From: Peter Wen
To: Internet:jzabel@atlintl.com; Internet:Mporr@atlintl.com
Date: 08/03/2006 3:37:12 PM
Subject: TLAA Section 4.3 Input

Mark/Joe,

Attached is TLAA input for Section 4.3 (Jim Medoff). You should have all TLAA input by now. The last page is "TLAA Reference", and it should go to Attachment 5 of the Audit and Review Report.

Thank you.

Peter

CC: James Davis; James Medoff

Mail Envelope Properties (44D25061.7C0 : 20 : 35164)

Subject:	TLAA Section 4.3 Input
Creation Date	08/03/2006 3:37:05 PM
From:	Peter Wen

Created By: PXW@nrc.gov

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MESSAGE	659	08/03/2006 3:37:05 PM
TLAA 4.3_Jim M.wpd	86454	08/03/2006 3:08:26 PM

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Expiration Date:	None
Priority:	Standard
ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

Junk Mail Handling Evaluation Results
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Message is from an internal sender

Junk Mail settings when this message was delivered

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Block List is not enabled

4.3 Metal Fatigue

A metal component subjected to cyclic loading at loads less than the static design load may fail due to fatigue. Metal fatigue of components may have been evaluated based on an assumed number of transients or cycles for the current operating term. The validity of such metal fatigue analysis is reviewed for the period of extended operation. The GALL Report identifies fatigue aging-related effects that require evaluation as possible time-limited aging analyses (TLAAs), pursuant to 10 CFR 54.21(c). The applicant provides its TLAA on Metal Fatigue in Section 4.3 of the LRA.

4.3.1 Fatigue Analyses for Class 1 Components

4.3.1.1 Summary of Technical Information in the Application

LRA Section 4.3.1 provides the applicant's TLAA assessment for metal fatigue of Class 1 components in the reactor coolant pressure boundary (RCPB). The applicant identifies that metal fatigue analyses for PNPS RCPB components (i.e., Class 1 components) conform to the definition for a TLAA in 10 CFR 54.3. The applicant identifies that the Class 1 components include the reactor pressure vessel (RPV) and its appurtenances, the components internal to the RPV (RPV internals), and Class 1 piping. Henceforth, this TLAA will be referred to as the TLAA on Class 1 Metal Fatigue.

The applicant identifies that the original 40-year metal fatigue evaluations for the reactor coolant pressure boundary (RCPB) components that were designed to are based on the methods for calculating cumulative usage factor methods (CUFs) in Section III of the ASME Boiler and Pressure Vessel Code (Section III) if the components were designed in accordance with Section III. The applicant stated that these CUFs are calculated in accordance with the "Procedure for Analysis for Cyclical Loading" in Article NB-3000 of Section III.

The applicant provides the 40-year CUFs for the RPV and its appurtenances, the RPV internals, and the Class 1 piping commodity groups in Table 4.3-1 of the LRA. The applicant provides the design basis operational and transient categories that form the basis of the applicant's 40-year CUF value calculations in LRA Table 4.3-2. LRA Table 4.3-2 includes the design basis upper limits for these transient categories and the applicant's projections of the number of cycles that will occur for these transient through the expiration of the PEO.

LRA Commitment #31

In a letter dated **Month Date,** 2006 **(MLXXXXXXX)**, the applicant has included **Commitment #31** on the PNPS LRA. In this commitment, the applicant committed either to: (1) perform updated 60-year CUF calculations for the Class 1 locations addressed in NUREG/CR-6260, including F_{en} adjustments to account for the impacts of the reactor water enviroment on the CUF values for these locations, (2) manage the aging effect of fatigue-induced cracking (i.e., "cracking -fatigue" in the appropriate AMR line items) using an NRC-approved inspection program, or (3) repair or replacement the affected components prior to entering the PEO and prior to exceeding a CUF of 1.0 for the affected RPV location. The scope of these NUREG/CR-6260 locations includes, but is not limited to, the locations in recirculation piping system (RRS) Loops A and B. The details for **Commitment #31** are provided in Appendix A of the Final Safety Evaluation Report for the PNPS LRA.

LRA Commitment #35

In a letter dated **Month Date,** 2006 **(MLXXXXXXX),** the applicant has included **Commitment #35** on the PNPS LRA. In this commitment, the applicant committed to either: (1) perform updated 60-year CUF calculations for the RPV components, (2) manage the aging effect of fatigue-induced cracking (identified as cracking-fatigue" in the appropriate AMR line items) using an NRC-approved inspection program, or (3) repair or replacement the affected components prior to entering the PEO and prior to exceeding a CUF of 1.0 for the affected RPV location. The details for **Commitment #35** are provided in Appendix A of the Final Safety Evaluation Report for the PNPS LRA.

Impact of Environmental Conditions on CUF Calculations

The applicant indicated that its evaluation of environmental factors on the CUF values for the Class 1 components is provided in LRA Section 4.3.3. The applicant provided the environmentally-impacted CUF values for Class 1 components in LRA Table 4.3-3. The project team evaluated the licensee's TLAA evaluations on environmentally-impacted fatigue analyses in Section 4.3.3 of this Audit Report.

4.3.1.2 Evaluation

Regulatory Bases for Metal Fatigue Evaluations

10 CFR 54.21(c)(1) provides the three options (criteria) for accepting analyses that are identified as TLAAs:

(i) The analysis remains valid for the period of extended operation (PEO).

(ii) The analysis has been projected to the end of the PEO and remains acceptable.

(iii) The effects of aging on the intended function(s) will be managed during the PEO.

The GALL Report identifies fatigue aging-related effects that require evaluation as possible time-limited aging analyses (TLAAs), pursuant to 10 CFR 54.21(c). The staff provides its bases for evaluating TLAAs on Metal Fatigue in Section 4.3 of NUREG-1800, Revision 1, "Standard Review Plant for License Renewal Application for Nuclear Power Plants" (SRP-LR).

Section III requires cumulative usage factor calculations (CUFs) as the basis for performing the metal fatigue analyses for those Class 1 components that were designed to Section III. Section III sets an acceptance criterion of 1.0 on CUF values and requires additional corrective action if these calculated values are projected to exceed this value prior to the expiration of the operating license. Section 4.3 of SRP-LR defines how the metal fatigue analyses for Section III components may be accepted in accordance with 10 CFR 54.21(c)(1)(i), (ii), or (iii).

The ANSI B31.1 design code (B31.1) requires a different type of fatigue analysis for those Class 1 components that were designed to B31.1 requirements. B31.1 requires calculation of a maximum allowable stress range for each B31.1 component that is subject to thermal cycling and a determination of the number of full thermal cycles that are projected to the expiration of the operating license. B31.1 then establishes what reduction factors must be applied to the maximum allowable stress ranges if the number of thermal cycles are projected to exceed

7000. Section 4.3 of SRP-LR defines how the metal fatigue analyses for B31.1 components may be accepted in accordance with 10 CFR 54.21(c)(1)(i), (ii), or (iii).

Scope of Review and Assessment

The project team reviewed the following parts of the PNPS LRA relative to the applicant's TLAA on Class 1 Metal Fatigue: (1) LRA Section 4.3.1, (2) LRA Table 4.3-1, (3) LRA Table 4.3-2, (4) Commitment #31, and (5) Commitment #35. The project team also reviewed those aging management review (AMR) line items in the LRA Tables 3.1.2-1, 3.1.2-2, and 3.1.2-3 in which "cracking -fatigue" (i.e., fatigue-induced cracking) was identified as an aging effect requiring management (AERM) and in which the TLAA on Class 1 Metal Fatigue was credited for management of the aging effect (henceforth referred to as the "Class 1 Fatigue AMRs").

The scope of the 40-year CUF values in LRA Table 4.3-1 for Class 1 components include those for the RPV, RPV nozzle appurtenances, RPV closure flange components, core shroud tie rods, and RRS piping Loops A and B. The project team also performed a review of PNPS License Renewal Document LRPD-06, PNPS 40-year design basis CUF calculations, and a General Electric Thermal Power Optimization Report for PNPS in order to assess whether the documents provided an acceptable basis for the 40-year CUF values that were listed for the Class 1 components in LRA Table 4.3-1.

The project team also reviewed the transients listed in LRA Table 4.3-2 to assess whether the total number of cycles projected at the expiration of the PEO (i.e., after 60 years of licensed operations has elapsed) will exceed the maximum number of cycles that are allowed for the transients in the PNPS design basis. The project team performed this review to determine whether the applicant should have included updated 60-year CUF calculations for those Class 1 components that were evaluated in accordance with 40-year CUF calculations, and if not, whether cycle counting alone, performed in accordance with the applicant's Fatigue Monitoring Program, would be sufficient to manage fatigue-induced cracking without implementation of the CUF updates recommended in GALL AMP X.M1, "Metal Fatigue of Reactor Coolant Pressure Boundary." The project team also compared the commodity groups in the Class 1 Fatigue AMRs to those commodity groups that were analyzed for metal fatigue in LRA Section 4.3.1 and in LRA Table 4.3-1.

The project team determined that LRA Table 4.3-2 and PNPS Document LRPD-06 both projected that the total number of cycles for over half of the operational transients analyzed in LRA Table 4.3-2 were projected to exceed the maximum number of cycles for these transients that are allowed by the current PNPS design basis. The project team also determined that the scope of the applicant's TLAA on Metal Fatigue of Class 1 Components did not appear to cover all of the commodity groups in the Class 1 Fatigue AMRs for which the TLAA had been credited for aging management of fatigue-induced cracking. The project team asked the applicant to respond to a series of questions in the following topical areas:

1. Requests for clarification on how the 40-year CUF values for those Class 1 components assessed in LRA Table 4.3-1 would remain valid for the PEO, particularly when the number of cycles for over half of the design basis transients were projected to exceed their design basis allowable limits at 60 years and when cycle counting alone was being relied on as the basis for accepting the TLAA in accordance with 10 CFR 54.21(c)(1)(i).

2. Requests for clarification on why the 40-year CUF values for the Class 1 components

listed in LRA Table 4.3-1 did not appear to reflect more recent 40-year CUF values provided in the GE Thermal Power Optimatization Report for PNPS and why the some components in LRA Table 4.3-1 were exempted from Section III mandated CUF calculations.

3. A request for submittal of a metal fatigue analysis discussion for those Class 1 piping components that were designed to the B31.1 requirements in manner that the applicant had provided for Non-Class 1 B31.1 components in LRA Section 4.3.2.

4. Requests for reconciliation of the commodity groups in the Class 1 Fatigue AMRs to those commodity groups that were analyzed in the TLAA on Metal Fatigue of Class 1 components.

5. A request for identification of all PNPS fracture mechanics or flaw evaluations that comply with the definition of a TLAA in 10 CFR 54.3.

The details of the project teams questions are provided in the Q&A Database, which was submitted onto Docket 50-293 in a letter dated **Month Date**, 2006 (**MLXXXXXXXXXX**). The applicant responded to the project team's questions of the Class 1 Fatigue AMRs in a letter dated **Month, Date,** 2006.

Fatigue Analyses for Reactor Pressure Vessel (RPV) and its Appurtenances

The applicant clarified that all of the RPV components were designed to Section III and stated that those RPV components which did not receive CUF calculations are bounded by the 40-year CUF calculations for the commodity groups in LRA Table 4.3-1. The applicant also stated that the following RPV components were exempted from receiving CUF calculations in accordance with Paragraph N–415.1, "Vessels Not Requiring Analysis for Cyclic Operation," of the 1965 Edition of Section III: (1) RPV main steam nozzles, (2) RPV vent nozzles, and (3) RPV instrumentation nozzles. The applicant clarified that Paragraph N–415.1 exempts these components from CUF calculations because the stress ranges for the cyclical operating transients on these components are mild and are below the endurance limit for the materials of construction in the components. The applicant clarified that the CUFs for the remaining components in LRA Table 4.3-1 are therefore bounding for the RPV main steam, vent, and instrumentation nozzles. The staff concludes that this is acceptable because the applicant has exempted these nozzles from a CUF calculation in accordance with the exemption criteria of an applicable Section III paragraph. **However, Question 503 with respect to this issue remains open because the staff is still awaiting the amendment of the LRA containing the revised 40-year CUF value for the recirculation outlet nozzle.**

The applicant also clarified that the stress ranges for the cyclical transients for recirculation outlet nozzle were above the stress threshold for exempting this component from a CUF calculation and therefore did not provide an acceptable basis for exempting the component in accordance with Section III paragraph N–415.1. The applicant therefore stated that the 40-year CUF value for the recirculation outlet nozzle should have been included in LRA Table 4.3-1 and stated that the LRA would be amended to correct this ommission.

In LRA section 4.3.1.4, Feedwater Nozzle Fatigue, the applicant stated that the CUF for feedwater nozzle considering both the currently analyzed system design transients and rapid cycling through the PEO was extrapolated at <0.899. However, based on the project team

calculation, this number seemed incorrect. The project team asked the applicant to explain how this number was calculated. In a letter dated July 19, 2006 (MLxxxxxxxxx), the applicant stated that the extrapolation in LRA Section 4.3.1.4 is no longer valid such that this section is not required and can be deleted. The applicant stated that PNPS will perform a new 60-year feedwater nozzle fatigue analysis prior to the period of extended operation as per **Commitment #35** on the PNPS LRA. **Commitment #35** will require the applicant committed to either: (1) perform updated 60-year CUF calculations for the RVP components (including the RPV appurtenances and nozzles), (2) manage the aging effect of fatigue-induced cracking (i.e., "cracking -fatigue" in the Class 1 Fatigue AMRs) using an inspection-based program that has been approved by the NRC, or (3) repair or replace the effected RPV location prior to entering the PEO and to exceeding a CUF value of 1.0. The activities within the scope of **Commitment #35** will ensure that either the 60-year CUF values for the RPV components, including the CUF value for the PNPS feedwater nozzle, will be acceptable (i.e., less than a value of 1.0) during the PEO or that the components will be inspected for evidence of cracking, repaired, or replaced prior to entering the PEO. These activities will ensure that fatigue-induced cracking will be managed by evaluation, inspection, or corrective action for the PEO and will ensure that the TLAA on Metal Fatigue of the RPV components (including the will be acceptable either in accordance with 10 CFR 54.21(c)(1)(ii) or (iii). Based on this evaluation, the staff concludes that the applicant's TLAA on Metal Fatigue of the RPV components, when taken in conjunction with **Commitment #35** is acceptable.

Fatigue Analyses for RPV Internal Components

The project team also determined that the applicant had indicated that the RPV internal components were designed to the intent of Section III and had determined that the core shroud tie rods (i.e., core shroud stabilizer repair assemblies) were the only RPV internals that received 40-year CUF calculations. The project team asked the applicant to clarify the meaning of the phrase "designed to the intent of ASME Section III," as made in reference to the design of the RPV internals. The applicant responded to this question by letter dated July 5, 2006 **(MLXXXXXXXX)**. The applicant clarified that, although the RPV internals were not specifically designed as ASME Section III components, the applicant did apply the Section III techniques for selecting the materials of construction, establishing the design wall thicknesses, and constructing the components. The applicant clarified though that it did not perform the Section III analyses and testing that would otherwise have been mandated if the RPV internals were Section III components.

The applicant stated that it will amend the information in LRA Section 4.3.1.2 to delete the sentence "Although not mandatory, the design of the reactor vessel internals is in accordance with the intent of ASME Section III" from the LRA section. The project team concluded it would acceptable to remove the referred-to sentence from LRA Section 4.3.1.2 because the RPV internals are not Section III components. In a letter dated July 19, 2006 (**MLXXXXXXXX**), the applicant provided the amendment for LRA section 4.3.1.2. Therefore, this issue is closed. The activities within the scope of **Commitment #35** (as discussed in the previous paragraph) will ensure that fatigue-induced cracking will be managed by evaluation, inspection, or corrective action for the PEO and will ensure that the TLAA on Metal Fatigue of the core shroud tie rods will be acceptable either in accordance with 10 CFR 54.21(c)(1)(ii) or (iii). Based on this evaluation, the staff concludes that the applicant's TLAA on Metal Fatigue of the RPV components, when taken in conjunction with **Commitment #35** is acceptable.

In a letter dated July 19, 2006 (**MLXXXXXXXX**), the applicant proposed to use the BWR Vessel

Internals program to manage fatigue-induced cracking for those RPV internals that were not designed to Section III. These RPV internals include the following commodity groups: (1) control rod guide tubes, (2) core plate assemblies, (3) core spray lines, (4) fuel supports, (5) incore instrumentation and guide tubes, (6) jet pump assemblies, (7) core shroud, shroud support, and shroud repair assemblies, and (8) top guide assembly. The applicant's BWR Vessel Internals Program is a valid augmented inspection program to credit with the management of cracking because it incorporates both NRC-mandated inspections of the RPV internals that are required in accordance with 10 CFR 50.55a and Section XI of the ASME Code, as well as augmented inspection and evaluation activities that are performed in accordance with NRC-approved, recommended guidelines from the Boiling Water Reactor Vessel and Internals Project (BWRVIP). The staff confirmed that these components are within the scope of the applicable BWRVIP reports that form the basis for the applicant's BWR Vessel Internals Program. Based on this analysis, the project team concludes that it is acceptable to credit the BWR Vessel Internals Program with aging management of fatigue-induced cracking in these RPV internal commodity groups. The applicant provides its BWR Vessel Internals Program in LRA Section B.1.8. The project team assesses the ability of the BWR Vessel Internals Program to manage cracking for these RPV internal commodity groups in Section **3.X.X** of this Audit Report. The response to the project team's question on reconciliation of the Class 1 Fatigue AMRs with those RPV internals analyzed for metal fatigue in LRA Section 4.3.1 will require that the applicant update some Non-Class 1 Fatigue AMRs. **Therefore the response to Joint Question 503, 504, and 505 remains open, pending confirmation and acceptance of the changes proposed for the PNPS LRA on Class 1 Fatigue AMRs.**

Fatigue Analyses for Class 1 Piping Components

The project team determined that the replacement piping for RRS Loops A and B was the only Class 1 piping that was designed to ASME Section III requirements and had received 40-year CUF calculations for the current operating period. In **Commitment #31**, the applicant committed to performing updated 60-year CUF values for RRS Loops A and B at least two years prior to entering the PEO. **Commitment #31** will require the applicant to take corrective action, as defined in the commitment, if any of the CUF values for the RRS piping are greater than 1.0. These activities will ensure that either the 60-year CUF values for the RRS piping components will be acceptable (i.e., less than a value of 1.0) during the PEO or that the components will be inspected for cracking, repaired, or replaced prior to entering the PEO. **Commitment #31** also provides for NRC review of the activities that are within the scope of commitment. Based on this evaluation, the staff concludes that the applicant's TLAA on Metal Fatigue of the RRS piping components, when taken in conjunction with **Commitment #31** is acceptable.

In LRA section 4.3.1.3, class 1 Piping and Components, the applicant stated that design transients are tracked and evaluated to ensure that cycle limits are not exceeded, thereby assuring that CUFs do not exceed 1.0. The section concludes that CUFs will remain valid for the PEO. This conclusion does not account for environmental impact on CUFs. The project team asked the applicant to clarify how environmental fatigue is tied into the conclusion made in section 4.3.1.3.

In a letter dated July 19, 2006 (**MLXXXXXXX**), the applicant responded that LRA Section 4.3.1.3 is revised to add the following sentence at the end of Section 4.3.1.3:

> The effects of the reactor coolant environment on fatigue are addressed in

Section 4.3.3 of the LRA.

The applicant indicated that LRA Section 4.3.1, page 4.3-4 is revised as follows:

- The PNPS Fatigue Monitoring Program ensures that the numbers of transient cycles experienced by the plant remain within the allowable numbers of cycles, and hence the component CUFs remain below their analyzed values.

The applicant indicated that the second sentence of the second paragraph in LRA Section 4.3.1.3 is changed as follows:

The design transients are tracked and evaluated to ensure that cycle limits are not exceeded, thereby assuring that CUFs remain below their analyzed values.

Based on the above changes, the project team found the responses to be acceptable.

The project team evaluated the impact of the reactor water environment on the CUF values for the RRS piping loops in Section 4.3.3 of this audit report. The evaluation included an assessment on how **Commitment #31** will address the impact or the reactor coolant environment on the 60-year CUF values for the critical PNPS Class 1 components locations addressed in NUREG/CR-6260 and how the activities of the commitment, when implemented, will ensure conformance with the recommended CUF analyses in NUREG/CR-6260 or else provide an acceptable alternatives to meeting the NUREG/CR-6260 criteria.

The applicant's response to the question on metal fatigue of the Class 1 piping components also confirmed that the components in the remaining Class 1 piping subsystems were all designed to B31.1 design code, with the exception of the following commodity groups: (1) CRD detector, (2) CRD drives, (3) RRS pump casing and cover, and (4) main steam line flow restrictors. For those Class 1 piping components that were designed to B31.1, the design code's metal fatigue analysis requires of the maximum allowable stress range for the components to be reduced if the number of cycles for the full thermal transients imparted on the components is projected to be greater than 7000 cycles. The applicant clarified that the total number of full thermal cycle transients projected through 60 years of operation was less than 7000 and that, based on this projection, the allowable stress range analyses for these components remain valid for the PEO in accordance with 10 CFR 54.21(c)(1)(i) and do not need to be reduced.

The project team reviewed the thermal transients that were defined and summarized in LRA Table 4.3-2 and confirmed that the total number of full thermal transients projected at the end of the PEO for PNPS (i.e., through 60 years of licensed power operations) will be less than 7000. Based on this confirmation, the project team concludes that the applicant has provided an acceptable basis for concluding that the maximum allowable stress range analysis for the B31.1 Class 1 piping components remains valid for the PEO in accordance with 10 CFR 54.21(c)(1)(i). **However, Question 504 with respect to this issue remains open because the staff is still awaiting the amendment of the LRA containing the revised information on Metal Fatigue Analyses forClass 1 B31.1 Piping.**

For management of fatigue-induced cracking in the CRD detector, the applicant stated that the component, although within scope, does not require an aging management review because the detector is periodically calibrated and checked for operability. The applicant therefore proposed

amend the LRA by deleting the Fatigue AMR for the CRD detector from LRA Table 3.1.2-3. The project team determined that this is an acceptable basis for removing this AMR from the LRA because the CRD detector is subject to periodic calibration and surveillance requirements. **However, Question 505 with respect to this issue remains open because the staff is still awaiting the amendment of the LRA containing the revised information deleting the Class 1 Fatigue AMR for the CRD Detectors.**

The applicant also clarified that fatigue-induced cracking is not an AERM for the CRD drives because the components operate a temperature less than 250°F and that this operating temperature is less than the applicant's thermal threshold of 270°F for inducing fatigue-induced cracking in the components. Based on this assessment, the project team concludes that the applicant has provided an acceptable basis for concluding that "cracking -fatigue" is not an AERM for the CRD drives. **However, Question 505 with respect to this issue remains open because the staff is still awaiting the amendment of the LRA deleting the Class 1 Fatigue AMR for the CRD Drives.**

The applicant credited the ISI program to manage fatigue-induced cracking in the RRS pump casing and cover. The ISI examinations for reactor coolant pumps are mandated by 10 CFR 50.55a and ASME Section XI Examination Categories BL1 And BL2. The examination categories require volumetric examinations of the pump casing welds once every inspection internal and visual VT-3 examinations of the casings and covers once every inspection interval. The volumetric examinations are capable of detecting an cracks in the welds. Since the ISI examinations for the pump casing include volumetric examinations of the casing welds, the ISI is an valid AMP to credit for management of fatigue-induced cracking in the components. The *project team reviewed the ISI program and its evaluation is documented in section* 3.0.3.3.3 of this audit and review report. **However, Question 505 with respect to this issue remains open because the staff is still awaiting the amendment of the LRA revising the Class 1 Fatigue AMRs for the RRS pump casings and covers to credit the ISI program for management of fatigue-induced cracking (i.e., "cracking- fatigue).**

The applicant credited the One-time inspection program to manage fatigue-induced cracking in the main steam line flow (MS) restrictors. The applicant stated that the main steam line flow restrictors are non pressure boundary components because they are welded internally to pipes that do serve as the pressure retaining components. Instead, the applicant informed the project team that the MS restrictors are designed to limit the rate of radioactive steam release during a design basis main steam line break downstream of the MS restrictors. Based on this discussion, the project team concurs that the MS restrictors do no serve a reactor coolant pressure boundary function for PNPS and that, based on the safety function to limit the rate of radioactive release during a postulated main steam line break, a one-time inspection using enhanced VT-1 visual examination (EVT-1) techniques is an appropriate inspection to determine whether fatigue-induced cracking is occurring in the MS restrictors. The project team reviewed the One-Time Inspection Program and its evaluation is documented in section 3.0.3.1.8 of this audit and review report. **However, Question 505 with respect to this issue remains open because the staff is still awaiting the amendment of the LRA revising the Class 1 Fatigue AMRs for the MS restrictors to credit the One-Time Inspection Program for management of fatigue-induced cracking (i.e., "cracking- fatigue).**

The project team also determined that the applicant had indicated that some fracture mechanics or flaw growth analyses could constitute TLAAs for the LRA but had failed to identify *what these analyses were and to include an assessment of them against the acceptance*

criteria of 10 CFR 54.21(c)(1). The project team asked the applicant to identify all fracture mechanics and flaw growth analyses that met the definition of a TLAA in 10 CFR 54.3 and, if any did exist, to amend LRA Section 4.0 to include them as TLAAs for the LRA and evaluate them for acceptance in accordance with 10 CFR 54.21(c)(1). The project team also asked the applicant to provide enough technical information to justify whether or not these fracture analysis or flow growth analyses conformed to the definition of a TLAA in 10 CFR 54.3, and if so, to provide a basis for accepting these analyses in accordance with 10 CFR 54.21(c)(1)(i), (ii), or (iii). The project team is deferring closure of this question until the issuance of the safety evaluation report for the PNPS LRA because the response to the project team's question requires additional technical review by the NRC. The NRC's basis for determining whether or not these flaw growth analyses are TLAAs for the PNPS LRA will be issued in the Safety Evaluation Report with Open Items. Therefore, the question on whether the flaw growth evaluations are TLAAs for the PNPS LRA is closed to a RAI for this audit report.

4.3.1.3 UFSAR Supplement

The applicant provided the UFSAR Supplement summary description for the TLAA on Metal Fatigue of PNPS Class 1 components in LRA Section A.2.2.2.1. The project team determined that UFSAR Supplement summary description A.2.2.2.1 needed updating to make reference to Commitments #31 *and #35 on the PNPS LRA. Therefore, the adequacy of the USFAR* Supplement summary description A.2.2.2.1 remains accepted but not closed, pending confirmation and acceptance of the change to reference Commitments #31 and #35 in the summary description. **Update this section based on changes that will be made by Entergy to UFSAR Supplement A.2.2.2.1, which will make references to Commitments #31 and #35.**

4.3.1.4 Conclusion

On the basis of its review, pending confirmation and acceptance of the appropriate amendments of the PNPS LRA, as discussed above, the project team concludes that the applicant has demonstrated that, pursuant to 10 CFR 54.21(c)(1)(ii), the metal fatigue analyses *for the Class 1 components will be either projected to the end of the PEO, or that, pursuant to* 10 CFR 54.21(c)(1)(iii), the effect of fatigue-induced cracking on the intended functions of components will be adequately managed for PEO. The project team also concluded that, pending acceptable amendment of the PNPS LRA to incorporate of Commitments #31 and #35 into the UFSAR Supplement summary description A.2.2.2.1, the UFSAR supplement contains an appropriate summary description of the RV internals fatigue analyses TLAA evaluation for the period of extended operation, as required by 10 CFR 54.21(d).

4.3.2 Fatigue of Non-Class 1 Components

4.3.2.1 Summary of Technical Information in the Application

The applicant evaluated those safety systems that provide a safety function equivalent to those for ASME Code Class 2 and 3 systems. The applicant stated that these systems were designed to B31.1. The applicant stated that B31.1 requires the applicant to assess whether the projected number of thermal cycles for these systems through 60 years of licensed operations would require the applicant to reduce the maximum allowable stresses for the components in accordance with the B31.1 maximum allowable stress reduction criteria.

The applicant stated that the number of thermal cycles projected for these systems through 60 years of licensed operation will not exceed 7000 cycles. Based on this projection, the applicant determined that, in accordance with the B31.1 acceptance criteria, no reductions of the maximum allowable stresses for these systems is necessary for the period of extended operation. The applicant therefore concluded that the piping stress calculations for these systems remain valid for the period of extended operation and are acceptable in accordance with 10 CFR 54.21(c)(1)(i).

4.3.2.2 Evaluation

Regulatory Bases for Evaluating TLAAs on Metal Fatigue of Non-Class 1 Components

The metal fatigue methods and criteria discussed in Section 4.3.1.2 for B31.1 methodologies are applicable to this assessment.

Scope of Review and Assessment

The project team reviewed LRA Section 4.3.2, including LRA Table 4.3-2, "Project Cycles," relative to the TLAA on Metal Fatigue for Non-Class 1 components. The project team also reviewed the AMR line items in the LRA Tables 3.2.2-X, 3.3.2-X and 3.4.2-X (i.e., AMR line items in the Non-Class 1 AMR tables, which are the AMR tables for Emergency Safety Feature Systems, Auxiliary Systems, and Steam and Power Conversion Systems) in which fatigue-induced cracking was identified as an AERM and in which the "TLAA - Metal Fatigue" was credited as the basis for management of the aging effect (identified as "cracking - fatigue" in the Non-Class 1 AMR Tables). The project team also reviewed PNPS Report No. LRPD-06, Revision 0, "Time Limited Aging Analyses – Mechanical Fatigue," relative to the applicant's metal fatigue methods for the PNPS Non-Class 1 components.

The project team determined that LRA Table 4.3-2 indicates that the total number of thermal cycles projected for PNPS through 60 years of licensed operations is 1684 cycles. Based on this number, the project team concluded that the applicant has made a valid conclusion that the total number of thermal cycles at 60 years will not exceed 7000 and that the stress calculations for the Non-Class 1 piping commodity groups designed to B31.1 will remain valid for the PEO. However, the project team determined that Section 4.3.2 did not clearly indicate which of these AMR commodity groups were designed to B31.1 and which commodity groups were not designed to B31.1 requirements. Thus, the project team was unable to conclude that the TLAA on Metal Fatigue was an appropriate means of aging management for those Non-Class 1 commodity groups that were designed to a design code other than B31.1. The project team asked the applicant to respond to the following requests:

(1) Identify which design codes were ~~application~~ applied to the non-piping commodity groups in the Non-Class 1 Fatigue AMRs.

(2) Clarify whether the design codes required a metal fatigue analysis and summarize what type of metal fatigue analysis calculation was required by the design code, if applicable.

(3) Discuss how the metal fatigue analysis was acceptable in accordance with 10 CFR 54.21(c)(1)(i), (ii), or (iii), if applicable.

(4) Propose an acceptable AMP to manage the aging effect "cracking - fatigue" for the PEO if the design code did not a metal fatigue analysis for the particular Non-Class 1 commodity group.

In a letter dated July 5, 2006 **(MLXXXXXXX)**, the applicant clarified that the following Non-Class 1 components were not designed in accordance with B31.1:

- residual heat removal system (RHR) heat exchanger shells and tubes, which were designed in accordance with Section III Class C and ASME Section VIII, Division 1 requirements
- RHR pump casings, which were designed to Section III, Class C requirements
- reactor core isolation cooling (RCIC) and high pressure coolant injection turbine casings which were designed in accordance with NEMA SM 23 requirements.
- reactor building closed cooling water (RBCCW) heat exchanger tubes
- All non-piping components in the Nonsafety-Related Components Affecting Saefty-Related Systems AMR tables for the auxiliary systems (i.e.., in the LRA 3.3.2-14-X Tables).

The applicant clarified that the design codes for these components do not require metal fatigue analyses for the components and therefore proposed to credit the one-time inspection program to manage "cracking -fatigue" in these components in lieu of the TLAA on Metal Fatigue. The applicant's One-Time Inspection Program is used, in part, to determine whether a specific aging effect of concern is occurring in components in which there has been no plant-specific operating experience with the aging effect. The applicant has not indicated any relevant operating experience with respect to the occurrence of fatigue-induced cracking in the RHR heat exchanger tubes and shells, RHR pump casings, or RBCCW heat exchanger tubes, or in the non-piping components for non-safety related systems within the scope of the 3.3.2-14 (a)(2) AMR Tables. GALL Program XI.M32, "One Time Inspection," states that either an enhanced VT-1 (EVT-1) visual examination or volumetric examination techniques (i.e., either ultrasonic or radiographic techniques) are to be used to detect cracking in plant components. The applicant's One-time Inspection Program (LRA AMP B.1.23) has been determined to be consistent with GALL AMP XI.M32 without exception. Therefore, staff concludes that it will be appropriate to credit a one-time inspection of these components using either an EVT-1 or volumetric examination technique to determine whether fatigue-induced cracking is an AERM for the PEO. The project team reviewed the One-Time Inspection Program and its evaluation is documented in section 3.0.3.1.8 of this audit and review report. **The response to the project team's question on reconciliation of the Non-class 1 Fatigue AMRs with those Non-Class 1 components analyzed for metal fatigue in LRA Section 4.3.2 will require that the applicant update some Non-Class 1 Fatigue AMRs. Therefore the response to Question 506 remains open, pending confirmation and acceptance of the AMR changes proposed for the PNPS LRA.**

4.3.2.3 UFSAR Supplement

The applicant provided the UFSAR Supplement summary description for the TLAA on Metal Fatigue of PNPS Class 1 components in LRA Section A.2.2.2.2. The summary description discusses how the number of full thermal transients is projected to remain below 7000 at the expiration of the PEO and, therefore, provides an acceptable description on the TLAA for Metal Fatigue for Non-Class 1 components in that it discusses how the maximum allowable stress range analysis for the components remains valid for the PEO in accordance with

10 CFR 54.21(c)(1)(i). In the applicant's response to the project team's question on management of "cracking -fatigue" in Non-Class 1 components, the applicant clarified which components in the Non-Class 1 AMR tables were fabricated in accordance with B31.1 design requirements and which Non-Class 1 components were fabricated in accordance with design codes which did not require metal fatigue analyses. Therefore, based on the project team's review of UFSAR Supplement Summary Description A.2.2.2.2, the project team concludes that the summary description is acceptable because it provides an acceptable basis on how the Non-Class 1 B31.1 components remains valid for PEO in accordance with 10 CFR 54.21(c)(1)(i) and because the applicant is no longer relying on the TLAA on Metal Fatigue to manage cracking in the Non-Class 1 that were designed to non-B31.1 design codes.

4.3.2.4 Conclusion

On the basis of its review, pending confirmation and acceptance of the appropriate amendments of the PNPS LRA, as discussed above, the project team concluded that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(i), that, for metal fatigue analyses for the Non-Class 1 components designed to B31.1 requirements, the analyses remain valid for the PEO. The project team also concludes that the applicant has proposed a valid AMP to manage "cracking - fatigue" in those Non-Class 1 components in which "cracking -fatigue" is an applicable AERM and for which the design code of record is a design code other than B31.1. The project team also concluded that the UFSAR supplement contains an appropriate summary description of the RV internals fatigue analyses TLAA evaluation for the period of extended operation, as required by 10 CFR 54.21(d).

4.3.3 Effects of Reactor Water Environment on Fatigue Life

In Generic Safety Issue (GSI)-190, "Fatigue Evaluation of Metal Components for 60-year Plant Life." the NRC assessed the generic impacts of the effects of reactor coolant environment on fatigue life of Class 1 components. In accordance with interim staff guidance document ISG-16, "Time-Limited Aging Analyses (TLAAs) Supporting Information for License Renewal Applications," the NRC has established its position that the environmental effects of the reactor coolant environments must be evaluated for their impacts on the 60-year metal fatigue CUF values for the high fatigue CUF locations listed in older vintage BWR plants.

4.3.3.1 Summary of Technical Information in the Application

In LRA Section 4.3.3, the applicant summarized the evaluation of the effects of reactor coolant environment on fatigue life of components and piping for the period of extended operation. The applicant evaluated the six locations identified in NUREG/CR-6260 (a total of nine components) using the guidance provided in NUREG-1801, chapter X.M1. These evaluations were performed using 40–year CUF values as identified in Table 4.3-1 of the LRA. The applicant stated that four of the nine components reviewed have environmentally adjusted CUF greater than 1.0. Table 4.3-3 provides the PNPS CUFs for NUREG/CR-6260 locations.

The LRA states that, prior to entering PEO, the applicant will implement one of the following actions for each location that may exceed a CUF of 1.0 when considering environmental effects:

(1) further refinement of the fatigue analyses to lower the predicted CUFs to less

than 1.0;

(2) management of fatigue at the affected locations by an inspection program that has been reviewed and approved by the NRC (details such as scope, qualification, method, and frequency will be submitted to the NRC prior to PEO);

(3) repair and replacement of the affected locations

LRA Commitment #31

In a letter dated July 19, 2006 **(MLXXXXXXXX)**, the applicant has included **Commitment #31** on the PNPS LRA. In this commitment, the applicant committed either to: (1) perform updated 60-year CUF calculations for the Class 1 locations addressed in NUREG/CR-6260, including F_{en} adjustments to account for the impacts of the reactor water enviroment on the CUF values for these locations, (2) manage the aging effect of fatigue-induced cracking (i.e., "cracking -fatigue" in the appropriate AMR line items) using an NRC-approved inspection program, or (3) repair or replacement the affected components prior to entering the PEO and prior to exceeding a CUF of 1.0 for the affected RPV location. The commitment also includes a commitment to implement corrective actions if the applicant determines that any CUF value is greater than 1.0.

4.3.3.2 Evaluation

Regulatory Bases

In GSI-166, "Adequacy of the Fatigue Life of Metal Components," the NRC raised concerns regarding the conservatism of the fatigue curves used in the design of the reactor coolant system components. Although the issues raised in GSI-166 were resolved for the current 40-year design life of operating components, the staff identified that the same issues would have to be assessed for their impacts on possible licension extension for operating reactors. The staff therefore issued GSI-190, "Fatigue Evaluation of Metal Components for 60-year Plant Life," to address these issues with respect to license renewal. The NRC closed GSI-190 in December 1999, concluding that the calculations supporting resolution of this issue, which included consideration of environmental effects and the nature of age-related degradation, indicate the potential for an increase in the frequency of pipe leaks as plants continue to operate. However, the NRC also concluded that, consistent with existing requirements in 10 CFR 54.21, licensees should address the effects of reactor coolant environment on component fatigue life as AMPs are formulated in support of license renewal. The NRC's bases for performing these evaluations are given in NUREG/CR-6260, NUREG/CR 6583, "Effects of LWR Coolant Environments on Fatigue Design Curves of Carbon and Low-Alloy Steels," for carbon and alloy steels, NUREG/CR 5704, "Effects of LWR Coolant Environments on Fatigue on Fatigue Design Curves of Austenitic Stainless Steels."

Scope of Review and Assessment

The applicant evaluated the component locations listed in NUREG/CR-6260 that are applicable to an older-vintage BWR plant for the effects of the reactor coolant environment on the fatigue life of the components. However, the applicant has not performed any 60-year CUF calculations. The 40-year numbers derived from Table 4.3-1 were multiplied by the F_{en} values to arrive at the environmentally adjusted CUFs as shown in Table 4.3-3.

Table 4.3-3 indicated that there were no PNPS-specific CUF values available for RR outlet nozzle, core spray safe end, and feedwater piping, and the applicant used the generic values for these components from NUREG/CR-6260. The project team asked the applicant to clarify three issues related to the LRA Section 4.3.3 and LRA Table 4.3-3:

(1) Notes for LRA Table 4.3-3 stated that generic values for these components were taken from NUREG/CR-6220. The project team asked the applicant whether this should have been NUREG/CR-6260. In its response, the applicant stated that this was a typo, it should be NUREG/CR-6260. The project team found the response acceptable.

(2) The project team informed the applicant that NUREG-6260 CUF is based on the specific plant used in the NUREG and is dependent on that plant's piping configuration. That value could not be used by PNPS unless it justified that its piping configuration was same as the NUREG-6260 plant. The project team asked the applicant to justify the use of the NUREG/CR-6260 values. In its response, the applicant stated that the CUF values were intended as typical values used to predict the magnitude of the effect of considering the reactor coolant environment on fatigue for PNPS. The applicant agreed to supplement the LRA to remove the CUFs from Table 4.3-3 that are taken from NUREG-6260. Furthermore, the applicant committed to perform additional environmentally adjusted fatigue analyses prior to PEO as stated below in (3).

(3) The project team asked the applicant to provide more details on its implementation plan, specifically (a) how will further refinement of the fatigue analyses be performed? And (b) if an AMP is used to manage fatigue, then include a commitment to issue for NRC approval 24 months prior to PEO.

In a letter dated July 19, 2006 (**MLXXXXXXXX**), the applicant made a commitment 31 that stated that at least 2 years prior to entering the period of extended operation, for the locations identified in NUREG/CR-6260 for BWRs of the PNPS vintage, PNPS will implement one or more of the following:

(1) Refine the fatigue analyses to determine valid CUFs less than 1 when accounting for the effects of reactor water environment. This includes applying the appropriate Fen factors to valid CUFs determined in accordance with one of the following:

1. For locations with existing fatigue analysis valid for the period of extended operation, use the existing CUF to determine the environmentally adjusted CUF.

2. More limiting PNPS-specific locations with a valid CUF may be substituted for the NUREG/CR-6260 locations.

3. Representative CUF values from other plants, adjusted to or enveloping the PNPS plant specific external loads may be used if demonstrated applicable to PNPS.

4. An analysis using an NRC-approved version of the ASME code of NRC-approved alternative (e.g., NRC-approved code case) may be performed to determine a valid CUF.

(2) Manage the effects of aging due to fatigue at affected locations by an inspection program that has been reviewed and approved by the NRC (e.g., periodic nondestructive examination of the affected locations at inspection intervals to be determined by a method acceptable to the NRC).

(3) Repair or replace the affected locations prior to the period of extended operation and the location exceeding a CUF of 1.0.

Should PNPS select the option to manage the aging effects due to environmental-assisted fatigue during the period of extended operation, details of the aging management program such as scope, qualification, method, and frequency will be submitted to the NRC at least 2 years prior to the period of extended

The project team noted that this issue is interlinked with the issues identified in subsection 4.3.1, Class 1 Fatigue. The CUFs for Class 1 components as identified in Table 4.3-1 may need to be re-calculated for 60 years, before the refinement of the fatigue analyses can be performed for the environmental effects for locations identified in NUREG/CR-6260.

4.3.3.3 UFSAR Supplement

The applicant provided the UFSAR Supplement summary description for the TLAA on Environmental Effect on Fatigue of PNPS limiting locations as identified in NUREG/CR-6260 in LRA Section A.2.2.2.3. The applicant stated that the effects of environmental impact were evaluated for license renewal. However, these effects were only evaluated for 40 years, and not for the PEO. As a result, the project team determined that the UFSAR Supplement summary description does not adequately describe the impact of environmental impact of *environmental fatigue on these locations because UFSAR Supplement* A.2.2.2.3 *will need to be* updated to refer to LRA Commitment #31, which is being relied upon for acceptance of the TLAA on Environmentally Impacted Metal Fatigue. **The applicant needs to respond to issues addressed in the subsection 4.3.3.2 project team evaluation and, if any commitment is made, then the commitment needs to be addressed in the UFSAR Supplement summary description. {OPEN ITEM}**

4.3.3.4 Conclusion

On the basis of its review, pending acceptable resolution of audit Questions on LRA Section 4.3.3 and pending acceptable amendments to LRA Section 4.3.3 and LRA Commitment #31, as discussed above, the project team concluded that the applicant has demonstrated, pursuant to 10 CFR 54.21(c)(1)(i), that, for the environmental metal fatigue analyses for the Class 1 components, the analyses remain valid for the period of extended operation. The project team also concluded that the UFSAR supplement contains an appropriate summary description of the RV internals fatigue analyses TLAA evaluation for the period of extended operation, as required by 10 CFR 54.21(d).

Attachment 5 References

1. PNPS Report No. LRPD-06, Revision 0, "Time Limited Aging Analyses – Mechanical Fatigue."

2. Altran Report No. 93177-TR-03, Revision 0, Volumes I, II, III, and IV, "Pilgrim Reactor Vessel Cyclic Load Analysis."

3. PNPS Calculation DC23A4096, Revision 3, "Loop A RRS Piping and Equipment Loads," July 25, 1994.

4. PNPS Calculation DC23A4097, Revision 2, "Loop B RRS Piping and Equipment Loads," February 26, 1988.

5. GE Report 25A5685, Revision 1, "Stress Report - Shroud Stabilizers Vessel," June 19, 1995.

6. GE Report GENE-771-79-1194, Revision 2, "Shroud Repair Hardware Stress Analysis," June 19, 1995.

6. 1965 Edition of Section III of the ASME Boiler and Pressure Vessel Code.

7. 1967 Edition of the ASME B31.1 Design Code.

8. NUREG-1800, Revision 1, "Standard Review Plan for License Renewal Applications for Nuclear Power Plants," September 2005.

9. General Electric Company Report No. GE-NE-0000-0000-1892-02, Revision 0, Thermal Power Optimization, Task-302 - RPV - Stress Evaluation, March 2002.