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10 CFR 50
10 CFR 51
10 CFR 54

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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Oyster Creek Generating Station
Facility Operating License No. DPR-16
NRC Docket No. 50-219

Subject: Response to NRC Request for Additional Information on Metal Fatigue Analysis Related to Oyster Creek Generating Station License Renewal Application (TAC No. MC7624)

Reference: NRC Request for Additional Information, dated April 29, 2008, Related to Oyster Creek Generating Station License Renewal Application (TAC No. MC7624)

In the referenced letter, the NRC requested AmerGen Energy Company, LLC (AmerGen) to provide additional information related to fatigue analysis performed in support of license renewal for Oyster Creek Generating Station (OCGS). This information was requested in the form of two questions, RAI 4.3.4-1 and RAI 4.3.4-2. The Enclosure to this letter provides AmerGen's response to these requests.

If you have any questions, please contact Fred Polaski, Manager License Renewal, at 610-765-5935.

I declare under penalty of perjury that the foregoing is true and correct.

Respectfully,

Executed on 05-01-2008

Michael P. Gallagher
Vice President, License Renewal
AmerGen Energy Company, LLC

Enclosure: Response to RAIs 4.3.4-1 and 4.3.4-2

A114
NRR

cc: Regional Administrator, USNRC Region I
USNRC Senior Project Manager, NRR - License Renewal, Safety
USNRC Project Manager, NRR - License Renewal, Environmental
USNRC Project Manager, NRR - OCGS
USNRC Senior Resident Inspector, OCGS
Bureau of Nuclear Engineering, NJDEP
File No. 05040

ENCLOSURE

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION RELATED TO OYSTER CREEK GENERATING STATION LICENSE RENEWAL APPLICATION FATIGUE ANALYSIS

RAI 4.3.4-1
- **Attachment 1**
- **Attachment 2**
- **Attachment 3**

RAI 4.3.4-2

RAI 4.3.4-1

The staff identified a concern regarding the methodology used by license renewal applicants to demonstrate the ability of nuclear power plant components to withstand the cyclic loads associated with plant transient operations for the period of extended operation. The analysis methodology of concern focused on the use of a Greens function to calculate stresses used in calculating the fatigue cumulative usage factor (CUF). It involves a simplified input for applying the Green's function in which only one value of stress is used to represent the stress field of actual plant transients. The use of this methodology requires a great deal of engineering judgment by the analyst to assure the simplification still provides conservative results. The staff understands that this methodology was used to calculate the environmentally impacted CUF for the Oyster Creek reactor recirculation outlet nozzle. The staff requests that OGCS perform an additional stress analysis of the recirculation outlet nozzle in accordance with the ASME Code, Section III, Subsection NB-3200 methodology (all six stress components are retained in the analysis) to confirm that the results of the previous Green's function evaluation is acceptable. Provide a summary of the results which includes the following information:

- A comparison of the calculated stresses and fatigue usage factors using the Green's function evaluation and the additional confirmatory analysis for each plant transient and transient pairs that contributed to the CUF.
- The environmental factor, F_{en}, used to evaluate each transient pair.
- A discussion of any differences in the analysis input parameters and analysis assumptions between the Green's function evaluation and the confirmatory analysis.

Response to RAI 4.3.4-1

AmerGen has performed confirmatory fatigue analysis of the Oyster Creek Generating Station (OCGS) reactor pressure vessel (RPV) recirculation outlet nozzle in accordance with the ASME Code, Section III, Subsection NB-3200 methodology, utilizing all six components of stress in the analysis. This new analysis confirms that the results of the original analysis are conservative and remain acceptable.

Table 1 compares the CUF and environmentally assisted fatigue (EAF) CUF results from the original analysis with those from the new analysis.

Table 1 - Summary of Fatigue Usage Results (60 Years)

Location	Analysis	CUF	Overall F_{en}	EAF CUF
Nozzle Corner	Original	0.1832	5.34	0.9781
	New	0.0207	6.60	0.1366

The input parameters and assumptions used in the original analysis and the new analysis are essentially the same with the exception of those described in the four notes below. In order to facilitate NRC review, this new analysis was prepared using assumptions similar to those made by a recent applicant also performing a confirmatory analysis. It was not the intent of the new analysis to duplicate the results of the original analysis, nor was it the intent to remove conservatism. Rather, the objective was to develop an independent ASME Code, Section III, Subsection NB-3200 fatigue calculation for the OCGS recirculation outlet nozzle using standard analytical methods and conventions previously accepted by the NRC to determine whether or not the original analysis results were conservative. The following notes describe how the new analysis differs from the original analysis:

1. In the new analysis, all six components of stress were extracted from finite element analysis of all transients, which were then utilized in calculating fatigue usage factor per NB-3216.2 of Section III of the ASME Code. No Green's functions were used. Calculated stresses are comparable and CUF is lower.
2. In the new 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. This is consistent with the method used by a recent applicant that performed a confirmatory analysis for one RPV nozzle, and is also consistent with the approach used in NUREG/CR-6260 for several component evaluations. In the original analysis for the OCGS recirculation outlet nozzle, 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.
3. For the Emergency Condenser transients in the new analysis, a 10,000 second hold time was assumed 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. This change was made to conservatively assure that the peak stress is captured after the downward shock and address all possible scenarios of event severity for future plant operation. This change resulted in a higher stress for these transients in the new analysis, but this increase in stress was an insignificant contributor to fatigue usage compared to the decrease in fatigue usage described by note 2 above.
4. For the new EAF analysis, detailed F_{en} multipliers 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 eliminate any possible non-conservatism in determining the strain rates and the resultant environmental fatigue multipliers for the new analysis, and to be consistent with the method used in a confirmatory analysis performed by another recent applicant. This change resulted in an increase in the overall F_{en} multiplier for the OCGS recirculation outlet nozzle in the new analysis.

Attachment 1 shows information from the original analysis, including the calculated stress, fatigue CUF, F_{en} multipliers, and EAF CUF values for each transient pair. Attachment 2 provides the same information from the new analysis for comparison with Attachment 1. Attachment 3 provides the transient descriptions and number of cycles associated with the transient numbers shown in both Attachment 1 and Attachment 2.

The original OCGS recirculation outlet nozzle EAF analysis was developed using a simplified method that utilized Green's functions to compute thermal transient stresses in which only one value of stress was used to represent the stress field. The new analysis confirms that the results of the original analysis are conservative and remain acceptable.

RAI 4.3.4-2

Confirm the reactor recirculation outlet nozzle was the only location where the Green's function (simplified calculation methodology) methodology was used to evaluate the fatigue CUF for license renewal.

Response to RAI 4.3.4-2

The reactor recirculation outlet nozzle was the only location where the Green's function methodology (simplified calculation methodology) was used to evaluate the fatigue CUF for OCGS license renewal.

Attachment 1: Original Analysis

Chemistry Mode:	HWC	NWC	
DO concentration:	1	180	ppb
% of Time:	59%	41%	

Transient 1	Transient 2	S_{alt} (psi)	n	N_{allow}	U	Strain Rate e-dot (%)	e-dot*	T_{MAX} (°F)	T_{MAX} (°C)	HWC F_{en}	NWC F_{en}	U_{env}
2	5	42,663	1	7,093	0.0001	1.18E-03	-6.739	525.0	273.9	2.45	16.45	0.0012
2	3	86,760	245	7,095	0.0345	2.41E-03	-6.029	525.0	273.9	2.45	13.46	0.2406
10	3	86,114	68	7,254	0.0094	5.68E-05	-6.908	427.0	219.4	2.45	7.32	0.0417
10	1	86,083	35	7,261	0.0048	5.68E-05	-6.908	427.0	219.4	2.45	7.32	0.0215
11	1	86,083	237	7,261	0.0326	5.68E-05	-6.908	427.0	219.4	2.45	7.32	0.1453
11	4	85,945	1	7,296	0.0001	5.67E-05	-6.908	427.0	219.4	2.45	7.32	0.0006
11	1	84,502	179	7,672	0.0233	5.57E-05	-6.908	427.0	219.4	2.45	7.32	0.1038
2	1	84,294	93	7,728	0.0120	5.55E-04	-6.908	525.0	273.9	2.45	17.25	0.1026
2	9	65,037	153	17,990	0.0085	4.28E-04	-6.908	525.0	273.9	2.45	17.25	0.0725
10	9	64,260	95	18,740	0.0051	2.14E-04	-6.908	427.0	219.4	2.45	7.32	0.0226
10	9	58,694	8	24,910	0.0003	1.96E-04	-6.908	427.0	219.4	2.45	7.32	0.0014
11	9	58,685	240	24,920	0.0096	1.96E-04	-6.908	427.0	219.4	2.45	7.32	0.0429
11	9	58,465	177	25,210	0.0070	1.95E-04	-6.908	427.0	219.4	2.45	7.32	0.0312
11	9	58,156	71	25,630	0.0028	6.07E-04	-6.908	427.0	219.4	2.45	7.32	0.0123
11	9	57,879	248	26,000	0.0095	6.04E-04	-6.908	427.0	219.4	2.45	7.32	0.0425
11	9	57,879	98	26,000	0.0038	6.04E-04	-6.908	427.0	219.4	2.45	7.32	0.0168
10	9	57,850	103	26,040	0.0040	7.59E-04	-6.908	427.0	219.4	2.45	7.32	0.0176
10	9	57,748	47	26,180	0.0018	4.28E-03	-5.454	359.8	182.1	2.45	3.66	0.0053
10	9	57,748	56	26,180	0.0021	4.28E-03	-5.454	359.8	182.1	2.45	3.66	0.0063
10	9	57,697	103	26,260	0.0039	2.52E-03	-5.983	427.0	219.4	2.45	6.33	0.0159
2	9	57,642	89	26,330	0.0034	2.63E-02	-3.637	544.7	284.9	2.45	7.51	0.0153
2	5	52,234	1	35,630	0.0000	2.39E-02	-3.736	544.7	284.9	2.45	7.74	0.0001
2	5	51,359	1	37,530	0.0000	2.35E-02	-3.753	544.7	284.9	2.45	7.78	0.0001
2	9	44,354	155	65,080	0.0024	2.03E-02	-3.899	544.7	284.9	2.45	8.14	0.0114
11	9	44,301	93	65,470	0.0014	3.41E-03	-5.681	390.7	199.3	2.45	4.64	0.0048
11	12	25,420	324	1,001,000	0.0003	1.96E-03	-6.236	390.7	199.3	2.45	4.94	0.0011
11	12	25,410	196	1,006,000	0.0002	1.38E-03	-6.589	427.0	219.4	2.45	6.96	0.0008
				Total, U_{60} =	0.1832						Total, $U_{60\text{-env}}$ =	0.9781
											Overall F_{en} =	5.34

Definitions:

Transient 1 = transient number for first transient in load pair.
Transient 2 = transient number for second transient in load pair.
Salt = alternating stress in psi.
n = number of applied cycles for load pair.
Nallow = allowable number of cycles for Salt from ASME Code Section III fatigue curve.
U = incremental fatigue usage for load pair, n/Nallow.
Strain rate e-dot (%) = tensile strain rate for load pair (%).
e-dot* = transformed strain rate computed in accordance with NUREG/CR-6583.
TMAX = maximum metal temperature for load pair (°F or °C).
HWC Fen: Fen multiplier computed in accordance with NUREG/CR-6583 for hydrogen water chemistry (HWC) conditions.
NWC Fen: Fen multiplier computed in accordance with NUREG/CR-6583 for normal water chemistry (NWC) conditions.
Uenv: Environmentally assisted fatigue usage factor, computed as (NWC Fen x 0.41 = HWC Fen x 0.59) x U.

Attachment 2: New Analysis

	HWC	NWC	
Chemistry Mode:	HWC	NWC	
DO Concentration:	1	180	ppb
% of Time:	59%	41%	

Transient 1	Transient 2	S_{alt} (psi)	n	N_{allow}	U	T_{MAX} (°F)	T_{MAX} (°C)	HWC F_{en}	NWC F_{en}	U_{env}
1	13	29,806	1	22,563	0.00004	537.0	280.6	2.455	19.164	0.00041
1	15	29,277	1	23,838	0.00004	120.0	48.9	2.455	2.455	0.00010
1	13	28,509	1	25,866	0.00004	570.0	298.9	2.455	25.574	0.00046
1	14	27,380	1	29,281	0.00003	535.0	279.4	2.455	18.831	0.00031
1	14	26,753	1	31,439	0.00003	544.0	284.4	2.455	20.373	0.00031
1	6	26,752	157	31,440	0.00499	408.0	208.9	2.455	6.202	0.01993
1	6	26,747	110	31,461	0.00350	416.0	213.3	2.455	6.652	0.01460
3	6	26,306	47	33,106	0.00142	416.0	213.3	2.455	6.652	0.00593
3	4	24,932	1	39,032	0.00003	451.0	232.8	2.455	9.034	0.00013
2	3	24,399	224	41,713	0.00537	531.0	277.2	2.455	18.184	0.04781
2	5	24,399	1	41,713	0.00002	531.0	277.2	2.455	18.184	0.00021
16	9	21,372	37	71,968	0.00051	338.0	170.0	2.455	3.363	0.00145
2	9	20,981	21	78,861	0.00027	548.0	286.7	2.455	21.099	0.00269
9	10	20,228	77	94,526	0.00081	542.0	283.3	2.455	20.020	0.00787
7	9	19,944	43	101,021	0.00043	526.0	274.4	2.455	17.406	0.00365
9	11	19,940	70	101,094	0.00069	543.0	283.9	2.455	20.196	0.00674
9	11	19,939	248	101,116	0.00245	543.0	283.9	2.455	20.196	0.02386
5	11	18,023	1	145,518	0.00001	543.0	283.9	2.455	20.196	0.00007
				Total, U_{60} =	**0.02069**				**Total, $U_{60\text{-}env}$ =**	**0.13655**
									Overall F_{en} =	**6.60**

Definitions:

Transient 1 = transient number for first transient in load pair.

Transient 2 = transient number for second transient in load pair.

Salt = alternating stress in psi.

n = number of applied cycles for load pair.

Nallow = allowable number of cycles for Salt from ASME Code Section III fatigue curve.

U = incremental fatigue usage for load pair, n/Nallow.

TMAX = maximum metal temperature for load pair (°F or °C).

HWC Fen: Fen multiplier computed in accordance with NUREG/CR-6583 for hydrogen water chemistry (HWC) conditions.

NWC Fen: Fen multiplier computed in accordance with NUREG/CR-6583 for normal water chemistry (NWC) conditions.

Uenv: Environmentally assisted fatigue usage factor, computed as (NWC Fen x 0.41 = HWC Fen x 0.59) x U.

Attachment 3: Transient Descriptions

Transient No.	Transient Description	No. of Cycles for 60 Years
1	Startup	272
2	Turbine Roll	246
3	Shutdown	272
4	300°F/hr Emergency Cooldown	1
5	SRV Blowdown	1
6	Scram	157
7	Turbine Trip	43
8	Loss of Feedwater Heaters	9
9	Shutdown Cooling Operation	248
10	Emergency Condenser Initiation	77 **
11	Emergency Condenser Subsequent Actuation	443 **
12	Emergency Condenser Stop	520
13	Overpressure to 1,375 psig *	1
14	Overpressure to 1,250 psig *	1
15	ASME Code Hydro Test to 1,563 psig *	1
16	Design Pressure Test at Operating Temperature *	37

Notes: * For the original analysis, these transients were grouped with the Shutdown Transient.
** For original analysis, 103 cycles of Emergency Condenser Initiation and 417 cycles of Emergency Condenser Subsequent Actuation were conservatively evaluated, compared to 77 cycles and 443 cycles, respectively, in the new analysis.