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Protecting People and the Environment

NUREG-2101

Safety Evaluation Report

Related to the License Renewal of Salem Nuclear Generating Station

Docket Numbers 50-272 and 50-311

PSEG Nuclear, LLC

Office of Nuclear Reactor Regulation

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ABSTRACT

This safety evaluation report (SER) documents the technical review of the Salem Nuclear Generating Station, Units 1 and 2, (Salem) license renewal application (LRA) by the U.S. Nuclear Regulatory Commission (NRC) staff (the staff). By letter dated August 18, 2009, PSEG Nuclear, LLC (PSEG or the applicant) submitted the LRA in accordance with Title 10, Part 54, of the *Code of Federal Regulations*, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.” PSEG requests renewal of the operating licenses (Facility Operating License Numbers DPR-70 and DPR-75) for a period of 20 years beyond the current expiration at midnight August 13, 2016, for Unit 1, and at midnight on April 18, 2020, for Unit 2.

Salem is located approximately 40 miles from Philadelphia, PA, and 8 miles from Salem, NJ. The NRC issued the construction permits for Unit 1 and Unit 2 on August 25, 1968. The NRC issued the operating license for Unit 1 on December 1, 1976, and for Unit 2 on May 20, 1981. Both units are pressurized water reactors that were designed and supplied by Westinghouse. License Amendment Nos. 243 (Salem Unit 1) and 224 (Salem Unit 2), dated May 25, 2001, authorized a 1.4 percent increase in the licensed rated power level of each unit to 3,459 megawatt thermal (MWt).

This SER presents the status of the staff’s review of information submitted through May 18, 2011, the cutoff date for consideration in this SER. The staff has resolved all issues associated with requests for additional information and closed all open items since publishing the SER with Open Items. The staff did not identify any new open items that must be resolved before any final determination can be made on the LRA.

TABLE OF CONTENTS

LIST OF TABLES

OI 4.3.4.2-1. (SER Sections 3.0.3.2.18, 4.3.4.2, and 4.3.7.2 – Metal Fatigue of Components and Piping)

During its review of the AP1000 design certification, the staff identified concerns regarding results of the WESTEMS™ program used by the applicant for ASME Code fatigue analyses. The AP1000 Westinghouse's responses to NRC questions regarding the AP1000 Technical Report describe the ability of users to modify intermediate data used in the analyses and different approaches for summation of moment stress terms. These items may impact the calculated fatigue cumulative usage factor (CUF). As a result of these concerns, the staff issued an RAI to the applicant asking whether the issues identified in the AP1000 review were applicable to the use of WESTEMS™ at Salem and to describe how the applicant uses WESTEMS™. In addition, the staff requested a benchmarking evaluation for two of the locations, monitored by WESTEMS™, and a comparison to the traditional ASME Code Section III CUF calculations. The staff reviewed the applicant's response and conducted an audit on January 18 and 19, and February 8, 2011, to review the applicant's benchmarking calculations. The audit confirmed that for the two monitored locations, Salem's use of WESTEMS™ NB-3200 module produced results that were consistent with those using the methodology in ASME Code Section III, NB-3200. By letter dated February 24, 2011, the applicant also provided Commitment Nos. 53 and 54 that address the issues that were identified in the AP1000 review. The staff's concern with Salem's use of the WESTEMS™ NB-3200 module is resolved.

In addition, the staff also noted that, while the applicant selected locations per NUREG/CR-6260 to evaluate the impact of the reactor coolant environment, it is not clear whether there were more limiting plant-specific locations that should be considered. Specifically, the staff was concerned whether the applicant has verified that the locations listed in NUREG/CR-6260 are bounding for Salem as compared to other plant-specific locations that are also subject to the effects of the reactor coolant environment on fatigue usage. In its letter dated December 21, 2010, the applicant committed in Commitment No. 52 to perform a review of design basis ASME Code Class 1 fatigue evaluations to determine whether the NUREG/CR-6260-based locations that have been evaluated for the effects of the reactor coolant environment on fatigue usage are the limiting locations for Salem. If more limiting locations are identified, the most limiting location will be evaluated for the effects of the reactor coolant environment on fatigue usage. The staff reviewed and accepted Commitment No. 52 as it is consistent with the recommendations in SRP-LR Sections 4.3.4.2 and 4.3.2.2, and GALL AMP X.M1. Additional information is documented in SER Sections 3.0.3.2.18, 4.3.4.2, and 4.3.7. Open Item OI 4.3.4.2-1 is closed.

1.6 Summary of Confirmatory Items

There are no confirmatory items associated with this SER.

Based on its audit, review of the LRA, and the review of the applicant's response to RAI B.2.1.40-1, the staff finds that operating experience related to the applicant's program demonstrates that it can adequately manage the detrimental effects of aging on SSCs within the scope of the program. The staff confirmed that the operating experience program element satisfies the criterion in SRP-LR Section A.1.2.3.10 and, therefore, the staff finds it acceptable.

UFSAR Supplement. LRA Section A.2.1.40 provides the UFSAR supplement for the Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Program. The staff reviewed this UFSAR supplement description of the program and notes that it conforms to the recommended description for this type of program as described in SRP-LR Table 3.6-2 as modified by LR-ISG-2007-02. The staff also notes that the applicant committed (Commitment No. 40) to implement the new Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Program prior to entering the period of extended operation for managing aging of applicable components.

The staff determines that the information in the UFSAR supplement, as amended, is an adequate summary description of the program, as required by 10 CFR 54.21(d).

Conclusion. On the basis of its review of the applicant's Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Program, the staff determines those program elements for which the applicant claimed consistency with the GALL Report and final LR-ISG-2007-02 are consistent. In addition, the staff reviewed the exception and its justification and determines that the AMP, with exception, is adequate to manage the aging effects for which the LRA credits it. The staff concludes that the applicant has demonstrated that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the UFSAR supplement for this AMP and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).

3.0.3.2.18 Metal Fatigue of Reactor Coolant Pressure Boundary

Summary of Technical Information in the Application. LRA Section B.3.1.1 describes the existing Metal Fatigue of Reactor Coolant Pressure Boundary Program as consistent, with enhancements, with GALL AMP X.M1, "Metal Fatigue of Reactor Coolant Pressure Boundary." LRA Section B.3.1.1 states that the program monitors and tracks the number of critical thermal and pressure transients to ensure that the cumulative usage factors (CUFs) for the reactor vessel, the pressurizer, the SGs, Class 1 and non-Class 1 piping, and Class 1 components subject to the reactor coolant, treated borated water, and treated water environments remain less than 1.0 through the period of extended operation. The applicant further stated that the program determines the number of transients that occur and uses the software program WESTEMS™ to compute CUFs for select locations. The applicant also stated that the program requires generating periodic fatigue monitoring reports on an annual basis, which includes a listing of transient events, cycle summary event details, CUFs, a detailed fatigue analysis report, and a cycle projection report. In addition, the applicant stated that if the fatigue usage for any location increases beyond expected, based on cycle accumulation trends and projections, or if the number of cycles would approach their limit, the corrective action program would be used to evaluate the condition and determine the corrective action.

Staff Evaluation. During its audit, the staff reviewed the applicant's claim of consistency with the GALL Report. The staff also reviewed the plant conditions to determine whether they are bounded by the conditions for which the GALL Report was evaluated.

The staff compared elements one through six of the applicant's program to the corresponding elements of GALL AMP X.M1. As discussed in the AMP Audit Report, the staff confirmed that these elements are consistent with the corresponding elements of GALL AMP X.M1.

The staff notes that LRA Sections A.3.1.1 and B.3.1.1, under the discussion of the Metal Fatigue of Reactor Pressure Boundary Program, state that WESTEMS™ computes CUFs for select locations. Furthermore, LRA Section 4.3.1 mentions that data from the WESTEMS™ fatigue monitoring software were reviewed to determine the number of pressurizer heatups and cooldowns. In addition, LRA Section 4.3.4.2 credits the WESTEMS™ code for the evaluation of fatigue for the pressurizer and surge line locations.

The staff identified concerns regarding the results determined by WESTEMS™ as a part of the ASME Code fatigue evaluation process as used in new reactor licensing. For example, Westinghouse's response to NRC questions regarding the AP1000 Technical Report (ADAMS Accession No. ML102300072) describes the ability of users to modify intermediate data (peak and valley stresses/times) used in the analyses. In addition, a response provided by Westinghouse on August 20, 2010 (ADAMS Accession No. ML102350440) describes different approaches for summation of moment stress terms. The staff noted that these concerns, raised by the staff on other licensing reviews, may have an impact on the calculated CUF used for license renewal. Furthermore, the possibility that such user modifications could result in non-conservative evaluations of CUF values formed, in part, the basis for the staff's conclusions in Regulatory Issue Summary (RIS) 2008-30, "Fatigue Analysis of Nuclear Power Plant Components," dated December 16, 2008. The RIS notes that simplification of the analysis requires a great deal of judgment by the analyst to ensure that the simplification still provides a conservative result. The staff recognizes that WESTEMS™ has been developed under a formal quality assurance program with supporting technical bases; however, it is difficult to ascertain the accuracy or conservatism of a location-specific application of WESTEMS™ given that a variety of analyst judgments may still be applied to the software outputs by the user on a case-specific basis. This concern was identified as Open Item OI 4.3.4.2-1.

By letter dated November 22, 2010, the staff issued RAI 4.3-07 requesting that the applicant provide the following:[1]

- [Bullet #1] - Clarify how WESTEMS™ is used at each Salem unit, especially with regard to the Metal Fatigue of Reactor Pressure Boundary Program. Specifically, what transients and locations are monitored by WESTEMS™, what WESTEMS™ stress modules are used, and are the stress models used at each Salem unit identical?

- [Bullet #2] - Describe whether the issues raised in ADAMS Accession Nos. ML102300072 dated August 13, 2010, and ML102350440 dated August 20, 2010, are applicable to each Salem WESTEMS™ monitored location. If not, please describe the reasons those issues are not applicable.

- [Bullet #3] - For each location monitored by WESTEMS™, describe the historical fatigue analyses of record starting from the original ASME Code Section III design basis fatigue

[1]The "Bullet" identifiers for each RAI subpart were created by the applicant in its response to the RAI.

analysis of record. For each follow-on analysis, please describe the reason for the reanalysis, whether the evaluation was referenced in the CLB, and whether an updated ASME Code Section III Design Specification and Code Reconciliation were performed in accordance with ASME Code Section III requirements. Please describe how these analyses are reflected in the results tabulated in [LRA] Tables 4.3.1-1, 4.3.4-1, 4.3.7-1, and 4.3.7-2.

- [Bullet #4] - Describe the environmentally-assisted fatigue (EAF) analyses performed for each monitored location, if any.

- [Bullet #5] - Describe the differences between the stress models used in WESTEMS™ and the stress models used in the currently governing fatigue analysis of record and the EAF analysis of record (if any) for each monitored location.

- [Bullet #6] - Describe how the transient counting results tabulated in [LRA] Tables 4.3.1-3 and 4.3.1-4 are incorporated into the fatigue results shown in [LRA] Tables 4.3.7-1 and 4.3.7-2.

The staff also requested in RAI 4.3-07 that benchmarking evaluations be performed for two of the limiting locations monitored in the Salem WESTEMS™ application using the same input parameters and assumptions as those used in traditional ASME Code Section III CUF calculations for each location. It was further requested that if traditional ASME Code Section III CUF calculations do not exist for either of the selected locations, they should be developed using techniques that allow independent comparison with the WESTEMS™ results. The intent of this benchmarking evaluation was to confirm that the results of the WESTEMS™ models, including any analyst judgments, are acceptable and comparable to traditional ASME Code Section III CUF analyses for the selected monitored locations.

The pressurizer surge nozzle and the 1.5-inch boron injection tank (BIT) line locations were selected as the two limiting locations for the benchmarking evaluations that the applicant indicated are monitored in the Salem WESTEMS™ application. The staff further requested the applicant to provide a summary of the benchmarking evaluations for each of these two components including the following information:

- [Benchmarking Bullet #1] - A comparison of the calculated stresses and CUF using WESTEMS™ to the same results from traditional ASME Code Section III CUF calculations for all transient pairs representing at least 75 percent of the total CUF from the ASME Code Section III CUF calculations. One comparison for each unique stress model used in WESTEMS™ for each selected location was considered to be sufficient.

- [Benchmarking Bullet #2] - Describe the differences in the results between the WESTEMS™ evaluation and the ASME Code Section III CUF calculations for each selected location, and provide a justification for acceptability of the differences.

The applicant responded to RAI 4.3-07 by letter dated December 21, 2010. During its review of the RAI response and as described below, the staff determined that it would audit the calculations performed by the applicant to verify the statements and conclusions in the response. The audit was conducted on January 18 and 19, 2011. During the audit, the staff identified a need for additional information (identified as “Audit Questions No. 1 to 6”), which the applicant provided responses to by letter dated January 31, 2011. The staff concluded its audit on February 8, 2011.

The following is a discussion of the staff's evaluation of the applicant's responses to the staff's RAIs and audit questions.

RAI 4.3-07, Bullet #1

In its response dated December 21, 2010, the applicant addressed RAI 4.3-07, Bullet #1 by stating that WESTEMS™ was used to prepare the EAF calculations for the following locations:

(1) pressurizer surge line nozzle safe end to pipe weld
(2) surge line hot leg nozzle to pipe weld
(3) RHR/accumulator nozzle to pipe weld
(4) normal and alternate charging line nozzles to pipe weld
(5) safety injection BIT nozzle to pipe weld

In addition to these calculations, the applicant stated that it will use WESTEMS™ as an online monitoring tool as a part of its Metal Fatigue of Reactor Coolant Pressure Boundary Program. The applicant stated that online plant data will be monitored by WESTEMS™, which will then be used by WESTEMS™ to calculate stresses at specific locations for Units 1 and 2. The applicant further stated that WESTEMS™ will also calculate stress time histories for the monitored locations and calculate CUF according to the methods defined in ASME Code Section III, subparagraph NB-3200 (NB-3200).

The applicant also stated that its Metal Fatigue of Reactor Coolant Pressure Boundary Program will use manual cycle counting to monitor design-basis transients for Class 1 components not monitored by WESTEMS™. The applicant stated that it does not currently use WESTEMS™ to count transients for Class 1 components not monitored by WESTEMS™. WESTEMS™ is only used to monitor the plant parameters (e.g., flow rates, pressures, temperatures, etc.) that are affected by thermal transients and are important for calculating stresses and CUF at the monitored locations.

The staff noted that Enhancement 2 of the applicant's Metal Fatigue of Reactor Coolant Pressure Boundary Program states that a software program will be used to automatically count transients and calculate CUF on "select components," which are the following locations monitored by WESTEMS™:

(1) pressurizer surge line nozzle safe end to pipe weld
(2) surge line hot leg nozzle to pipe weld
(3) RHR/accumulator nozzle to pipe weld
(4) normal and alternate charging line nozzles to pipe weld
(5) safety injection BIT nozzle to pipe weld
(6) auxiliary feedwater nozzle transition piece (for Unit 1 only)

The applicant stated that the stress models for both units are identical for the RHR/accumulator nozzle to pipe weld, normal and alternate charging line nozzles to pipe weld, and the safety injection BIT nozzle to pipe weld locations. The applicant also stated that the auxiliary feedwater nozzle transition piece is only applicable to Unit 1, since this component does not exist in Unit 2. Furthermore, for the Unit 1 auxiliary feedwater nozzle transition piece, the

WESTEMS™ model has not yet been developed, and when it is developed, it will use a monitoring model consistent with the stress model employed in the governing fatigue analysis of record. Additional information about the component stress models are documented below under the staff's review of RAI 4.3-07, Bullet #5.

The applicant further stated that there is a slight difference between the two units in the stress models for the pressurizer surge line nozzle safe end to pipe weld location. The Unit 1 surge line is 14-inch schedule 140 piping and has a SA-182 F316 safe end, while the Unit 2 surge line is 14-inch schedule 160 piping and has a SA-182 F316L safe end. The applicant stated that, for the surge line hot leg nozzle to pipe weld location, there is a small difference in the stress models due to the difference in the hot leg nozzle geometry at the surge line connection due to the difference in piping schedules between the Units 1 and 2 surge lines.

The staff noted this slight difference in geometry and piping schedule and determined that these differences are not significant with respect to the demonstrations requested in the benchmark evaluations. Therefore, the staff found it acceptable that the applicant used the Unit 2 components (pressurizer surge nozzle safe end to pipe weld and safety injection BIT nozzle coupling to cold leg weld) as the bounding components for the benchmarking evaluations because the 60-year EAF-adjusted CUF (CUF_{en}) values for the Unit 2 components were higher than the Unit 1 components.

Based on its review, the staff finds the applicant's response to RAI 4.3-07 Bullet #1 acceptable because the applicant clarified the usage of WESTEMS™ in its EAF calculations, identified the locations that will be monitored by WESTEMS™, and justified the stress models used at each unit and for any differences between the stress models, as described above. The staff's concerns described in RAI 4.3-07 Bullet #1 are resolved.

<u>RAI 4.3-07, Bullet #2 (including Audit Questions No. 1 to No. 6) and "WESTEMS™ Benchmarking Evaluation - Bullets #1 and #2"</u>

In its response dated December 21, 2010, the applicant addressed RAI 4.3-07, Bullet #2 by stating that the issues identified in the NRC letters dated August 13, 2010 (ADAMS Accession No. ML102300072), and August 20, 2010 (ADAMS Accession No. ML102350440), from the NRC Office of New Reactors are not applicable to any of its monitored WESTEMS™ locations.

The applicant stated that the letter dated August 13, 2010, has two open items, OISRP3.9.1-EMB-05 R3 and OI-SRP3.9.1-EMB-06 R2, and both of these items pertain to the WESTEMS™ NB-3600 module. The Salem EAF calculations and the online fatigue usage monitoring at Salem do not use the NB-3600 module. Therefore, the concerns discussed in the two open items in the August 13, 2010, letter are not applicable to the Salem application of WESTEMS™.

During the audit on January 18–19, 2011, and February 8, 2011, the staff confirmed that calculations performed by the Salem WESTEMS™ do not use the NB-3600 module. The staff also confirmed that the WESTEMS™ module that will be used to monitor online fatigue usage at selected locations does not use the NB-3600 module. The applicant committed in Commitment No. 54 that it will not use or implement the NB-3600 option (module) of the WESTEMS™ program in future online fatigue monitoring and design calculations. Therefore, those portions of this RAI are resolved. It should be noted that the applicant originally proposed three commitments, Commitment Nos. 53, 54, and 55, in responses to the staff's concerns addressed during the audit. During the audit, the staff agreed that Commitment 53 was not necessary and it was retracked by the applicant. Commitments Nos. 54 and 55 were then renumbered to Commitments Nos. 53 and 54, respectively. The discussion in this SER, except for a short discussion below on the retracted Commitment 53, refers to the final Commitment Nos. as shown in the Commitment List in Appendix A of this SER.

The applicant stated that the letter dated August 20, 2010, has one open item, OISRP3.9.1-EMB1-07 R3, which pertains to the ability of the user to modify the stress peak and valley times, selected for inclusion in the fatigue calculations during design fatigue evaluations performed by WESTEMS™. The applicant stated that the Salem WESTEMS™ online fatigue monitoring module does not allow the user to modify the stress peak and valley times used in the online fatigue calculations. Therefore, the issue in the August 20, 2010, letter does not apply to the Salem use of WESTEMS™ for online monitoring. However, the applicant stated that the Salem EAF calculations were performed using the WESTEMS™ design module and that module and the associated Salem-specific fatigue calculations did involve user intervention for adjustment to the stress peak and valley times. Specifically, the analyst removed redundant stress peak and valley times from the fatigue analyses. The applicant stated that the removal of these redundant stress peak and valley times: (1) were technically justified, verified, and documented in the supporting engineering calculations associated with the benchmark evaluations; (2) were considered to have an insignificant impact on the final calculated CUF; and (3) would not result in any CUF exceeding the allowable value of 1.0. The staff's review of the documentation for the removal of redundant stress peak and valley times is documented below.

In its response dated December 21, 2010, the applicant addressed RAI 4.3-07, "WESTEMS™ Benchmarking Evaluation - Bullets #1 and #2" by stating it was currently performing a benchmarking evaluation for both the Unit 2 pressurizer surge nozzle and 1.5-inch BIT safety injection nozzle. The applicant stated that a summary of the results from the benchmarking evaluations would be submitted to the NRC by January 7, 2011.

In its response dated January 7, 2011, the applicant provided a summary of its two benchmarking evaluations. The applicant stated that it performed two benchmarking evaluations to confirm that the results of the WESTEMS™ models, including any analyst judgments, are acceptable and comparable to traditional ASME Code Section III fatigue analyses for the two selected monitored locations. The applicant further stated that the input parameters and assumptions used in the traditional ASME Code Section III fatigue analyses (as documented by representative hand calculations) were the same as those used by the WESTEMS™ design models implemented at Salem. This was confirmed by the staff during the audit performed on January 18–19, 2011, and February 8, 2011.

The applicant stated in its January 7, 2011, letter that the benchmarking evaluation for the Unit 2 pressurizer surge nozzle and 1.5-inch BIT safety injection nozzle consisted of the following:

(1) benchmarking of calculated stresses

(2) benchmarking of WESTEMS™ with a traditional ASME Code Section III analysis (representative hand calculation)

(3) benchmarking of additional fatigue pairs with spreadsheet calculations

(4) benchmarking of the WESTEMS™ online monitoring model

The applicant discussed the detailed steps for each portion of the benchmarking of calculated stresses for both of the selected components. The applicant stated that, in order to benchmark the calculated stresses for both components, the nozzle transfer function stress response from the WESTEMS™ module for each component was compared to an equivalent ANSYS™ finite element analysis of the same input loadings. The applicant stated that an arbitrary transient was imposed on each component to induce a severe thermal shock. Furthermore, the time history stress responses of the two WESTEMS™ models, for each component, at each of several analysis section numbers, were compared to the finite element results. The staff noted that an analysis section number (ASN) referred to a specific area or cross section of the component. Based on the comparisons for all cases, the applicant concluded that the WESTEMS™ transfer functions were acceptable to generate stress histories for all transients input to the Salem WESTEMS™ models.

During the audit, the staff reviewed the details of the applicant's benchmarking evaluation with regards to the calculated stresses for the two limiting components. The staff confirmed that the comparison of the time history stress responses of the two WESTEMS™ models adequately duplicated the results of separate finite element analyses and concluded that the WESTEMS™ transfer functions were acceptable to generate stress histories for use in the benchmarking evaluations of the Unit 2 pressurizer surge nozzle and 1.5-inch BIT safety injection nozzle.

The staff noted that, for the Unit 2 pressurizer surge nozzle safe end to pipe weld location, a hand calculation was performed according to the NB-3200 methodology using a traditional approach to calculate the CUF for the controlling fatigue pair that has the largest incremental usage factor and significant alternating stress. The applicant stated that the controlling fatigue transient pair for this component was formed from stress states of a plant heatup transient with a maximum system ΔT (difference between the pressurizer temperature and the RCS temperature) of 160 °C (320 °F) (heatup at 160 °C (320 °F) ΔT) at the corresponding peak and valley times. During the audit, the staff reviewed the applicant's benchmarking evaluations and confirmed that the applicant had selected the controlling transient pair, which provided the largest incremental usage factor and had the largest significant alternating stress. The staff also confirmed in this benchmarking evaluation that the stress states of a plant heatup at 160 °C (320 °F) ΔT formed the controlling fatigue pair for this component. The staff noted that the largest incremental usage factor from the stress states of a plant heatup at 160 °C (320 °F) ΔT was calculated to be 0.0078 by the hand calculation and by WESTEMS™. The staff also reviewed the hand calculations performed by the applicant for this controlling fatigue transient pair and confirmed that they were performed consistent with the methodology defined in NB-3200. The staff noted that the applicant performed the hand calculation for this single controlling fatigue transient pair to demonstrate that it was consistent with the methodology in NB-3200. The staff further noted that in order to calculate the incremental fatigue usage for the remaining fatigue pairs representing at least 75 percent of the total CUF; the applicant used a Microsoft™ Excel spreadsheet to complete the calculations. The staff, therefore, finds the benchmarking CUF calculations for the pressurizer surge nozzle to be acceptable because the applicant demonstrated that the hand calculations were consistent with the methodology in NB-3200. During the audit, the staff found that the results of hand calculations and the WESTEMS™ design module were essentially identical for all fatigue transient pairs that represented at least 75 percent of the total calculated CUF. The staff finds that the differences were negligible and can be attributed to round off uncertainty.

Based on its review and audit, the staff finds that the Salem application of WESTEMS™ provides results that are consistent with a traditional NB-3200 analysis for the Salem Unit 2 pressurizer surge nozzle safe end to pipe weld.

The staff noted that for the Unit 2 safety injection BIT nozzle to cold leg weld, a hand calculation was performed using NB-3200 methodology to calculate the CUF for the controlling fatigue transient pair that has the largest incremental usage factor and significant alternating stress. The applicant stated that the controlling pair for this component was formed from the two stress states of the inadvertent safety injection transient at the corresponding peak and valley times. During the audit, the staff reviewed the applicant's benchmarking evaluations and confirmed that the applicant selected the controlling fatigue transient pair, which provided the largest incremental usage factor and had the largest significant alternating stress. The staff also confirmed in this benchmarking evaluation that the stress states of an inadvertent injection transient formed the controlling fatigue pair for this component. The staff noted that the largest incremental usage factor from the stress states of an inadvertent injection transient was calculated to be 0.1529 by the hand calculation and 0.1527 by WESTEMS™. The staff also reviewed the hand calculation performed by the applicant for this controlling fatigue transient pair and confirmed that it was consistent with the methodology defined in NB-3200. The staff noted that the applicant performed the hand calculation for this single controlling fatigue pair to demonstrate that it was consistent with the methodology in ASME Code Section III NB-3200 and this resultant fatigue usage from the single transient pair produced a CUF of 0.1527, or 89 percent of the 60-year design CUF for this location as reported in LRA Table 4.3.7-2. The applicant stated that the safety injection BIT nozzle to cold leg weld had only a single fatigue transient pair contributing to over 75 percent of the CUF and, therefore, it was not required to generate additional calculations. The staff finds the benchmarking CUF calculations for the BIT nozzle to be acceptable because the applicant demonstrated that the hand calculations were consistent with the methodology in NB-3200 for the fatigue pairs contributing to at least 75 percent of the total CUF, as requested by the staff. The staff finds that the differences were negligible and can be attributed to round off uncertainty.

Based on its review and the audit, the staff finds that the Salem WESTEMS™ application provides results that are consistent with a traditional NB-3200 analysis for the Unit 2 safety injection BIT nozzle to cold leg weld.

In its response dated January 7, 2011, the applicant stated that, as a part of its completion of the benchmarking evaluations for the Unit 2 pressurizer nozzle safe end to pipe weld location and Unit 2 safety injection BIT nozzle to cold leg weld location, a comparison was made between the results of the WESTEMS™ design module and the online module used to monitor CUF for locations in the enhanced Metal Fatigue of Reactor Coolant Pressure Boundary Program. The applicant further stated that this step demonstrates that the online monitoring model produces conservative estimates of CUF. The staff noted that, for this portion of the benchmarking evaluations, the WESTEMS™ online monitoring module used the same input design transient loadings as those used in the design module. The staff found this evaluation to be acceptable because it provided a consistent basis for comparison between the fatigue usage obtained in the WESTEMS™ design module and the online monitoring module and demonstrated that the WESTEMS™ online monitoring module was conservative compared to the design module. During its audit, the staff noted that, at the controlling location of the Unit 2 pressurizer surge nozzle safe end to pipe weld, the CUF values calculated by the WESTEMS™ NB-3200 design analysis mode and the WESTEMS™ online monitoring mode were 0.1121 and 0.8061, respectively. The staff also noted that at the controlling location of the Unit 2 safety injection BIT nozzle (coupling) to cold leg weld, the CUF values calculated by the WESTEMS™ NB-3200 design analysis mode and the WESTEMS™ online monitoring mode were 0.1717 and 0.7078, respectively. The staff noted the large differences in the calculated CUF between the design mode and online monitoring mode for each of the two benchmark locations and questioned the reasons for these differences.

The applicant explained (both during the audit and in its January 7, 2011, letter) that the major contributing factors to the differences were as follows:

- The stress peaks and valleys in the online monitoring mode are grouped in 1 ksi intervals. Therefore, stresses are rounded up to the next 1 ksi in magnitude, which leads to increased CUF estimates.
- Different types of stresses are assigned an appropriate sign (positive, "+," or negative, "-") for conservative combination by WESTEMS™. A conservative approach is used by the WESTEMS™ online monitoring module that assigns the sign of the controlling principal stress, determined from the six stress components. This approach results in conservative stress intensity ranges. The purpose of this approach is to maintain conservatism while minimizing computational requirements over time for the monitoring system. Due to the conservative stress intensity ranges and any associated elastic-plastic strain correction factors (K_e) resulting from this assumption, a conservative CUF is computed.
- The WESTEMS™ design analysis mode provides the user with controls on the transient pairing and allows user intervention to remove redundant peaks and valleys that may be present as an artifact of the WESTEMS™ calculation process. Such intervention is not allowed in the "online monitoring" mode. Inclusion of redundant peaks and valleys leads to a more conservative CUF in the online monitoring mode.

Based on its audit and review, the staff finds that, for the applicant's use in determining CUF for Salem, the WESTEMS™ online monitoring mode provides conservative estimates of CUF compared to traditional NB-3200 calculations.

<u>Audit Questions</u>

During the first portion of the audit in January 2011, the staff identified five Audit Questions for additional information. The applicant responded to these five Audit Questions in a letter dated January 31, 2011. During the final day of the audit, in February 2011, the staff identified one additional Audit Question. The applicant responded, in a letter dated February 24, 2011, with updated responses to the first five Audit Questions and a response to the one additional Audit Question. These six questions and the applicant's responses are summarized below.

<u>Audit Question No.1</u>:

> In order to close-out the Salem WESTEMS audit, for the WESTEMS "Design CUF" module analysis of the BIT and surge nozzles, provide written explanation and justification of any user intervention in the process including the user intervention applied to the peak and valley selection process.

In its response dated January 31, 2011, the applicant stated that Westinghouse revised the Salem benchmark calculations for the Unit 2 pressurizer surge nozzle safe end to pipe weld and the Unit 2 safety injection BIT nozzle coupling to cold leg weld to document and technically justify the user intervention that was applied in the CUF calculations. The revisions to the benchmark evaluations specifically documented the following:

(1) Description of the WESTEMS™ stress peak and valley selection algorithm.

(2) WESTEMS™ results without analyst intervention during the CUF calculation.

(3) Graphical identification of the stress peaks and valleys removed by the analyst.

(4) Technical justification for analyst removal of the stress peaks and valleys on a transient-by-transient basis. Documentation is provided in the new section in the applicant's evaluation justifying removal of redundant stress peaks and valleys for each transient.

(5) For the Unit 2 safety injection BIT nozzle coupling to cold leg weld location, two new tables were added comparing the fatigue pairs and corresponding CUF calculated using analyst intervention to the CUF calculated where no analyst intervention was involved. For the Unit 2 pressurizer surge nozzle safe end to pipe weld location, the CUF calculated using analyst intervention and the CUF calculated where no analyst intervention was involved were identical.

The applicant provided justification for removal of redundant stress peaks and valleys for the Unit 2 safety injection BIT nozzle coupling to cold leg weld location. The applicant clarified that the 60-year design CUF listed in LRA Table 4.3.7-2 reflects justified analyst intervention during the stress peak and valley process. The staff agreed that for these cases, the analyst intervention in removing redundant stress peaks and valleys was justified.

During the final day of the audit, on February 8, 2011, the staff confirmed that the applicant revised its fatigue evaluations for Unit 2 pressurizer surge nozzle safe end to pipe weld location and Unit 2 safety injection BIT nozzle coupling to cold leg weld location to document the staff requests made after the initial 2 days of the audit. In addition, the staff reviewed the graphical comparison of the stress peaks and valleys eliminated by the analyst and the analyst's written technical justification for doing so. The staff noted that there were instances in which stress peaks and valleys were removed by the analyst, added by the analyst, or were not modified by the analyst from the WESTEMS™ program run. The applicant discussed with the staff in detail the justification for removing any stress peaks and valleys from the WESTEMS™ program run. During this review and the associated discussion, the staff noted that the justification for the removal of two stress peaks and valleys from the Unit 2 safety injection BIT nozzle coupling to cold leg weld location fatigue evaluation was not correct and not sufficiently documented in the calculation.

In its response dated February 24, 2011, the applicant provided the detailed basis for the analyst removal of the peak and valley times from the data. The applicant stated that the bases for removing the peak and valley times include:

- One peak was removed because it represented the same total stress as a prior peak and, since the primary plus secondary stress in this evaluation does not result in any K_e (simplified elastic-plastic penalty factor applied to alternating stress when the primary plus secondary stress intensity range limit is exceeded) values greater than 1.0, it is redundant with the previous peak and not required.

- Two of the peaks in the transient are redundant peaks of the initial state captured by a peak time, since the transient returns to the same stress state as it started, and this stress state is redundant to another transient that begins at a similar plant no-load condition.

The applicant also stated that the analyst added one peak that was not selected by WESTEMS™ at the initial time of the transient for additional conservatism in the fatigue evaluation. The staff found that the addition of any stress peaks and valleys is acceptable because this practice will yield a more conservative CUF value. The applicant stated that the BIT nozzle calculation has been updated to properly capture the basis for the user intervention activity.

With the submittal of the information by a letter dated February 24, 2011, the staff verified that the applicant has adequate documentation and written technical justification for removal of stress peaks and valleys by the analyst in determination of the CUF for the two locations investigated in the benchmark evaluations.

The staff noted that 10 CFR 54.37(a) states that all information and documentation required by, or otherwise necessary, to document compliance with the provisions of 10 CFR Part 54 shall be retained in an auditable and retrievable form for the term of the renewed operating license or renewed combined license by the licensee. The staff further noted that these benchmarking evaluations and revised EAF analyses, which are to include the written explanation and technical justification of any user intervention applied for any WESTEMS™ “Design CUF” (NB-3200) module analyses, support the applicant’s disposition of this TLAA, in accordance with 10 CFR 54.21(c)(1)(iii).

Based on its review, the staff finds the applicant’s response to Audit Question No. 1, as amended by letter dated February 24, 2011, acceptable because, in accordance with 10 CFR 54.37(a), the applicant provided justification and documentation for any user intervention applied to any WESTEMS™ “Design CUF” (NB-3200) module analyses. This supports the applicant’s disposition in accordance with 10 CFR 54.21(c)(1)(iii) for these monitored locations. Audit Question No. 1 is resolved.

Audit Question No. 2:

> For any WESTEMS “Design CUF” module analyses performed for the remaining monitored locations at Salem (i.e., other than the BIT and surge nozzles), provide written explanation and justification of any user intervention applied in the process including the user intervention applied to the peak and valley selection process prior to two years before entering the period of extended operation.

In its response dated January 31, 2011, the applicant proposed Commitment No. 53[2] to revise the fatigue calculations for all locations monitored at Units 1 and 2 to include written explanation and technical justification of any user intervention applied for any WESTEMS™ “Design CUF” module analyses at least 2 years prior to the period of extended operation. In its response dated February 24, 2011, the applicant revised the response to Audit Question No. 2 and retracted the proposed Commitment No. 53. The applicant stated that, after discussions with the vendor who performed the fatigue calculations, the stress peak and valley editing during the fatigue calculation process for the remaining locations monitored by WESTEMS™ at Units 1 and 2 is consistent with that used for the two locations that were the subject of the WESTEMS™ benchmarking audit. Therefore, the applicant stated that it is unnecessary to revise existing EAF calculations performed for the remaining WESTEMS™ monitored locations to include a

2 This was the Commitment noted above that was later retracted. The former Commitment No. 54 was renumbered Commitment 53.

written explanation and justification of any user intervention applied for any WESTEMS™ “Design CUF” (NB-3200) module analyses.

Based on its review, the staff finds the applicant’s response to Audit Question No. 2, as amended by letter dated February 24, 2011, and removal of proposed Commitment No. 53 (January 31, 2011), acceptable because the staff has re-considered the need for proposed Commitment No. 53 and found that the audit results and documentation provided during the February audit provide reasonable assurance of the applicant’s acceptable methods and ability to document the user interaction in deleting and adding stress peaks and valleys, and thus implementation of proposed Commitment No. 53 is not necessary. However, in order to comply with the requirements of 10 CFR 54.37(a), the staff expects that the applicant would be able to show, through its documentation and references, where user intervention was needed for use of WESTEMS™ “Design CUF” (NB-3200) module analyses. Audit Question No. 2 is resolved.

Audit Question No. 3:

> For any use of the WESTEMS “Design CUF” module in the future at Salem, include written explanation and justification of any user intervention in the process.

In its response dated January 31, 2011, and subsequently updated in the letter dated February 24, 2011, the applicant provided Commitment No. 53 (initially identified as proposed Commitment No. 54 in the January 31, 2011, response) to include written explanation and justification of any user intervention in future evaluations using the WESTEMS™ “Design CUF” (NB-3200) module. The commitment will be implemented within 60 days of issuance of the renewed operating license. The staff noted that Units 1 and 2 will enter the period of extended operation in August 2016 and April 2020, respectively. The staff finds the applicant’s accelerated implementation schedule reasonable because the applicant is aggressively ensuring that a written explanation and justification of any user intervention in future evaluations using the WESTEMS™ “Design CUF” (NB-3200) module is documented and provides the applicant sufficient time to document and implement necessary procedures.

The staff noted that 10 CFR 54.37(a) states that all information and documentation required by, or otherwise necessary, to document compliance with the provisions of 10 CFR Part 54 shall be retained in an auditable and retrievable form for the term of the renewed operating license or renewed combined license by the licensee. The staff further noted that these revised EAF evaluations, which are to include the written explanation and technical justification of any user intervention applied for any WESTEMS™ “Design CUF” module analyses, support the applicant’s disposition of this TLAA, in accordance with 10 CFR 54.21(c)(1)(iii).

Based on its review, the staff finds the applicant’s response to Audit Question No. 3 and Commitment No. 53 acceptable because the applicant will document, with a written explanation and technical justification, any user intervention associated with future evaluations using the WESTEMS™ “Design CUF” (NB-3200) module to ensure that the basis for the conclusions in these evaluations are auditable and retrievable. Audit Question No. 3 is resolved.

Audit Question No. 4:

> Provide a commitment that the NB-3600 option of the WESTEMS “Design CUF” module will not be implemented or used in the future at Salem.

In its response dated January 31, 2011, and subsequently updated in a letter dated February 24, 2011, the applicant provided Commitment No. 54 (initially identified as proposed Commitment No. 55 in the January 31, 2011, response) not to use or implement the NB-3600 module of the WESTEMS™ program in future online monitoring and design CUF calculations. The commitment will be implemented within 60 days of issuance of the renewed operating license. The staff finds the applicant's accelerated implementation schedule reasonable because the applicant is ensuring that the NB-3600 module of the WESTEMS™ program is not used for online monitoring and design calculations and provides the applicant sufficient time to document and implement necessary procedures to prevent the use of the NB-3600 module.

Based on its review, the staff finds the applicant's response to Audit Question No. 4 acceptable because: (1) one of the open items identified in the staff's letter dated August 13, 2010, is not applicable to the applicant, (2) the staff confirmed that the applicant's EAF calculations used only the NB-3200 module of the WESTEMS™ program, and (3) the applicant committed (Commitment No. 54) not to use or implement the NB-3600 module of the WESTEMS™ program in future online monitoring and design CUF calculations. Audit Question No. 4 is resolved.

Audit Question No. 5:

> Provide a description of the peak and valley selection process used by WESTEMS and how that process aligns with ASME Code NB-3216 methodology.

In its response dated January 31, 2011, the applicant stated that the WESTEMS™ algorithm selects stress peaks and valleys consistent with the criteria in ASME Code Section III, NB-3216. The applicant stated that performing a fatigue evaluation in accordance with ASME Code Section III, subparagraph NB-3200 requires calculating the stress differences for each type of stress cycle in accordance with NB-3216. The staff noted that, as delineated in NB-3216.2(b), the analyst is required to choose a point in time when the stress components are one of the extremes for the cycle (either maximum or minimum algebraically). The applicant stated that WESTEMS™ fatigue evaluations employ a stress-intensity-based approach to "choose a point in time" as follows:

> For each transient cycle in the component fatigue evaluation, the six stress components of Primary plus Secondary stress and of Total stress are calculated for the entire transient time history. Then, the stress intensities for the Primary plus Secondary stress and the Total stress time histories are calculated. Relative maxima and minima within the Primary plus Secondary stress and Total stress intensity time histories for each transient are identified using the second derivative test (comparing the slopes of the stress history around a time point).

The applicant stated that this stress-intensity-based approach identifies the time points of these extremes. From those extremes, the stress component ranges, the principal stress ranges, and the resulting stress intensity ranges are calculated between two selected stress states using the corresponding component stress at those time points. The applicant also stated that when using the stress-intensity-based approach, the time points where stress conditions are extreme are picked at the relative stress peak and valleys, or at the maximum or minimum stress states along the stress intensity time history. The applicant stated the stress-intensity-based approach is consistent with the procedure used in NB-3216.2 and employs similar practices to those used by analysts over many decades of applying NB-3200 requirements.

Based on its review, the staff finds the applicant's response to Audit Question No. 5 acceptable because the stress-intensity-based approach is a practical method to interpret and apply ASME Code Section III, NB-3216.2 methodology regarding the selection of extremes for cyclic loading. Audit Question No. 5 is resolved.

The staff's request in Audit Question No. 6 and the applicant's response are discussed in RAI 4.3-07, Bullet #5.

Based on a 3-day audit, the staff found the Salem CUF calculations, and the applicant's use of WESTEMS™ to perform NB-3200 fatigue evaluations, addresses the staff's concerns and provide assurance that the WESTEMS™ "Design-CUF" (NB-3200) fatigue evaluation provides a consistent analysis with the ASME Code Section III, NB-3200 analysis of the Salem WESTEMS™ application. The staff concludes the following:

- There is reasonable assurance that Salem's use of the WESTEMS™ "Design-CUF" (NB-3200) module provides calculations of CUFs that are consistent with traditional ASME Code Section III analyses.
- There is reasonable assurance that the ability of program users to delete or add stress peak and valley times has been properly justified and documented.
- The WESTEMS™ NB-3600 module is not currently used in the Salem application of WESTEMS™ and any future use of the NB-3600 module requires staff review and approval prior to use.

Based on its review, the staff finds the applicant's response to RAI 4.3-07, Bullet #2 acceptable because, based on the 3-day audit and the applicant's responses associated with the Audit Questions, the staff found that the applicant's CUF calculations and its use of WESTEMS™ to perform NB-3200 fatigue evaluation address staff concerns regarding the user intervention process and the use of the NB-3600 module. Therefore, the staff's concern described in RAI 4.3-07, Bullet #2 is resolved.

<u>RAI 4.3-07, Bullet #3</u>

In its response dated December 21, 2010, the applicant provided a summary table of the history of fatigue analyses prepared for each of the locations monitored by WESTEMS™ at Salem. In the RAI response, the applicant also provided a detailed description of the information contained in this summary table.

The applicant stated that for all of the monitored component locations, with the exception of the Unit 1 auxiliary feedwater nozzle transition piece that is not part of the RCPB, the EAF evaluations were performed to address the GALL Report recommendations to evaluate the effects of the reactor water environment on fatigue. The applicant stated that it used NUREG/CR-6583 and NUREG/CR-5704 to account for EAF by increasing the fatigue usage factor by an appropriate F_{en} factor. The applicant stated these NUREG reports do not require a complete ASME Code Section III qualification of the components, but only a CUF calculation.

The applicant clarified that only the pressurizer surge nozzle safe end to pipe weld and the surge line hot leg nozzle to pipe weld had an existing ASME Code Section III fatigue evaluation, which were updated to ASME Code Section III from the original American Standards

Association/United States of America Standards (ASA/USAS) B31.1 design code in Westinghouse Commercial Atomic Power Vendor Report (WCAP)-12914 to address NRC Bulletin 88-11 concerns. The applicant stated that a design specification was not prepared for the updated evaluation because the original design was the ASA/USAS B31.1 Power Piping Code. The staff noted that the stratification effects postulated for the standard Westinghouse plant transient conditions, as described in WCAP-12914, were included in the plant-specific benchmark evaluation for this component.

The applicant also explained that the pressurizer surge nozzle safe end to pipe weld location was also re-evaluated in 2003 in WCAP-16194. This analysis was a plant-specific evaluation of insurge/outsurge transients previously defined by the Westinghouse Owners' Group (WOG) in WCAP-14950, "Mitigation and Evaluation of Pressurizer Insurge/Outsurge Transients," February 1998. These transients were not considered in the original design analysis for the pressurizer surge nozzle and piping. This analysis was performed using the 1989 Edition of the ASME Code. Furthermore, the relevant design specifications were not updated to include these additional details. Although the insurge/outsurge transients and stratification effects postulated during the design specification transients are described in WCAP-16194, the staff noted that WCAP-16194 did not provide a formal ASME Code Section III reconciliation between the 1986 and 1989 ASME Code editions. The applicant stated that the latest evaluations for the surge line and nozzle locations are documented in WCAP-16994-P and WCAP-16995-P for Salem Units 1 and 2, respectively, and that these evaluations used the same ASME Code edition (1986) as was used in WCAP-12914. The applicant further stated that the evaluations documented in WCAP-16994-P and WCAP-16995-P for Salem Units 1 and 2, respectively, are considered to be the latest governing analyses of record.

The staff noted that the RHR accumulator nozzle to pipe weld, normal and alternate charging nozzle to pipe weld, and BIT nozzle at socket weld components were originally designed to the ASA/USAS B31.1 Power Piping Code and, therefore, there was no design specification to cover fatigue analysis for these components because ASA/USAS B31.1 does not require explicit fatigue analysis. The staff also noted that the EAF evaluations documented in WCAP-16994-P and WCAP-16995-P only performed a CUF calculation; therefore, a full ASME Code Section III qualification was not performed. The applicant stated that the ASME Code Section III CUF values documented in WCAP-16994-P and WCAP-16995-P were calculated using transients from Westinghouse systems standard specifications applicable to Westinghouse 4-loop plants. The transients, ASME Code methodology, and criteria used for the evaluations were documented in WCAP-16994-P and WCAP-16995-P and their supporting calculations.

Since the original design for the Salem piping components were based on ASA/USAS B31.1 Power Piping Code requirements, the staff agrees that a formal code reconciliation was not necessary to address the recommendations of GALL AMP X.M1 to consider the effects of reactor water environment because only a CUF calculation was needed.

Based on its review, the staff finds the applicant's response to RAI 4.3-07, Bullet #3 acceptable because for each monitored location, the applicant: (1) clarified the associated historical fatigue analyses, (2) justified not performing a formal code reconciliation, and (3) performed its CUF calculations consistent with the methodology in ASME Code Section III. Therefore, the staff's concern described in RAI 4.3-07, Bullet #3 is resolved.

RAI 4.3-07, Bullet #4

In its response dated December 21, 2010, the applicant stated that each location monitored by WESTEMS™ was evaluated for EAF, except for the Unit 1 auxiliary feedwater nozzle transition piece, which is not a Class 1 component. The applicant further stated that the EAF analyses for each monitored location consisted of the following general steps:

(1) prepare transfer function databases, including thermal transfer function and mechanical transfer function models, using the ANSYS™ Finite Element Code

(2) create WESTEMS™ models for the Salem-specific component locations

(3) define input design-basis thermal transients for each monitored location and create transient input files

(4) perform applicable stress and fatigue calculations for limiting component locations using the stress and fatigue analysis methods of ASME Code Section III, NB-3200 to determine the 60-year CUF using the transfer function models in WESTEMS™

(5) evaluate the reactor coolant environmental effects as an environmental multiplier (F_{en}) and apply this multiplier to the 60-year CUF

During the audit on January 18–19, 2011, and February 8, 2011, the staff reviewed the applicant's methodology used to perform the Salem benchmark evaluations. The staff confirmed that the applicant used the design-basis transients as inputs into the WESTEMS™ design analysis module to calculate CUF. The staff's review of the applicant's methodology used to determine F_{en} values is documented in SER Section 4.3.7.2.

Based on its review, the staff finds the applicant's response to RAI 4.3-07, Bullet #4 acceptable because: (1) the applicant clarified the general steps in the EAF analyses and (2) the Metal Fatigue of Reactor Coolant Pressure Boundary Program monitors the transients to ensure that the CUF considering environmental effects remains below the design limit of 1.0. Therefore, the staff's concern described in RAI 4.3-07, Bullet #4 is resolved.

RAI 4.3-07, Bullet #5

In its response dated December 21, 2010, the applicant stated that the current governing fatigue analysis for each of the locations monitored by WESTEMS™, with the exception of the Unit 1 auxiliary feedwater nozzle transition piece, is the recent EAF analysis described in WCAP-16994-P and WCAP-16995-P for Units 1 and 2, respectively. Furthermore, the ASME Code Section III CUF values were calculated for each location using transients from Westinghouse systems standard specifications applicable for Westinghouse 4-loop plants. The staff concluded that these EAF analyses consist of an analysis performed consistent with the methodology of NB-3200 and also incorporate up-to-date transients and associated loadings.

The applicant stated that the stress models used in these EAF analyses are the same as the stress models employed in the Salem WESTEMS™ online monitoring module. The applicant also stated that, for the future application of the WESTEMS™ online monitoring for the Unit 1 auxiliary feedwater nozzle transition piece, the model will use a monitoring model consistent with the stress model employed in the governing fatigue analysis of record.

However, based on the discussions during the February 8, 2011, audit, the staff identified that, for the Salem pressurizer surge nozzle safe end to pipe weld location, a different version of the WESTEMS™ stress model was used for the fatigue analysis than the model that will be used for online fatigue monitoring. The staff requested, in Audit Question No. 6, the applicant to clarify the contradiction. In its response dated February 24, 2011, the applicant amended the response to RAI 4.3-07, Bullet #5 indicating that the pressurizer surge nozzle safe end to pipe weld location and the surge line hot leg nozzle to pipe weld location are the two monitored locations that have a different stress model between the EAF analysis and the online monitoring. The applicant stated that the stress models for these two locations in the EAF analysis are specific to each Salem unit due to the slight physical differences in the pipe wall thickness of the 14-inch surge line. The staff noted that the difference in the pipe wall thickness is documented in its evaluation of the applicant's response to RAI 4.3-07, Bullet #1. The applicant stated that the stress model to be used in the online monitoring will be common to both units, and the applicant determined that this approach will be conservative and bounding for these two locations. The applicant confirmed that the same stress models were used for the EAF analysis and online monitoring for all other locations to be monitored by WESTEMS™.

The staff noted that a meaningful comparison can be made between the calculated CUF from design transients and the actual CUF calculated from actual plant transients because each location monitored by WESTEMS™, with the exception of the Unit 1 auxiliary feedwater nozzle transition piece, used the same stress models in the EAF analysis and the WESTEMS™ online monitoring tool. This CUF comparison is useful and informative because it can be used to determine if a design fatigue analysis remains valid.

Based on its review, the staff finds the applicant's response to RAI 4.3-07, Bullet #5 and Audit Question No. 6 acceptable because: (1) the applicant clarified whether the stress model used in the online monitoring and that used in the EAF analyses are the same or not; (2) for the two monitored locations at the pressurizer surge lines, justification is provided that a common and conservative model will be used for both units due to the slight physical difference; and (3) the applicant has used (or will use) the same stress models for the monitoring tool and the governing fatigue analysis of record for all remaining four locations monitored by WESTEMS™, such that meaningful comparison between the calculated CUF and the CUF calculated from actual transients can be used to determine if a design fatigue analysis remains valid and if the design limit of 1.0 will be exceeded. The staff's concern described in RAI 4.3-07, Bullet #5 is resolved.

<u>RAI 4.3-07, Bullet #6</u>

In its response dated December 21, 2010, the applicant stated that the transient counting results (i.e., current number of cycles) were used as a basis for the 60-year projected cycles. In addition, the applicant stated that the current cycles, the 60-year projected cycles, and the NSSS (40-year) design limit for each of the design transients are listed in LRA Tables 4.3.1-3 and 4.3.1-4. The applicant also stated that either the 60-year projected cycles, or the bounding NSSS (40-year) design limit values were used as inputs into the ASME Code Section III 60-year CUF calculations documented in WCAP-16994-P and WCAP-16995-P for Units 1 and 2, respectively. The staff noted that the results of the calculations are listed in the column entitled, "60-Year Design CUF," in LRA Tables 4.3.7-1 and 4.3.7-2. Furthermore, the 60-year design CUF values were multiplied by the corresponding fatigue life correction factor, F_{en}, to obtain the 60-year CUF_{EAF} values listed in LRA Tables 4.3.7-1 and 4.3.7-2 for Salem Units 1 and 2, respectively.

The staff noted that those locations identified by the applicant as plant-specific components corresponding to the NUREG/CR-6260 locations and the associated TLAAs were dispositioned in accordance with 10 CFR 54.21(c)(1)(iii), as amended by letter dated July 13, 2010, stating that the effects of the reactor coolant environment on component fatigue life will be adequately managed for the period of extended operation. The staff also noted that the applicant committed (via Commitment No. 52) by letter dated December 21, 2010, as part of its Metal Fatigue of Reactor Coolant Pressure Boundary Program, to ensure that the most limiting plant-specific locations are evaluated for effects of reactor coolant environment. The staff's review of the applicant's disposition and Commitment No. 52 is documented in SER Section 4.3.7.2.

Based on its review, the staff finds the applicant's response to RAI 4.3-07, Bullet #6 acceptable because the applicant's Metal Fatigue of Reactor Coolant Boundary Program monitors fatigue usage to ensure that the CUF, including environmental effects, remains below the design limit of 1.0. Furthermore, the applicant committed (Commitment No. 52) to ensure that the effects of reactor water environment on fatigue life will be considered for the most limiting plant-specific locations, and the applicant clarified how the transient cycles are incorporated into the EAF analyses. The staff's concern described in RAI 4.3-07, Bullet #6 is resolved, and Open Item OI 4.3.4.2-1 is closed.

The staff also reviewed the portions of the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements associated with the enhancements to determine whether the program will be adequate to manage the aging effects for which it is credited. The staff's evaluation of these enhancements follows.

Enhancement 1. LRA Section B.3.1.1 states an enhancement to the "parameters monitored or inspected" program element. This enhancement expands the existing program to include additional transients beyond those defined in the TSs and the UFSAR, and also expands the program to encompass other components identified to have fatigue as an analyzed aging effect, which require monitoring. The applicant committed to implement this enhancement prior to the period of extended operation, as identified in Commitment No. 47, LRA Appendix A, Section A.5.

The staff reviewed this enhancement against the corresponding program element in GALL AMP X.M1. During its review, it was not evident to the staff whether the stated enhancement was being made to make the "parameters monitored or inspected" program element consistent with the corresponding element in GALL AMP X.M1. It was also not clear to the staff what was being enhanced relative to the information that was already provided for the Metal Fatigue of Reactor Coolant Pressure Boundary Program and whether the enhancement will be on the basis document or the implementing procedure, or both.

By letter dated June 30, 2010, the staff issued RAI B.3.1.1-1, Request 1, requesting that the applicant confirm if the stated enhancement is being proposed to make the "parameters monitored or inspected" program element consistent with GALL AMP X.M1. The staff also asked the applicant to clarify whether the enhancement will be of the basis document or the implementing procedure for this program, or both.

In its response dated July 28, 2010, the applicant clarified that the purpose of the stated enhancement was to make the "parameters monitored or inspected" program element consistent with the corresponding program element in GALL AMP X.M1 because the GALL

Report recommends the monitoring of all plant transients that cause cyclic strains, which are significant contributors to cumulative fatigue usage. The applicant clarified that the enhancement was necessary because additional transients were identified that would need to be tracked by the program, beyond those in the current program. The applicant also clarified that the enhancement will be implemented by issuing new implementing procedures and revising current program implementing procedures to include monitoring of the additional transients added by Enhancement 1.

Based on its review, the staff finds the applicant's response to RAI B.3.1.1-1, Request 1, acceptable because: (1) Enhancement 1 will make the program element consistent with that in the "parameters monitored or inspected" program element in GALL AMP X.M1, and (2) the applicant has appropriately reflected this enhancement in Commitment No. 47 and will implement the enhancement prior to entering the period of extended operation, as recommended in SRP-LR Section 3.0. The staff's concern described in RAI B.3.1.1-1, Request 1 is resolved.

During its review, the staff identified that the transients specified in the TS Table 5.7-1 are required to be tracked pursuant to the requirements in TS 5.7.1. The staff also identified that the design-basis transients are located in the UFSAR and includes transients listed in TS Table 5.7-1 and transients that are outside of the TS requirements. It was not evident to the staff which process would be taken to track those design-basis transients that are in the UFSAR but that are outside TS 5.7.1.

By letter dated June 30, 2010, the staff issued RAI B.3.1.1-1, Request 2, requesting that the applicant clarify the process, procedure, or protocol that will be used to track the occurrences of those design-basis transients that are listed in the UFSAR but are not within TS 5.7.1.

In its response dated July 28, 2010, the applicant clarified that the design-basis transients are discussed in UFSAR Section 5.2.1.5 and are listed in UFSAR Tables 5.2-10 and 5.2-10a. The applicant also clarified that the implementation of appropriate station procedures will be used to track the occurrences of those design-basis transients in the UFSAR that are outside of TS 5.7.1. The applicant clarified that the existing plant procedures currently track transients listed in the TSs but that, under Enhancement 1, the procedures will be enhanced to ensure that those design-basis transients that are outside of TS 5.7.1 will be tracked for the period of extended operation. The applicant stated that the enhanced procedures will be credited for implementation of the Metal Fatigue of Reactor Coolant Pressure Boundary Program. The applicant stated that the implementing procedures will be annotated to identify the associated license renewal program commitments.

Based on its review, the staff finds the applicant's response to RAI B.3.1.1-1, Request 2, acceptable because the applicant: (1) clarified that its plant procedures will ensure that those UFSAR design-basis transients outside of TS 5.7.1 will be tracked by the applicant's Metal Fatigue of Reactor Coolant Pressure Boundary Program and (2) is monitoring all plant transients that cause cyclic strains, which are significant contributors to cumulative fatigue usage, as recommended by the GALL Report. The staff's concern described in RAI B.3.1.1-1, Request 2 is resolved.

The staff also noted that the applicant identified additional transients that would need to be added to the scope of the program and to the appropriate implementing procedures. However, the applicant did not identify which transients would need to be added to the scope of the Metal Fatigue of Reactor Coolant Pressure Boundary Program. Thus, it was not evident to the staff which transients were being referred to in the Enhancement 1 or whether it is necessary to track these additional transients for possible inclusion in updated CUF analyses. It was also not evident to the staff whether the applicant would be updating the design-basis transients in the UFSAR to include these additional transients.

By letter dated June 30, 2010, the staff issued RAI B.3.1.1-1, Request 3, requesting that the applicant identify the additional transients that were being referred to in Enhancement 1 and clarify which ASME Code Class 1 components these additional transients are related to. The staff also asked the applicant to clarify whether an update of the design basis will be performed to include these transients and if so, identify which of the sections or tables of the UFSAR will be updated. The staff also requested that the applicant clarify whether this would be covered within the applicable LRA commitment. The staff also asked the applicant to justify its basis for omitting these transients from the design basis if the design basis will not be updated to include these transients.

In its response dated July 28, 2010, the applicant clarified that the only additional transient referred to in Enhancement 1 that is related to a Class 1 component is the "Inadvertent Auxiliary Spray to Pressurizer" transient. The applicant stated that the design-basis transient is related to the pressurizers in the RCPB and their associated surge nozzles. The applicant stated that the transient is within the scope of the current TSs or UFSAR. The applicant clarified, however, that this transient is manually counted by the current program. The applicant clarified that this transient is included in the design basis due to its inclusion in the current program and thus, no changes to the design-basis transient discussions in the UFSAR sections are required or are being anticipated as a result of the inclusion of this transient.

Based on its review, the staff finds the applicant's response to RAI B.3.1.1-1, Request 3 acceptable because: (1) the applicant identified that the "Inadvertent Auxiliary Spray to Pressurizer" transient is the only additional design-basis transient that was not accounted for in the implementing procedures, (2) the applicant clarified that the transient is already accounted for in the design basis, and (3) implementation of the enhancement will correct the omission of this transient in the implementing procedure prior to entering the period of extended operation. The staff's concern described in RAI B.3.1.1-1, Request 3 is resolved.

During the staff's review, it was identified that the program will be enhanced to expand the "fatigue monitoring program to encompass other components identified to have fatigue as an analyzed aging effect, which require monitoring." However, the staff noted that Enhancement 4 is similar to Enhancement 1, which affects the "corrective actions" program element. The "corrective actions" program element of GALL AMP X.M1 states, in part, that for programs that monitor a sample of high fatigue usage locations, "corrective actions include a review of additional affected reactor coolant pressure boundary locations." The staff noted that this program element in GALL AMP X.M1 specifically discusses expansion of programs to additional RCPB components. Thus, it is not apparent to the staff whether the expansion criteria in Enhancement 1 is applicable to the "scope of the program," "monitoring and trending," or "corrective actions" program elements or whether it is redundant with the enhancement discussed in Enhancement 4.

By letter dated June 30, 2010, the staff issued RAI B.3.1.1-1, Request 4, requesting that the applicant clarify whether the expansion criterion in Enhancement 1 is applicable to the "monitoring and trending" or "corrective actions" program element, or whether it is redundant with Enhancement 4. The staff also asked the applicant to justify why the expansion of the transients and components aspect of Enhancement 1 is not applicable to the "scope of the program" or "monitoring and trending" program elements and if the expansion of the transients and components aspect does not relate to a corrective action activity.

In its response dated July 28, 2010, the applicant clarified that the expansion criterion in Enhancement 1 is for the expansion of the number of transients and components being monitored by the Metal Fatigue of Reactor Coolant Pressure Boundary Program. The applicant also stated that it does not pertain to the expansion of American National Standards Institute (ANSI) B31.1 RCPB piping locations into the scope of the program as a result of being scoped into the EAF analysis. As a result, the applicant clarified that the expansion criterion in Enhancement 1 was not redundant with Enhancement 4, which does pertain to the EAF analysis. The applicant also clarified that, although Enhancement 1 does not provide enhancements to the "scope of the program" or the "corrective actions" program elements, a supplemental review of Enhancement 1 determined that the enhancement is applicable to the "monitoring and trending" program element because: (1) the "monitoring and trending" program element in GALL AMP X.M1 recommends that the program monitor a sample of high fatigue usage locations and that the sample be augmented to include, as a minimum, the locations identified in NUREG/CR-6260 or alternative locations based on the plant's configuration; (2) the applicant determined that additional transients and a sample of high fatigue usage locations met the GALL Report recommendation; and (3) the implementation of Enhancement 1 will account for the need to add these transients and component locations to the scope of the program, as addressed in the "parameters monitored and inspected" and "monitoring and trending" program elements.

The staff also noted that by letter dated July 28, 2010, the applicant amended Enhancement 1 to be applicable to the "parameters monitored or inspected" and "monitoring and trending" program elements. Based on its review, the staff finds the applicant's response to RAI B.3.1.1-1, Request 4 acceptable because: (1) the applicant amended Enhancement 1 to include both the "parameters monitored or inspected" and "monitoring and trending" program elements, (2) implementation of the applicant's amended enhancement will ensure the inclusion of the additional component locations and transients into the implementing procedures, and (3) the implementation of the program during the period of extended operation will be consistent with the "parameters monitored or inspected" and "monitoring and trending" program element recommendations in GALL AMP X.M1. The staff's concern described in RAI B.3.1.1-1, Request 4 is resolved.

Based on its review, the staff finds Enhancement 1, when implemented prior to the period of extended operation, acceptable because it is consistent with the recommendations of GALL AMP X.M1 as described above.

Enhancement 2. LRA Section B.3.1.1 states an enhancement to the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements. The staff noted that this enhancement expands the existing program to use a software program to automatically count transients and calculate cumulative usage on select components. The applicant committed to implement this enhancement prior to the period of extended operation, as identified in Commitment No. 47, LRA Appendix A, Section A.5.

The staff noted that this software program does not use the Green's functions analysis methodology, as discussed in NRC RIS 2008-30, and is based on methods defined in ASME Code Section III, NB-3200. The staff noted that the applicant's enhancement incorporates use of a software program to automatically count transients and calculate cumulative usage on select components as a preventive measure to mitigate fatigue cracking of metal components of the RCPB, which is an acceptable approach and is consistent with the recommendation in GALL AMP X.M1.

During the staff's review, it was not evident whether Enhancement 2 is being made to make the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements consistent with the corresponding program elements in GALL AMP X.M1. It was also not apparent to the staff exactly what is being enhanced and specifically whether it will involve an enhancement of the computer programming for the monitoring software, the basis document, or the implementing procedure. It is also not evident to the staff how this enhancement will be tied to program elements and to the implementing procedure for the software package if the enhancement only pertains to an update of WESTEMS™ to cover the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements in GALL AMP X.M1.

By letter dated June 30, 2010, the staff issued RAI B.3.1.1-2 requesting that the applicant confirm that Enhancement 2 is being proposed to make the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements consistent with GALL AMP X.M1. The staff also asked the applicant to clarify what will be enhanced. In addition, the staff asked the applicant to justify why the associated program elements and implementing procedure would not have to be updated to account for Enhancement 2, if the implementation of the enhancement will be limited only to an anticipated update of WESTEMS™.

In its response dated July 28, 2010, the applicant clarified that Enhancement 2 will make the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements consistent with GALL AMP X.M1 and that each of these elements has attributes which will be enhanced with the expansion to the existing software program. The applicant clarified that the current Metal Fatigue of Reactor Coolant Pressure Boundary Program uses a fatigue monitoring software program for monitoring of the CUF values associated with the pressurizer lower head and surge nozzle. The applicant clarified that Enhancement 2 will expand the current fatigue monitoring program to apply and implement the use of the fatigue monitoring software program to monitor the CUF values for additional selected component locations, including the remainder of EAF locations, that correspond to those recommended in NUREG/CR-6260 and that the enhancement is not only limited to a potential update of WESTEMS™. The applicant further clarified that the enhancement for implementation of WESTEMS™ will include not only installation of the fatigue monitoring software program to include monitoring for additional locations and potential CUF updates of the locations, but also call for the establishment of new procedures and revision of existing procedures and for the implementation of these procedures to account for WESTEMS™.

The staff noted that the implementation of the WESTEMS™ fatigue software involves including additional locations that are not currently being monitored by the software program. The staff also noted the enhancement to apply WESTEMS™ for cycle counting and potentially for CUF updates of the component locations and also includes updating the implementing procedures to incorporate the applications of WESTEMS™. The staff also noted that the corresponding "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements in GALL AMP X.M1 incorporate key component location selection, cycle monitoring, CUF update, and development of appropriate acceptance criteria elements that would need to be enveloped by the software programming in order to validate WESTEMS™.

Based on its review, the staff finds the applicant's response to RAI B.3.1.1-2 and Enhancement 2 acceptable because: (1) the applicant is applying the enhancement for the software program to the "scope of the program," "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements to ensure that the implementation of the software program will be consistent with the corresponding program elements in GALL AMP X.M1; (2) the enhancement includes the need to incorporate the use of the software program into the implementing procedures; and (3) the applicant has included the need for this enhancement in Commitment No. 47 to implement the enhancement prior to entering the period of extended operation. The staff's concern described in RAI B.3.1.1-2 is resolved.

Enhancement 3. LRA Section B.3.1.1 states an enhancement to the "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements. The staff noted that this enhancement expands on the existing program to address the effects of the reactor coolant environment on component fatigue life by assessing the impact of the reactor coolant environment on a sample of critical components for the plant identified in NUREG/CR-6260. The applicant committed to implement this enhancement prior to the period of extended operation, as identified in Commitment No. 47, LRA Appendix A, Section A.5.

The staff reviewed this enhancement against the corresponding program elements in GALL AMP X.M1. The staff noted that the applicant's Enhancement 3 appropriately expands the existing program to address the effects of the reactor coolant environment on component fatigue life by assessing the impact of the reactor coolant environment on a sample of critical components for the plant identified in NUREG/CR-6260, as required by GALL AMP X.M1. However, it was not evident to the staff whether this enhancement was being used to make the "preventive actions," "parameters monitored or inspected," and "acceptance criteria" program elements consistent with GALL AMP X.M1. Specifically, it was not evident to the staff how this enhancement related to the acceptance criterion recommendation for environmental fatigue calculations in the "acceptance criteria" program element of GALL AMP X.M1. It is also not evident to the staff how this enhancement related to the "preventive actions" and "parameters monitored or inspected" program elements in GALL AMP X.M1, which do not mention criteria for environmental calculations or assessments.

By letter dated June 30, 2010, the staff issued RAI B.3.1.1-3 requesting that the applicant confirm that the stated enhancement is being proposed to make the "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements of the Metal Fatigue of Reactor Coolant Pressure Boundary Program consistent with GALL AMP X.M1. The applicant was also requested to clarify how this enhancement relates to the recommendations of the "acceptance criteria," "preventive actions," and "parameters monitored or inspected" program elements in GALL AMP X.M1.

In its response dated July 28, 2010, the applicant clarified that Enhancement 3 is proposed for the purpose of making the "preventive actions," "parameters monitored or inspected," "monitoring and trending," and "acceptance criteria" program elements consistent with those in GALL AMP X.M1. In regard to the relationship of the enhancement to the "preventive actions" program element, the applicant clarified that the enhancement will ensure that the program's monitoring methods will consider the impacts of the reactor water environment on the CUF values for the components that are monitored. The staff noted that the "preventive actions" program element of GALL AMP X.M1 recommends that maintaining the fatigue usage factor below the design code limit and considering the effect of the reactor water environment, as described under the program description, will provide adequate margin against fatigue cracking of RCS components due to anticipated cyclic strains. The staff noted that the applicant's application of Enhancement 3 to the "preventive actions" program element is being proposed to ensure that the program's monitoring of the CUFs for RCPB components will take into account the environmental effects of the reactor coolant environment on the CUF values to maintain it below the design limit of 1.0.

Based on this review, the staff finds that the preventive actions, when subject to Enhancement 3, will be acceptable for implementation because: (1) the application of the enhancement will ensure that the monitoring of the CUF values will appropriately account for the impact of the reactor coolant environment on the CUF values for the components, (2) application of the enhancement will ensure that the implementation of the "preventive actions" program element will be consistent with the corresponding "preventive actions" program element in GALL AMP X.M1, and (3) the applicant has included this enhancement as Commitment No. 47 and has committed to implement this commitment prior to entering the period of extended operation.

In regard to the relationship of the enhancement to the "parameters monitored or inspected" and "monitoring and trending" program elements, the applicant clarified that the enhancement will ensure that the program's CUF monitoring methods will consider and apply the environmental fatigue life correction factor, F_{en}, adjustments to the CUF values for a sample of RCPB components that are identified as critical environmental fatigue locations. The applicant clarified that this is in conformance with the recommendations for identifying EAF analysis component locations, as given in NUREG/CR-6260. The staff noted that the "parameters monitored or inspected" program element of GALL AMP X.M1 recommends, in part, that the program should monitor all plant transients that cause cyclic strains and which are significant contributors to the fatigue usage factor and that the plant transients that cause significant fatigue usage for each critical RCPB component be monitored. The staff also noted that the "monitoring and trending" program element of GALL AMP X.M1 recommends that the program should monitor a sample of high fatigue usage locations and that the sample is to include the locations identified in NUREG/CR-6260, as a minimum, or propose alternatives based on a plant's specific configuration.

Based on its review, the staff finds that the CUF monitoring methods, when subject to Enhancement 3, will be acceptable for implementation because: (1) the applicant identified the critical RCPB locations for EAF analyses and has applied the F_{en} factors, (2) the enhancement will ensure the application of the program's cycle monitoring and CUF monitoring methods to the CUF values for those RCPB components that have been identified as the critical EAF locations, (3) this is consistent with the "parameters monitored or inspected" and "monitoring and trending" program elements of GALL AMP X.M1, and (4) the applicant has incorporated this enhancement in Commitment No. 47 and has committed to implement this commitment prior to entering the period of extended operation.

In regard to the relationship of the enhancement to the "acceptance criteria" program element, the applicant clarified that the enhancement was being proposed to ensure conformance with the "acceptance criteria" program element in GALL AMP X.M1. The applicant clarified that this was being proposed to ensure that, for the critical EAF RCPB locations, the monitoring of the CUF values for the components would be performed against the design code CUF limits, as adjusted using the design life adjustment factors developed for assessing the impact of reactor coolant environment on the fatigue life of the components. The staff noted that the "acceptance criteria" program element of GALL AMP X.M1 recommends that the program's acceptance criteria should maintain the fatigue usage below the design code limit considering environmental fatigue effects as described under the program description. The staff noted that the applicant's acceptance criteria, which will be modified by Enhancement 3, would ensure that the monitoring of the CUF values for the critical EAF analysis locations would be performed against F_{en}-adjusted CUF limits in the RCPB.

Based on its review, the staff finds the acceptance criteria, subject to Enhancement 3, acceptable for implementation because: (1) the application of the enhancement will ensure that the acceptance criteria on CUF monitoring of the critical EAF locations in the RCPB will be performed against appropriate F_{en}-adjusted CUF limits, (2) application of the enhancement will ensure that the implementation of the "acceptance criteria" program element is consistent with GALL AMP X.M1, and (3) the applicant has incorporated this enhancement in Commitment No. 47 and has committed to implement this commitment prior to entering the period of extended operation.

Based on its review, the staff finds the applicant's response to RAI B.3.1.1-3 and Enhancement 3 acceptable because: (1) the applicant described in detail how its Enhancement 3 is consistent with the recommendations of the GALL Report; and (2) the staff confirmed that when Enhancement 3 is implemented prior to the period of extended operation, the applicant's program will be consistent with the recommendations of GALL AMP X.M1, as described above. The staff's concern described in RAI B.3.1.1-3 is resolved.

Enhancement 4. LRA Section B.3.1.1 states an enhancement to the "corrective actions" program element. The staff noted that this enhancement expands on the existing program element to address the expanded review of RCPB locations if the usage factor for one of the environmental fatigue sample locations approaches its design limit.

During the staff's review, it was not evident whether the stated enhancement is being made to make the "corrective actions" program element consistent with the corresponding program element in GALL AMP X.M1. It was also not apparent to the staff what is being enhanced, specifically whether the enhancement will involve the basis document or the implementing procedure. By letter dated June 30, 2010, the staff issued RAI B.3.1.1-4 requesting that the applicant confirm that the stated enhancement is being proposed to make the "corrective actions" program element consistent with that in GALL AMP X.M1. The applicant was also requested to clarify what will be enhanced.

In its response dated July 28, 2010, the applicant clarified that Enhancement 4 is being proposed to make the "corrective actions" program element consistent with that in GALL AMP X.M1. The applicant also clarified that the enhancement will ensure that new revisions to existing implementing procedures will be issued to include the review of additional RCPB locations, if the usage factor for one of the environmental fatigue sample locations approaches its design limit.

The staff noted that the "corrective actions" program element of GALL AMP X.M1 states:

> The program provides for corrective actions to prevent the usage factor from exceeding the design code limit during the period of extended operation. Acceptable corrective actions include repair of the component, replacement of

the component, and a more rigorous analysis of the component to demonstrate that the design code limit will not be exceeded during the extended period of operation. For programs that monitor a sample of high fatigue usage locations, corrective actions include a review of additional affected RCPB locations. As discussed in the appendix to this report, the staff finds the requirements of 10 CFR Part 50, Appendix B, acceptable to address the corrective actions.

The staff noted that the applicant conservatively considers the EAF analysis locations in the RCPB to be high usage factor locations and Enhancement 4 ensures that the CUF monitoring would be applied to additional component locations if the monitored CUF value for an EAF analysis location was to reach the design limit. The staff noted that the implementation of Enhancement 4 will make the "corrective actions" program element consistent with the recommendation in GALL AMP X.M1 to include a review of additional RCPB component locations if an action limit on CUF monitoring is reached.

Based on its review, the staff finds the applicant's response to RAI B.3.1.1-4 and Enhancement 4 acceptable because: (1) Enhancement 4 ensures that sample expansion of the program's CUF monitoring activities will be applied to other locations if the monitored CUF for a critical EAF analysis component was to reach its design limit, (2) Enhancement 4 is consistent with the recommendations in the corresponding "corrective actions" program element in GALL AMP X.M1, and (3) the applicant has included this enhancement as Commitment No. 47 and has committed to implement this commitment prior to entering the period of extended operation. The staff has noted a concern as to whether the applicant verified that the locations per NUREG/CR-6260 are bounding as compared to other plant-specific locations (e.g., locations with a higher CUF value). The staff's evaluation of the issue on the selection of the plant-specific locations is documented in SER Section 4.3.7.2. The staff's concern described in RAI B.3.1.1-4 is resolved.

Operating Experience. LRA Section B.3.1.1 summarizes operating experience related to the Metal Fatigue of Reactor Coolant Pressure Boundary Program. The applicant stated the Metal Fatigue of Reactor Coolant Pressure Boundary Program has remained responsive to industry and plant-specific emerging issues and concerns. To support this statement, the applicant listed examples where it addresses NRC Bulletins 88-11 and 88-08. The applicant addressed concerns raised in NRC Bulletin 88-11 on pressurizer surge line thermal stratification by analyzing and demonstrating the acceptability of the CUF and by including the thermal stratification into the fatigue evaluation for the period of extended operation. Also, the applicant addressed concerns raised in NRC Bulletin 88-08 on thermal stresses in piping connected to the RCS by performing evaluations to ensure that the safety injection lines, normal and alternate charging lines, and the auxiliary spray lines would not experience failure. Based on this evaluation, the applicant implemented a leakage monitoring program for the safety injection lines. In addition, the applicant demonstrated that monitored transient cycles have not exceeded the imposed 40-year design limits and have been within their respective administrative limits.

The staff reviewed operating experience information in the application and during the audit to determine whether the applicable aging effects and industry and plant-specific operating experience were reviewed by the applicant and are evaluated in the GALL Report. As discussed in the Audit Report, the staff conducted an independent search of the plant operating experience information to determine whether the applicant had adequately incorporated and evaluated operating experience related to this program. During its review, the staff found no operating experience to indicate that the applicant's program would not be effective in adequately managing aging effects during the period of extended operation.

Based on its audit and review of the application, the staff finds that operating experience related to the applicant's program demonstrates that it can adequately manage the detrimental effects of aging on SSCs within the scope of the program and that implementation of the program has resulted in the applicant taking appropriate corrective actions. The staff confirmed that the operating experience program element satisfies the criterion in SRP-LR Section A.1.2.3.10 and, therefore, the staff finds it acceptable.

UFSAR Supplement. LRA Section A.3.1.1 provides the UFSAR supplement for the Metal Fatigue of Reactor Coolant Pressure Boundary Program. The staff reviewed this UFSAR supplement description of the program and notes that it conforms to the recommended description for this type of program as described in SRP-LR Table 4.3-2. The staff also notes that the applicant committed (Commitment No. 47) to enhance the Metal Fatigue of Reactor Coolant Pressure Boundary Program prior to entering the period of extended operation. Specifically, the applicant committed to: (1) include additional transients beyond those defined in the TSs and the UFSAR and expanding the fatigue monitoring program to encompass other components identified to have fatigue as an analyzed aging effect, which require monitoring; (2) use a software program to automatically count transients and calculate cumulative usage on select components; (3) address the effects of the reactor coolant environment on component fatigue life by assessing the impact of the reactor coolant environment on a sample of critical components for the plant identified in NUREG/CR-6260; and (4) require a review of additional RCPB locations if the usage factor for one of the environmental fatigue sample locations approaches its CUF acceptance criterion limit. The staff verified that these commitment provisions specifically involve the four enhancements that the applicant proposed in LRA Section B.3.1.1, as amended, and by letter dated July 28, 2010.

The staff determines that the information in the UFSAR supplement is an adequate summary description of the program, as required by 10 CFR 54.21(d).

Conclusion. On the basis of its audit and review of the applicant's Metal Fatigue of Reactor Coolant Pressure Boundary Program, the staff determines that those program elements for which the applicant claimed consistency with the GALL Report are consistent. Also, the staff reviewed the enhancements and confirmed that their implementation through Commitment No. 47 prior to the period of extended operation would make the existing AMP consistent with the GALL Report AMP to which it was compared. The staff concludes that the applicant has demonstrated that the effects of aging will be adequately managed so that the intended function(s) will be maintained consistent with the CLB for the period of extended operation, as required by 10 CFR 54.21(a)(3). The staff also reviewed the UFSAR supplement for this AMP and concludes that it provides an adequate summary description of the program, as required by 10 CFR 54.21(d).

3.0.3.3 AMPs That Are Not Consistent with or Not Addressed in the GALL Report

In LRA Appendix B, the applicant identified the following AMPs as plant-specific:

- High Voltage Insulators
- Periodic Inspection
- Aboveground Non-Steel Tanks

4.3 <u>Metal Fatigue of Piping and Components</u>

A metal component that is subjected to cyclic loads may fail at load levels lower than its design load carrying capacity due to a well-known phenomenon known as fatigue. Fatigue involves crack initiation and propagation. The fatigue life of a structural component depends on the material used for the structure, the environment to which the structural component is exposed, and the number of occurrences or repetitions of cyclic loads and the magnitude of the applied fluctuating loads.

LRA Section 4.3 states that metal fatigue was evaluated in the design process for pressure boundary components, including the reactor vessel, reactor coolant pumps (RCPs), SGs, pressurizer, piping, valves, and components of primary, secondary, auxiliary, steam, and other systems. Furthermore, the applicant stated that fatigue TLAAs for pressure boundary components are characterized by determining the applicable design codes and specifications that specify the fatigue design requirements.

Fatigue is age-related degradation caused by cyclic stressing of a component by either mechanical or thermal stresses. Fatigue analyses are TLAAs if they meet the six defined elements pursuant to 10 CFR 54.3(a). If the analyses are based on a number of cycles estimated for the current license term, they may meet the 10 CFR 54.3(a)(3) criterion of “defined by the current operating term.” The applicant evaluated the TLAAs in accordance with 10 CFR 54.21(c)(1).

4.3.1 Nuclear Steam Supply System Pressure Vessel and Component Fatigue Analyses

4.3.1.1 Summary of Technical Information in the Application

LRA Section 4.3.1 summarizes the evaluation of the pressure vessel components for the period of extended operation. This TLAA is based on the analysis in UFSAR Section 5.2. The applicant stated that metal fatigue evaluation was performed for the nuclear steam supply system (NSSS) pressure vessel and its components that included reactor vessel, reactor vessel closure head, pressurizer, SGs, and RCP casings. The applicant also stated that these components were designed in accordance with ASME Boiler and Pressure Vessel (B&PV) Code Section III for Class A or Class 1 and, therefore, were subject to fatigue analyses. The applicant further stated that these analyses were based upon the number and the amplitudes of design basis transients described in the design specifications and summarized in LRA Table 4.3.1-2, “Design Transient Cycles for NSSS Class A and Class 1 Components at Salem Units 1 and 2.” The applicant reviewed fatigue monitoring data to determine the number of cumulative cycles of each transient that occurred during plant operation. Based on this data, the applicant derived the 60-year projected number of cycles and compared these values to the design basis number of cycles. The applicant concluded that the 60-year projected number of cycles remained bounded by the design-basis number of cycles and that the design-basis fatigue analyses will remain valid for the 60 years of operation. In this TLAA, the applicant dispositioned the TLAA pressure vessel and component fatigue analyses based on the criterion in 10 CFR 54.21(c)(1)(i).

4.3.1.2 Staff Evaluation

The staff reviewed the TLAAs in LRA Section 4.3.1 for NSSS pressure vessel and components against the acceptance criteria in SRP-LR Section 4.3.2.1.1.1 and review procedures in SRP-LR Section 4.3.3.1.1.1 in order to verify, in accordance with 10 CFR 54.21(c)(1)(i), that the NSSS pressure vessel and its components fatigue analyses remain valid for the period of extended operation.

The staff also reviewed the following additional documents that are relevant to the staff's evaluation of this TLAA:

- TS 5.7, "Component Cyclic or Transient Limit"
- UFSAR Section 5.2, "Integrity of Reactor Coolant Pressure Boundary"
- UFSAR Table 5.2-10, "Design Thermal and Loading Cycles – AREVA NP Model 61/19T SG – Unit 2"
- UFSAR Table 5.2-10a, "Design Thermal and Loading Cycles – Model F SG – Unit 1"
- 10 CFR 50.55a, "Codes and Standards"

The staff reviewed the applicant's cycle projection methodology in LRA Section 4.3.1 and the actual 60-year transient projection data in LRA Tables 4.3.1-3 and 4.3.1-4 against the design basis limits in LRA Table 4.3.1-2 to determine whether the applicant provided an acceptable basis to disposition the TLAAs in accordance with 10 CFR 54.21(c)(1)(i).

During its review, the staff noted that the applicant is using a linear basis to project the cumulative cycles for the design basis transients to the end of the period of extended operation. The staff noted the applicant's projection methodology is based on 28.5 years of operation for Unit 1 and 25.6 years of operation for Unit 2. The staff confirmed that the applicant derived an average rate of past transient occurrences using 28.5 and 25.6 years of operation for Units 1 and 2. The staff determined that the applicant derived the 60-year cycle projections by adding the cumulative number of occurrences as of December 31, 2007, to the number of cycles predicted to occur in the 31.5 and 34.4 years of future operation for Units 1 and 2, respectively. The staff concluded that this projection methodology is based on the assumption that all monitored transients would not exhibit increasing trends. During its audit and based on the additional information provided by the applicant as referenced in the audit report, the staff confirms that none of the transients listed in LRA Table 4.3.1-2 exhibited increasing trends over the period of operation for which they were assessed (i.e., operations through December 31, 2007). The staff notes that this supports the applicant's conclusion that the linear extrapolation basis is conservative because the linear averaging used in the projection basis is bounding for the actual decreasing trend in transient cycle occurrences over time.

However, the staff also noted that the applicant's 60-year transient occurrence projection basis did not indicate whether there were any gaps in the counting of the design basis transients since the initial startup of the Salem units. By letter dated June 14, 2010, the staff issued RAI 4.3-01 requesting that the applicant clarify whether the cycle counting for the design basis transients at Units 1 and 2 has been performed during the entire period of past operation.

In its response dated July 13, 2010, the applicant stated that it conducted a review of past plant documents to establish cycle counts, which included licensee event reports, monthly operating reports, and the plant's computer-based data archive system. The applicant stated that this review confirmed there were no unmonitored periods during the entire period of past operation. The applicant stated that the review included the entire time of operation except during periods of hot shutdown or cold shutdown conditions. The applicant stated that for each of the design basis transients listed in LRA Tables 4.3.1-3 and 4.3.1-4, the applicant used the larger of the two values for current cycles that either came from the 2007 annual cyclic data report or the review of plant historical information.

Based on its review, the staff finds the applicant's response to RAI 4.3-01 acceptable because the applicant has performed cycle counting during the entire period of past operation, and the applicant has performed a review of plant records to identify any uncounted transients. Further, the applicant has used the highest cycle count resulting from either of the two processes in its evaluation cycles. The staff's concern described in RAI 4.3-01 is resolved.

The staff notes that LRA Section 4.3.1 does not reference the design-basis documents used to confirm the design basis transient limits provided in LRA Table 4.3.1-2. By letter dated June 14, 2010, the staff issued RAI 4.3-02 requesting that the applicant clarify which CLB documents or design-basis documents were used to determine the design basis transient limits for those listed in LRA Table 4.3.1-2, "Design Transient Cycles for NSSS Class A and Class 1 Components at Salem Units 1 and 2."

In its response dated July 13, 2010, the applicant provided a table that lists the CLB or design-basis documents referenced for each of the transients listed in LRA Table 4.3.1-2. The list of references includes:

- Units 1 and 2 TSs, Table 5.7-1, "Component Cyclic or Transient Limits"
- UFSAR Table 5.2-10a, "Design Thermal and Loading Cycles*, Model F SG – Unit 1," Revision 24
- UFSAR Table 5.2-10, "Design Thermal and Loading Cycles*, AREVA NP Model 61/19T SG – Unit 2," Revision 24
- WCAP-12914, "Structural Evaluation of Salem Nuclear Plant Units 1 and 2 Pressurizer Surge Lines, Considering the Effects of Thermal Stratification," Revision 1
- PSEG Calculations 3SC-013, "Salem Unit 1 & 2 – NRC Bulletin 88-08 Evaluation of Aux. Spray Line," Revision 0
- Safety Evaluation SGS/M-SE-006, "Safety Injection Transients, 1 and ½ Inch Injection Nozzles – Reactor Coolant System, No. 1 Unit," Revision 0, February 9, 1977

The staff reviewed these documents and concluded that they do provide design basis transient limiting values provided in LRA Table 4.3.1-2. The staff's concern described in RAI 4.3-02 is resolved.

Therefore, based on this review, the staff concludes that the applicant's 60-year transient projection basis is acceptable because the linear extrapolation methodology is conservative relative to the actual decreasing trend in transient occurrences from recent plant operations.

The staff reviewed the 60-year cycle projections for the transients in LRA Tables 4.3.1-3 and 4.3.1-4 against the design basis limit values listed for the transients in LRA Table 4.3.1-2. The staff confirmed that the 60-year projected cycles were based on the projection methodology as described above and that for these transients, the 60-year projected number of cycles listed in LRA Tables 4.3.1-3 and 4.3.1-4 are bounded by the design basis limit values listed for the transients in LRA Table 4.3.1-2. Therefore, the staff finds that the applicant has provided a valid basis for dispositioning the TLAAs in accordance with 10 CFR 54.21(c)(1)(i) because the applicant's 60-year linear extrapolation methodology bounds the actual trend in transient occurrences and the 60-year projections results listed for the transients in LRA Tables 4.3.1-3, 4.3.1-4, 4.3.2-1, 4.3.2-2, 4.3.6-1, and 4.3.6-2 are bounded by the design basis limit values listed for these transients in LRA Table 4.3.1-2.

4.3.1.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of NSSS pressure vessel components fatigue analyses in LRA Section A.4.3.1. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's actions to address NSSS pressure vessel components fatigue analyses is adequate.

4.3.1.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.1.1.1, the staff concludes that the applicant has provided an acceptable demonstration, pursuant to 10 CFR 54.21(c)(1)(i), that for the metal fatigue TLAA, the analyses for the NSSS pressure vessel and components remain valid for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the NSSS pressure vessel and its components, as required pursuant to 10 CFR 54.21(d).

4.3.2 Pressurizer Safety Valve and Pilot-Operated Relief Valve Fatigue Analyses

4.3.2.1 Pressurizer Safety Valve

4.3.2.1.1 Summary of Technical Information in the Application

LRA Section 4.3.2 summarizes the evaluation of pressurizer safety valves for the period of extended operation. In this TLAA, the applicant stated that the fatigue analyses for pressurizer safety valves are a TLAA that require evaluation for the period of extended operation. The applicant also stated that for the design basis analyses, the pressurizer safety valves are based on a total of 50 design cycles. The applicant derived the 60-year projected number of cycles used in fatigue analyses of the pressurizer safety valves based on fatigue monitoring data recorded during plant operation. The applicant concluded that the total number of cycles projected for 60 years for the transients of concern (loss of load, feedwater line break, RCP locked rotor, and control rod ejection) remained bounded by the design basis number of cycles, and thus the design basis fatigue analyses will remain valid for the period of extended operation.

In this TLAA, the applicant dispositioned the TLAA for fatigue of pressurizer safety valve fatigue analyses based on the criterion in 10 CFR 54.21(c)(1)(i).

4.3.2.1.2 Staff Evaluation

The staff reviewed the TLAAs in LRA Section 4.3.2.1 for fatigue of the pressurizer safety valves against the acceptance criteria in SRP-LR Section 4.3.2.1.3 and the review procedures in SRP-LR Section 4.3.3.1.3 in order to verify, in accordance with 10 CFR 54.21(c)(1)(i), that the pressurizer safety valves fatigue analyses remain valid for the period of extended operation.

The staff also reviewed the following additional documents that are relevant to the staff's evaluation of this TLAA:

- TS 5.7, "Component Cyclic or Transient Limit"
- UFSAR Section 5.5, "Components and Subsystem Design"
- UFSAR Table 5.2-10, "Design Thermal and Loading Cycles – AREVA NP Model 61/19T SG – Unit 2"
- UFSAR Table 5.2-10a, "Design Thermal and Loading Cycles – Model F SG – Unit 1"
- 10 CFR 50.55a, "Codes and Standards"

The staff notes that the applicant's metal fatigue analysis assessment for the pressurizer safety valves is based on a design specification that limits the total number of transient occurrences (for all transients applicable to the valves) to a value of 50. The staff also notes that the applicant identified that the following design basis transients are applicable to the applicant's TLAA for the pressurizer pilot-operated relief valves (PORVs): (1) "Loss of Load," (3) "Feedwater Line Break," (3) "RCP Locked Rotor" and (4) "Control Rod Ejection."

The staff notes that LRA Table 4.3.2-1 lists the current total number of occurrences to date and the 60-year projection results for the applicable design basis transients. During its review, the staff confirms that the applicant is using a linear basis to determine the 60-year cycle projections, consistent with the projection methodology evaluated and found to be acceptable by the staff in SER Section 4.3.1.

The staff notes that the applicant's evaluation is based on a projection of one occurrence each, of the "Feedwater Line Break," "RCP Locked Rotor," and "Control Rod Ejection" transients during the period of extended operation, even though there have been no occurrences of these transients at the plant during current licensed operations. The staff finds this assumption to be acceptable because the applicant has programs, requirements, or design features to minimize the probability for the occurrence of these transients. The staff confirms that, for the pressurizer safety valves, the total number of transient occurrences projected for 60 years of operation for all applicable transients is 7 and 4 for Salem Units 1 and 2, respectively. The staff notes that this demonstrates the number of transient occurrences remains bounded by the total number of transient occurrences allowed in the design specification for the valves.

The staff held a teleconference with the applicant on August 1, 2010, to discuss the disposition of the TLAAs on the pressurizer safety valves and pressurizer PORVs as discussed in LRA

Sections 4.3.2.1 and 4.3.2.2. The staff noted that the analyses the applicant claimed to be TLAAs for the pressurizer safety valves (LRA Section 4.3.2.1) and pressurizer PORVs (LRA Section 4.3.2.2) appeared to be limited only to the total number of cycles and thus, the analyses for these valve types do not appear to be associated with the evaluation of an aging effect. The staff noted that the applicant would not normally have to identify these analyses as TLAAs because they do not appear to conform to Criterion 2 in 10 CFR 54.3(a) (i.e., consider the effects of aging).

By letter dated August 26, 2010, the applicant stated that, upon further review, it determined there are no TLAAs associated with the pressurizer safety valves and PORVs, since the design analyses associated with these valves do not meet all of the criteria of a TLAA as defined in 10 CFR 54.3(a).

The applicant further stated that as part of the detailed TLAA documentation search, it found Westinghouse design specifications for component cycles associated with the valves; however, these design specifications do not consider the effects of aging of the pressurizer safety valves and PORVs. The staff noted that the second criterion of a TLAA, as defined in 10 CFR 54.3(a), states that a TLAA are those licensee calculations and analyses that consider the effects of aging. Furthermore, the staff noted that, since these analyses did not consider the effects of aging, they would not normally have been considered TLAAs; however, the LRA conservatively identified these analyses as TLAAs, evaluated the projected number of cycles associated with the valves' operations, and dispositioned the TLAAs in accordance with 10 CFR 54.21(c)(1)(i). The applicant amended its LRA such that the applicable sections, LRA Sections 4.3.2 and A.4.3.2, are deleted to remove the analyses associated with the valves as TLAAs.

Based on its review, the staff finds it acceptable that LRA Sections 4.3.2 and A.4.3.2 were deleted and that the fatigue analyses for the pressurizer safety valves are not TLAAs because these analyses did not consider the effects of aging and, therefore, do not meet the definition of a TLAA, as defined in 10 CFR 54.3(a).

4.3.2.1.3 UFSAR Supplement

By letter dated August 26, 2010, the applicant amended its LRA to delete LRA Section A.4.3.2. The staff's review of this amendment is documented in SER Section 4.3.2.1.2.

4.3.2.1.4 Conclusion

On the basis of its review, the staff concludes that the fatigue analyses for the pressurizer safety valves are not TLAAs, as defined in 10 CFR 54.3(a). The staff also concludes that a UFSAR supplement is not required.

4.3.2.2 Pressurizer Pilot-Operated Relief Valve Fatigue Analyses

4.3.2.2.1 Summary of Technical Information in the Application

LRA Section 4.3.2 summarizes the evaluation of pressurizer PORVs for the period of extended operation. In this TLAA, the applicant stated that the fatigue analyses for pressurizer PORVs are a TLAA that requires evaluation for the period of extended operation. The applicant also stated that for pressurizer PORVs, the design basis analyses are based on a total of 20,000 design cycles. Based on fatigue monitoring data recorded during plant operation, the applicant derived the 60-year projected number of cycles used in the fatigue analyses of the pressurizer PORVs.

The applicant concluded that the total number of cycles projected for 60 years of operation remain bounded by the design basis number of cycles and that the design basis fatigue analyses will remain valid for the period of extended operation. The applicant dispositioned the TLAA for fatigue of pressurizer PORVs based on the criterion in 10 CFR 54.21(c)(1)(i).

4.3.2.2.2 Staff Evaluation

The staff reviewed the TLAAs in LRA Section 4.3.2.2 for fatigue of the pressurizer PORVs against the acceptance criteria in SRP-LR Section 4.3.2.1.3 and the review procedures in SRP-LR Section 4.3.3.1.3 in order to confirm, in accordance with 10 CFR 54.21(c)(1)(i), that the pressurizer PORVs fatigue analyses remain valid for the period of extended operation.

The staff also reviewed the same additional documents as described in SER Section 4.3.2.1.2. The staff noted that the applicant's metal fatigue analysis for the pressurizer PORVs is based on a design specification that limits the number of transient cycles to 20,000 occurrences for all transients that are applicable to the valves. The staff also noted that the applicant identified that the following design basis transients are applicable to the applicant's TLAA for the pressurizer PORVs: (1) large step load with steam dump, (2) loss of load, (3) loss of flow, and (4) loss of power.

The staff noted that LRA Table 4.3.2-2 lists the total number of cumulative occurrences for these transients to date and the 60-year projection results for these transients. The staff confirms that these projections are based on the applicant's projection methodology provided in LRA Section 4.3.1. The staff evaluated this projection methodology in SER Section 4.3.1 and determined that the applicant's 60-year design basis transient projection basis and results were acceptable and conservative. The staff confirmed that, for the pressurizer PORVs, the total number of 60-year projected cycles is 91 and 40 for Salem Units 1 and 2, respectively. The staff notes that this projected number of transient occurrences is bounded by the number of transient occurrences allowed in the design specification for the pressurizer PORVs (i.e., less than 20,000).

The staff held a teleconference with the applicant on August 1, 2010, to discuss the disposition of the TLAAs on the pressurizer safety valves and PORVs, as discussed in LRA Sections 4.3.2.1 and 4.3.2.2. The staff noted that the analyses that the applicant claimed to be TLAAs for the pressurizer safety valves (LRA Section 4.3.2.1) and pressurizer PORVs (LRA Section 4.3.2.2) appeared to be limited only to the total number of cycles and thus, the analyses for these valve types do not appear to be associated with the evaluation of an aging effect. The staff noted that the applicant would not normally have to identify these analyses as TLAAs because they do not appear to conform to Criterion 2 in 10 CFR 54.3(a) (i.e., consider the effects of aging).

By letter dated August 26, 2010, the applicant stated that, upon further review, it determined there are no TLAAs associated with the pressurizer safety valves and PORVs, since the design analyses associated with these valves do not meet all of the criteria of a TLAA as defined in 10 CFR 54.3(a).

The staff's review of the August 26, 2010, letter and the deletion of LRA Sections 4.3.2 and A.4.3.2 are documented in SER Section 4.3.2.1.2.

Based on its review, the staff finds it acceptable that LRA Sections 4.3.2 and A.4.3.2 were deleted and that the fatigue analyses for the pressurizer PORVs are not TLAAs because these analyses did not consider the effects of aging and, therefore, do not meet the definition of a TLAA as defined in 10 CFR 54.3(a).

4.3.2.2.3 UFSAR Supplement

By letter dated August 26, 2010, the applicant amended its LRA to delete LRA Section A.4.3.2. The staff's review of this amendment is documented in SER Section 4.3.2.1.2.

4.3.2.2.4 Conclusion

On the basis of its review, the staff concludes that the fatigue analyses for the pressurizer PORVs are not TLAAs, as defined in 10 CFR 54.3(a). The staff also concludes that a UFSAR supplement is not required.

4.3.3 American Standards Association/United States of America Standards B31.1 Piping Fatigue Analyses

4.3.3.1 Summary of Technical Information in the Application

LRA Section 4.3.3 summarizes the evaluation of American Standards Association/United States of America Standards (ASA/USAS) B31.1 piping for the period of extended operation. This TLAA is based on the analysis in UFSAR Section 5.2. In this TLAA, the applicant stated that the piping was designed in accordance with ASA/USAS B31.1 piping code and, therefore, fatigue analyses were not required, but cyclic load was considered in a simplified manner in the design process. The applicant determined that the total number of 60-year projected cycles does not exceed 7,000 cycles, which is the minimum number of cycles required that would result in application of an allowable stress reduction factor. Therefore, the applicant concluded that the existing analyses of ASA/USAS B31.1 piping for which the allowable range of secondary stresses depends on the number of assumed thermal cycles, remain valid for the period of extended operation, in accordance with 10 CFR 54.21(c)(1)(i).

4.3.3.2 Staff Evaluation

The staff reviewed the TLAA in LRA Section 4.3.3 for fatigue of ASA/USAS B31.1 piping against the acceptance criteria in SRP-LR Section 4.3.2.1.2.1 and the review procedures in SRP-LR Section 4.3.3.1.2.1 in order to verify, in accordance with 10 CFR 54.21(c)(1)(i), that the ASA/USAS B31.1 piping fatigue analyses remain valid for the period of extended operation.

The staff reviewed the applicant's cycle projection methodology in LRA Section 4.3.1 and found the applicant's methodology acceptable. From the information provided in LRA Tables 4.3.1-3 and 4.3.1-4, the staff determined that the total number of projected cycles for the design transients applicable to the ASA/USAS B31.1 piping used 4,936 and 4,264 for Salem Units 1 and 2, respectively, and will not exceed the 7,000-cycle limit. Therefore, the staff concludes that the applicant's design transient cycle projection for the period of extended operation will be less than the limit of 7,000 cycles and thus the analysis remain valid for the period of extended operation.

4.3.3.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of ASA/USAS B31.1 piping fatigue analyses in LRA Section A.4.3.3. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's metal fatigue TLAA for the ASA/USAS B31.1 piping is adequate.

4.3.3.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.1.2.1, the staff concludes that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(i), that the metal fatigue analyses for the ASA/USAS B31.1 piping remain valid for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the ASA/USAS B31.1 piping, as required by 10 CFR 54.21(d), and, therefore, is acceptable.

4.3.4 Supplementary ASME Code Section III, Class 1 Piping and Component Fatigue Analyses

4.3.4.1 NRC Bulletin 88-08, Thermal Stresses in Piping Connected to Reactor Coolant Systems

4.3.4.1.1 Summary of Technical Information in the Application

LRA Section 4.3.4 summarizes the evaluation of supplementary ASME Code Section III, Class 1 piping and component fatigue analysis for the period of extended operation. This TLAA is based on the analysis in response to NRC Bulletin 88-08. In this TLAA, the applicant stated that Units 1 and 2 piping systems were originally designed in accordance with the ASA/USAS B31.1 piping code, however, a number of updated fatigue analyses have been performed for some piping systems and components to address transients that have been identified based on industry practice that were not originally considered. The applicant further stated that these transients include those associated with potential valve leakage transients identified in GL 88-08 for the auxiliary spray line.

The applicant stated that the staff approved Salem's response to NRC Bulletin 88-08, which included the evaluation of the fatigue analyses of the normal and alternate charging lines and the auxiliary spray lines. The applicant also stated that the analyses were based on the requirements of ASME Code Section III, 1986 Edition, Subsection NB-3653 and the fatigue curves of I-9.2.1 and I-9.2.2 and concluded that the cumulative usage factor (CUF) would remain less than 1.0 for the normal and alternate charging lines.

The applicant also performed a fatigue evaluation of the auxiliary spray line for a life of 40 years. The analysis showed that the inadvertent auxiliary spray transient controlled the calculated fatigue usage. The resulting fatigue usage was calculated to be less than 1.0 for 40 years.

In this TLAA, the applicant dispositioned the TLAA for the auxiliary spray lines in accordance with 10 CFR 54.21(c)(1)(i) and the normal and alternate charging lines in accordance with 10 CFR 54.21(c)(1)(iii) for the period of extended operation using the Metal Fatigue of Reactor Coolant Pressure Boundary Program.

4.3.4.1.2 Staff Evaluation

During its review, the staff noted that the applicant is using a linear basis to project the cumulative cycles for the design basis transients to the end of the period of extended operation. The staff accepted the applicant's methodology in SER Section 4.3.1. The staff determined that the applicant revised the auxiliary spray lines fatigue analyses to reduce the original design basis transients from 10 to 5 inadvertent auxiliary spray transients, in response to GL 88-08, in 1999.

The staff confirmed that the 60-year projected cycles for the inadvertent auxiliary spray transient are 2 and 3 for Units 1 and 2, respectively, from LRA Tables 4.3.1-3 and 4.3.1-4. These projected cycle counts are less than the design basis of 10 for this transient. Based on this review, the staff finds that the applicant has provided an acceptable basis for demonstrating that the metal fatigue TLAA for the auxiliary spray lines are acceptable in accordance with 10 CFR 54.21(c)(1)(i) because the staff has confirmed that the number of auxiliary spray transient occurrences, as projected through the period of extended operation, will be bounded by the number of occurrences allowed under the applicant's design basis for this transient.

The staff's review of the normal and alternate charging lines determined that the applicant previously revised the charging lines fatigue analyses to include additional transients, in response to GL 88-08. During aging management program (AMP) audit interviews of the applicant's technical staff, the NRC staff clarified that additional transients incorporated into the charging lines fatigue analyses were included in LRA Tables 4.3.1-3 and 4.3.1-4. These transients are inadvertent auxiliary spray to pressurizer and inadvertent safety injection transients. To address the reactor coolant environmental effects, the applicant re-evaluated the charging lines (the charging to pipe weld) fatigue analysis. The applicant presented the results of this re-evaluation in LRA Section 4.3.7. The staff's evaluation and acceptance of the fatigue analyses for the charging lines is documented in SER Section 4.3.7.

4.3.4.1.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of supplementary ASME Code Section III, Class 1 piping and components fatigue analyses in LRA Section A.4.3.4. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's metal fatigue TLAA for the supplementary ASME Code Section III, Class 1 piping and components is adequate.

4.3.4.1.4 Conclusion

On the basis of its review, the staff concludes that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(i), that the auxiliary spray lines remain valid for the period of extended operation. The staff's evaluation and acceptance of the charging lines are documented in SER Section 4.3.7. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the supplementary ASME Code Section III, Class 1 piping and components, as required by 10 CFR 54.21(d).

4.3.4.2 NRC Bulletin 88-11, Pressurizer Surge Line Thermal Stratification

4.3.4.2.1 Summary of Technical Information in the Application

LRA Section 4.3.4 summarizes the evaluation of supplementary ASME Code Section III, Class 1 piping and component fatigue analysis for the period of extended operation. This TLAA is based on the analysis in response to NRC Bulletin 88-11. The applicant stated that Units 1 and 2 piping systems were originally designed in accordance with the ASA/USAS B31.1 piping code, however, a number of updated fatigue analyses have been performed for some piping systems and components to address transients that have been identified based on industry practice that were not originally considered.

The applicant further stated that these transients include those associated with thermal stratification of the pressurizer surge line as described in NRC Bulletin 88-11. LRA Section 4.3.4 also stated that a plant-specific WESTEMS™ model was developed for the pressurizer and surge line to evaluate the effects of pressurizer insurge and outsurge transients and surge line stratification on the pressurizer surge nozzle safe end to pipe weld and the surge line hot leg nozzle. These results were also used in the evaluation of the reactor water environmental effects on the surge line.

In this TLAA, the applicant dispositioned the TLAA for the pressurizer surge line based on the criterion in 10 CFR 54.21(c)(1)(ii).

4.3.4.2.2 Staff Evaluation

The staff's review of the pressurizer surge line thermal stratification determined that the applicant previously evaluated the effects of thermal stratification and plant-specific transients on the pressurizer surge line, in response to GL 88-11. This evaluation demonstrated that the surge line weld to the pressurizer surge nozzle is a controlling location for the pressurizer surge line. To address reactor coolant environmental effects, the applicant re-evaluated the pressurized surge line (the pressurizer surge line hot leg nozzle and pressurizer nozzle to safe end weld) using ASME B&PV Code Section III, Class 1 fatigue analysis. The applicant presented the results of this re-evaluation in LRA Section 4.3.7.

During its review of the LRA, the staff identified concerns regarding the results determined by the WESTEMS™ program as a part of the ASME Code fatigue evaluation process. For example, Westinghouse's response to NRC questions regarding the AP1000 Technical Report (see Agencywide Document Access and Management System (ADAMS) Accession No. ML102300072, dated August 13, 2010) describes the ability of users to modify intermediate data (peak and valley stresses/times) used in the analyses. In addition, a response provided on August 20, 2010 (ADAMS Accession No. ML102350440), describes different approaches for summation of moment stress terms. These items can have significant impacts on calculated fatigue CUF. The staff issued an RAI requesting information on how WESTEMS™ was used in the Salem analyses, whether these issues apply to the Salem analyses, the environmentally-assisted fatigue (EAF) analyses, and the differences between the stress models used in WESTEMS™ and the stress models used in the current governing analysis of record and the EAF analysis of record. The staff also requested a benchmarking evaluation to compare calculated stresses and CUF using WESTEMS™ to the same results from the initial design basis analyses of record. This was identified as Open Item OI 4.3.4.2-1. This Open Item was closed and its resolution is discussed in SER Section 3.0.3.2.18.

The staff's evaluation of the fatigue analyses for the pressurizer surge line is documented in SER Section 4.3.7.

4.3.4.2.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of supplementary ASME Code Section III, Class 1 piping and components fatigue analyses in LRA Section A.4.3.4. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, and the closure of Open Item OI 4.3.4.2-1, the staff concludes that the summary description of the applicant's metal fatigue TLAA for the supplementary ASME Code Section III, Class 1 piping and components is adequate.

4.3.4.2.4 Conclusion

The staff's evaluation and acceptance of the pressurizer surge line are documented in SER Section 4.3.7. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the supplementary ASME Code Section III, Class 1 piping and components, as required by 10 CFR 54.21(d).

4.3.4.3 Salem Unit 1 Steam Generator Feedwater Nozzle Transition Piece

4.3.4.3.1 Summary of Technical Information in the Application

LRA Section 4.3.4 summarizes the evaluation of supplementary ASME Code Section III, Class 1 piping and component fatigue analysis for the period of extended operation. This TLAA is based on the replacement of the Unit 1 SGs. In this TLAA, the applicant stated that Units 1 and 2 piping systems were originally designed in accordance with the ASA/USAS B31.1 piping code, however, a number of updated fatigue analyses have been performed for some piping systems and components to address transients that have been identified based on industry practice that were not originally considered. The applicant also stated that, as a part of the Salem Unit 1 SG replacement, a new feedwater nozzle transition piece forging was designed in accordance with ASME B&PV Code Section III, Class 1.

In this TLAA, the applicant dispositioned the TLAA for the feedwater nozzle transition piece forging based on the criterion in 10 CFR 54.21(c)(1)(iii) for the period of extended operation using the Metal Fatigue of Reactor Coolant Pressure Boundary Program.

4.3.4.3.2 Staff Evaluation

The staff's review of the feedwater nozzle transition piece determined that hot standby operation transients were replaced with thermal stratification loadings in the updated fatigue analysis for the feedwater nozzle transition piece forging. For the remaining plant life of 15 cycles, the applicant assumed 800 hours of auxiliary feedwater flow per cycle, resulting in a design limit of 12,000 hours of auxiliary feedwater operation. The applicant stated that the thermal stratification loads are managed by the Metal Fatigue of Reactor Coolant Pressure Boundary Program, where the number of auxiliary feedwater flow operational hours will be tracked and compared to the design limit of 12,000 hours. However, the LRA does not provide sufficient information for the staff to determine how the Metal Fatigue of Reactor Coolant Pressure Boundary Program tracks and compares the design limit of 12,000 hours for the auxiliary feedwater flow operation, and which transients tracked by the Metal Fatigue of Reactor Coolant Pressure Boundary Program will assure that the design limit of 12,000 hours for the auxiliary feedwater flow operation is not exceeded. By letter dated June 14, 2010, the staff issued RAI 4.3-04 requesting that the applicant justify why the enhancement of the Metal Fatigue of Reactor Coolant Pressure Boundary Program for tracking of the hourly operations of this transient is an acceptable basis to disposition this TLAA in accordance with 10 CFR 54.21(c)(1)(iii).

In its response dated July 13, 2010, the applicant stated that it has revised its management of the Salem Unit 1 SG feedwater nozzle transition piece and rather than manually tracking hours of the auxiliary feedwater pump during the period of extended operation, the applicant will use WESTEMS™ to automatically compute the CUF for the Unit 1 SG feedwater nozzle transition piece. The applicant further stated that a design limit will be determined for cumulative usage, based on auxiliary feedwater operation, at the transition piece as opposed to tracking the number of auxiliary feedwater flow operational hours. The applicant stated that the design limit is a CUF of 1.0. The applicant stated that all the design basis transients considered in the original analysis will remain the same and these transients are monitored by the Metal Fatigue of Reactor Coolant Pressure Boundary Program. The applicant stated that the hot standby transient was replaced with the thermal stratification loads, which are caused by the auxiliary feedwater pump. The applicant further stated that if the fatigue usage for this location approaches 80 percent of the design limit, the corrective action program will be initiated to evaluate the condition and determine corrective actions.

Based on its review, the staff finds the applicant's response to RAI 4.3-04 acceptable because the applicant has modified its approach for aging management based on the pump operation hours to CUF values and the applicant's Metal Fatigue of Reactor Coolant Pressure Boundary Program ensures that the cumulative usage design limit of 1.0 is not exceeded. During its review of the LRA, the staff identified concerns regarding the results determined by the WESTEMS™ program as a part of the ASME Code Section III fatigue evaluation. This concern was identified as Open Item OI 4.3.4.2-1 and its resolution is discussed in SER Section 3.0.3.2.18. The staff's concern with the issue on the use of WESTEMS™ as described in RAI 4.3-04 is resolved.

4.3.4.3.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of supplementary ASME Code Section III, Class 1 piping and components fatigue analyses in LRA Section A.4.3.4. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's metal fatigue TLAA for the supplementary ASME Code Section III, Class 1 piping and components is adequate.

4.3.4.3.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.1.1.3, the staff concludes that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(iii), that the effects of aging on the feedwater nozzle transition piece forging intended functions will be adequately managed for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the supplementary ASME Code Section III, Class 1 piping and components, as required by 10 CFR 54.21(d).

4.3.4.4 Salem Unit 1 Steam Generator Primary Manway Studs

4.3.4.4.1 Summary of Technical Information in the Application

LRA Section 4.3.4 summarizes the evaluation of supplementary ASME Code Section III, Class 1 piping and component fatigue analysis for the period of extended operation. This TLAA is based on the qualification of the SG primary manway studs for a longer life. In this TLAA, the applicant stated that Units 1 and 2 piping systems were originally designed in accordance with the ASA/USAS B31.1 piping code, however, a number of updated fatigue analyses have been performed for some piping systems and components to address transients that have been identified based on industry practice that were not originally considered. The applicant also stated that, as a part of the Unit 1 SG replacement, the design basis for Unit 1 SG manway studs was updated to include fatigue considerations.

In this TLAA, the applicant dispositioned the TLAA for the Salem Unit 1 SG manway studs based on the criterion in 10 CFR 54.21(c)(1)(i).

4.3.4.4.2 Staff Evaluation

The staff's review of the SG manway studs fatigue analysis determined that, as specified in the LRA, Westinghouse conducted a series of tests to qualify the SG manway studs for 40 years of plant operation. The staff also noted that, although LRA Section 4.3.4.4 indicated that the 60-year projected cycles for the Unit 1 SG manway studs were bounded by the number of cycles assumed in the 40-year design basis fatigue analysis, the LRA did not provide sufficient information to identify which transients were used in the design basis analysis and the 60-year fatigue analysis of the SG manway studs. By letter dated June 14, 2010, the staff issued RAI 4.3-03 requesting that the applicant identify what transients were used in the 40-year fatigue analysis of the SG manway studs and clarify whether limiting cycle numbers for these transients were equivalent to the design basis transient limits.

In its response dated July 13, 2010, the applicant stated that Westinghouse conducted a series of tests to qualify the SG manway studs for a 40-year life. The applicant further stated that these tests were performed for Westinghouse Model F SGs in accordance with ASME Code Section III, Appendix II, 1989 Edition. The applicant stated that the test parameters were determined by using the design transients from the general design specification for the Westinghouse Model F SG. The applicant stated that because the transients used for the fatigue qualification tests considered a larger population of SGs, the testing parameters included additional transients (i.e., reactor coolant pipe break, steam pipe break, operating basis earthquake (OBE), etc.). The applicant further stated that all of the 40-year design transients in the general design specification for Model F SGs were determined to bound the corresponding 40-year design transients for the Unit 1 SGs. The applicant stated that the 40-year design transients for the Unit 1 Model F SGs are bounded by those presented in LRA Table 4.3.1-3 and that there are no other 40-year design transients that are applicable to the Unit 1 Model F SG primary manway studs fatigue analyses that were not listed in LRA Table 4.3.1-3. The applicant further stated that the 60-year cycle projections contained in LRA Table 4.3.1-3 are bounded by the test parameters used for the primary manway stud fatigue qualification testing. The applicant also stated that Westinghouse concluded after fatigue testing that the CUF was less than 1.0. The applicant further stated that because the 60-year cycle projections are bounded by the test parameters, the 60-year projected CUF is also less than 1.0.

Based on its review, the staff finds the applicant's response to RAI 4.3-03 acceptable because: (1) the applicant indicated that the Steam Generator Primary Manway Studs have been fatigue tested in accordance with the ASME Code and (2) this fatigue testing bounds the design bases transient limits and the 60-year projected cycles are less than the design bases limits, which means that the fatigue testing also bounds the period of extended operation. The staff's concern described in RAI 4.3-03 is resolved.

4.3.4.4.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of supplementary ASME Code Section III, Class 1 piping and components fatigue analyses in LRA Section A.4.3.4. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's metal fatigue TLAA for the supplementary ASME Code Section III, Class 1 piping and components is adequate.

4.3.4.4.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.1.1.1, the staff concludes that the applicant has demonstrated pursuant to 10 CFR 54.21(c)(1)(i), that the Unit 1 SG manway studs fatigue analyses remain valid for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the supplementary ASME Code Section III, Class 1 piping and components, as required pursuant to 10 CFR 54.21(d).

4.3.5 Reactor Vessel Internals Fatigue Analyses

4.3.5.1 Summary of Technical Information in the Application

LRA Section 4.3.5 summarizes the evaluation of reactor vessel internals for the period of extended operation. In this TLAA, the applicant stated that the Salem reactor vessel internals were designed and constructed prior to the development of ASME code requirements for core support structures, and the RCS functional design requirements were considered. The applicant also stated that the reactor vessel internals were implicitly designed for low cycle fatigue based upon the RCS design basis transients and were identified as a TLAA. In this TLAA, the applicant dispositioned the TLAA for reactor vessel internals fatigue analyses based on the criterion in 10 CFR 54.21(c)(1)(i).

4.3.5.2 Staff Evaluation

The staff reviewed the TLAA in LRA Section 4.3.5 for reactor vessel internals fatigue analyses against the acceptance criteria in SRP-LR Section 4.3.2.1.3 and the review procedures in SRP-LR Section 4.3.3.1.3 in order to verify, in accordance with 10 CFR 54.21(c)(1)(i), that the reactor vessel internals fatigue analyses remain valid for the period of extended operation.

During its review, the staff noted that LRA Section 4.3.5 states that the reactor vessel internals were designed based on the RCS design transient projections for 40 years. During the AMP audit and based on the additional information provided by the applicant as referenced in the Audit Report, the staff clarified that the RCS design transient projections for 40 years refer to the RCS design-basis transients. The staff reviewed the 60-year cycle projections, as summarized in LRA Tables 4.3.1-3 and 4.3.1-4, and confirmed that these projections were based on the projection methodology as described in SER Section 4.3.1. The staff further confirmed that, for transients used in the reactor vessel internals fatigue analyses, the 60-year projected number of transient cycles for the reactor vessel internals are bounded by the design basis number of cycles. Therefore, the staff concludes that the applicant has provided a valid basis for dispositioning the metal fatigue TLAA for the reactor vessel internals in accordance with the criterion in 10 CFR 54.21(c)(1)(i) because: (1) the applicant’s 60-year linear extrapolation basis for the transients in LRA Tables 4.3.1-3 and 4.3.1-4 bounds the actual trend in transient occurrences for the Salem units, and (2) the staff has confirmed that the 60-year transient occurrence projections for these components are bounded by the design-basis limit values listed for these transients.

4.3.5.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of reactor vessel internals fatigue analyses in LRA Section A.4.3.5.

On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's metal fatigue TLAA for the reactor vessel internal components is adequate.

4.3.5.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.1.3, the staff concludes that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(i), that the metal fatigue TLAA for the reactor vessel internals remains valid for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the reactor vessel internal components, as required by 10 CFR 54.21(d), and, therefore, is acceptable.

4.3.6 Spent Fuel Pool Bottom Plates Fatigue Analyses

4.3.6.1 Summary of Technical Information in the Application

LRA Section 4.3.6 summarizes the evaluation of fatigue on spent fuel pool (SFP) bottom plates for the period of extended operation. This TLAA is based on a response to a staff RAI dated February 26, 1996, for when an analysis was performed to show that the SFP liner and anchors would not experience significant deformations as a result of thermal loadings. Because the SFP liner and anchors were identified as a TLAA for the 40-year plant life, the applicant performed an evaluation of these components for the period of extended operation. The applicant further stated that based on these analyses, the resulting number of allowable cycles for the SFP liner bottom plates plant normal heatup and cooldowns is 1,638 cycles. This number of allowable cycles is much greater than the projected number of plant heatups and cooldowns (266 for Unit 1 and 312 for Unit 2).

The applicant also stated that a separate analysis of the SFP liner bottom plate and anchors determines a CUF of 0.00063 under upset conditions, based on one design-basis event (DBE) and 20 OBE cycles. The applicant projects 1 DBE and 2 OBEs for Unit 1, and 1 DBE and 3 OBEs for Unit 2.

The applicant stated that because the 60-year projected number of cycles used in fatigue analyses of the SFP liner and anchors remained bounded by the design basis number of cycles, the design basis fatigue analyses will remain valid for 60 years of operation. The applicant dispositioned the TLAA for fatigue of SFP bottom plates based on 10 CFR 54.21(c)(1)(i).

4.3.6.2 Staff Evaluation

The staff reviewed the TLAA in LRA Section 4.3.6 for fatigue of SFP bottom plates against the acceptance criteria in SRP-LR Section 4.3.2.1.3 and the review procedures in SRP-LR Section 4.3.3.1.3 in order to verify that the SFP liner and anchors fatigue analyses remain valid for the period of extended operation, in accordance with 10 CFR 54.21(c)(1)(i).

The staff also reviewed the following additional documents that are relevant to the staff's evaluation of this TLAA:

- UFSAR Section 9.1.2, "Spent Fuel Pool"
- UFSAR Table 5.2-10, "Design Thermal and Loading Cycles – AREVA NP Model 61/19T SG – Unit 2"
- UFSAR Table 5.2-10a, "Design Thermal and Loading Cycles – Model F SG – Unit 1"
- 10 CFR 50.55a, "Codes and Standards"

During its review, the staff noted that the applicant's 60-year cycle projections for plant heatups and cooldowns were based on the projection methodology accepted by the staff in SER Section 4.3.1. The staff further confirmed that the total number of 60-year projected cycles is 266 and 312 for Units 1 and 2, respectively, and would remain bounded by the 1,638 allowable cycle limit.

Since the plant has experienced neither an OBE nor a DBE, the staff further confirms that the 60-year cycle projections would remain bounded by 1 DBE and 20 OBE cycles. Therefore, the staff concludes that the applicant's design transient cycle projection provides a conservative estimate of the number of transients occurring through the period of extended operation because the transients are not expected to go over the design-basis value based on the observed operating experience.

4.3.6.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of the SFP bottom plates fatigue analyses in LRA Section A.4.3.6. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes that the summary description of the applicant's actions to address the SFP bottom plates fatigue analyses is adequate.

4.3.6.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.1.3, the staff concludes that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(i), the analyses for the SFP bottom plate liner and anchors will remain valid for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation for the SFP bottom plate liner and anchors, as required by 10 CFR 54.21(d), and, therefore, is acceptable.

4.3.7 Environmentally-Assisted Fatigue Analyses

4.3.7.1 Summary of Technical Information in the Application

LRA Section 4.3.7 summarizes the evaluation of EAF for the period of extended operation. This TLAA evaluates the effects of the RCS environment on the following fatigue life representative components that are identified in NUREG/CR-6260 for older vintage Westinghouse plants:

- reactor vessel shell and lower head
- reactor vessel inlet and outlet nozzles
- surge line
- charging system nozzle
- safety injection system nozzle
- residual heat removal system Class 1 piping

In this TLAA, the applicant stated that the plant-specific components were identified for the NUREG/CR-6260 sample locations and EAF calculations followed the guidance of NUREG/CR-6583 for components made of carbon and low-alloy steels and the guidance of NUREG/CR-5704 for components made of austenitic stainless steel. The applicant further stated that no CUF values considering environmental effects will exceed the code limit of 1.0 for 60 years of operation. In this TLAA, the applicant dispositioned the TLAA for EAF based on 10 CFR 54.21(c)(1)(ii).

4.3.7.2 Staff Evaluation

The staff reviewed the TLAAs in LRA Section 4.3.7 for EAF against the acceptance criteria in SRP-LR Section 4.3.2.2 and the review procedures in SRP-LR Section 4.3.3.2 in order to verify, in accordance with 10 CFR 54.21(c)(1)(ii), that the analyses for the NUREG/CR-6260 sample locations have been projected to the end of the period of extended operation.

During its review, the staff determined that, using plant-specific design fatigue results, the applicant identified the plant-specific components and limiting components locations for the NUREG/CR-6260 sample locations and performed EAF calculations for these components to evaluate the effects of the RCS environment on fatigue life. However, the LRA does not provide sufficient information on the methodology used in determining the plant-specific components and limiting component locations for the NUREG/CR-6260 sample locations. By letter dated June 14, 2010, the staff issued RAI 4.3-05 requesting that the applicant justify the methodology, assumptions, component locations, and results that the applicant included in the EAF evaluation for the LRA.

In its response dated July 13, 2010, the applicant provided the methodology used to determine the Salem plant-specific locations that bound the locations provided in the NRC guidance document NUREG/CR-6260.

For the reactor vessel shell and lower head, the applicant stated that it selected the core support guide welds as the limiting component based on guidance provided in Section 5.5.1 of NUREG/CR-6260. The applicant further stated that the controlling fatigue location is the outer corner of the weld that connects the core support guide to the reactor vessel inner wall. For the reactor vessel inlet and outlet nozzles, the applicant selected the reactor vessel inlet and outlet nozzles as the limiting components based on the guidance provided in Section 5.5.2 of NUREG/CR-6260. The applicant further stated that the controlling fatigue location is the outside surface of the nozzle-to-shell juncture. For the pressurizer surge line, the applicant stated that it evaluated fatigue in WCAP-12913, “Structural Evaluation of Salem Nuclear Plant Units 1 and 2 Pressurizer Surge Lines, Considering the Effects of Thermal Stratification,” Revision 1. The applicant further stated that additional fatigue analysis was conducted for the pressurizer lower head and surge nozzles in WCAP 16194, “Evaluation of Pressurizer Insurge/Outsurge Transients for Salem Units 1 and 2,” Revision 0. The applicant stated that it used both these fatigue calculations and the information provided in NUREG/CR-6260 Section 5.5.3 to select the surge line hot leg nozzles as a limiting component for the pressurizer surge line. For the RCS piping charging system nozzles, the applicant stated that both the normal and alternating charging nozzles were chosen based on the guidance provided in NUREG/CR-6260 Section 5.5.4. The applicant further stated that it developed a detailed model of the nozzles and applied a stress analysis for the nozzles and connections to determine the exact limiting locations. The staff noted that this limiting location is the weld that connects the nozzle to the charging line piping. For the RCS piping safety injection nozzles, the applicant stated that it reviewed the safety injection system nozzles connected to the RCS cold leg based on the guidance provided in NUREG/CR-6260 Section 5.5.5. Based on this review, the applicant stated that the 1.5-inch boron injection tank nozzles were selected to represent this location. The applicant further stated that it developed a detailed model of the 1.5-inch boron injection tank nozzles and applied a stress analysis, which determined the fatigue controlling location was the boron injection tank piping region at the socket weld that connects the nozzle to the safety injection line piping. The applicant stated that for the residual heat removal system Class 1 piping, it used guidance in NUREG/CR-6260 Section 5.5.6 to review the residual heat removal system Class 1 piping, specifically the letdown path and return path to the RCS primary loop. Based on this review, the applicant stated it determined the 10-inch accumulator/residual heat removal injection cold leg nozzles to be the limiting fatigue location. The applicant further stated that it developed a detailed model and applied stress analyses for the 10-inch accumulator/residual heat removal injection cold leg nozzles and their connections to determine that the controlling fatigue location is the weld that connects the accumulator nozzle to the residual heat removal line piping.

The applicant responded to the question on the assumption used for the 60-year EAF calculations by first generating the 60-year CUF for the six sample locations listed in LRA Tables 4.3.7-1 and 4.3.7-2 and then applying the environmental fatigue life correction factor, F_{en}. The first assumption the applicant made was that the 40-year NSSS transient design cycles and auxiliary transient design cycles, or their respective 60-year projected number of cycles, would bound the actual number of cycles experienced during the period of extended operation. The applicant stated that it will validate the basis for this assumption by implementing the Metal Fatigue of Reactor Coolant Pressure Boundary Program to monitor transients and use the WESTEMS™ code to compute the cumulative fatigue at select NUREG/CR-6260 sample locations to ensure that the 60-year CUF values remain less than the design limit.

In the applicant’s response to the request for the assumptions used in the F_{en} calculations, the applicant stated it used the NUREG/CR-6583 and NUREG/CR-5704 methodologies to evaluate the environmental effects on carbon, low-alloy, and stainless steels. For low-alloy steel components, the applicant stated that it set both the temperature and oxygen content parameter to zero, which will maximize the F_{en} value at 2.532 for low-alloy steel components. For stainless steel components, it assumed that the oxygen content was less than 0.05 parts per million (ppm), which is based on normal operations of less than 5 ppb. The applicant further stated that it reviewed the dissolved oxygen data, which indicated that the dissolved oxygen content was less than 0.05 ppm since 2000, except for short periods of time during start-up and shutdown conditions. To determine the strain rate, the applicant stated it used an integrated method known as the modified rate approach. The applicant also stated that transient total stress time histories were used to determine the corresponding strain rates of the tensile producing portion of the stress cycle for the different fatigue pairs for all of the applicable analyzed transients.

The staff notes that the applicant's response did not specify the dissolved oxygen data prior to 2000 and that it is not clear whether the applicant's primary water chemistry specifications maintained dissolved oxygen less than 0.05 ppm since initial plant start-up. The staff notes that if there were extended periods of time, prior to 2000, in which the applicant operated with dissolved oxygen greater than 0.05 ppm, the assumptions used in the determination of the F_{en} value for carbon and low-alloy steels may not be valid. This is important to the carbon and low-alloy steel components because a dissolved oxygen content greater than 0.05 ppm can increase the F_{en} value. The staff notes that the assumption of less than 0.05 ppm dissolved oxygen is conservative when determining the F_{en} value for stainless steel because it increases the F_{en} value. The staff identified this as Open Item OI 4.3.4.2-1.

Regarding the question whether the critical fatigue locations include nickel alloys, the applicant stated that none of the six critical fatigue locations include nickel alloy materials and that low-alloy steel is used to construct the components for the critical fatigue locations associated with the reactor vessel shell and lower head and reactor vessel inlet and outlet nozzles. The applicant also stated that stainless steel is used in the construction of the critical fatigue locations associated with the: (1) pressurizer surge line nozzle, (2) RCS piping charging system nozzles, (3) RCS piping system safety injection nozzles, and (4) residual heat removal system Class 1 piping.

In response to the question requesting if there are other plant-specific locations that may be more limiting than those identified in NUREG/CR-6260, the applicant stated the selection of the locations are compliant with NUREG/CR-6260 and the determination of the limiting locations was presented in response to the first request of this RAI. The applicant stated that because the locations are compliant with NUREG/CR-6260 and the limiting locations were identified and evaluated, no other plant-specific locations were required to be identified and evaluated for EAF. The staff notes that SRP-LR Section 4.3.2.2 states that the critical components should include, as a minimum, those selected in NUREG/CR-6260. Furthermore, the staff notes that there may be more limiting plant-specific locations (e.g., locations with a higher CUF value). It is not clear to the staff whether these locations were also considered or are the locations selected by the applicant for EAF evaluations, the limiting plant-specific locations (e.g., locations with a higher CUF value) for the plant. The staff was concerned whether the applicant verified that the locations per NUREG/CR-6260 are bounding as compared to other plant-specific locations (e.g., locations with a higher CUF value). This was also identified as part of Open Item OI 4.3.4.2-1.

By letter dated November 22, 2010, the staff issued RAI 4.3-08 to address both portions of Open Item OI 4.3.4.2-1. RAI 4.3-08, Part 1 requested the applicant to confirm and justify that the locations selected for EAF analyses, consistent with NUREG/CR-6260, are the most limiting and bounding for the plant. Furthermore, if these locations are not the most limiting and bounding for the plant, clarify the locations that require an EAF analysis and the actions that will be taken for these additional locations. If the most limiting location consists of nickel alloy, the NUREG/CR-6909 methodology for nickel alloy will be used. The staff also requested in RAI 4.3-08, Part 2 that the applicant justify the statement, "Fen is maximized when these two terms are set equal to zero" made in response to RAI 4.3-05. Finally, the staff requested in

Part 3 that the applicant clarify whether dissolved oxygen content has always been maintained less than 0.05 ppm since initial plant start-up, and provide justification to support this clarification. If not, justify why the Fen values provided in LRA Tables 4.3.7-1 and 4.3.7-2 do not account for these periods of time in which dissolved oxygen content was not maintained less than 0.05 ppm, including the "short periods of time during start-up and shutdown conditions."

In its response to Part 1, dated December 21, 2010, the applicant committed (Commitment No. 52) to the following:

> [It] will perform a review of design basis ASME Code Class 1 fatigue evaluations to determine whether the NUREG/CR-6260 based locations that have been evaluated for the effects of the reactor coolant environment on fatigue usage are the limiting locations for the Salem plant configuration. If more limiting locations are identified, the most limiting location will be evaluated for the effects of the reactor coolant environment on fatigue usage. If any of the limiting locations consist of nickel alloy, NUREG/CR-6909 methodology for nickel alloy will be used in the evaluation.

Based on its review, the staff finds the applicant's responses to RAI 4.3-05; RAI 4.3-08, Part 1; and Commitment No. 52 acceptable because: (1) the applicant will review its design basis ASME Code Class 1 fatigue evaluations to determine whether the NUREG/CR-6260 based locations are the limiting locations for its plant-specific configuration; (2) if more limiting locations are identified, the applicant will perform EAF analyses for the most limiting location; (3) if any of the limiting locations consist of nickel alloy, the NUREG/CR-6909 methodology for nickel alloy will be used in the evaluation; (4) NUREG/CR-6909 will be used for determining a conservative F_{en} factor for any new nickel-alloy components that require EAF analysis; and (5) Commitment No. 52 is consistent with the recommendations in SRP-LR Sections 4.3.2.2 and 4.3.3.2, and GALL AMP X.M1, to consider environmental effects for the NUREG/CR-6260 locations, at a minimum. The staff's concerns described in RAI 4.3-05 and RAI 4.3-08, Part 1 are resolved, and this portion of Open Item OI 4.3.4.2-1 is closed.

In its response to Part 2, dated December 21, 2010, the applicant clarified that the two terms in the statement, "F_{en} is maximized when these two terms are set equal to zero" referred to the correction temperature, T, and the transformed oxygen content parameter, O*. The staff noted that during the applicant's review, it identified a typographical error in its response to RAI 4.3-05 (Part 3), dated July 13, 2010, and amended the term "0.001124T" to "0.00124T." The staff reviewed Equation 6.5b of NUREG/CR-6583 and confirmed that the use of the term "0.00124T" is correct. The applicant stated that it agrees that the above statement is not accurate for all situations, particularly when a negative transformed total strain rate, ε*, is used and the resultant F_{en} value would exceed 2.532.

The applicant stated that it applied a zero term for transformed dissolved oxygen content, O*, making the third term (0.101S*T*O* ε*) of Equation 6.5b from NUREG/CR-6583 equal to zero for its plant-specific environmental fatigue analyses, since the dissolved oxygen content was assumed to be less than 0.05 ppm. The staff noted that the applicant's response to RAI 4.3-08, Part 3 further explains this assumption. The staff's review of RAI 4.3-08, Part 3 is documented below, in SER Section 4.3.7.2. Furthermore, a conservative value of zero was used for the second term (0.00124T) in Equation 6.5b. The applicant stated that the statement, "F_{en} is maximized when these two terms are set equal to zero" is not accurate for analyses other than its plant-specific environmental fatigue analyses. The staff finds that setting the second term (0.00124T) in Equation 6.5b to zero is acceptable because it yields a larger F_{en} factor, which is more conservative. The staff noted that the response to RAI 4.3-05 (Part 3), dated July 13, 2010, was amended to remove the statement, "F_{en} is maximized when these two terms are set equal to zero" and finds this acceptable because the statement is not accurate for all situations of transformed dissolved oxygen content, transformed total strain rate, transformed temperature, and transformed sulfur content.

In its response to Part 3, dated December 21, 2010, the applicant clarified that during Modes 1 (Power Operations) and 2 (Startup), where the RCS is greater than or equal to 177 °C (350 °F) and reactivity condition (K_{eff}) is greater than 0.99, the dissolved oxygen concentrations are always less than 0.05 ppm (50 ppb), specifically, less than 0.005 ppm (5 ppb) as determined from the RCS quarterly chemistry data since 2000. The applicant stated that the reason for the extremely low dissolved oxygen levels is due to the RCS environment containing a hydrogen concentration of a minimum of 25 cc/kg (cubic centimeters per kilogram), as specified for Westinghouse PWRs to keep the oxygen level in the RCS below the limit of detection (5 ppb). The applicant stated that it had this specification limit of RCS hydrogen imposed since original start-up of the units. The staff finds it reasonable, during Modes 1 and 2, since the applicant has operated with a minimum of 25 cc/kg of RCS hydrogen, that dissolved oxygen was always less than 0.05 ppm (50 ppb), specifically, less than 0.005 ppm (5 ppb) since original start-up of the units.

The staff reviewed Equation 6.5b for low-alloy steels from NUREG/CR-6583 and noted that the transformed temperature, T*, is set to zero when the RCS temperature is less than 150 °C (302 °F), which negates the contribution from dissolved oxygen in this equation. The applicant stated that any dissolved oxygen values exceeding 0.05 ppm (50 ppb) during Mode 5 (Cold Shutdown – RCS temperature less than 93 °C (200 °F)) and Mode 6 (Refueling – RCS temperature less than 60 °C (140 °F)) do not contribute to EAF due to the low RCS temperatures. The staff finds that the transformed oxygen content parameter, O*, in Equation 6.5b can be ignored in Modes 5 and 6 because the RCS temperature during these modes does not exceed the threshold of 150 °C (302 °F) described in NUREG/CR-6583, therefore, setting the term "0.101S*T*O* ε*" equal to zero.

The applicant stated that there are possible short periods of time where the RCS dissolved oxygen levels can exceed 0.05 ppm, while the RCS temperatures exceed 150 °C (302 °F) for carbon and low-alloy steel. These short periods of time are during Mode 3 (Hot Standby – RCS temperature greater than 177 °C (350 °F) and K_{eff} is less than 0.99) and Mode 4 (Hot Shutdown – RCS temperature greater than 93 °C (200 °F) but less than 177 °C (350 °F) and K_{eff} is less than 0.99). The applicant stated that during the time when the RCS is heating from 150 °C (302 °F) (Mode 4) to 177 °C (350 °F) (Mode 3), or cooling from 177 °C (350 °F) (Mode 3) to 150 °C (302 °F) (Mode 4), the RCS dissolved oxygen levels could exceed 0.05 ppm (50 ppb), but are less than or equal to 0.10 ppm (100 ppb). Furthermore, the oxygen control is attained through hydrazine addition to the primary system. The applicant stated that the short periods of time are less than 24 hours per plant heatup and are less than 8 hours per plant cooldown.

The staff noted that the projected number of heatups and cooldowns for Unit 1 are 133 and 133, respectively, and 157 and 155 for Unit 2, respectively. The applicant stated that for additional conservatism, the 40-year NSSS design specification of 200 heatups and 200 cooldowns is multiplied by a time period of 24 hours for the heatup event and 8 hours for the cooldown event, which resulted in 6,400 hours. Furthermore, the projected effective full power hours for each unit is obtained by multiplying the effective full power years of 50 by 8,760 hours in a year, or 438,000 hours. The applicant determined that the percentage of time that the RCS temperature will be heating from 150 °C (302 °F) to 177 °C (350 °F), and cooling from 177 °C (350 °F) to

150 °C (302 °F) is less than 1.5 percent of the total operating time. The applicant determined an adjusted F_{en} value, which considers the dissolved oxygen level effect during Mode 3 and Mode 4, and noted that it results in a 0.4 percent increase in the CUF_{EAF} for the Units 1 and 2 reactor vessel inlet nozzles which are fabricated from low-alloy steel.

The staff finds that the short periods of time when the dissolved oxygen levels can exceed 0.05 ppm does not have a significant impact to the overall F_{en} value because the duration of time that both units operate with dissolved oxygen levels in excess of 0.05 ppm will conservatively be 1.5 percent of the total operating time after 60 years of operation and the resultant increase in F_{en} value is approximately 0.4 percent, which is negligible. The staff noted that this is applicable for both carbon and low-alloy steel components.

The applicant stated that it has not changed the chemistry control with regards to oxygen control in the RCS when the temperature is greater than 150 °C (302 °F) since original plant start-up, therefore, the values observed in the past 10 years (2000 to 2010) are representative of past operations. Furthermore, it will continue to and is committed to maintain its primary water chemistry, including the previously discussed limitations on dissolved oxygen, through the Water Chemistry Program, which incorporates Electric Power Research Institute (EPRI) guidelines.

Based on its review, the staff finds the applicant's response to RAI 4.3-8, Parts 2 and 3 acceptable because: (1) the applicant confirmed that it has always maintained dissolved oxygen levels less than 0.05 ppm since initial plant start-up during Modes 1 and 2; (2) the impact of dissolved oxygen levels greater than 0.05 ppm but less than or equal to 0.10 ppm, during Modes 3 and 4, on the F_{en} value are negligible, as described above; (3) the impact of dissolved oxygen levels greater than 0.05 ppm during Modes 5 and 6, when the temperature is less than 150 °C (302 °F), do not need to be considered, as described above; (4) the applicant will continue to maintain its primary water chemistry during the period of extended operation; and (5) the applicant justified that a F_{en} value of 2.532 for low-alloy steel components is conservative, based on its plant-specific operating conditions. The staff's concerns described in RAI 4.3-05 and RAI 4.3-08, Parts 2 and 3 are resolved, and this part of Open Item OI 4.3.4.2-1 is closed.

The staff also noted that, in LRA Section 4.3.7, the applicant stated that the fatigue analyses for the NUREG/CR-6260 sample locations have been projected to the end of the period of extended operation, in accordance with 10 CFR 54.21(c)(1)(ii). The staff noted, however, that LRA Section B.3.1.1 indicated that the Metal Fatigue of Reactor Coolant Pressure Boundary Program will be enhanced to address the effects of the reactor coolant environment on component fatigue life by assessing the impact of the reactor coolant environment on a sample of critical components for the plant, as identified in NUREG/CR-6260. Therefore, it was not evident to the staff whether the applicant had chosen to use its Metal Fatigue of Reactor Coolant Pressure Boundary Program as the basis for accepting the EAF analysis TLAA, in accordance with the TLAA acceptance criterion in 10 CFR 54.21(c)(1)(iii), and for managing the effects of environmental fatigue on the intended functions of the applicant's NUREG/CR-6260 sample locations during the period of extended operation. Therefore, in a letter dated June 14, 2010, the staff issued RAI 4.3-06 requesting that the applicant clarify: (1) how the Metal Fatigue of Reactor Coolant Pressure Boundary Program would be used to monitor the effects of the reactor coolant environment on the metal fatigue analyses for the plant's critical NUREG/CR-6260 locations, and (2) whether the AMP would be used to disposition the EAF analyses for these components in accordance with the TLAA acceptance criterion in 10 CFR 54.21(c)(1)(iii).

In its response dated July 13, 2010, the applicant stated that the Metal Fatigue of Reactor Coolant Pressure Boundary Program addresses the effects of the reactor coolant environment on component fatigue life on fatigue limiting locations. The applicant further stated that it would revise site procedures to include the effects of the reactor coolant environment for each of the six locations discussed in LRA Section 4.3.7 in a periodic fatigue monitoring report. In addition, the applicant modified the LRA to indicate that the aging of these fatigue limiting locations will be managed by 10 CFR 54.21(c)(1)(iii) using the Metal Fatigue of Reactor Coolant Pressure Boundary Program.

Based on its review, the staff finds the applicant's response to RAI 4.3-06 acceptable because the Metal Fatigue of Reactor Coolant Pressure Boundary Program monitors the transients to ensure that the CUF considering environmental effects remains below the design basis of 1.0. The staff finds this an appropriate approach because the applicant has modified its LRA to indicate that the aging of these fatigue limited locations is managed in accordance with 10 CFR 54.21(c)(1)(iii). The staff's concern described in RAI 4.3-06 is resolved.

4.3.7.3 UFSAR Supplement

The applicant provided a UFSAR supplement summary description of its TLAA evaluation of EAF analyses in LRA Section A.4.3.7. On the basis of its review of the UFSAR supplement, consistent with SRP-LR Section 4.3.3.3, the staff concludes, with the closure of Open Item OI 4.3.4.2-1, that the summary description of the applicant's actions to address EAF analyses is adequate.

4.3.7.4 Conclusion

On the basis of its review, consistent with SRP-LR Section 4.3.3.2, the staff concludes that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(iii), that the effects of reactor coolant environment on component fatigue life will be adequately managed for the period of extended operation. The staff also concludes that the UFSAR supplement contains an appropriate summary description of the TLAA evaluation, as required by 10 CFR 54.21(d), and, therefore, is acceptable.