Response to Action Item 3-53 Section 3.6.3

MCB Issue List Regarding APR-1400, FSAR Section 3.6.3

Issue #1 (AI 3-53.9)

The potential for water or steam hammer in a particular piping system could represent a loading condition which would need to be evaluated when considering whether or not a piping system meets LBB requirements.

NUREG-0927, “Evaluation of Water Hammer Occurrence in Nuclear Power Plants,” provides recommendations to be included in operating and maintenance procedures which include: A) prevention of rapid valve motion, B) proper filling and venting of water-filled lines and components, C) introduction of voids into water-filled lines and components, D) introduction of steam or heated water that can flash into water filled lines, E) introduction of water into steam-filled lines or components, F) proper warm-up of steam-filled lines, G) proper drainage of steam-filled lines, and H) the effects of valve alignments on line conditions.

Please provide additional information in the APR1400 FSAR Section 3.6.3 regarding how each of the items A) through H) is, or is not, implemented within the APR1400 design in each of those systems being proposed for LBB to ensure that water hammer will not be a concern in those systems during plant operation.

Response

Each of the items A) through H) in Section 3.12 of NUREG-0927 is, or not, implemented within the APR1400 design as follows:

A) Prevention of rapid valve motion

Valve discharge loads associated with the PZR have been identified and included in the component design basis.

There are no fast-acting valves in the DVI and SC piping systems. The stroking times of the valves on DVI and SC lines are approximately 30 to 80 seconds. Therefore, there is little potential to water hammer loading due to rapid valve movement as described in the Subsection 3.6.3.4.2.3.

B) Proper filling and venting of water-filled lines and components

The reactor coolant gas vent system (RCGVS) is used to vent/discharge non-condensable gases and steam from the high points of the RCS. Non-condensable gases from the reactor vessel closure head and the pressurizer steam space will be vented during plant startup process to fill the RCS.

For DVI and SC lines, high-point vents are designed to prevent water hammer by providing proper venting capability of the lines.

The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in each piping system designed for LBB.

C) Introduction of voids into water-filled lines and components

Voids are vented appropriately during plant startup and the reactor coolant loop is designed to operate at a pressure greater than the saturation pressure of the coolant. The RCS is

operated at higher pressure than other connecting systems. Therefore, there is little potential of void introduction into the RCL piping and surge line from the connecting systems.
For DVI and SC lines, high-point vents are designed to prevent water hammer by providing proper venting of the lines. The cover gas of the SIT is initiated after the tanks are filled with water, so the possibility of gas intrusion into the water filled piping in the DVI line does not need to be assumed.
The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in each piping system designed for LBB.

D) Introduction of steam or heated water that can flash into water filled lines
The reactor coolant loop is designed to operate at a pressure greater than the saturation pressure of the coolant and there is no valve in the loop. The RCS is operated at higher pressure than other connecting systems. Therefore, there is little possibility of introduction of steam or heated water into the RCL piping and surge line.
For DVI lines, high temperature RCS leakage to cold DVI line can be monitored by pressure indication and alarm installed the downstream of DVI check valve. Therefore, the MCR operator can take action to prevent potential water hammer due to check valve leakage and the probability of water hammer is not to be assumed.
Under normal power operation, the valves in the line are closed and the fluid in the line is at ambient temperature. Thus, a low vapor pressure and steam bubble formation do not occur. During SC operation, the system is open to the RCS and has the same vapor pressure as the RCS, which would be subcooled due to the hydrostatic head formed by the water and steam in the PZR. Therefore, steam bubble formation is precluded by the characteristics inherent to the system.

E) Introduction of water into steam-filled lines or components
The reactor coolant loop is designed to operate at a pressure greater than the saturation pressure of the coolant. Therefore, there is little possibility of introduction into the RCL piping and surge line and of a water hammer occurrence.
Because there is no steam filled lines or components in DVI/SC systems, this issue is not a cause of water hammer in the systems.

F) Proper warm-up of steam-filled lines
Because there is no steam filled lines in the APR1400 LBB applied piping, this issue is not a cause of water hammer in the systems.

G) Proper drainage of steam-filled lines
Because there is no steam filled lines in the APR1400 LBB applied piping, this issue is not a cause of water hammer in the systems.

Response to Action Item 3-53 Section 3.6.3

H) The effects of valve alignments on line conditions.
Because valve alignments are not required in the APR1400 LBB applied piping, this issue is not a cause to the water hammer in the systems.

Impact on DCD
Subsection 3.6.3.4.2, Subsection 3.6.4, Subsection 3.6.5 and Table 1.8-2 will be revised as indicated on the attached markup.

Impact on PRA
There is no impact on the PRA.

Impact on Technical Specifications
There is no impact on the Technical Specification.

Impact on Technical/Topical/Environmental Reports
There is no impact on any Technical, Topical or Environmental Reports.

3.6.3.4.1.2 Leak-Before-Break Applicability to Piping

Use of high-quality steels, stainless steel, or stainless steel liners in the RCL, SL, DVI, and SC piping prevents erosion, erosion/corrosion, and erosion/cavitation. Additionally, water chemistry for the RCS is closely controlled and monitored. There is no evidence of unusual wall thinning in these pipes due to erosion, erosion/corrosion, or erosion/cavitation in pressurized water reactor (PWR) plants. Therefore, these pipes have a very low level of susceptibility to failure from these failure mechanisms.

3.6.3.4.2 Susceptibility to Failure from Water Hammer

Insert (A) of next page.

3.6.3.4.2.1 Reactor Coolant Loop (RCL) and Surge Line (SL)

There is a low potential for water hammer in the subcooled water solid portions of the RCS because these portions of the RCS are designed to preclude void formation. Safety valve discharge loads associated with the PZR have been identified and included in the component design basis. Therefore, the RCL and SL piping have a low level of susceptibility to failure from water hammer.

Insert (B) of next page.

3.6.3.4.2.2 Direct Vessel Injection (DVI) Line

The most likely cause for water hammer events in the DVI line is leaking check valves, allowing hot water to enter a low-pressure region and then flash into steam bubbles. The steam pocket thus formed would permit a steam pocket collapse type of water hammer to occur if it were suddenly pressurized by the addition of water to the low-pressure piping.

NUREG/CR-2781 (Reference 16) identifies four water hammer events from the NUREG/CR-2059 (Reference 17) database involving the safety injection system (SIS). EPRI research on water hammer events included these four events and two more related to the SIS as reported in EPRI NP-6766 (Reference 18). Five of these six events occurred in piping upstream of the injection check valves due to steam pocket collapse (3 events), filling of a voided line (1 event), and an unknown cause (1 event). The sixth event occurred in the low-head safety injection suction pump piping due to an unknown cause.

(A)

NUREG-0927 (Reference 23) provides recommendations to be included in operating and maintenance procedures which include: A) prevention of rapid valve motion, B) proper filling and venting of water-filled lines and components, C) introduction of voids into water-filled lines and components, D) introduction of steam or heated water that can flash into water filled lines, E) introduction of water into steam-filled lines or components, F) proper warm-up of steam-filled lines, G) proper drainage of steam-filled lines, and H) the effects of valve alignments on line conditions.

The implementations within the APR1400 design for each of the items in NUREG-0927 are described in Subsection 3.6.3.4.2.1 through Subsection 3.6.3.4.2.3. Each of items E) though H) in NUREG-0927 is not a cause to the water hammer in piping systems designed for LBB because there is no steam filled lines and valve alignments are not required. The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in each piping system designed for LBB (COL3.6(4)).

(B)

The reactor coolant gas vent system (RCGVS) is used to vent/discharge non-condensable gases and steam from the high points of the RCS. Non-condensable gases from the reactor vessel closure head and the pressurizer steam space will be vented during plant startup process to fill the RCS.

Delete

~~The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in this line (COL3.6(4)).~~ High-point vents provide for the proper venting of lines and pumps. If the piping is then pressurized (above the calculated leakage-induced temperatures/saturation pressures), the pressure coupled with the generally low temperature of the DVI system provides reasonable assurance that the lines will remain full and that steam bubbles will not develop near the check valves.

Further protection against this type of water hammer is provided administratively by monitoring the pressure in the injection line and flushing upon high pressure. Pressure indication and alarms are provided to alert the operator of an increase in pressure to 6.89 MPa (1,000 psig) (from a normal of approximately 4.27 MPa [620 psig]). Increased pressure is an indication of high-temperature RCS leakage past the DVI check valve. Upon an alarm, the operator opens the injection line drain valve to depressurize the injection line to the safety injection tank (SIT) pressure while replenishing the volume with subcooled water at containment ambient temperature. The replenishment is performed slowly so as not to exceed the makeup capability, therefore minimizing the potential for collapse of any steam pockets that may have formed.

Normal valve operation, pump startup, and pump trip create negligible fluid transient loads for the DVI system. The sixth event, as reported in EPRI NP-6766, is not a concern for the APR1400 because the SIS does not have a low-head safety injection pump. All results of all design basis events are mitigated with the use of four high-pressure pumps.

Based on system operating procedures that require venting of DVI lines and the low number and low severity of events reported for safety injection type systems in PWRs, the susceptibility to water-hammer-induced failures in the DVI system is low. Thus, the DVI system meets the screening criterion for the water hammer.

3.6.3.4.2.3 <u>Shutdown Cooling Line</u>

The PWR residual heat removal (RHR) system piping is susceptible only to a small number of the generic causes of water hammer such as rapid valve opening or closing and steam bubble collapse.

There is little potential for water hammer loading due to rapid valve opening or closing because there are no fast-acting valves in the shutdown cooling system (SCS), and a steam

moderate-energy piping systems and that are susceptible to the consequences of piping failures.

COL 3.6(2) The COL applicant is to provide a list of site-specific high- and moderate-energy piping systems including layout drawings and protection features and the failure modes and effects analysis for safe shutdown due to the postulated HELBs.

COL 3.6(3) The COL applicant is to confirm that the bases for the LBB acceptance criteria are satisfied by the final as-built design and materials of the piping systems as site-specific evaluations, and is to provide the information including LBB evaluation report for the verification of LBB analyses.

COL 3.6(4) The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in ~~the DVI line.~~ each piping system designed for LBB

3.6.5 References

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission.

2. NUREG-0800, Standard Review Plan, Section 3.6.1, "Plant Design for Protection against Postulated Piping Failures in Fluid Systems Outside Containment," Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

3. NUREG-0800, Standard Review Plan, Section 3.6.2, "Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping," Rev. 2, U.S. Nuclear Regulatory Commission, March 2007.

4. NUREG-0800, Standard Review Plan, Section 3.6.3, "Leak-Before-Break Evaluation Procedures," Rev. 1, U.S. Nuclear Regulatory Commission, March 2007.

5. NUREG-0800, Standard Review Plan, BTP 3-3, "Protection against Postulated Piping Failures in Fluid Systems Outside Containment," Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

17. NUREG/CR-2059, “Compilation of Data Concerning Known and Suspected Water Hammer Events in Nuclear Power Plants, CY 1969-May 1981,” U.S. Nuclear Regulatory Commission, May 1982.

18. EPRI NP-6766, “Water Hammer Prevention, Mitigation, and Accumulation, Volume 1: Plant Water Hammer Experience,” Final Report, July 1992.

19. EPRI MRP-111, Materials Reliability Program (MRP), “Resistance to Primary Water Stress Corrosion Cracking of Alloys 690, 52, and 152 in Pressurized Water Reactors (MRP-111),” March 2004.

20. Regulatory Guide 1.45, “Guidance on Monitoring and Responding to Reactor Coolant System Leakage,” Rev. 1, U.S. Nuclear Regulatory Commission, May 2008.

21. V. Kumar, M.D. German, and C.F. Shih, “An Engineering Approach for Elastic-Plastic Fracture Analysis,” EPRI Report No. NP-1931 (prepared by General Electric Company) (July 1981).

22. EPRI NP-3596-SR, Rev. 1, "PICEP: Pipe Crack Evaluation Program,″ December 1992.

23. NUREG-0927, Revision 1, “Evaluation of Water-Hammer Occurrence in Nuclear Power Plants: Technical Findings Relevant to Unresolved Safety Issue A-1,” U.S. Nuclear Regulatory Commission, March 1984.

Table 1.8-2 (3 of 29)

Item No.	Description
COL 3.4(1)	The COL applicant is to provide site-specific information on protection measures for the design-basis flood, as required in Subsection 2.4.10.
COL 3.4(2)	The COL applicant is to provide flooding analysis with flood protection and mitigation features from internal flooding for the CCW Heat Exchanger Building and ESW Building.
COL 3.4(3)	The COL applicant is to confirm that the potential site-specific external flooding events are bounded by design-basis flood values or otherwise demonstrate that the design is acceptable.
COL 3.4(4)	The COL applicant is to identify any site-specific physical models that could be used to predict prototype performance of hydraulic structures and systems.
COL 3.5(1)	The COL applicant is to provide the procedure for heavy load transfer to strictly limit the transfer route inside and outside containment during plant maintenance and repair periods.
COL 3.5(2)	The COL applicant is to perform an assessment of the orientation of the turbine generator of this and other unit(s) at multi-unit sites for the probability of missile generation using the evaluation of Subsection 3.5.1.3.2 to verify that essential SSCs are outside the low-trajectory turbine missile strike zone.
COL 3.5(3)	The COL applicant is to evaluate site-specific hazards induced by external events that may produce more energetic missiles than tornado or hurricane missiles, and provide reasonable assurance that seismic Category I and II structures are designed to withstand these loads.
COL 3.5(4)	The COL applicant is to evaluate the potential for site proximity explosions and missiles due to train explosions (including rocket effects), truck explosions, ship or barge explosions, industrial facilities, pipeline explosions, or military facilities.
COL 3.5(5)	The COL applicant is to provide justification for the site-specific aircraft hazard and an aircraft hazard analysis in accordance with the requirements of NRC RG 1.206.
COL 3.6(1)	The COL applicant is to identify the site-specific SSCs that are safety related or required for safe shutdown that are located near high- and moderate-energy piping systems and that are susceptible to the consequences of piping failures.
COL 3.6(2)	The COL applicant is to provide a list of site-specific high- and moderate-energy piping systems including layout drawings and protection features and the failure modes and effects analysis for safe shutdown due to the postulated HELBs.
COL 3.6(3)	The COL applicant is to confirm that the bases for the LBB acceptance criteria are satisfied by the final as-built design and materials of the piping systems as site-specific evaluations, and is to provide the information including LBB evaluation report for the verification of LBB analyses.
COL 3.6(4)	The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in ~~DVI line~~ each piping system designed for LBB.
COL 3.7(1)	The COL applicant is to [illegible] at are applied to the seismic design of the site [illegible] d the basis for the plant shutdown. The COL ap[illegible] of the site-specific SSE and OBE.
COL 3.7(2)	The COL applicant is to confirm that the horizontal components of the SSE site-specific ground motion in the free-field at the foundation level of the structure satisfy a peak ground acceleration of at least 0.1 g.

Response to Action Item 3-53 Section 3.6.3

MCB Issue List Regarding APR-1400, FSAR Section 3.6.3

Issue #2 (AI 3-53.10)

In APR1400 FSAR Section 3.6.3, the applicant states that according to EPRI-MRP-111, "Resistance to Primary Water Stress Corrosion Cracking of Alloys 690, 52, and 152 in Pressurized Water Reactors", primary water stress corrosion cracking (PWSCC) in dissimilar metal Alloy 52/152 butt welds is unlikely. However, Alloy 52 welds are not completely immune to (PWSCC). Contributing factors which could increase an Alloy 52 butt welds susceptibility to PWSCC include factors, for example dilution effects on dissimilar metal welds, weld residual stresses, etc., which may be controlled by the implementation of specific welding processes/parameters (e.g., heat input).

Revise APR1400 FSAR Section 3.6.3 to state that welding procedures (including those for repairs) will be qualified to minimize tensile stresses on the internal diameters, dilution effects, etc. In addition, revise APR1400 FSAR Section 3.6.3 to state that weld repairs that will be in contact with the fluid will be made such that there will be compressive stress conditions on the wetted surface.

Response

The following two sentences will be added into the fourth paragraph of FSAR Section 3.6.3.4.4. FSAR Section 3.6.4 and Table 1.8-2 will be revised to identify the additional combined license information as follows:

FSAR 3.6.3.4.4

Welding procedures including repair procedure will be qualified by the COL applicant to minimize tensile stresses on the internal diameters and dilution effects. Weld repairs that will be in contact with the fluid will be made such that there will be compressive stress conditions on the wetted surface (COL 3.6(5))

FSAR 3.6.4

COL 3.6(5) The COL applicant is to provide the information on welding of Alloy 52/52M/152 concerning the residual stress and dilution effects of welds.

Table 1.8-2

COL 3.6(5) The COL applicant is to provide the information on welding of Alloy 52/52M/152 concerning the residual stress and dilution effects of welds.

Impact on DCD

Subsection 3.6.3.4.4, Subsection 3.6.4 and Table 1.8-2 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Response to Action Item 3-53 Section 3.6.3

Impact on Technical Specifications
There is no impact on the Technical Specification.

Impact on Technical/Topical/Environmental Reports
There is no impact on any Technical, Topical or Environmental Reports.

According to EPRI MRP-111 (Reference 19), primary water stress corrosion cracking in alloy 52/152 butt welds in dissimilar-metal welds is unlikely.

Add here. "Welding procedures including repair procedure will be qualified by the COL applicant to minimize tensile stresses on the internal diameters and dilution effects. Weld repairs that will be in contact with the fluid will be made such that there will be compressive stress conditions on the wetted surface (COL 3.6(5))."

Refer to Subsections 5.2.3.2, 5.2.3.3, and 5.2.3.4 for water chemistry controls and fabrication of reactor coolant boundary components.

3.6.3.4.5 Susceptibility to Fa

Pipe degradation or failure fro support failure is prevented by reasonable assurance of a low probability of the event or its impact on safety-related structures. As an example, the overhead polar crane is designed to seismic Category II to prevent it from becoming a missile and impacting these piping systems or other safety-related equipment. Therefore, the RCL, SL, DVI, and SC piping has a very low level of susceptibility to failure from indirect causes.

3.6.3.4.6 Susceptibility to Cleavage-Type Failure

Cleavage-type failures are generally not a concern for the system operating temperatures and materials used for the RCL, SL, DVI, and SC piping. Reasonable assurance of the resistance to brittle cleavage-type failure is provided by fracture toughness test or ASME Section III, Appendix G analysis, and maintained on the full scope of system operation based on the pressure-temperature limit curve. In addition, material tests (ASME Section III required toughness tests and J-Resistance [J-R] tests) show the materials for these pipelines to be highly ductile and highly resistant to cleavage-type failures at operating temperature.

3.6.3.4.7 Susceptibility to Failure from Fatigue Cracking

The RCL, SL, DVI, and SC piping is designed to meet the ASME Section III Subsection NB fatigue criteria. All design basis transients identified in Subsection 3.9.1 are included in the detailed stress analyses. In the detailed stress analysis, the effects on thermal stratification and turbulence penetration are considered. If the impacts by these phenomena are sufficiently low, these phenomena are not considered in the design. Therefore, these pipes have a very low susceptibility to failure from fatigue cracking.

moderate-energy piping systems and that are susceptible to the consequences of piping failures.

COL 3.6(2) The COL applicant is to provide a list of site-specific high- and moderate-energy piping systems including layout drawings and protection features and the failure modes and effects analysis for safe shutdown due to the postulated HELBs.

COL 3.6(3) The COL applicant is to confirm that the bases for the LBB acceptance criteria are satisfied by the final as-built design and materials of the piping systems as site-specific evaluations, and is to provide the information including LBB evaluation report for the verification of LBB analyses.

COL 3.6(4) The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in the DVI line.

Add here. "COL 3.6(5)
The COL applicant is to provide the information on welding of Alloy 52/52M/152 concerning the residual stress and dilution effects of welds."

3.6.5 References

1. 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” U.S. Nuclear Regulatory Commission.

2. NUREG-0800, Standard Review Plan, Section 3.6.1, “Plant Design for Protection against Postulated Piping Failures in Fluid Systems Outside Containment,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

3. NUREG-0800, Standard Review Plan, Section 3.6.2, “Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping,” Rev. 2, U.S. Nuclear Regulatory Commission, March 2007.

4. NUREG-0800, Standard Review Plan, Section 3.6.3, “Leak-Before-Break Evaluation Procedures,” Rev. 1, U.S. Nuclear Regulatory Commission, March 2007.

5. NUREG-0800, Standard Review Plan, BTP 3-3, “Protection against Postulated Piping Failures in Fluid Systems Outside Containment,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

Table 1.8-2 (3 of 29)

Item No.	Description
COL 3.4(1)	The COL applicant is to provide site-specific information on protection measures for the design-basis flood, as required in Subsection 2.4.10.
COL 3.4(2)	The COL applicant is to provide flooding analysis with flood protection and mitigation features from internal flooding for the CCW Heat Exchanger Building and ESW Building.
COL 3.4(3)	The COL applicant is to confirm that the potential site-specific external flooding events are bounded by design-basis flood values or otherwise demonstrate that the design is acceptable.
COL 3.4(4)	The COL applicant is to identify any site-specific physical models that could be used to predict prototype performance of hydraulic structures and systems.
COL 3.5(1)	The COL applicant is to provide the procedure for heavy load transfer to strictly limit the transfer route inside and outside containment during plant maintenance and repair periods.
COL 3.5(2)	The COL applicant is to perform an assessment of the orientation of the turbine generator of this and other unit(s) at multi-unit sites for the probability of missile generation using the evaluation of Subsection 3.5.1.3.2 to verify that essential SSCs are outside the low-trajectory turbine missile strike zone.
COL 3.5(3)	The COL applicant is to evaluate site-specific hazards induced by external events that may produce more energetic missiles than tornado or hurricane missiles, and provide reasonable assurance that seismic Category I and II structures are designed to withstand these loads.
COL 3.5(4)	The COL applicant is to evaluate the potential for site proximity explosions and missiles due to train explosions (including rocket effects), truck explosions, ship or barge explosions, industrial facilities, pipeline explosions, or military facilities.
COL 3.5(5)	The COL applicant is to provide justification for the site-specific aircraft hazard and an aircraft hazard analysis in accordance with the requirements of NRC RG 1.206.
COL 3.6(1)	The COL applicant is to identify the site-specific SSCs that are safety related or required for safe shutdown that are located near high- and moderate-energy piping systems and that are susceptible to the consequences of piping failures.
COL 3.6(2)	The COL applicant is to provide a list of site-specific high- and moderate-energy piping systems including layout drawings and protection features and the failure modes and effects analysis for safe shutdown due to the postulated HELBs.
COL 3.6(3)	The COL applicant is to confirm that the bases for the LBB acceptance criteria are satisfied by the final as-built design and materials of the piping systems as site-specific evaluations, and is to provide the information including LBB evaluation report for the verification of LBB analyses.
COL 3.6(4)	The COL applicant is to provide the procedure for initial filling and venting to avoid the known causes for water hammer in DVI line.
COL 3.7(1)	The COL applicant is to determine the site-specific SSE and OBE that are applied to the seismic design of the site-specific seismic Category I and II SSCs and the basis for the plant shutdown. The COL applicant is also to verify the appropriateness of the site-specific SSE and OBE.
COL 3.7(2)	The COL applicant is to confirm that the horizontal components of the SSE site-specific ground motion in the free-field at the foundation level of the structure satisfy a peak ground acceleration of at least 0.1 g.

Add here.
"COL 3.6(5)"
"The COL applicant is to provide the information on welding of Alloy 52/52M/152 concerning the residual stress and dilution effects of welds."

Response to Action Item 3-53 Section 3.6.3

MCB Issue List Regarding APR-1400, FSAR Section 3.6.3

Issue #3 (AI 3-53.11)

The presence of potential unmitigated, active degradation mechanisms in a piping system would exclude it from considerations for LBB approval. One such potential active degradation mechanism is fatigue.

In the APR1400 FSAR Section 3.6.3, the applicant states that Class 1 piping which satisfies the requirements of the American Society of Mechanical Engineers (ASME) Code Section III, Subsection NB is designed for low cycle fatigue including thermal stratification. However, the applicant does not address the operational controls established to minimize vibrational fatigue. Revise FSAR Section 3.6.3 to provide additional information regarding the controls that will be in place to address the potential for vibration-induced fatigue cracking or failure in piping systems under consideration for LBB approval, or explain why vibrational fatigue is not an issue in these systems.

Response

The potential for vibration-induced fatigue cracking within the RCL is primarily due to vibrations by the reactor coolant pumps (RCP) operation. The RCP-induced vibrations are minimized by limiting pump shaft and frame vibrations during hot functional testing and operation. Also, piping vibrations are tested during initial test program as addressed in Subsection 3.9.2.1. During operation, RCP vibration monitoring system monitors the pump shaft and frame vibrations and provides the alarms to the operators in the main control room (see Subsection 7.7.1.5).

DVI and SC piping systems where LBB is applied are not operated during full power operation mode. Therefore, these system piping will not experience of vibration and result in vibration fatigue problem.

Impact on DCD

Subsection 3.6.3.4.7 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specification.

Impact on Technical/Topical/Environmental Reports

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

According to EPRI MRP-111 (Reference 19), primary water stress corrosion cracking in alloy 52/152 butt welds in dissimilar-metal welds is unlikely.

Refer to Subsections 5.2.3.2, 5.2.3.3, and 5.2.3.4 for water chemistry controls and fabrication of reactor coolant boundary components.

3.6.3.4.5 Susceptibility to Failure from Indirect Causes

Pipe degradation or failure from indirect causes such as fires, missiles, and component support failure is prevented by designing, fabricating, and inspecting to criteria that provide reasonable assurance of a low probability of the event or its impact on safety-related structures. As an example, the overhead polar crane is designed to seismic Category II to prevent it from becoming a missile and impacting these piping systems or other safety-related equipment. Therefore, the RCL, SL, DVI, and SC piping has a very low level of susceptibility to failure from indirect causes.

3.6.3.4.6 Susceptibility to Cleavage-Type Failure

The potential for vibration-induced fatigue cracking within the RCL is primarily due to vibrations by the reactor coolant pumps (RCP) operation. The RCP-induced vibrations are minimized by limiting pump shaft and frame vibrations during hot functional testing and operation. Also, piping vibrations are tested during initial test program as addressed in Subsection 3.9.2.1. During operation, RCP vibration monitoring system monitors the pump shaft and frame vibrations and provides the alarms to the operators in the main control room (see Subsection 7.7.1.5).

DVI and SC piping systems where LBB is applied are not operated during full power operation mode. Therefore, these system piping will not experience of vibration and result in vibration fatigue problem.

The RCL, SL, DVI, and SC piping is designed to meet the ASME Section III Subsection NB fatigue criteria. All design basis transients identified in Subsection 3.9.1 are included in the detailed stress analyses. In the detailed stress analysis, the effects on thermal stratification and turbulence penetration are considered. If the impacts by these phenomena are sufficiently low, these phenomena are not considered in the design. Therefore, these pipes have a very low susceptibility to failure from fatigue cracking.

Response to Action Item 3-53 Section 3.6.3

MCB Issue List Regarding APR-1400, FSAR Section 3.6.3

Issue #4 (AI 3-53.12)
In APR1400 FSAR Section 3.6.3, the applicant states that pipe degradation or failure from indirect causes such as fires, missiles, and component support failures is prevented by designing, fabricating, and implanting inspection criteria that provide reasonable assurance of a low probability of the event or its impact on safety-related structures.
Revise FSAR Section 3.6.3 to list the Sections in the APR1400 FSAR that provide a detailed description of the programs in place to prevent pipe degradation or failure from the indirect causes from the examples described above.

Response
The DCD sections that provide detailed description of the design to prevent pipe degradation or failure from the indirect causes on LBB applied piping (RCL, SL, DVI and SC) are provided below:

Seismic events: The LBB-applied piping systems are designed to Seismic Category I (see Section 3.2).

System over-pressurization: Over-pressure protection for RCS, primary side of auxiliary or emergency systems connected to the RCS, and secondary side of SG is described in Subsection 5.2.2.

Human error: Section 18.1 describes human factors engineering program to support the operator and minimize the potential for operator errors.

Fires: Fire prevention and protection are described in Subsection 9.5.1.

Flooding: Flood protection and evaluation are described in Section 3.4.

Missiles: Missile protection is described in Section 3.5.

Damages from moving equipment: The containment polar crane is designed to maintain its integrity without dropping its load during an SSE. Subsection 9.1.5 describes the overhead heavy load handling system.

Failures of structures, systems or components (SSC): The SSCs in close proximity to the LBB-applied piping system are safety-related and seismically designed (see Section 3.2).

Impact on DCD
Subsection 3.6.3.4.5 will be revised as indicated on the attached markup.

Response to Action Item 3-53 Section 3.6.3

Impact on PRA
There is no impact on the PRA.

Impact on Technical Specifications
There is no impact on the Technical Specification.

Impact on Technical/Topical/Environmental Reports
There is no impact on any Technical, Topical or Environmental Reports.

According to EPRI MRP-111 (Reference 19), primary water stress corrosion cracking in alloy 52/152 butt welds in dissimilar-metal welds is unlikely.

Refer to Subsections 5.2.3.2, 5.2.3.3, and 5.2.3.4 for water chemistry controls and fabrication of reactor coolant boundary components.

3.6.3.4.5 Susceptibility to Failure from Indirect Causes

Pipe degradation or failure from indirect causes such as fires, missiles, and component support failure is prevented by designing, fabricating, and inspecting to criteria that provide reasonable assurance of a low probability of the event or its impact on safety-related structures. ~~As an example, the overhead polar crane is designed to seismic Category II to prevent it from becoming a missile and impacting these piping systems or other safety-related equipment.~~ ~~Therefore, the RCL, SL, DVI, and SC piping has a very low level of susceptibility to failure from indirect causes.~~

The detailed description are provided below:

a. Seismic events: The LBB-applied piping systems are designed to Seismic Category I (see Section 3.2).

b. System over-pressurization: Over-pressure protection for RCS, primary side of auxiliary or emergency systems connected to the RCS, and secondary side of SG is described in Subsection 5.2.2.

c. Human error: Section 18.1 describes human factors engineering program to support the operator and minimize the potential for operator errors.

d. Fires: Fire prevention and protection are described in Subsection 9.5.1.

e. Flooding: Flood protection and evaluation are described in Section 3.4.

f. Missiles: Missile protection is described in Section 3.5.

g. Damages from moving equipment: The containment polar crane is designed to maintain its integrity without dropping its load during an SSE. Subsection 9.1.5 describes the overhead heavy load handling system.

h. Failures of structures, systems or components (SSC): The SSCs in close proximity to the LBB-applied piping system are safety-related and seismically designed (see Section 3.2).