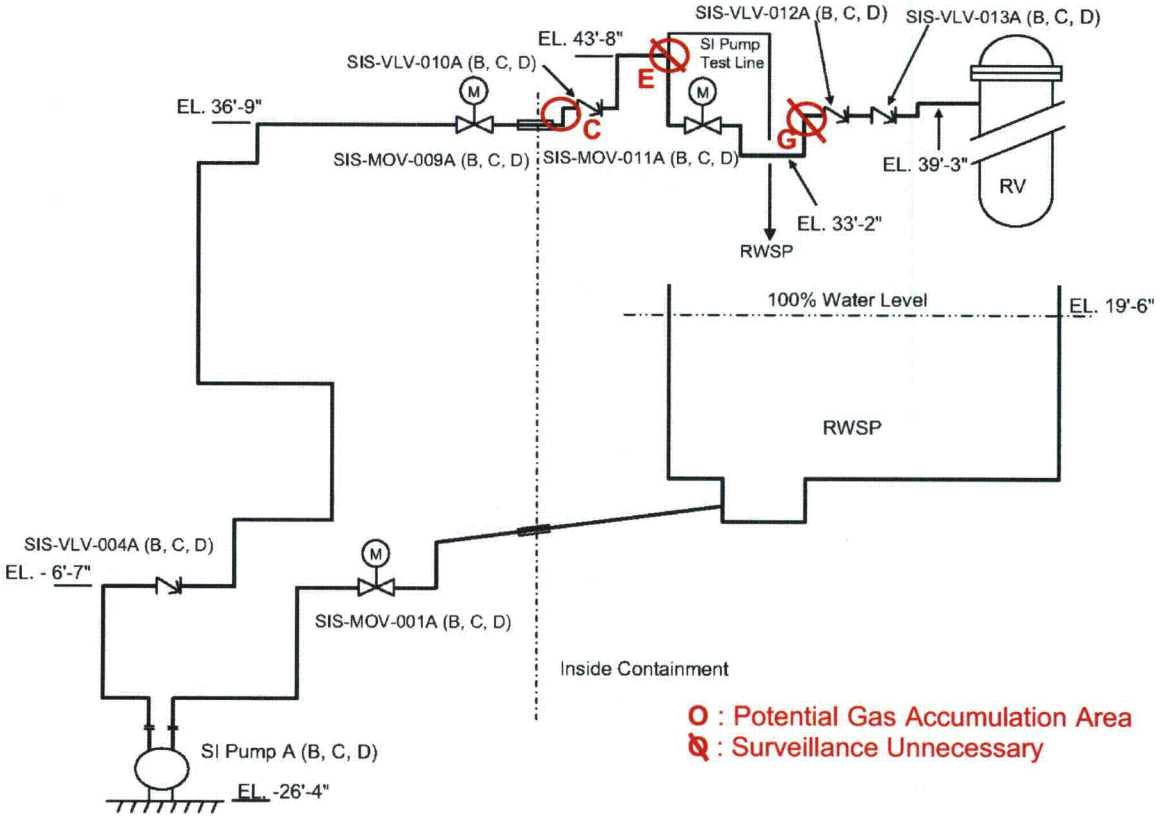


Figure 05.04.07-H

Impact on DCD

DCD Tier 2 Subsection 5.4.7.2.1, Subsection 6.2.2.2, and Subsection 6.3.2.1.1 will be revised as shown in the attached mark-ups for consistency in discussion of design features to prevent gas accumulation. In addition, Figure 6.2.2-10 will be added to illustrate CS/RHR elevations as shown in the attached mark-up.

DCD Tier 2 Chapter 16 Sections 3.4.6, 3.4.7, 3.4.8, 3.5.2, 3.9.5, and 3.9.6 (and associated bases) are revised as shown in the attached mark-ups to add surveillance requirements for gas accumulation.

DCD Tier 1 Section 2.4.4, Table 2.4.4-5, Section 2.4.5, Table 2.4.5-5, Section 2.11.3, and Table 2.11.3-5 will be revised as shown in the attached mark-ups to clarify ITAAC for design features to prevent gas accumulation.

Impact on R-COLA

R-COLA Part 4, Technical Specifications, is affected by changes to DCD Tier 2 Ch. 16.

Impact on S-COLA

S-COLA Part 4, Technical Specifications, is affected by changes to DCD Tier 2 Ch. 16.

Impact on PRA

There is no impact on the PRA.

Impact on Technical / Topical Reports

MHI Technical Report MUAP-07036, "Justification for Deviations between NUREG-1431 Rev. 3.1 and US-APWR Technical Specifications", Rev. 2, will be revised to address changes to DCD Tier 2 Ch. 16 in the attached mark-ups.

- The RHRS trains are supplied by separate electrical trains thereby being operationally independent of each other.

- The RHRS is designed to be fully operable by the control room operator during single failure for normal operation except for restoring power to the suction isolation valves.

- The RHRS is designed to be operated during mid-loop or drain down operation to allow maintenance or inspection of the reactor head, SG and reactor coolant pump seals.

- The RHR system is designed to prevent an interfacing system LOCA by two motor operated valves in series on the suction line with power lockout capability and design pressure with sufficient wall thickness to withstand the RCS pressure without rupture. In the event that both these valves are opened, the RHR system is designed to withstand high pressure and discharge the RCS inventory to the in-containment RWSP.

- The CS/RHR pump damage from overheating and loss of flow is prevented by minimum flow lines.

- The RHRS is provided with a leakage detection system to minimize the leakage from those portions of the RHR system outside of the containment that contain or may contain radioactive material following an accident.

- The RHRS is designed for protection against missiles (Refer to Section 3.5), protection against dynamic effects associated with the postulated rupture of piping and pipe whipping (Refer to Section 3.6), discharging fluids inside and outside the containment (Refer to Section 3.4), fires, loss-of-coolant accidents loads, seismic effects (Refer to Section 3.7), and to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents (Refer to Section 3.11).

5.4.7.2 System Design

5.4.7.2.1 System Description

The RHRS as shown in Figure 5.4.7-1 consists of four independent subsystems, each of which receives electrical power from one of four safety buses. The P&ID for the four loop RHR system is as shown in Figure 5.4.7-2. Each subsystem includes one CS/RHR pump, one CS/RHR heat exchanger, associated piping, valves, and instrumentation necessary for operational control. Table 5.4.7-2 provides the important system design parameters and CS/RHR pump characteristic curve is as shown in Figure 5.4.7-3. The CS/RHR heat exchangers and the CS/RHR pumps have functions in both the CS system and the RHRS. The mode diagram is as shown in Figure 5.4.7-4.

The RHRS is placed in operation when the pressure and temperature of the RCS are approximately 400 psig and 350° F, respectively.

The inlet lines to the RHRS are connected to the hot legs of four reactor coolant loops (RCLs), while the return lines are connected to the cold legs of each of the RCLs. The RHRS suction lines are isolated from the RCS by two normally-closed motor-operated valves with power lockout capability that are connected in series and located inside the containment. Each discharge line is isolated from the RCS by two check valves located inside the containment and by a normally closed motor-operated valve.

During RHRS operation, each CS/RHR pump takes suction from one of the RCS hot legs by a separate suction line. The pumps then discharge the reactor coolant through the CS/RHR heat exchangers, which transfers heat from the hot reactor coolant fluid to the CCWS circulating through the shell side of the CS/RHR heat exchangers. The cooled reactor coolant is then returned to the RCS cold legs.

CS/RHR pumps transfer borated water from the RWSP to the refueling cavity at the beginning of the refueling operation, and after refueling drain the water back to the RWSP until the water level is brought back to the flange of the reactor vessel.

Coincident with operation of the RHRS, a portion of the reactor coolant flow from the two trains may be diverted downstream of the residual heat exchangers to the CVCS low-pressure isolation letdown line for cleanup and/or pressure control. By regulating the diverted flowrate and the charging flow, the RCS pressure may be controlled.

The RCS cooldown rate is manually controlled by regulating the reactor coolant flow through the tube side of the CS/RHR heat exchangers. The flow control valve in the bypass line around two of the four CS/RHR heat exchangers automatically maintains a constant return flow to the RCS. Instrumentation is provided to monitor system pressure, temperature, and total flow.

When the RHRS is in operation, the water chemistry is the same as that of the reactor coolant. Provision is made for the process sampling system to extract samples from the flow of reactor coolant downstream of the residual heat removal heat exchanger. A local sampling point is also provided on each RHR train between the pump and heat exchanger.

Pump protection is provided using a minimum flow line with an open valve and an orifice at the downstream side of the CS/RHR heat exchanger to the upstream side of the CS/RHR pump suction. This line is sized to provide sufficient pump flow when the CS/RHR pump is shutoff. Also following a LOCA the RHR system is isolated from the RCS and the CSS is placed in operation to provide the make-up source from the RWSP. This is further discussed in Subsection 6.2.2.

The RHRS suction isolation valves in each inlet line from the RCS are interlocked to prevent them from being opened when the RCS pressure is greater than approximately 400 psig. The valves have a control room alarm which alerts the operators if one or both of the valves is not fully closed and the RCS pressure exceeds 400 psig.

Potential voids, caused by insufficient venting or air entrainment during mid-loop operation, may be formed in the CS/RHR lines. Design features to prevent air entrainment during mid-loop operation are described in Subsection 5.4.7.2.3.6. The horizontal sections of the CS/RHR piping are designed to have a continuous downward

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slope on the pump suction side and a continuous upward slope on the pump discharge side up to the full-flow test line. Vent valves are included at all local high points on horizontal sections and inverted-U piping sections, and are designed to be accessible and identifiable. Inservice testing required by Subsection 3.9.6.2 includes periodic testing through the full-flow test lines located at the high point of the RHR piping to the RCS cold legs (see Figure 6.2.2-10), which discharge to the RWSP. These tests periodically discharge potential voids, minimize unacceptable dynamic effects such as water hammer, and ensure operability of the suction and discharge lines. The vent and pipe slope design also facilitate system venting following maintenance procedures which are part of the operating procedures described in Subsection 13.5.2. The operating procedures described in Subsection 13.5.2 also describe surveillance procedures including surveillance locations, methods, and acceptance criteria to meet technical specifications for verifying that susceptible piping is sufficiently full of water.

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5.4.7.2.2 Equipment and Component Description

All components in contact with borated water such as piping, pumps, valves, and equipment for the RHRS are made of austenite stainless steel. However, the shells of the CS/RHR heat exchangers are made of carbon steel. The materials are used to fabricate RHRS components and are in compliance with ASME Section III Materials requirements.

5.4.7.2.2.1 CS/ RHR Pump

The CS/RHR pumps are horizontal, motor-operated centrifugal pumps with mechanical seals. A single unit is provided in each of the four trains. The pumps are installed in separate shielded rooms so that one of the four pumps may be maintained while the others are in operation.

The pumps are sized to deliver reactor coolant flow through the CS/RHR heat exchangers to meet the plant cooldown requirements. The design head of the CS/RHR pumps is determined to be 410 feet considering pressure losses during RHR operation. During normal plant shutdown, mid-loop operation, and safe shutdown, the RHR pumps are aligned to take the suction from the hot leg and discharge the reactor coolant through the CS/RHR heat exchanger and transfer it to the cold leg of the RCS. The use of separate pumps in each RHR train ensures that cooling capacity is only partially lost should one pump become inoperative.

The CS/RHR pump is used for transferring the refueling water from the RWSP to the refueling cavity and may be used for returning the refueling water from the refueling cavity back to the RWSP.

The CS/RHR pumps are protected from overheating and loss of suction flow through pump shutoff by means of minimum flow bypass lines that ensure flow to the pump suction. The minimum flow line is used for pump testing during normal operations. The minimum flow system would preclude any pump damage caused by operator error and operate safely during this period of no flow.

The CSS is located in the Reactor Building and the Containment. Both structures are seismic category I and provide tornado missile barriers to protect the CSS. The CSS includes four 50% capacity CS/RHR pump trains and assumes one is out of service for maintenance and one becomes inoperative due to a single failure upon the initiation of the CSS. The CSS is designed with sufficient redundancy to ensure reliable performance, including the failure of any component coincident with occurrence of a design basis event, as discussed in DCD Chapters 3, 7, and 15.

Subsection 6.2.1 discusses the containment environmental conditions during accident conditions, and Chapter 3, Section 3.11 discusses the suitability of equipment for design environmental conditions. All valves required to be actuated during CSS operation are located to prevent vulnerability to flooding.

Protection of the CSS from missiles is discussed in Section 3.5. Protection of the CSS against dynamic effects associated with rupture of piping is described in Section 3.6. Protection from flooding is discussed in Section 3.4.

MUAP-08013-P (Ref. 6.2-36) contains requirements for design and evaluation of ECCS and CSS ex-vessel downstream components to ensure the ECCS and CSS systems and their components will operate as designed under post-LOCA conditions. DCD_06.02.02-84

The CSS is designed for periodic inservice testing and inspection of components in accordance with ASME Code Section XI.

6.2.2.2 System Design

Figure 6.2.2-1 is the flow diagram of the CSS, showing the major components, instruments, and the appropriate system interconnections. Table 6.2.2-1 presents design and performance data for CSS components. The performance data for CS/RHR pump and CS/RHR heat exchanger is shown in Chapter 5, Subsection 5.4.7.

The CSS receives electrical power for its operation and control from onsite emergency power sources and offsite sources, as shown in Chapter 8. In the unlikely event of a LOCA or secondary system line break that significantly increases the containment pressure, the containment spray automatically initiates to limit peak containment pressure to well below the containment design pressure. In addition to preserving containment structural integrity, containment spray limits the potential post-accident radioactive leakage by reducing the pressure differential between the containment atmosphere and the environment and also ensures atmosphere mixing in containment. DCD_06.02.05-44

The CS/RHR system can be manually initiated and operated from the MCR and the remote shutdown console (RSC). In addition to the typical system status and operating information (e.g., valve position indication, pump run status), the containment temperature and pressure are indicated and recorded in the MCR and RSC.

Dual-use components are the CS/RHR heat exchangers and CS/RHR pumps. Motor-operated valves permit CSS or RHRS recirculation of the reactor core. The four CSS containment isolation valves are normally closed, but open automatically on a P signal. The CSS containment isolation valves are interlocked and are allowed to open only if either of the corresponding two in-series RHR hot leg suction isolation valve is

closed. Further, the RHR hot leg suction valves are interlocked so that they cannot be opened unless the corresponding CSS containment isolation valves are closed. This arrangement prevents the reactor vessel water inventory from being sprayed into the containment.

Following a DBA, the containment pressure approaches atmospheric pressure. When the containment pressure is reduced sufficiently and the operator determines that containment spray is no longer required, the operator terminates containment spray. The operator closes the containment spray header isolation valves and aligns system flow through the CS/RHR heat exchanger back to the RWSP through the full flow test line. The pit water is then recirculated and cooled.

Potential voids, caused by insufficient venting, may be formed in the CS/RHR lines. The horizontal sections of the CS/RHR piping are designed to have a continuous downward slope on the pump suction side and a continuous upward slope on the pump discharge side up to the full-flow test line. Vent valves are included at all local high points on horizontal sections and inverted-U piping sections and are designed to be accessible and identifiable. Inservice testing required by Subsection 3.9.6.2 includes periodic testing through the full-flow test lines located at the high point of the RHR piping to the RCS cold legs (see Figure 6.2.2-10), which discharge to the RWSP. These tests periodically discharge potential voids, minimize unacceptable dynamic effects such as water hammer, and ensure operability of the suction and discharge lines. The vent and pipe slope design also facilitate system venting following maintenance procedures which are part of the operating procedures described in Subsection 13.5.2. Subsection 5.4.7.2.1 discusses gas accumulation for the RHR system, portions of which are shared with the containment spray system. No additional surveillance requirements are necessary for locations of the containment spray system which are not shared by the RHR system. DCD_05.04.07-11 DCD_05.04.07-11

CS/RHR components are procured by qualified vendors, approved to supply under components and materials. Chapter 14, Section 14.2 "Initial Plant Test Program," discusses component and integrated system tests performed prior to un-conditional plant operations.

6.2.2.2.1 CS/RHR Pumps

These components are included in the RHRS. Four dual-purpose CS/RHR pumps are provided, one for each of four 50% capacity trains. They are motor-driven centrifugal pumps with mechanical seals. The pumps are sized to deliver 3,000 gpm at a discharge head of 410 ft. The 100% capacity design flow rate (two of four 50% capacity CS/RHR pumps) is based on 15.2 gpm flow per nozzle and 348 nozzles. With a minimum flow rate for each pump of 355 gpm, the required two-pump 100% flow rate is, thus, 6,000 gpm. The CS/RHR pump discharge head is based on a static head of 215 ft. and pressure losses equivalent to 165 ft. Including a margin of 30 ft. The design head of the CS/RHR pumps is 410 ft.

All four CS/RHR pumps automatically start and the containment isolation valves automatically open on the receipt of a P signal, delivering a flow from four CSS trains to the CSS spray rings. Initiating signals, setpoints, logic, and control are described in Chapter 7, "Instrumentation and Controls" Chapter 8, "Electric Power," discusses electrical power supplies and the available sources for the CSS.

6.2.2.2.2 CS/RHR Heat Exchangers

These components are included in the RHRS. Four CS/RHR heat exchangers are provided. They are horizontal tube and shell heat exchangers. The CS/RHR system water flows through the tubes, and the component cooling water flows through the shell.

6.2.2.2.3 Containment Spray Piping

Each of the RWSP suction valves is normally open to ensure that suction piping remains full and aligned to provide a ready flow path to the CS/RHR pumps. Each CSS train's discharge line to the containment spray rings is provided with a normally closed, motor-operated containment isolation gate valve.

The system piping is normally filled and vented to the containment isolation valves (CSS-MOV-004A, B, C, and D) at elevation 36.75 ft. (typical for all four 50% containment spray trains) prior to plant startup. The minimum piping "keep full" level corresponds to the RWSP 100% water level at elevation ~~19.5 ft.~~20 ft. - 2 in. A conservative value of 100 seconds time delay is assumed between the system initiation and the spray ring flow for purposes of LOCA and the containment response analyses. The delay time associated with accidents is provided in Subsection 6.2.1.1.3.4 and Table 6.2.1-5. | MIC-03-06-00070

6.2.2.2.4 Containment Spray Nozzles

The containment spray nozzles are of the type and manufacture commonly used in United States commercial nuclear applications. The nozzles are fabricated from 304 stainless steel, and each is fitted with a 0.375 in. orifice. As shown in Figure 6.2.2-2, the one-piece construction provides a large, unobstructed flow passage that resists clogging by particles, while producing a hollow cone spray pattern. Figure 6.2.2-3 shows each nozzle's orientation on a spray ring. The nozzle orientation is identified as vertical down (No. 1 nozzle, R-5605); 45° from vertical down (No. 3 nozzle, R-5604); and horizontal (No. 2, and No. 4 nozzles, R-5603). Figure 6.2.2-4 presents the spray pattern and typical spray coverage of each nozzle type.

Figure 6.2.2-5 is a sectional view of containment showing the elevation of the spray rings (A, B, C, and D) and the typical spray pattern from the nozzle to the containment operating floor level (elevation 76 ft. - 5 in). Figure 6.2.2-6 presents a plan view showing the location of each nozzle on each spray ring and the predicted spray coverage on the operating floor of the containment. Figure 6.2.2-6 also tabulates the number and orientation of the nozzles on each spray ring. Of the 348 containment spray nozzles distributed among the four containment spray rings, there are only four vertical up No. 4 nozzles (R-5603)—one on each spray ring. In addition to their spray function, these nozzles also serve as the high point vent on each spray ring.

6.2.2.2.5 Refueling Water Storage Pit

The RWSP is the protected, reliable, and safety-related source of boric acid water for the containment spray and SI. (Section 6.3 describes the SI function for the US-APWR ECCS.) The RWSP also is used to fill the refueling cavity in support of refueling operations. The RWSP is located on the lowest floor inside the containment, with a ~~minimum 81,230~~84,750 ft^3 ~~capability~~capacity available, it is designed with sufficient | MIC-03-06-00070

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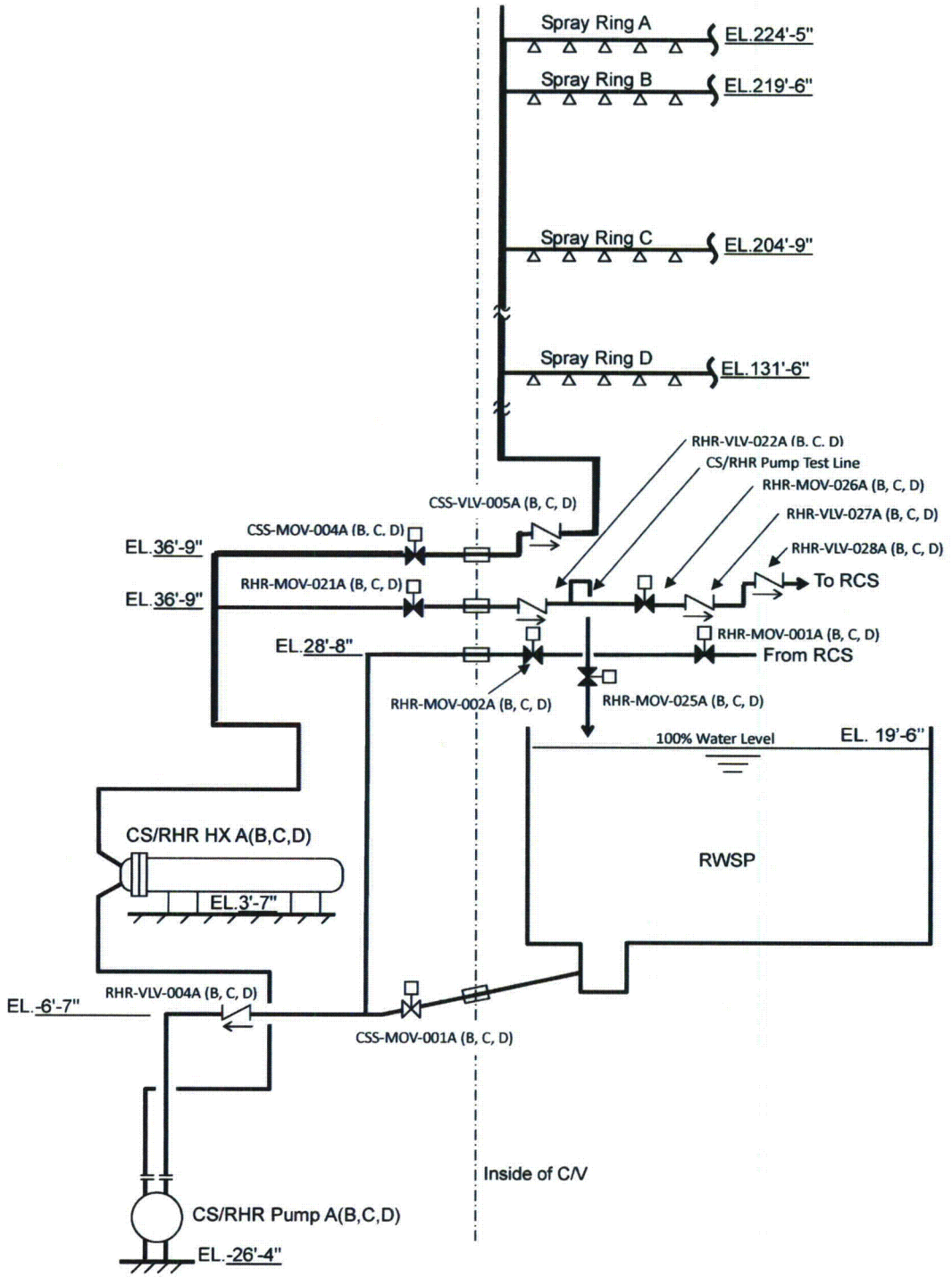

Figure 6.2.2-10 CS/RHR Elevation Diagram

6.3.2 System Design

6.3.2.1 Schematic Piping and Instrumentation Diagrams

Figure 6.3-1 is a simplified flow diagram of the ECCS. Figure 6.3-2 is the piping and instrumentation diagram showing system locations for all components, including system interconnections, instruments, alarms and indications. Chapter 7, Section 7.3, discusses the instrumentation and control, including the actuation logic, the component redundancy, the system interlocks, and the indication for the SIS.

6.3.2.1.1 High Head Injection System

There are four independent and dedicated SI pump trains. The SI pump trains are automatically initiated by a S signal, and supply boric acid water (at approximately 4,000 ppm boron) from the RWSP to the reactor vessel. Each 50% capacity train includes a safety injection pump suction isolation valve , a dedicated, 50% capacity SI pump, a safety injection pump discharge containment isolation valve, a direct vessel safety injection line isolation valve, and a hot leg injection isolation valve.

Figure 6.3-3 presents an elevation drawing of the SIS. System piping would normally be filled and vented from the RWSP to the reactor vessel injection nozzles at elevation 39 ft-3 in prior to startup. Thus, the injection piping is completely filled with water. A series of four check valves are installed between each SI pump and the direct vessel injection (DVI) nozzles at the reactor vessel. This series of check valves provides a "keep full" function, while preventing a drain-down to the RWSP. As shown, ~~24~~23 ft-~~2~~6 in ~~are~~is available between the 100% RWSP level at elevation ~~19~~20 ft-~~6~~2 in, and the highest SI piping at elevation 43 ft-8 in. Using a conservative value of 120°F, which is the maximum operating temperature in containment, a static head 30 ft. high is required for water column separation. Void formation due to water column separation in the SI piping is precluded and no delay is assumed between the system initiation and the injection flow into the reactor vessel downcomer. This design feature minimizes the potential for water hammer. Potential voids, caused by insufficient venting, may be formed in the SIS lines. The horizontal sections of the SIS piping are designed to have a continuous downward slope on the pump suction side and a continuous upward slope on the pump discharge side up to the full-flow test line. Vent valves are included at all local high points on horizontal sections and inverted-U piping sections and are designed to be accessible and identifiable. Inservice testing required by Subsection 3.9.6.2 includes periodic testing through the full-flow test lines located at the high point of the SIS and discharge into the RWSP. See Figure 6.3-3. These tests periodically discharge potential voids, minimize unacceptable dynamic effects such as water hammer, and ensure operability of the suction and injection lines. The vent and pipe slope design also facilitate system venting following maintenance procedures which are part of the operating procedures described in Subsection 13.5.2. The operating procedures described in Subsection 13.5.2 also describe surveillance procedures including surveillance locations, methods, and acceptance criteria to meet technical specifications for verifying that susceptible piping is sufficiently full of water.The ECCS delivery lag time is provided in Chapter 15, "Transient and Safety Analyses." Table 6.2.1-5 provides ESF system parameter information relating to ECCS and CSS actuation timing.

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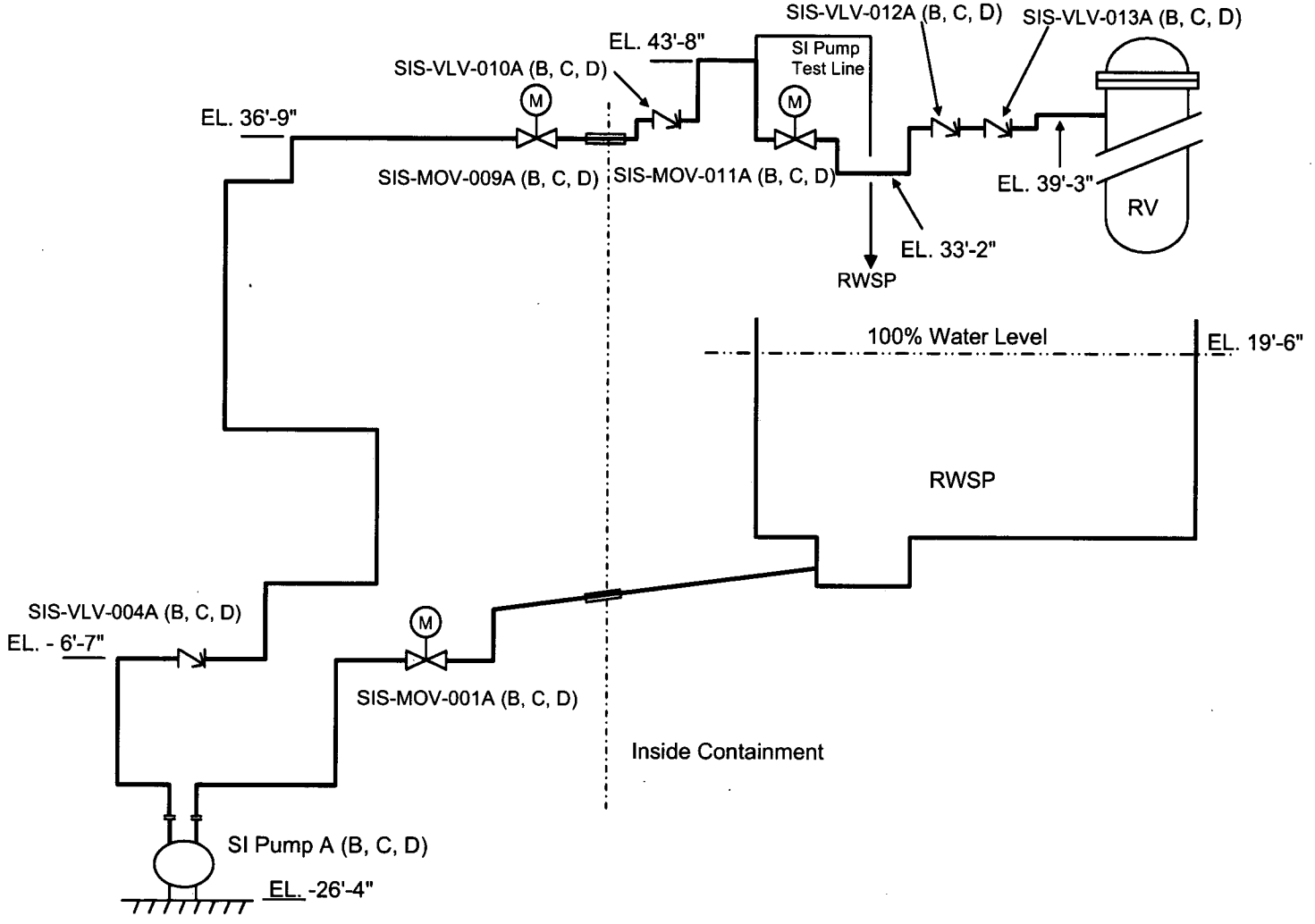

Figure 6.3-3 SIS Elevation Diagram

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY	
SR 3.4.6.4	----------NOTE---------- Not required to be performed unless no RCPs are in operation. ---------- Verify each valve that isolates unborated water sources is secured in the closed position.	[7 days OR In accordance with the Surveillance Frequency Control Program]	DCD_15.4.6-6
SR 3.4.6.5	----------NOTE---------- Not required to be performed until 12 hours after entering MODE 4. ---------- Verify required RHR loop locations susceptible to gas accumulation are sufficiently filled with water.	[31 days OR In accordance with the Surveillance Frequency Control Program]	DCD_05.04.07-11

SURVEILLANCE REQUIREMENTS

SR 3.4.7.5	Verify required RHR loop locations susceptible to gas accumulation are sufficiently filled with water.	[31 days OR In accordance with the Surveillance Frequency Control Program]	DCD_05.04.07-11

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY	
SR 3.4.8.4	----------NOTE---------- Not required to be performed unless no RCPs are in operation. ---------- Verify each valve that isolates unborated water sources is secured in the closed position.	[7 days OR In accordance with the Surveillance Frequency Control Program]	DCD_15.4.6-6
SR 3.4.8.5	Verify RHR loop locations susceptible to gas accumulation are sufficiently filled with water.	[31 days OR In accordance with the Surveillance Frequency Control Program]	DCD_05.04.07-11

SURVEILLANCE REQUIREMENTS

SURVEILLANCE			FREQUENCY
SR 3.5.2.1	Verify the following valves are in the listed position (with power to the valve operator removed).		[12 hours OR In accordance with the Surveillance Frequency Control Program]
	Number	Function	Position
	SIS-AOV -201B and C	Accumulator Makeup	CLOSED
	SIS-MOV -024A,B,C and D	Safety Injection Pump Full-Flow Test Line Stop	CLOSED
SR 3.5.2.2	---------- NOTE---------- Not required to be met for system vent flow paths opened under administrative control. ---------- Verify each SIS manual, power operated, and automatic valve in the flow path, that is not locked, sealed, or otherwise secured in position, is in the correct position.		[31 days OR In accordance with the Surveillance Frequency Control Program]
SR 3.5.2.3	Verify each SI pump's developed head at the test flow point is greater than or equal to the required developed head.		In accordance with the Inservice Testing Program
SR 3.5.2.4	Verify each ECCS valve manually activated during a design basis accident event in the flow path that is not locked, sealed, or otherwise secured in position, actuates to the correct position.		In accordance with the Inservice Testing Program
SR 3.5.2.5	Verify each SI pump starts automatically on an actual or simulated actuation signal.		[24 months OR In accordance with the Surveillance Frequency Control Program]

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SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.5.2.6	Verify by visual inspection, each SIS train ECC/CS STRAINER is not restricted by debris and shows no evidence of structural distress or abnormal corrosion.	[24 months OR In accordance with the Surveillance Frequency Control Program]
SR 3.5.2.7	Verify ECCS locations susceptible to gas accumulation are sufficiently filled with water.	[31 days OR In accordance with the Surveillance Frequency Control Program]

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SURVEILLANCE REQUIREMENTS

SR 3.9.5.2	Verify required RHR loop locations susceptible to gas accumulation are sufficiently filled with water.	[31 days OR In accordance with the Surveillance Frequency Control Program]	DCD_05.04.07-11

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.9.6.3	Perform a complete cycle of each low-pressure letdown line isolation valve.	[24 months OR In accordance with the Surveillance Frequency Control Program]
SR 3.9.6.4	Verify RHR loop locations susceptible to gas accumulation are sufficiently filled with water.	[31 days OR In accordance with the Surveillance Frequency Control Program]

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BASES

LCO (continued)

An OPERABLE RCS loop comprises an OPERABLE RCP and an OPERABLE SG, which has the minimum water level specified in SR 3.4.6.2.

Similarly for the RHR System, an OPERABLE RHR loop comprises an OPERABLE CS/RHR pump capable of providing forced flow to an OPERABLE CS/RHR heat exchanger. RCPs and CS/RHR pumps are OPERABLE if they are capable of being powered and are able to provide forced flow if required. Management of gas voids is important to RHR System OPERABILITY. DCD_05.04.07-11

APPLICABILITY In MODE 4, this LCO ensures forced circulation of the reactor coolant to remove decay heat from the core and to provide proper boron mixing. One loop of RCS or two loops of RHR provides sufficient circulation for ~~these purposes~~the removal of decay heat from the core. However, two loops of RHR do not provide sufficient circulation to provide proper boron mixing. Therefore, the LCO requires that the valves used to isolate unborated water sources be secured in the closed position when no RCPs are running. ~~a~~Additional loops consisting of RCS and RHR loops are required to be OPERABLE to meet single failure considerations. DCD_15.4.6-6

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 3.4.7,	"RCS Loops - MODE 5, Loops Filled,"
LCO 3.4.8,	"RCS Loops - MODE 5, Loops Not Filled,"
LCO 3.9.5,	"Residual Heat Removal (RHR) and Coolant Circulation - High Water Level" (MODE 6), and
LCO 3.9.6,	"Residual Heat Removal (RHR) and Coolant Circulation - Low Water Level" (MODE 6).

BASES

SURVEILLANCE REQUIREMENTS (continued)

DCD_05.04.07-11

SR 3.4.6.5

RHR System piping and components have the potential to develop voids and pockets of entrained gases. Preventing and managing gas intrusion and accumulation is necessary for proper operation of the required RHR loop(s) and may also prevent water hammer, pump cavitation, and pumping of noncondensible gas into the reactor vessel.

Selection of RHR System locations susceptible to gas accumulation is based on a review of system design information, including piping and instrumentation drawings, isometric drawings, plan and elevation drawings, and calculations. The design review is supplemented by system walk downs to validate the system high points and to confirm the location and orientation of important components that can become sources of gas or could otherwise cause gas to be trapped or difficult to remove during system maintenance or restoration. Susceptible locations depend on plant and system configuration, such as stand-by versus operating conditions.

The RHR System is OPERABLE when it is sufficiently filled with water. Acceptance criteria are established for the volume of accumulated gas at susceptible locations. If accumulated gas is discovered that exceeds the acceptance criteria for the susceptible location (or the volume of accumulated gas at one or more susceptible locations exceeds an acceptance criteria for gas volume at the suction or discharge of a pump), the Surveillance is not met. If it is determined by subsequent evaluation the the RHR system is not rendered inoperable by the accumulated gas (i.e., the system is sufficiently filled with water), the Surveillance may be declared met. Accumulated gas should be eliminated or brought within the acceptance criteria limits.

RHR System locations susceptible to gas accumulation are monitored and, if gas is found, the gas volume is compared to the acceptance criteria for the location. Susceptible locations in the same system flow path which are subject to the same gas intrusion mechanisms may be verified by monitoring a representative sub-set of susceptible locations. Monitoring may not be practical for locations that are inaccessible due to radiological or environmental conditions, the plant configuration, or personnel safety. For these locations alternative methods (e.g., operating parameters, remote monitoring) may be used to monitor the susceptible location. Monitoring is not required for susceptible locations where the maximum potential accumulated gas void volume has been evaluated and determined to not challenge system OPERABILITY. The accuracy of the method used for monitoring the susceptible locations and trending of the results should be sufficient to assure system OPERABILITY during the Surveillance interval.

BASES

SURVEILLANCE REQUIREMENTS (continued)

This SR is modified by a Note that states the SR is not required to be performed until 12 hours after entering MODE 4. In a rapid shutdown, there may be insufficient time to verify all susceptible locations prior to entering MODE 4. DCD_05.04.07-11

[The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the RHR System piping and the procedural controls governing system operation.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The Surveillance Frequency may vary by location susceptible to gas accumulation.]

REFERENCES ~~None.~~1. Subsection 15.4.6 DCD_15.4.6-6

BASES

LCO (continued)

a. No operations are permitted that would dilute the RCS boron concentration with coolant with boron concentrations less than required to meet SDM of LCO 3.1.1, therefore maintaining the margin to criticality. Boron reduction with coolant at boron concentrations less than required to assure SDM is maintained is prohibited because a uniform concentration distribution throughout the RCS cannot be ensured when in natural circulation and

b. Core outlet temperature is maintained at least 10°F below saturation temperature, so that no vapor bubble may form and possibly cause a natural circulation flow obstruction.

Note 2 allows one RHR loop to be inoperable for a period of up to 2 hours, provided that the other RHR loop is OPERABLE and in operation. This permits periodic surveillance tests to be performed on the inoperable loop during the only time when such testing is safe and possible.

Note 3 requires that the secondary side water temperature of each SG be ≤ 50°F above each of the RCS cold leg temperatures before the start of a reactor coolant pump (RCP) with an RCS cold leg temperature ≤ Low Temperature Overpressure Protection (LTOP) arming temperature specified in the PTLR. This restriction is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started.

Note 4 provides for an orderly transition from MODE 5 to MODE 4 during a planned heatup by permitting removal of RHR loops from operation when at least one RCS loop is in operation. This Note provides for the transition to MODE 4 where an RCS loop is permitted to be in operation and replaces the RCS circulation function provided by the RHR loops. The requirement for isolation of the unborated water sources is removed as soon as one RCP is in operation. DCD_15.4.6-6

CS/RHR pumps are OPERABLE if they are capable of being powered and are able to provide flow if required. A SG can perform as a heat sink via natural circulation when it has an adequate water level and is OPERABLE. Management of gas voids is important to RHR System OPERABILITY. DCD_05.04.07-11

BASES

SURVEILLANCE REQUIREMENTS (continued)

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SR 3.4.7.5

RHR System piping and components have the potential to develop voids and pockets of entrained gases. Preventing and managing gas intrusion and accumulation is necessary for proper operation of the required RHR loop(s) and may also prevent water hammer, pump cavitation, and pumping noncondensible gas into the reactor vessel.

Selection of RHR System locations susceptible to gas accumulation is based on a review of system design information, including piping and instrumentation drawings, isometric drawings, plan and elevation drawings, and calculations. The design review is supplemented by system walk downs to validate the system high points and to confirm the location and orientation of important components that can become sources of gas or could otherwise cause gas to be trapped or difficult to remove during system maintenance or restoration. Susceptible locations depend on plant and system configuration, such as stand-by versus operating conditions.

The RHR System is OPERABLE when it is sufficiently filled with water. Acceptance criteria are established for the volume of accumulated gas at susceptible locations. If accumulated gas is discovered that exceeds an acceptance criteria for the susceptible location (or the volume of accumulated gas at one or more susceptible locations exceeds an acceptance criteria for gas volume at the suction or discharge of a pump), the Surveillance is not met. If it is determined by subsequent evaluation that the RHR System is not rendered inoperable by the accumulated gas (i.e., the system is sufficiently filled with water), the Surveillance may be declared met. Accumulated gas should be eliminated or brought within the acceptance criteria limits.

RHR System locations susceptible to gas accumulation are monitored and, if gas is found, the gas volume is compared to the acceptance criteria for the location. Susceptible locations in the same system flow path which are subject to the same gas intrusion mechanisms may be verified by monitoring a representative sub-set of susceptible locations. Monitoring may not be practical for locations that are inaccessible due to radiological or environmental conditions, the plant configuration, or personnel safety. For these locations alternative methods (e.g., operating parameters, remote monitoring) may be used to monitor the susceptible location. Monitoring is not required for susceptible locations where the maximum potential accumulated gas void volume has been evaluated and determined to not challenge system OPERABILITY. The accuracy of the method used for monitoring the susceptible locations and trending of the results should be sufficient to assure system OPERABILITY during the Surveillance interval.

BASES

SURVEILLANCE REQUIREMENTS (continued)

[The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the RHR System piping and the procedural controls governing system operation.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The Surveillance Frequency may vary by location susceptible to gas accumulation.]

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REFERENCES

1. NRC Information Notice 95-35, "Degraded Ability of Steam Generators to Remove Decay Heat by Natural Circulation."

BASES

LCO

The purpose of this LCO is to require that at least three RHR loops be OPERABLE and two of these loops be in operation. An OPERABLE loop is one that has the capability of transferring heat from the reactor coolant at a controlled rate. Heat cannot be removed via the RHR System unless forced flow is used. A minimum of two running CS/RHR pumps meets the LCO requirement for two loops in operation. An additional RHR loop is required to be OPERABLE to meet single failure considerations.

Additionally, this LCO requires that all sources of unborated water be isolated from the RCS to prevent an inadvertent boron dilution event in MODE 5. However, planned dilution and makeup operations are sometimes required during MODE 5 to compensate for transient conditions which result in a continuous change in the RCS mass. This LCO allows exception to the requirement to isolate all sources of unborated water for the purpose of performing these planned and procedurally controlled operations, but requires that the isolation status be immediately restored following the planned actions. DCD_15.4.6-6

The LCO requires the low-pressure letdown line isolation valves to be OPERABLE to mitigate the effects associated with loss of RCS inventory.

Note 1 permits one CS/RHR pump to be removed from operation for ≤ 15 minutes when switching from one loop to another. The circumstances for stopping one CS/RHR pump is to be limited to situations when the outage time is short and core outlet temperature is maintained > 10°F below saturation temperature. The Note prohibits boron dilution with coolant at boron concentrations less than required to assure SDM of LCO 3.1.1 is maintained or draining operations when RHR forced flow is stopped.

Note 2 allows one RHR loop to be inoperable for a period of ≤ 2 hours, provided that the other two required loops are OPERABLE and in operation. This permits periodic surveillance tests to be performed on the inoperable loop during the only time when these tests are safe and possible.

An OPERABLE RHR loop is comprised of an OPERABLE CS/RHR pump capable of providing forced flow to an OPERABLE CS/RHR heat exchanger. CS/RHR 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 RHR System OPERABILITY. DCD_05.04.07-11

BASES

SURVEILLANCE REQUIREMENTS (continued)

DCD_05.04.07-11

SR 3.4.8.5

RHR System piping and components have the potential to develop voids and pockets of entrained gases. Preventing and managing gas intrusion and accumulation is necessary for proper operation of the required RHR loop(s) and may also prevent water hammer, pump cavitation, and pumping noncondensible gas into the reactor vessel.

Selection of RHR System locations susceptible to gas accumulation is based on a review of system design information, including piping and instrumentation drawings, isometric drawings, plan and elevation drawings, and calculations. The design review is supplemented by system walk downs to validate the system high points and to confirm the location and orientation of important components that can become sources of gas or could otherwise cause gas to be trapped or difficult to remove during system maintenance or restoration. Susceptible locations depend on plant and system configuration, such as stand-by versus operating conditions.

The RHR System is OPERABLE when it is sufficiently filled with water. Acceptance criteria are established for the volume of accumulated gas at susceptible locations. If accumulated gas is discovered that exceeds an acceptance criteria for the susceptible location (or the volume of accumulated gas at one or more susceptible locations exceeds an acceptance criteria for gas volume at the suction or discharge of a pump), the Surveillance is not met. If it is determined by subsequent evaluation that the RHR System is not rendered inoperable by the accumulated gas (i.e., the system is sufficiently filled with water), the Surveillance may be declared met. Accumulated gas should be eliminated or brought within the acceptance criteria limits.

RHR System locations susceptible to gas accumulation are monitored and, if gas is found, the gas volume is compared to the acceptance criteria for the location. Susceptible locations in the same system flow path which are subject to the same gas intrusion mechanisms may be verified by monitoring a representative sub-set of susceptible locations. Monitoring may not be practical for locations that are inaccessible due to radiological or environmental conditions, the plant configuration, or personnel safety. For these locations alternative methods (e.g., operating parameters, remote monitoring) may be used to monitor the susceptible location. Monitoring is not required for susceptible locations where the maximum potential accumulated gas void volume has been evaluated and determined to not challenge system OPERABILITY. The accuracy of the method used for monitoring the susceptible locations and trending of the results should be sufficient to assure system OPERABILITY during the Surveillance interval.

BASES

SURVEILLANCE REQUIREMENTS (continued)

[The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the RHR System piping and the procedural controls governing system operation.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The Surveillance Frequency may vary by location susceptible to gas accumulation.]

DCD_05.04.07-11

REFERENCES None.

LCO

In MODES 1, 2, and 3, three independent (and redundant) SIS trains are required to ensure that sufficient SIS flow is available, assuming a single failure affecting one of the three required trains. Additionally, individual components within the SIS trains may be called upon to mitigate the consequences of other transients and accidents.

In MODES 1, 2, and 3, an SIS train consists of the piping, instruments, and controls to ensure an OPERABLE flow path capable of taking suction from the RWSP upon an ECCS actuation signal.

During an event requiring ECCS actuation, a flow path is required to

provide an abundant supply of water from the RWSP to the RCS via the SI pumps and their respective supply headers to each of the four direct vessel injection nozzles. In the long term, this flow path may be switched to supply its flow between the RCS hot and cold legs. Management of gas voids is important to ECCS OPERABILITY.

DCD_05.04.07-11

The flow path for each train must maintain its designed independence to ensure that no single failure can disable the capability of two or more SIS trains.

As indicated in Note 1, the SIS flow paths may be isolated for 2 hours in MODE 3, under controlled conditions, to perform pressure isolation valve testing per SR 3.4.14.1. The flow path is readily restorable from the control room.

As indicated in Note 2, operation in MODE 3 with SIS trains made incapable of injecting in order to facilitate entry into or exit from the Applicability of LCO 3.4.12, "Low Temperature Overpressure Protection (LTOP) System," is necessary for plants with an LTOP arming temperature at or near the MODE 3 boundary temperature of 350°F. LCO 3.4.12 requires that certain pumps be rendered incapable of injecting at and below the LTOP arming temperature. When this temperature is at or near the MODE 3 boundary temperature, time is needed to make pumps incapable of injecting prior to entering the LTOP Applicability, and provide time to restore the inoperable pumps to OPERABLE status on exiting the LTOP Applicability.

BASES

ACTIONS (continued)

B.1 and B.2

If the inoperable trains cannot be returned to OPERABLE status within the associated Completion Time, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to MODE 3 within 6 hours and MODE 4 within 12 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.5.2.1

Verification of proper valve position ensures that the flow path from the SI pumps to the RCS is maintained. Misalignment of these valves could render two SIS trains inoperable. Securing these valves in position by removal of power ensures that they cannot change position as a result of an active failure or be inadvertently misaligned. [A 12 hour Frequency is considered reasonable in view of other administrative controls that will ensure a mispositioned valve is unlikely. OR The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk and is controlled under the Surveillance Frequency Control Program.]

SR 3.5.2.2

Verifying the correct alignment for manual and power operated valves in the SIS flow paths provides assurance that the proper flow paths will exist for SIS operation. This SR does not apply to valves that are locked, sealed, or otherwise secured in position, since these were verified to be in the correct position prior to locking, sealing, or securing. This Surveillance does not require any testing or valve manipulation. Rather, it involves verification that those valves capable of being mispositioned are in the correct position. [The 31 day Frequency is appropriate because the valves are operated under administrative control, and an improper valve position would only affect a single train. This Frequency has been shown to be acceptable through operating experience. OR The Surveillance Frequency is based on operating experience, equipment reliability, and plant risk and is controlled under the Surveillance Frequency Control Program.]

The Surveillance is modified by a Note which exempts system vent flow paths opened under administrative control. The administrative control should be proceduralized and include stationing a dedicated individual at the system vent flow path who is in continuous communication with the operators in the control room. This individual will have a method to rapidly close the system vent flow path and restore the system to a condition equivalent to the design condition if directed.

DCD_05.04.07-11

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.2.7

DCD_05.04.07-11

ECCS piping and components have the potential to develop voids and pockets of entrained gases. Preventing and managing gas intrusion and accumulation is necessary for proper operation of the ECCS and may also prevent water hammer, pump cavitation, and pumping of noncondensible gas into the reactor vessel.

Selection of ECCS locations susceptible to gas accumulation is based on a review of system design information, including piping and instrumentation drawings, isometric drawings, plan and elevation drawings, and calculations. The design review is supplemented by system walk downs to validate the system high points and to confirm the location and orientation of important components that can become sources of gas or could otherwise cause gas to be trapped or difficult to remove during system maintenance or restoration. Susceptible locations depend on plant and system configuration, such as stand-by versus operating conditions.

The ECCS is OPERABLE when it is sufficiently filled with water. Acceptance criteria are established for the volume of accumulated gas at susceptible locations. If accumulated gas is discovered that exceeds an acceptance criteria for the susceptible location (or the volume of accumulated gas at one or more susceptible locations exceeds an acceptance criteria for gas volume at the suction or discharge of a pump), the Surveillance is not met. If it is determined by subsequent evaluation that the ECCS is not rendered inoperable by the accumulated gas (i.e., the system is sufficiently filled with water), the Surveillance may be declared met. Accumulated gas should be eliminated or brought within the acceptance criteria limits.

ECCS locations susceptible to gas accumulation are monitored and, if gas is found, the gas volume is compared to the acceptance criteria for the location. Susceptible locations in the same system flow path which are subject to the same gas intrusion mechanisms may be verified by monitoring a representative sub-set of susceptible locations. Monitoring may not be practical for locations that are inaccessible due to radiological or environmental conditions, the plant configuration, or personnel safety. For these locations alternative methods (e.g., operating parameters, remote monitoring) may be used to monitor the susceptible location. Monitoring is not required for susceptible locations where the maximum potential accumulated gas void volume has been evaluated and determined to not challenge system OPERABILITY. The accuracy of the method used for monitoring the susceptible locations and trending of the results should be sufficient to assure system OPERABILITY during the Surveillance interval.

BASES

SURVEILLANCE REQUIREMENTS (continued)

[The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the ECCS piping and the procedural controls governing system operation.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The Surveillance Frequency may vary by location susceptible to gas accumulation.]

DCD_05.04.07-11

REFERENCES

1. 10 CFR 50, Appendix A, GDC 35.

2. 10 CFR 50.46.

3. Subsection 6.2.1.

4. Subsection 15.6.5.

5. Chapter 19.

B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.3 Safety Injection System (SIS) - Shutdown

BASES

BACKGROUND

The Background section for Bases 3.5.2, "Safety Injection System (SIS) - Operating," is applicable to these Bases, with the following modifications.

In MODE 4, the SIS train requirement is two trains.

An SIS flow path consists of piping, valves, and an SI pump such that water from the refueling water storage pit (RWSP) can be injected into the Reactor Coolant System (RCS) following the accidents described in Bases 3.5.2.

APPLICABLE SAFETY ANALYSES

The Applicable Safety Analyses section of Bases 3.5.2 also applies to this Bases section.

Due to the stable conditions associated with operation in MODE 4 and the reduced probability of occurrence of a Design Basis Accident (DBA), the SIS operational requirements are reduced. It is understood in these reductions that certain automatic ECCS actuation is not available. In this MODE, sufficient time exists for manual actuation of the required SIS to mitigate the consequences of a DBA.

Only two trains of SIS are required for MODE 4. This requirement dictates that single failures are not considered during this MODE of operation. The SIS trains satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

In MODE 4, two of the four independent (and redundant) SIS trains are required to be OPERABLE to ensure that sufficient SIS flow is available to the core following a DBA.

In MODE 4, an ECCS train consists of the piping, instruments, and controls to ensure an OPERABLE flow path capable of taking suction from the RWSP.

During an event requiring ECCS actuation, a flow path is required to provide an abundant supply of water from the RWSP to the RCS via the SI pumps to the reactor vessel direct injection nozzles associated with the SIS train. Management of gas voids is important to ECCS OPERABILITY. DCD_05.04.07-11

BASES

LCO (continued)

b. Mixing of borated coolant to minimize the possibility of criticality, and

c. Indication of reactor coolant temperature.

An OPERABLE RHR loop includes a CS/RHR pump, a heat exchanger, valves, piping, instruments, and controls to ensure an OPERABLE flow path and to determine the low end temperature. The flow path starts in one of the RCS hot legs and is returned to the RCS cold legs. Management of gas voids is important to RHR System OPERABILITY. DCD_05.04.07-11

The LCO is modified by a Note that allows the required operating RHR loops to be removed from operation for up to 1 hour per 8 hour period, provided no operations are permitted that would dilute the RCS boron concentration by introduction of coolant into the RCS with boron concentration less than required to meet the minimum boron concentration of LCO 3.9.1. Boron concentration reduction with coolant at boron concentrations less than required to assure the RCS boron concentration is maintained is prohibited because uniform concentration distribution cannot be ensured without forced circulation. This permits operations such as core mapping or alterations in the vicinity of the reactor vessel hot leg nozzles and RCS to CS/RHR isolation valve testing. During this 1 hour period, decay heat is removed by natural convection to the large mass of water in the refueling cavity.

APPLICABILITY Two RHR loops must be OPERABLE and in operation in MODE 6, with the water level ≥ 23 ft above the top of the reactor vessel flange, to provide decay heat removal and mixing of the borated coolant. The 23 ft water level was selected because it corresponds to the 23 ft requirement established for fuel movement in LCO 3.9.7, "Refueling Cavity Water Level." Requirements for the RHR System in other MODES are covered by LCOs in Section 3.4, Reactor Coolant System (RCS), and Section 3.5, Emergency Core Cooling Systems (ECCS). RHR loop requirements in MODE 6 with the water level < 23 ft are located in LCO 3.9.6, "Residual Heat Removal (RHR) and Coolant Circulation - Low Water Level."

BASES

ACTIONS (continued)

SR 3.9.5.2

DCD_05.04.07-11

RHR System piping and components have the potential to develop voids and pockets of entrained gases. Preventing and managing gas intrusion and accumulation is necessary for proper operation of the required RHR loop(s) and may also prevent water hammer, pump cavitation, and pumping noncondensible gas into the reactor vessel.

Selection of RHR System locations susceptible to gas accumulation is based on a review of system design information, including piping and instrumentation drawings, isometric drawings, plan and elevation drawings, and calculations. The design review is supplemented by system walk downs to validate the system high points and to confirm the location and orientation of important components that can become sources of gas or could otherwise cause gas to be trapped or difficult to remove during system maintenance or restoration. Susceptible locations depend on plant and system configuration, such as stand-by versus operating conditions.

The RHR System is OPERABLE when it is sufficiently filled with water. Acceptance criteria are established for the volume of accumulated gas at susceptible locations. If accumulated gas is discovered that exceeds an acceptance criteria for the susceptible location (or the volume of accumulated gas at one or more susceptible locations exceeds an acceptance criteria for gas volume at the suction or discharge of a pump), the Surveillance is not met. If it is determined by subsequent evaluation that the RHR System is not rendered inoperable by the accumulated gas (i.e., the system is sufficiently filled with water), the Surveillance may be declared met. Accumulated gas should be eliminated or brought within the acceptance criteria limits.

RHR System locations susceptible to gas accumulation are monitored and, if gas is found, the gas volume is compared to the acceptance criteria for the location. Susceptible locations in the same system flow path which are subject to the same gas intrusion mechanisms may be verified by monitoring a representative sub-set of susceptible locations. Monitoring may not be practical for locations that are inaccessible due to radiological or environmental conditions, the plant configuration, or personnel safety. For these locations alternative methods (e.g., operating parameters, remote monitoring) may be used to monitor the susceptible location. Monitoring is not required for susceptible locations where the maximum potential accumulated gas void volume has been evaluated and determined to not challenge system OPERABILITY. The accuracy of the method used for monitoring the susceptible locations and trending of the results should be sufficient to assure system OPERABILITY during the Surveillance interval.

BASES

ACTIONS (continued

[The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the RHR System piping and the procedural controls governing system operation.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The Surveillance Frequency may vary by location susceptible to gas accumulation.]

DCD_05.04.07-11

REFERENCES 1. Subsection 5.4.7.

BASES

LCO (continued)

The LCO requires the low-pressure letdown line isolation valves to be OPERABLE to mitigate the effects associated with loss of RCS inventory.

This LCO is modified by two Notes. Note 1 permits the RHR pumps to be removed from operation for ≤ 15 minutes when switching from one train to another. The circumstances for stopping all RHR pumps are to be limited to situations when the outage time is short and the core outlet temperature is maintained > 10 degrees F below saturation temperature. The Note prohibits boron dilution or draining operations when RHR forced flow is stopped.

Note 2 allows one RHR loop to be inoperable for a period of 2 hours provided the other loops are OPERABLE and in operation. Prior to declaring the loop inoperable, consideration should be given to the existing plant configuration. This consideration should include that the core time to boil is short, there is no draining operation to further reduce RCS water level and that the capability exists to inject borated water into the reactor vessel. This permits surveillance tests to be performed on the inoperable loop during a time when these tests are safe and possible.

An OPERABLE RHR loop consists of an CS/RHR pump, a heat exchanger, valves, piping, instruments and controls to ensure an OPERABLE flow path and to determine the low end temperature. The flow path starts in one of the RCS hot legs and is returned to the RCS cold legs. Management of gas voids is important to RHR System OPERABILITY. DCD_05.04.07-11

All RHR pumps may be aligned to the Refueling Water Storage Pit to support filling or draining the refueling cavity or for performance of required testing.

APPLICABILITY Three RHR loops are required to be OPERABLE, and two RHR loops must be in operation in MODE 6, with the water level < 23 ft above the top of the reactor vessel flange, to provide decay heat removal and mixing of the borated coolant. Requirements for the RHR System in other MODES are covered by LCOs in Section 3.4, Reactor Coolant System (RCS), and Section 3.5, Emergency Core Cooling Systems (ECCS). RHR loop requirements in MODE 6 with the water level ≥ 23 ft are located in LCO 3.9.5, "Residual Heat Removal (RHR) and Coolant Circulation - High Water Level."

In MODE 6 Low Water Level, low-pressure letdown line isolation valves are automatically closed upon detection of RCS loop low-level signal to prevent loss of RCS inventory.

The function is effective to prevent core damage during plant shutdown, based on probabilistic risk assessment.

SURVEILLANCE REQUIREMENTS

SR 3.9.6.4

DCD_05.04.07-11

RHR System piping and components have the potential to develop voids and pockets of entrained gases. Preventing and managing gas intrusion and accumulation is necessary for proper operation of the required RHR loop(s) and may also prevent water hammer, pump cavitation, and pumping noncondensible gas into the reactor vessel.

Selection of RHR System locations susceptible to gas accumulation is based on a review of system design information, including piping and instrumentation drawings, isometric drawings, plan and elevation drawings, and calculations. The design review is supplemented by system walk downs to validate the system high points and to confirm the location and orientation of important components that can become sources of gas or could otherwise cause gas to be trapped or difficult to remove during system maintenance or restoration. Susceptible locations depend on plant and system configuration, such as stand-by versus operating conditions.

The RHR System is OPERABLE when it is sufficiently filled with water. Acceptance criteria are established for the volume of accumulated gas at susceptible locations. If accumulated gas is discovered that exceeds an acceptance criteria for the susceptible location (or the volume of accumulated gas at one or more susceptible locations exceeds an acceptance criteria for gas volume at the suction or discharge of a pump), the Surveillance is not met. If it is determined by subsequent evaluation that the RHR System is not rendered inoperable by the accumulated gas (i.e., the system is sufficiently filled with water), the Surveillance may be declared met. Accumulated gas should be eliminated or brought within the acceptance criteria limits.

RHR System locations susceptible to gas accumulation are monitored and, if gas is found, the gas volume is compared to the acceptance criteria for the location. Susceptible locations in the same system flow path which are subject to the same gas intrusion mechanisms may be verified by monitoring a representative sub-set of susceptible locations. Monitoring may not be practical for locations that are inaccessible due to radiological or environmental conditions, the plant configuration, or personnel safety. For these locations alternative methods (e.g., operating parameters, remote monitoring) may be used to monitor the susceptible location. Monitoring is not required for susceptible locations where the maximum potential accumulated gas void volume has been evaluated and determined to not challenge system OPERABILITY. The accuracy of the method used for monitoring the susceptible locations and trending of the results should be sufficient to assure system OPERABILITY during the Surveillance interval.

SURVEILLANCE REQUIREMENTS

[The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the RHR System piping and the procedural controls governing system operation.

OR

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program. The Surveillance Frequency may vary by location susceptible to gas accumulation.]

DCD_05.04.07-11

1.b Each mechanical division of the ECCS (Divisions A, B, C & D) is physically separated from the other divisions, with the exception of inside the containment, so as not to preclude accomplishment of the safety function.

2.a.i The ASME Code Section III components of the ECCS identified in Table 2.4.4-2 are fabricated, installed and inspected in accordance with ASME Code Section III requirements.

2.a.ii The ASME Code Section III components of the ECCS identified in Table 2.4.4-2 are reconciled with the design requirements.

2.b.i The ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements. DCD_05.04.07-11

2.b.ii The ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, is reconciled with the design requirements. DCD_05.04.07-11

3.a Pressure boundary welds in ASME Code Section III components, identified in Table 2.4.4-2, meet ASME Code Section III requirements for non-destructive examination of welds.

3.b Pressure boundary welds in ASME Code Section III piping, identified in Table 2.4.4-3, meet ASME Code Section III requirements for non-destructive examination of welds.

4.a The ASME Code Section III components, identified in Table 2.4.4-2, retain their pressure boundary integrity at their design pressure.

4.b The ASME Code Section III piping, identified in Table 2.4.4-3, retains its pressure boundary integrity at its design pressure.

5.a The seismic Category I equipment, identified in Table 2.4.4-2, can withstand seismic design basis loads without loss of safety function.

5.b The seismic Category I piping, including supports, identified in Table 2.4.4-3 can withstand seismic design basis loads without a loss of its safety function.

6.a The Class 1E equipment identified in Table 2.4.4-2 as being qualified for a harsh environment can withstand the environmental conditions that would exist before, during, and following a design basis accident without loss of safety function for the time required to perform the safety function.

6.b Class 1E equipment, identified in Table 2.4.4-2, is powered from its respective Class 1E division.

6.c Separation is provided between redundant divisions of ECCS Class 1E cables, and between Class 1E cables and non-Class 1E cables.

Table 2.4.4-5 Emergency Core Cooling System Inspections, Tests, Analyses, and Acceptance Criteria (Sheet 2 of 10)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria	
2.b.i The ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.	2.b.i Inspection of the as-built ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, will be performed.	2.b.i The ASME Code Section III data report(s) (certified when required by ASME Code) and inspection reports (including N-5 Data Reports where applicable) exist and conclude that the as-built ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.	DCD_05.04.07-11 DCD_05.04.07-11
2.b.ii The ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, is reconciled with the design requirements.	2.b.ii A reconciliation analysis of the piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3, using as-designed and as-built information and ASME Code Section III design report(s) (NCA-3550) will be performed.	2.b.ii The ASME Code Section III design report(s) (certified, when required by ASME Code) exist and conclude that the design reconciliation has been completed in accordance with the ASME Code, for the as-built ASME Code Section III piping of the ECCS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.4-3. The report documents the results of the reconciliation analysis.	DCD_05.04.07-11 DCD_05.04.07-11
3.a Pressure boundary welds in ASME Code Section III components, identified in Table 2.4.4-2, meet ASME Code Section III requirements for non-destructive examination of welds.	3.a Inspections of the as-built pressure boundary welds in ASME Code Section III components identified in Table 2.4.4-2, will be performed in accordance with the ASME Code Section III.	3.a The ASME Code Section III code reports exist and conclude that the ASME Code Section III requirements are met for non-destructive examination of the as-built pressure boundary welds in ASME Code Section III components identified in Table 2.4.4-2.	

2.4.5 Residual Heat Removal System (RHRS)

2.4.5.1 Design Description

The RHRS cools the reactor by removing decay heat and other residual heat from the reactor core and the reactor coolant system (RCS) during normal plant shutdown and cooldown conditions via the component cooling water system (CCWS). Any two of the four subsystems have a 100% capability for safe shutdown. The RHRS provides cooling for the in-containment RWSP during normal plant operation when required and can also provide a portion of the RCS flow to the chemical and volume control system (CVCS) during normal plant startup and cooldown operations to control RCS pressure. The RHRS can operate during mid-loop or drain down operation to allow maintenance or inspection of the reactor head, steam generator, and reactor coolant pump seals and can transfer borated water from the RWSP to the refueling cavity at the beginning of a refueling operation.

The RHRS is a safety-related system. Portions of the RHRS (i.e., heat exchangers and pumps) are shared with the containment spray system (CSS). The RHRS provides the containment isolation function, as described in Section 2.11.2, for the piping that penetrates the containment. The RHRS is used as an alternate for core cooling / injection in case all safety injection systems fail.

1.a The functional arrangement of RHRS is as described in the Design Description of Subsection 2.4.5.1 and in Table 2.4.5-1 and as shown in Figure 2.4.5-1.

1.b Each mechanical division of the RHRS (Divisions A, B, C & D) is physically separated from the other divisions with the exception of inside the containment so as not to preclude accomplishment of the safety function.

2.a.i The ASME Code Section III components of the RHRS, identified in Table 2.4.5-2, are fabricated, installed and inspected in accordance with ASME Code Section III requirements.

2.a.ii The ASME Code Section III components of the RHRS identified in Table 2.4.5-2 are reconciled with the design requirements.

2.b.i The ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements. DCD_05.04.07-11

2.b.ii The ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3 is reconciled with the design requirements. DCD_05.04.07-11

Table 2.4.5-5 Residual Heat Removal System Inspections, Tests, Analyses, and Acceptance Criteria (Sheet 2 of 9)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria	
2.b.i The ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.	2.b.i Inspection of the as-built ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3, will be performed.	2.b.i The ASME Code Section III data report(s) (certified when required by ASME Code) and inspection reports (including N-5 Data Reports where applicable) exist and conclude that the as-built ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3 is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.	DCD_05.04.07-11 DCD_05.04.07-11
2.b.ii The ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3 is reconciled with the design requirements.	2.b.ii A reconciliation analysis of the piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3, using as-designed and as-built information and ASME Code Section III design report(s) (NCA-3550) will be performed.	2.b.ii The ASME Code Section III design report(s) (certified, when required by ASME Code) exist and conclude that design reconciliation has been completed in accordance with the ASME Code, for the as-built ASME Code Section III piping of the RHRS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.4.5-3. The report documents the results of the reconciliation analysis.	DCD_05.04.07-11 DCD_05.04.07-11
3.a Pressure boundary welds in ASME Code Section III components, identified in Table 2.4.5-2, meet ASME Code Section III requirements for non-destructive examination of welds.	3.a Inspections of the as-built pressure boundary welds in ASME Code Section III components identified in Table 2.4.5-2, will be performed in accordance with the ASME Code Section III.	3.a The ASME Code Section III code reports exist and conclude that the ASME Code Section III requirements are met for non-destructive examination of the as-built pressure boundary welds in ASME Code Section III components identified in Table 2.4.5-2.	

2.11.3 Containment Spray System (CSS)

2.11.3.1 Design Description

The CSS is a safety-related system. The purposes of the CSS are to cool the containment and remove fission products following an accident, thus the system serves as a dual-function engineered safety feature (ESF).

The CSS functions by automatically spraying borated water into the containment upon receipt of a containment spray actuation signal. This action limits the containment internal peak pressure to well below the design pressure and reduces it to approximately atmospheric pressure in a design basis LOCA or secondary system piping failure.

The CSS provides the containment isolation function, as described in Section 2.11.2, for the lines penetrating the containment.

The CSS and the residual heat removal system (RHRS) share major components which are containment spray/residual heat removal (CS/RHR) pumps and heat exchangers. The CSS includes:

- four CS/RHRS pumps (included in RHRS)
- four CS/RHRS heat exchangers (included in RHRS)
- a spray ring header composed of four concentric interconnected rings, piping, spray nozzles and valves

The CSS includes four 50% capacity CS/RHR pumps divisions. Each recirculation sump pit of the refueling water storage pit (RWSP) contains paired suction piping for the CS/RHRS pump and the safety injection pump. RWSP suction isolation valves can be closed to prevent leakage of RWSP water from CS/RHRS.

1.a The functional arrangement of the CSS is as described in the Design Description of Subsection 2.11.3.1 and in Table 2.11.3-1, and as shown in Figure 2.11.3-1.

1.b Each mechanical division of the CSS (Divisions A, B, C & D) is physically separated from the other divisions with the exception of inside the containment so as not to preclude accomplishment of the safety function.

2.a.i The ASME Code Section III components of the CSS, identified in Table 2.11.3-2, are fabricated, installed, and inspected in accordance with ASME Code Section III requirements.

2.a.ii The ASME Code Section III components of the CSS identified in Table 2.11.3-2 are reconciled with the design requirements.

2.b.i The ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements. DCD_05.04.07-11

2.b.ii The ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3 is reconciled with the design requirements. DCD_05.04.07-11

3.a Pressure boundary welds in ASME Code Section III components, identified in Table 2.11.3-2, meet ASME Code Section III requirements for non-destructive examination of welds.

3.b Pressure boundary welds in ASME Code Section III piping, identified in Table 2.11.3-3, meet ASME Code Section III requirements for non-destructive examination of welds.

4.a The ASME Code Section III components, identified in Table 2.11.3-2, retain their pressure boundary integrity at their design pressure.

4.b The ASME Code Section III piping, identified in Table 2.11.3-3, retains its pressure boundary integrity at its design pressure.

5.a The seismic Category I equipment, identified in Table 2.11.3-2, can withstand seismic design basis loads without loss of safety function.

5.b The seismic Category I piping, including supports, identified in Table 2.11.3-3 can withstand seismic design basis loads without a loss of its safety function.

6.a Class 1E equipment identified in Table 2.11.3-2 as being qualified for a harsh environment can withstand the environmental conditions that would exist before, during, and following a design basis accident without loss of safety function for the time required to perform the safety function.

6.b The Class 1E equipment, identified in Table 2.11.3-2, is powered from its respective Class 1E division.

6.c Separation is provided between redundant divisions of CSS Class 1E cables, and between Class 1E cables and non-Class 1E cable.

7.a Deleted.

7.b The CSS provides containment spray during design basis accidents.

7.c The CS/RHR pumps have sufficient net positive suction head (NPSH).

8.a Controls are provided in the MCR to open and close the remotely operated valves identified in Table 2.11.3-2.

9.a The motor-operated valves and check valves, identified in Table 2.11.3-2 as having an active safety function, perform an active safety function to change position as indicated in the table.

9.b After loss of motive power, the remotely operated valves, identified in Table 2.11.3-2, assume the indicated loss of motive power position.

Table 2.11.3-5 Containment Spray System Inspections, Tests, Analyses, and Acceptance Criteria (Sheet 2 of 8)

Design Commitment		Inspections, Tests, Analyses		Acceptance Criteria		
2.b.i	The ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3, is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.	2.b.i	Inspection of the as-built ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3 will be performed.	2.b.i	The ASME Code Section III data report(s) (certified when required by ASME Code) and inspection reports (including N-5 Data Reports where applicable) exist and conclude that the as-built ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3 is fabricated, installed, and inspected in accordance with ASME Code Section III requirements.	DCD_05.04.07-11 DCD_05.04.07-11
2.b.ii	The ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3 is reconciled with the design requirements.	2.b.ii	A reconciliation analysis of the piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3, using as-designed and as-built information and ASME Code Section III design report(s) (NCA3550) will be performed.	2.b.ii	The ASME Code Section III design report(s) (certified, when required by ASME Code) exist and conclude that design reconciliation has been completed in accordance with the ASME Code for the as-built ASME Code Section III piping of the CSS, including supports and design features described in the design basis to limit potential gas accumulation, identified in Table 2.11.3-3. The report documents the results of the reconciliation analysis.	DCD_05.04.07-11 DCD_05.04.07-11
3.a	Pressure boundary welds in ASME Code Section III components, identified in Table 2.11.3-2, meet ASME Code Section III requirements for non-destructive examination of welds.	3.a	Inspections of the as-built pressure boundary welds in ASME Code Section III components identified in Table 2.11.3-2 will be performed in accordance with the ASME Code Section III.	3.a	The ASME Code Section III code reports exist and conclude that the ASME Code Section III requirements are met for non-destructive examination of the as-built pressure boundary welds in ASME code Section III components identified in Table 2.11.3-2.	