Safety Evaluation Report

Related to the License Renewal of Oyster Creek Nuclear Generating Station

Supplement 1

Docket No. 50-219

AmerGen Energy Company, LLC

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

September 2008

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ABSTRACT

This document is a supplemental safety evaluation report (SSER) for the license renewal application (LRA) for Oyster Creek Nuclear Generating Station (OCGS) as filed by AmerGen Energy Company, LLC. (AmerGen or the applicant). By letter dated July 22, 2005, AmerGen submitted its application to the United States (US) Nuclear Regulatory Commission (NRC) for renewal of the OCGS operating license for an additional 20 years. The NRC staff issued a final safety evaluation report (SER) in two volumes, dated March, 2007(ML071290023 and ML071310246), which summarizes the results of its safety review of the renewal application for compliance with the requirements of Title 10, Part 54, of the *Code of Federal Regulations*, (10 CFR Part 54), "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." This document only lists the changes to the March 2007 SER.

This SSER documents clarifications provided by the applicant to drywell shell aging management program commitments. The applicant provided these clarifications as a result of the Atomic Safety and Licensing Board hearing, which was held September 24-25, 2007 in Toms River, NJ. This SSER also documents the staff's evaluation of the applicant's response to an April 2008 request for additional information (RAI) regarding the use of Green's function in calculating fatigue cumulative usage factors (CUF) for OCGS components.

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ABBREVIATIONS

ACRS	Advisory Committee on Reactor Safeguards
AmerGen	AmerGen Energy Company, LLC
AMP	aging management program
ASLB	Atomic Safety and Licensing Board
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CUF	cumulative usage factor
DO	dissolved oxygen
EAF	environmentally assisted fatigue
HWC	hydrogen water chemistry
F_{en}	fatigue life correction factor
LAS	low-alloy steel
LRA	license renewal application
NRC	Nuclear Regulatory Commission
NWC	normal water chemistry
OCGS	Oyster Creek Generating Station
RAI	request for additional information
RO	reactor recirculation outlet nozzle
SC	structures and components
SIA	Structural Integrity Associates
SER	safety evaluation report
SSER	supplemental safety evaluation report
3-D	three dimensional
US	United States
UFSAR	updated final safety analysis report

SECTION 1

INTRODUCTION AND GENERAL DISCUSSION

1.1 <u>Introduction</u>

This document is a supplemental safety evaluation report (SSER) for the license renewal application (LRA) for Oyster Creek Nuclear Generating Station (OCGS) as filed by AmerGen Energy Company, LLC. (AmerGen or the applicant). By letter dated July 22, 2005, AmerGen submitted its application to the United States (US) Nuclear Regulatory Commission (NRC) for renewal of the OCGS operating license for an additional 20 years. The NRC staff (the staff) issued a final safety evaluation report (SER) in two volumes, dated March, 2007 (ADAMS Accession Nos. ML071290023 and ML071310246), which summarizes the results of its safety review of the renewal application for compliance with the requirements of Title 10, Part 54, of the *Code of Federal Regulations*, (10 CFR Part 54), “Requirements for Renewal of Operating Licenses for Nuclear Power Plants.” This SSER supplements portions of Sections 1, 4, 6, and Appendix A of the March 2007 SER.

In a letter dated January 14, 2008 (ML080160540), the applicant provided clarifications to commitments related to the aging management program for the OCGS drywell shell, associated with AmerGen’s renewal application. This letter was a result of the Atomic Safety and Licensing Board hearing, which was held September 24-25, 2007 in Toms River, NJ. Clarifications made to these commitments are included in Appendix A. Commitment number 27-2 changed the enhancement from “Refueling Outages” to “Prior to filling the reactor cavity with water.” Commitment number 27-18 expanded the “required thickness values” to “Code-specified safety factors” for “refueling load cases and post-accident load case.” Commitment 27-22 specifies that the applicant will verify that the sand bed drain lines are clear from obstruction every other refueling outage.

Additionally, on April 29, 2008, the staff issued a request for additional information (RAI) to the applicant requesting they address the staff’s concerns with regard to the use of Green’s function in calculating fatigue cumulative usage factors (CUF) for OCGS components. The Staff’s concerns with licensee use of Green’s function are discussed in detail in Draft NRC Regulatory Issue Summary 2008-XX, “Fatigue Analysis of Nuclear Power Plant Components,” dated April 11, 2008 (ML080950235). Section 4 of this SSER contains the staff’s evaluation of the applicant’s response to that RAI.

1.7 <u>SUMMARY OF PROPOSED LICENSE CONDITIONS</u>

The staff does not have any changes or update to this section of the original SER (ML071290023 and ML071310246).

SECTION 2

STRUCTURES SYSTEMS AND COMPONENTS

The staff does not have any changes or update to this section of the original SER (ML071290023 and ML071310246).

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SECTION 3

AGING MANAGEMENT REVIEW RESULTS

The staff does not have any changes or update to this section of the original SER (ML071290023 and ML071310246).

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SECTION 4

TIME LIMITED AGING ANALYSIS

4.3.4 Effects of Reactor Coolant Environment on Fatigue Life of Components and Piping (Generic Safety Issue 190)

4.3.4.1 Summary of Technical Information in the Application

The staff does not have any changes or update to this section of the original SER (ML071290023 and ML071310246).

4.3.4.2 Staff Evaluation

Subsequent to the issuance of NUREG-1875 in April 2007, the staff issued a request for additional information (RAI) on April 29, 2008 (ADAMS Accession No. ML081080077), to address concerns identified with the use of Green's function in calculating fatigue cumulative usage factors (CUF) of Oyster Creek Generating Station (OCGS) components.

As a matter of background, the Green's function approach involves performing a detailed stress analysis of a component to calculate its response to a step change in temperature. This detailed analysis is used to establish an influence function, which is subsequently used to calculate the stresses caused by actual plant temperature transients. In implementing this approach, OCGS used a simplified input for applying the Green's function in which only one value of stress was used for the evaluation of the actual plant transients. Detailed stress analysis, however, requires consideration of six stress components, as discussed in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section III, Subarticle NB-3200. Thus, the concern is whether the simplified implementation of the Green's function method provides acceptable and conservative results. AmerGen used the simplified input for applying the Green's function to perform fatigue calculations at OCGS for the reactor recirculation outlet (RO) nozzles.

The staff's RAI asked the applicant to perform a confirmatory detailed fatigue analysis (herein referred to as "confirmatory analysis") of the RO nozzles in accordance with the methodology of ASME Code, Section III, Subarticle NB-3200, which retains all six stress components, to determine whether the analysis that employed the simplified Green's function methodology (herein referred to as "original analysis"), which uses a single stress term, provided acceptable results. The staff's RAI also asked that the applicant confirm that the RO nozzles were the only components where the Green's function was used to evaluate the fatigue CUF for license renewal.

In its response to the staff's RAI, dated May 1, 2008 (ML081270386), the applicant stated that it used the Green's function methodology in the OCGS license renewal only to evaluate the fatigue CUF for the RO nozzles. Therefore, in the case of OCGS license renewal, the concern related to the simplified Green's function methodology involves only the RO nozzles.

The applicant performed the requested confirmatory analysis. The following four items show the applicant's description of the differences between the original analysis and the confirmatory analysis, stated in its response to the staff's RAI, and the staff's view of the applicant's statements.

(1) The applicant stated that Green's function was not used in the confirmatory analysis and that all six components of stress were extracted from a finite element analysis of all transients and then used in calculating the fatigue usage factor in accordance with Subparagraph NB-3216.2 in Section III of the ASME Code. The applicant also stated: "Calculated stresses are comparable and CUF is lower."

The staff audited the calculations underlying the confirmatory analysis and determined that the confirmatory analysis calculations were performed in accordance with the ASME Code, Section III, Subarticle NB-3200. The staff found that the stress analysis calculated for all six stress components were extracted from the stress results of the ANSYS model at the nozzle limiting location which were subsequently used in the fatigue calculation of the nozzle. The staff also found that calculated stresses were comparable to the original analysis and the fatigue evaluation resulted in a lower CUF.

(2) The applicant stated that in the original analysis for the OCGS RO nozzles, stresses were conservatively extracted on the stainless steel cladding surface and were evaluated using the carbon steel fatigue curve, which provided very conservative fatigue usage results. The applicant also stated that in the confirmatory analysis, "the nozzle cladding was neglected for the fatigue calculation, as permitted in NB-3122.3 of Section III of the ASME Code, and the base metal was evaluated for stresses and fatigue usage." The applicant stated that this was "consistent with the approach used in NUREG/CR-6260 for several component evaluations."

The staff notes that ASME Code Section III, Subparagraph NB-3122.3, directs that for stresses and fatigue evaluation purposes the presence of the cladding should be considered in the analyses and both materials, cladding and base metal, shall meet the code stresses and fatigue requirements. However, if the integrally bonded cladding is not considered to add to the component's structural integrity, as the code states "is 10% or less of the total thickness of the component", Subparagraph NB-3122.3 allows the analyst to exclude the cladding from the stress and fatigue evaluation and evaluate only the stresses and fatigue on the base metal.

The staff confirmed during the audit that in the confirmatory analysis the cladding was included in the ANSYS finite element model and stresses were extracted on the base metal surface adjacent to cladding (base metal stresses), which were then used to evaluate the base metal for fatigue usage. This is permitted by the ASME Code. Therefore, the staff finds this approach acceptable.

(3) The applicant stated that in performing the confirmatory fatigue evaluation for the emergency condenser transients, an input of hold time was assumed in the analysis, between the initial downward shock in temperature and the subsequent warm-up. The original analysis did not include this hold time based on plant-specific transient evaluation. The applicant stated that it made this change to conservatively ensure that the peak stress is captured after the downward shock, and to address all possible scenarios of event severity for future plant operation.

The staff finds this method acceptable as it addresses steady state periods and captures peak stresses. Furthermore, the staff's audit confirmed that this change resulted in a higher stress for those transients in the confirmatory analysis, however, as the applicant stated in its response, and the Staff confirmed, this increase in stress was an insignificant contributor to fatigue usage compared to the decrease in fatigue usage described by item 2 above.

(4) For the confirmatory environmentally assisted fatigue (EAF) analysis, the applicant stated that it used detailed environmental fatigue factor (F_{en}) multipliers that were determined for each load pair based on maximum transient temperatures with assumed low strain rates, resulting in a maximized strain rate term for each of these F_{en} multipliers. In the original EAF analysis, detailed F_{en} multipliers were determined for each load pair based upon both maximum transient temperatures and calculated strain rates. This change was made to conservatively determine the strain rates and the resultant environmental fatigue multipliers for the confirmatory analysis. This change resulted in an increase in the overall F_{en} multiplier for the OCGS RO nozzles in the confirmatory analysis.

During its audit, the staff noted that the F_{en} multipliers, as calculated in the original analysis using strain rates calculated for each load pair, were in accordance with NUREG/CR-6583, "Effects of LWR Coolant Environments on Fatigue Design Curves of Carbon and Low-Alloy Steels", issued February 1998, and in the confirmatory analysis the NUREG/CR-6583 bounding strain rate of 0.001 percent per second (%/s) was used for the F_{en} multipliers in all load pairs. Therefore, the staff finds the strain rate values used in both analyses acceptable. In addition, the staff noted that using the maximum transient temperatures resulted in conservative F_{en} multiplier values, and is, therefore, acceptable.

In its response to the staff's RAI the applicant submitted tabulated results of both the original analysis and the confirmatory analysis. The tables show that the confirmatory analysis resulted in an EAF CUF of 0.1366 for the nozzle corner location versus the original analysis EAF CUF of 0.9781 at the same location. The detailed confirmatory analysis found the original analysis results conservative by a factor of approximately seven.

The staff audited the applicant's calculations in the confirmatory and original analyses, reviewing plant data and analysis records. The staff's audit review showed that both analyses used the same ANSYS axisymmetric finite element model. In addition, the staff found that the applicant had verified that its contractor, Structural Integrity Associates (SIA), who performed both the original and confirmatory analyses, had also validated that both analyses utilized the same finite element model. The staff also confirmed that the tabulated results shown in the RAI response tables for the original analysis and the confirmatory analysis were for the inside corner of the nozzle at the blend radius on the cladding surface and on the base metal surface adjacent to cladding respectively.

The staff reviewed the methodology to calculate the F_{en} multipliers in both the original and confirmatory analyses and found that both used the same low-alloy steel (LAS) equation shown in NUREG/CR-6583 and developed detailed F_{en} multipliers for each load pair. Therefore, the staff finds the methodology of deriving the F_{en} multipliers acceptable.

The staff also reviewed the four inputs (sulfur content, temperature, strain rate and dissolved oxygen (DO)) used to develop the F_{en} multipliers as specified in NUREG/CR-6583 for LAS. Both analyses used the NUREG/CR-6583 bounding sulfur content of 0.015 weight percent. In the original analysis F_{en} values were determined based upon maximum transient temperatures and calculated strain rates. In the confirmatory analysis F_{en} values were determined based upon maximum transient temperatures and an assumed slow strain rate equal to the NUREG/CR-6583 bounding strain rate of 0.001%/s. The staff finds this acceptable because it produces a higher, thus conservative, overall F_{en} multiplier in the confirmatory analysis.

The staff found that both analyses accounted for the DO water chemistry effect for hydrogen water chemistry (HWC) as well as the normal water chemistry (NWC) employed by the applicant prior to the implementation of HWC. The staff reviewed available plant data for both HWC and NWC. F_{en} values were based on 59 percent HWC and 41 percent NWC. The staff's Audit of the available chemistry data showed that this is a conservative representation of Oyster Creek's water chemistry. The staff also reviewed plant data for DO and verified that the appropriate values were used to calculate the F_{en} multipliers in accordance with NUREG/CR-6583 for LAS and is, therefore, acceptable. In addition, the applicant stated that water chemistry (HWC and noble metals chemistry) and water chemistry monitoring will ensure that DO levels remain below the value used to calculate the F_{en} values.

Based on its review, the staff finds that the applicant adequately accounted for the water chemistry effects in the evaluation of EAF.

The staff's review of the applicant's calculations verified that the confirmatory analysis resulted in a CUF of 0.0207 and a EAF CUF of 0.1366 for the limiting nozzle corner location compared to the original analysis CUF of 0.1832 and EAF CUF of 0.9781 at the same location. The original analysis conservatively used stresses from the stainless steel cladding surface, which were then used for the fatigue evaluation of the LAS base metal. The applicant stated that the assumptions in the original analysis resulted in a conservative estimate of the fatigue usage. In the confirmatory analysis, the stainless steel cladding was excluded (see above under item 2) for the fatigue calculation, as permitted in Subparagraph NB-3122.3 in Section III of the ASME Code, and the base metal stresses were used for the fatigue evaluation.

The staff agrees that the applicant's fatigue evaluation which uses the base metal stresses, and not the cladding stresses, to perform the fatigue analysis of the base metal is in accordance with the ASME Code Section III.

From the staff's review of the calculations and from discussions with the applicant's contractor SIA during the audit, the staff determined that the primary difference between the original and confirmatory analyses, in addition to the use of all six stress components in the confirmatory analysis, was that in the original analysis, stresses were extracted at the cladding surface and it was assumed that those were the stresses at the base metal surface beneath the cladding, while in the confirmatory analysis, stresses were extracted at the base metal surface itself. Thus, because the ASME Code does not require the conservative assumption they made in the original analysis, and because the stresses at the cladding surface are greater than those at the base metal surface (at the interface with the cladding), the original analysis was more conservative than it needed to be. That factor contributed the most to the decreased fatigue CUF in the confirmatory analysis.

The staff's audit confirmed that the original analysis results are conservative by a factor of approximately seven when compared to the detailed confirmatory analysis results. Based on the staff review, the original analysis is acceptable.

4.3.4.3 UFSAR Supplement

The staff does not have any changes or update to this section of the original SER (ML071290023 and ML071310246).

4.3.4.4 Conclusion

Based on its review of selected analysis records, the staff finds that the applicant's derivation of F_{en} values is in accordance with NUREG/CR-6583 and that the applicant has adequately accounted for reactor water chemistry effects in calculating the EAF usage for the RO nozzles. In addition, the staff determined that the confirmatory analysis is in accordance with the rules and requirements of ASME Code, Section III, Subarticle NB-3200, and is, therefore, acceptable. Furthermore, the detailed confirmatory analysis found the original analysis results conservative and, therefore, acceptable.

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SECTION 5

REVIEW BY THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The staff has provided the Advisory Committee on Reactor Safeguards with a copy of this Supplemental Safety Evaluation Report.

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SECTION 6

CONCLUSION

On the basis of its review of the LRA, the staff concludes that the requirements of 10CFR§54.29(a) have been met. The staff concludes that the confirmatory analysis performed by the applicant, to address concerns with the use of Green's function in calculating fatigue cumulative usage factors (CUF) for OCGS components, is acceptable.

APPENDIX A

COMMITMENTS FOR LICENSE RENEWAL OF OCGS

During the review of the Oyster Creek Generating Station (OCGS) license renewal application (LRA) by the staff of the United States (US) Nuclear Regulatory Commission (NRC) (the staff), AmerGen Energy Company, LLC. (the applicant) made commitments related to aging management programs (AMPs) to manage the aging effects of structures and components (SCs) both prior to and during the period of extended operation. The following table lists revised commitments 27-2, 27-18 as well as a new commitment 27-22.

COMMITMENT NUMBER	ITEM NUMBER AND COMMITMENT	UFSAR SUPPLEMENT LOCATION (LRA APP. A)	ENHANCEMENT OR IMPLEMENTATION SCHEDULE	SOURCE
27) ASME Section XI, Subsection IWE	(2) A strippable coating will be applied to the reactor cavity liner to prevent water intrusion into the gap between the drywell shield wall and the drywell shell during periods when the reactor cavity is flooded. (18) AmerGen will perform a 3-D finite element structural analysis of the primary containment drywell shell using modern methods and current drywell shell thickness data to better quantify the margin that exists above the required minimum for buckling. The analysis will include sensitivity studies to determine the degree to which uncertainties in the size of thinned areas affect Code margins. If the analysis determines that the drywell shell does not meet Code-specified safety factors (i.e., 2.0 for the refueling load case and 1.67 for the post-accident load case), the NRC will be notified in accordance with 10 CFR 50 requirements. (22) Verify that the sand bed drain lines are clear from obstruction.	A.1.27	Prior to filling the reactor cavity with water. Prior to the period of extended operation. Every other refueling outage.	Section B.1.27

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