APPENDIX A

POTENTIAL ADVERSE FLOW EFFECTS

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO EXTENDED POWER UPRATE LICENSE AMENDMENT REQUEST

HOPE CREEK GENERATING STATION

A.1 Regulatory Evaluation

Plant operation at extended power uprate (EPU) conditions can result in adverse flow effects on the main steam (MS), feedwater (FW), and condensate systems and their components (including the steam dryer in boiling-water reactor (BWR) plants) from increased system flow and flow-induced vibration. Some plant components, such as the steam dryer, do not perform a safety function, but must retain their structural integrity to avoid the generation of loose parts that might adversely impact the capability of other plant equipment to perform their safety functions. The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the evaluation by PSEG Nuclear LLC (PSEG) of potential adverse flow effects for the proposed EPU license amendment at Hope Creek Generating Station (Hope Creek), including consideration of the design input parameters and the design-basis loads and load combinations for the Hope Creek steam dryer for normal operation, upset, emergency, and faulted conditions. The NRC staff's review covered the analytical methodologies, assumptions, and computer programs used in the evaluation of the Hope Creek steam dryer. The NRC staff's review also included a comparison of the resulting stresses against applicable limits.

The NRC staff reviewed the licensee's evaluation of MS, FW, and condensate system components at Hope Creek for potential susceptibility to adverse flow effects from EPU operation. The NRC's acceptance criteria are based on the General Design Criteria (GDC) in Appendix A, "General Design Criteria for Nuclear Power Plants," to Part 50 in Title 10 of the *Code of Federal Regulations* (10 CFR 50), including: (1) GDC 1, insofar as it requires those systems and components which are essential to the prevention of accidents which could affect the public health and safety or to mitigation of their consequences be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety functions to be performed; (2) GDC 2, insofar as it requires that those systems and components which are essential to the prevention of accidents which could affect the public health and safety or to mitigation of their consequences be designed to withstand the effects of earthquakes combined with the effects of normal or accident conditions; and (3) GDC 40 and 42, insofar as they require that protection be provided for engineered safety features against the dynamic effects and missiles that might result from plant equipment failures, as well as the effects of a loss-of-coolant accident. NRC Standard Review Plan Sections 3.9.1, 3.9.2, 3.9.3, and 3.9.5 contain specific review criteria.

A.2 Technical Evaluation

A.2.1 Steam Dryer

PSEG summarized its assessment of the Hope Creek steam dryer stresses at EPU conditions in Attachment 7, "Steam Dryer Evaluation," of PSEG Letter LR-N06-0286,[1] dated September 18, 2006. PSEG submitted its revised assessment of the Hope Creek steam dryer in Attachment 5, "Steam Dryer Evaluation, Rev. 1," of PSEG Letter LR-N07-0099,[2] dated April 30, 2007. The Hope Creek steam dryer is similar to an upgraded BWR 4/5 curved hood design, with the following on-site modifications performed prior to Hope Creek initial operation to improve its structural integrity:

- The 0.125-inch (in) thick outer hoods were replaced with 0.5-in hood, and outer hood welds were strengthened.
- The 0.1875-in thick central steam outlet end plates were replaced with 0.5-in plates.
- The 0.5 x 1-in tie bars were replaced with 2 x 2-in tie bars and the number of tie bars was increased.
- The 0.187-in reinforcing strips were added to extend the effective weld lengths between the middle and inner hoods and end plates. The inside corners of these hoods to the end plates were back-welded to a minimum height of 50-in above the support ring.

The Hope Creek dryer has not experienced any cracking associated with fatigue failure during its operation for over 20 years, including the last 3 years at the current licensed thermal power (CLTP) (3339 megawatt thermal (MWt), which is about 101.4 percent of the original licensed thermal power (OLTP). Since PSEG's stress analyses indicate sufficient margin to failure, no modifications to the dryer are planned prior to or subsequent to issuance of the proposed EPU license amendment.

In comparison to other nuclear power plants that have received EPU license amendments, the Hope Creek main steam line (MSL) flow velocities are comparable to those in the Vermont Yankee nuclear power plant, which received an EPU license amendment in 2006. There are no dead-end branch lines attached to the Hope Creek MSLs. All Hope Creek MSL safety relief valves (SRVs) are Target Rock 7567F models, and function as safety relief and power operated relief valves. All valves and standoff pipes are nominally the same throughout the MSLs. The MSL velocities at the Hope Creek plant are 145 feet per second (fps) at CLTP and 167 fps at EPU, which is about equal to the MSL velocity of 168 fps at Quad Cities Unit 2 (QC2) at OLTP.

The licensee's contractor, Continuum Dynamics, Inc. (CDI), has constructed a steam dryer finite element (FE) model based on field measurements made on an abandoned steam dryer, which was intended for the previously planned Hope Creek Unit 2. The FE model was developed by CDI using the ANSYS Version 10.0 code. All CDI activities related to the steam dryer FE

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[1] PSEG Letter (LR-N06-0286) to NRC dated September 18, 2006, "Request for License Amendment Extended Power Uprate, Hope Creek Generating Station Facility, Operating License NPF-57, Docket No. 50-354" ADAMS Accession No. ML062680451

[2] PSEG Letter (LR-N07-0099) to NRC dated April 30, 2007, "Response to Request for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML071290559

analyses were performed under CDI's quality assurance program, which is consistent with the requirements in 10 CFR 50, Appendix B, "Quality Assurance Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

To measure acoustic pulsations within the MSLs, PSEG instrumented Hope Creek MSLs with strain gages at eight locations approximating the benchmarked QC2 locations. This includes two locations on each MSL, with four equally spaced, circumferentially oriented strain gages at each location. The steam dryer loads estimated from the strain gage measurements under the CLTP conditions, using CDI's Acoustic Circuit Model (ACM) of the steam volumes within the MSLs and Reactor Pressure Vessel (RPV), are reported in LR-N06-0286,[3] Attachment 18, CDI Report No. 06-17, "Hydrodynamic Loads on Hope Creek Unit 1 Steam Dryer to 200 Hz," Rev. 2, September 2006.[4]

As discussed in LR-N06-0286, Attachment 7, "Steam Dryer Evaluation," PSEG performed two steam dryer stress analyses using the direct time history analysis capability of the ANSYS code: (1) one presented in CDI Report No. 06-24, "Stress Analysis of the Hope Creek Unit 1 Steam Dryer for CLTP,"[5] based on dryer loads computed with the Bounding Pressure ACM using MSL strain gage measurements from Hope Creek at CLTP conditions; and (2) another presented in CDI Report No. 06-27, "Stress Analysis of the Hope Creek Unit 1 Steam Dryer Using 1/8th Scale Model Pressure Measurement Data,"[6] based on dryer loads estimated by the same ACM model using MSL inputs from an 1/8th Scale Model Test (SMT) at both CLTP and EPU conditions. The stress analyses were performed using 1 percent Rayleigh damping with anchor points at 10 and 150 Hz. The fluctuating pressure loads predicted by the ACM included a strong 80-Hz signal that was not present in the MSL pressure signals. Therefore, it was removed from the pressure loads before they were applied to the steam dryer.

Prior to the MSL strain gage measurements taken at Hope Creek in spring 2006, some strain gages on MSLs C and D failed. Subsequently, PSEG used the data taken for MSLs A and B, which are essentially mirror images of MSLs C and D, respectively, for the failed gages. The stress results in the first analysis, where dryer loads were based on in-plant Hope Creek MSL measurements at CLTP, did not show any stresses that exceeded allowable fatigue limits. This is consistent with the performance of the Hope Creek steam dryer at CLTP conditions.

However, the stress results in the second analysis where the dryer loads were based on SMT MSL measurements at EPU conditions, with the frequencies of the loads shifted by up to ±10 percent (to account for uncertainty in the resonance frequencies of the FE model), predicted stresses on the dryer above the fatigue limit for welds at the top of the steam outlet end plates, a weld at the bottom of the drain channel to skirt, and a weld between the middle hood and its end plates.

During its review of the Hope Creek steam dryer analysis, the NRC staff identified several questions regarding the SMT analysis, in-plant MSL data, ACM, and stress analysis results submitted by PSEG. These questions were discussed during an audit of the Hope Creek steam dryer stress analysis conducted at the CDI office in New Jersey on May 29 to 31, 2007. The

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[3] PSEG Letter (LR-N06-0286) to NRC dated September 18, 2006, "Request for License Amendment Extended Power Uprate, Hope Creek Generating Station Facility, Operating License NPF-57, Docket No. 50-354" ADAMS Accession No. ML06268045
[4] ADAMS Accession No. ML062680460
[5] ADAMS Accession No. ML062680464
[6] ADAMS Accession No. ML062690044

1/8th scale model tests performed by CDI were adequate to reproduce the onset of SRV acoustic resonances that may be present during Hope Creek power ascension from CLTP to EPU conditions, but not for reproducing the amplitudes of the resonances. During the audit, PSEG determined that SMT data would be used only for qualitative assessments of the 118 Hz acoustic resonance frequency and the potential strength of the signal at that frequency, and not for assessing dryer stresses or developing power ascension limit curves.

Regarding in-plant MSL measurements, PSEG stated during the audit that the new 2007 in-plant data obtained at Hope Creek with all MSL strain gages working properly were being used for recomputing the stresses. In LR-N07-0099,[7] Attachment 5, "Steam Dryer Evaluation," Rev. 1, April 2007,[8] PSEG stated that it would double the number of strain gages from four to eight at each of the eight MSL strain gage locations to provide added redundancy to support the EPU power ascension. The additional strain gages were to be placed at 45º spacing from the existing strain gages.

Three primary areas related to the ACM were addressed during the CDI audit: (1) the presence of an 80-Hz fictitious signal; (2) ACM bias errors and uncertainties; and (3) potential singing (acoustic resonance) tones. During the audit, sensitivity studies of the ACM were performed by changing the axial distance between positions of the strain gage locations. The results showed that the 80-Hz peak was not affected by the MSL strain gage locations and was still present. As discussed in LR-N07-0099, Attachment 5, "Steam Dryer Evaluation," Rev. 1, April 2007, PSEG installed a pressure transducer on an instrument line off the top of the reactor vessel head in February 2007 to evaluate the presence of an 80-Hz signal. The data showed that there was an 80-Hz acoustic mode in the RPV steam dome, but that it was relatively small in comparison to other frequency signals. PSEG also confirmed that there was no significant 80-Hz load in the SMT steam dome.

During the May 2007 audit, PSEG informed the NRC staff that it would use a new ACM model developed to predict low frequency pressure loads more accurately. PSEG indicated its intent to revise the frequency-dependent bias and uncertainties for the new ACM using the QC dryer data. PSEG also indicated its intent to compute a worst-case tonal ACM bias and uncertainty based on QC data at 155 Hz (where the ACM underestimates dryer loads), and to apply this bias and uncertainty to any valve singing tone that may appear at Hope Creek during power ascension. With respect to calculating the steam dryer stresses, PSEG indicated its intent to apply the bias errors and uncertainties associated with the ACM, instrumentation and any other sources to the worst stresses calculated by up to ± 10 percent frequency shift. The stresses thus calculated would be used in developing limit curves.

During the audit, PSEG proposed a new frequency-domain approach for performing the stress analysis of the steam dryer. Compared to the traditional transient analysis approach (which uses direct time-history analysis) using Rayleigh damping, the new approach employs harmonic analysis and allows the use of specified damping at each natural frequency. The new approach is not subject to errors associated with transients caused by incorrect initial conditions (as traditional time-domain approaches are). The new approach is capable of prompt computation of the transient response of steam dryer during power ascension.

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[7] PSEG Letter (LR-N07-0099) to NRC dated April 30, 2007, "Response to Request for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML071290559
[8] ADAMS Accession No. ML0712905632

Acoustic Circuit Model

PSEG developed a new acoustic circuit model (ACM Rev. 4) to predict full scale steam dryer loads from in-plant measurements, with the inclusion of a low frequency hydrodynamic contribution. The model is described in LR-N07-0171,[9] Attachment 3, CDI Report 07-09P (Rev. 1), “Methodology to Predict Full Scale Steam Dryer Loads from In-Plant Measurements, with the Inclusion of a Low Frequency Hydrodynamic Contribution” (Proprietary), [10] and is based on the Bounding Pressure Model defined in LR-N06-0286,[11] Attachment 20, CDI Report 05-28P, “Bounding Methodology to Predict Full Scale Steam Dryer Loads from In-Plant Measurements (C.D.I. Proprietary).”[12] The new model improves the prediction of the steam dryer loads at low frequencies up to 60 Hz. **[[**

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The parameters of the new ACM Rev. 4 are “tuned” by means of QC2 in-plant measurements at OLTP (790 megawatts electric [MWe]) because the corresponding Mach number (M=0.105) in QC2 MSLs would be similar to that for Hope Creek at EPU conditions. The MSL strain gage measurements are used to estimate the **[[** **]]**. The predictions of the new version are compared with the pressure measurements on the steam dryer in QC2. The low frequency (≤ 60 Hz) prediction appears to envelop the QC2 measurements at low frequencies. In addition, the new model seems to reduce the bias and uncertainty errors in the frequency range of 40 to 60 Hz (bias from 14 to 0.4 percent and uncertainty from 15 to 7 percent).

In LR-N07-0171, Attachment 3, CDI Report 07-09P (Rev. 1), “Methodology to Predict Full Scale Steam Dryer Loads from In-Plant Measurements, with the Inclusion of a Low Frequency Hydrodynamic Contribution,” PSEG compared the direct measurements and ‘blind’ simulations of the surface pressures on the QC2 dryer (prior to the installation of acoustic side branches (ASBs) at QC) and established the bias errors and uncertainties associated with ACM-generated loads on the dryer. The bias errors and uncertainties of the analysis were found to be frequency-dependent. For example, the bias errors were negative (conservative), or less than **[[ ]]** percent, for all evaluated frequency ranges with the exception of a positive **[[ ]]** percent bias error between 116 and 120 Hz. The uncertainty values extended from **[[ ]]** percent within specific intervals over the evaluated frequency range. PSEG did not take credit for conservative (negative) bias values in the stress results. The large bias error (**[[ ]]** percent) for frequencies between 116 and 120 Hz is based on the ACM’s underestimation of the dryer loads caused by flow-induced acoustic resonances in the SRVs of the QC2 plant at 156 Hz. Because similar errors may occur for other SRV resonances in other plants, PSEG will apply the **[[ ]]** percent bias and **[[ ]]** percent uncertainty to any SRV resonance that may appear in the MSL signals during Hope Creek power ascension.

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9 PSEG Letter (LR-N07-0171) to NRC dated August 3, 2007, “Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate” ADAMS Accession No. ML072250369
10 CDI Report 07-09P (Rev. 1), “Methodology to Predict Full Scale Steam Dryer Loads from In-Plant Measurements, with the Inclusion of a Low Frequency Hydrodynamic Contribution” (Proprietary) ADAMS Accession No. ML072250371
11 PSEG Letter (LR-N06-0286) to NRC dated September 18, 2006, “Request for License Amendment Extended Power Uprate, Hope Creek Generating Station Facility, Operating License NPF-57, Docket No. 50-354” ADAMS Accession No. ML062680451
12 ADAMS Accession No. ML061300484 (Proprietary)

The NRC staff questioned the validation of the ACM Rev. 4 such that it can be reliably used for estimating the pressure loads on the Hope Creek steam dryer. Because additional data from other plants were not available, PSEG was requested to use other available data from QC2 to help support the use of ACM Rev. 4 at Hope Creek. In response, PSEG evaluated the ACM Rev. 4 using QC2 data at a higher Mach number (M = 0.11) and presented the results in LR-N08-0006, Attachment 1. The staff believed that QC2 measurements at lower Mach numbers (M < 0.105) would have been more appropriate to support ACM Rev. 4, because that would correspond to conditions closer to Hope Creek CLTP conditions. However, such measurements were not available to PSEG.

Comparisons between ACM Rev. 4 predictions and the pressure measurements on the dryer at M = 0.11 yielded nearly the same bias and uncertainty errors as those from the initial benchmarking at M = 0.105. Similar to the benchmarking results at M = 0.105, the model predictions bound the plant data at low frequencies, **[[**

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As a result, the NRC staff considers ACM Rev. 4 with the application of bias errors and uncertainties as discussed in this safety evaluation (SE) to be adequate for use in evaluating the Hope Creek steam dryer in support of the proposed EPU license amendment.

<u>Stress Analysis of Steam Dryer</u>

In LR-N07-0171,[13] Attachment 5, CDI Report 07-17P, Rev. 1, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model,"[14] PSEG describes a new, computationally efficient stress analysis approach for calculating the transient stress response of the dryer to plant pressure fluctuations. Rather than using a traditional direct time-history analysis, which requires long computation times and includes the transient solution associated with inaccurate initial conditions (typically zero displacement and velocity), the new approach is based on harmonic analysis. In the new approach, the **[[**

]]. The resulting frequency-based stresses are then inverse-transformed to the time domain. The new stress analysis approach allows for applying specified damping (in terms of percent of the critical modal damping) to each of the natural frequencies of the steam dryer.

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[13] PSEG Letter (LR-N07-0171) to NRC dated August 3, 2007, "Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate" ADAMS Accession No. ML072250369
[14] ADAMS Accession No. ML072250375

PSEG applied 1 percent of the critical damping value to all natural frequencies of the steam dryer, and a weld factor of 1.8 to all fillet weld locations in calculating alternate stress intensities. The acoustic and hydrodynamic loads acting on the steam dryer at CLTP were estimated using ACM Rev. 4 presented in CDI Report No. 07-18P, "Acoustic and Low Frequency Hydrodynamic Loads at CLTP Level On Hope Creek Unit 1 Steam Dryer to 200 Hz."[15] The analysis results presented in Revision 1 of CDI Report 07-17P, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model,"[16] account for the biases and uncertainties in the loads, including those associated with the ACM Rev. 4 model, MSL strain gage measurements and locations, and measurements of pressure sensors that were installed on QC2 dryer. The minimum allowable to calculated stress ratio (SR) was 1.58 at 0 percent frequency shift (maximum stress intensity), and occurs at the junction of the skirt and upper support ring. At this location, the dryer stress field is dominated by the weight-induced static stress field. The smallest alternating stress ratio (SR_a) was 1.86 occurring at the -7.5 percent frequency shift (alternate stress intensity). The dominant stress contributions occur in the 80.0 to 80.2 Hz range. However, there is no evidence of an 80 Hz peak in the MSL pressure measurements. Therefore, PSEG concluded that a significant portion of the 80 Hz signal is nonphysical and filtered 90 percent of this signal from the pressure loads. As a result, the minimum stress ratio increased to SR=1.66, and the minimum alternating stress ratio increased to SR_a = 3.58. The operating history of the Hope Creek steam dryer does not reveal fatigue cracking of the dryer, which is consistent with the low alternating stress intensities (<13,600 psi) predicted by the frequency-domain approach for the dryer operating at CLTP.

The NRC staff identified five areas where additional information was requested related to the FE stress analysis results presented in CDI Report 07-17P, Rev. 1: (1) verification of frequency-domain approach; (2) underestimation associated with frequency discretization; (3) FE mesh convergence; (4) peak frequency response function amplitudes; and (5) filtering of the 80 Hz signal. The resolution of these items is discussed below:

<u>Verification of Frequency-Domain Approach</u>: The stress analysis of the Hope Creek steam dryer represents the first application of the frequency-domain approach. The NRC staff requested a comprehensive evaluation of the approach to ensure the reliable prediction of dryer stresses. In LR-N07-0298,[17] Attachment 1, as a response to RAI 14.110, PSEG evaluated the new frequency-domain approach by comparing its stress results for the following two cases with the corresponding transient analysis results performed with 1 percent Rayleigh damping:

(1) Use of actual damping at each natural frequency of the steam dryer model as specified by 1 percent Rayleigh damping; and

(2) A constant 1 percent of the critical damping for all the frequencies.

PSEG provides a thorough analysis of dryer response to plant pressure fluctuations at frequencies between 100 and 150 Hz using the new frequency-domain approach and the traditional direct time-history analysis approach. Both constant and Rayleigh damping are evaluated. For the direct time-history analysis calculations, initial conditions of zero motion

[15] ADAMS Accession No. ML072250373
[16] ADAMS Accession No. ML072250375
[17] PSEG Letter (LR-N07-0298), to NRC dated November 30, 2007, "Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate" ADAMS Accession No. ML073460793

along with estimated motion based on the harmonic analysis results were considered.

The analyses results show that the new frequency-domain approach is well formulated, and correctly implemented in CDI's computer analysis. The harmonic and direct time-history analysis results for stresses are nearly identical for consistent damping and using initial conditions based on harmonic analysis results. The effects of Rayleigh damping are as expected, with levels increasing for frequencies where the Rayleigh damping is lower than the constant 1 percent of the critical damping.

Underestimation Associated with Frequency Discretization: Although PSEG employs a fine frequency discretization while using the frequency-domain approach for FE stress analysis, an underestimation is associated with not completely resolving peaks in the stress spectra. In LR-N08-0006,[18] Attachment 1, "Response to Request for Additional Information,"[19] PSEG states that the frequency-domain approach can introduce a frequency discretization error of **[[ ]]** percent as the worst-case error and provides analytical justification showing that the average bias error due to the use of the discrete frequency schedule is **[[ ]]** percent. PSEG included this average bias error in the end-to-end bias error and uncertainty in estimating the steam dryer stresses under CLTP conditions.

Finite Element Mesh Convergence: The NRC staff requested PSEG to provide pertinent parametric evaluations related to FE mesh convergence in high strain and stress regions in the Hope Creek steam dryer to assess whether the mesh dimensions and spacing used for the model are adequate. In LR-N07-0298,[20] Attachment 1 (Proprietary), as a response to RAI 14.79, PSEG provided a thorough analysis of the stress convergence properties of a section of the Hope Creek dryer model (comprising the middle hood with two hood supports, side plate, cover plates and closure plate) loaded with pressures computed from Hope Creek MSL inputs to the ACM. Static analysis (with gravitational loads) results show that the mesh sizing used for the full steam dryer calculation provides converged stresses and, therefore, there are no bias errors or uncertainties for static stress analysis. Dynamic analyses performed at three representative frequencies show that the FE model used to analyze the Hope Creek dryer stresses might underestimate stresses by **[[ ]]** percent. One exception involves "hot spots" such as near the reentrant corner created by welding of the top of the closure plate to the hood where modeling stresses cannot converge. For such locations, the peak stresses at the welds are estimated by evaluating the stresses away from the welds (i.e., the nominal stresses, which will be accurately converged) and multiplying them by the weld factor. PSEG took a conservative approach of using the nominal stresses at the welds, which are somewhat higher than those away from the welds, and multiplying them by appropriate weld factors.

In LR-N08-0028,[21] Attachment 1, "Responses to Requests for Additional Information,"[22] PSEG evaluates the displacement convergence properties for dynamic analysis of the same section of the Hope Creek steam dryer that was used for the stress convergence studies. PSEG estimates a **[[ ]]** percent bias error associated with displacement convergence. As a result,

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[18] PSEG Letter (LR-N08-0006) to NRC dated January 15, 2008, "Response to Request for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML080250029
[19] ADAMS Accession No. ML080360470 (Proprietary)
[20] PSEG Letter (LR-N07-0298) to NRC dated November 30, 2007, "Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate" ADAMS Accession No. ML073460793
[21] PSEG Letter (LR-N08-0028) to NRC dated January 25, 2008, "Responses to Requests for Additional Information - Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML080360467
[22] ADAMS Accession No. ML080360470

the bias error associated with stress convergence in dynamic analysis is **[[ ]]** percent **[[ ]]**.

Peak Frequency Response Function Amplitudes: The ±10 percent shifting in the frequency of the Hope Creek steam dryer loading accounts for uncertainty and bias in the FE model resonance frequencies, but not for errors in the mean and peak frequency response amplitudes. These errors are due to uncertainty or bias in plate dimensions, boundary conditions (joints between plates and other members), pre-stresses within members and the welds, and friction between internal vanes and other components. The NRC staff requested PSEG to estimate these errors.

In its response, PSEG described the vibration response tests that were performed on the Hope Creek Unit 2 (HC2) steam dryer in LR-N07-0330,[23] Attachment 3, "Hope Creek Steam Dryer Vibration Test Report – STI Technologies, Inc. Technical Report #PA2168, Revision 1."[24] The HC2 dryer, originally constructed for the unfinished Unit 2, was suspended from straps and driven with a shaker at eight locations spanning the upper and lower support rings and upper tie bars. The dryer was tested indoors in ambient air conditions. For each shaker drive location, up to 20 accelerometers were attached to the dryer to measure acceleration at peak response locations over frequencies between 10 and 250 Hz. Each accelerometer was calibrated according to the National Institute of Science and Technology measurement standards.

In LR-N07-0330, Attachment 2, "CDI Report 07-27P, Finite Element Modeling Bias and Uncertainty Estimates Derived From the Hope Creek Unit 2 Dryer Shaker Test,"[25] PSEG discussed the development of an FE model to simulate the tested HC2 dryer, and utilized the results to identify the peak response locations. Accelerometers were installed at these locations on the HC2 dryer. For each drive location, the shaker was driven with slowly varying frequency (a sine sweep), and peak frequencies were identified. The dryer response at the peak frequencies was measured by applying constant frequency input to the shaker.

In CDI Report 07-27P, "Finite Element Modeling Bias and Uncertainty Estimates Derived From the Hope Creek Unit 2 Dryer Shaker Test," PSEG states that the HC2 dryer, when suspended in air, had small loss factors of about **[[ ]]** percent (leading to many more visible resonant peaks in the measurements than those occurring in the original FE model, which was analyzed with 1 percent damping). Therefore, PSEG developed a procedure that allowed it to compare measurements and simulations in a reasonable timeframe.

Rather than solving for the dryer acceleration response using direct analysis methods, PSEG employed a modal analysis method. However, it did not use all the modes between 0 and 300 Hz in its evaluation. Instead, PSEG used modes with resonance frequencies **[[ ]]** percent below and above the frequency of interest, and accounted for the effects of the remaining lower and higher frequency modes with a correction algorithm. Comparison of vibration results obtained using the direct and modal analyses methods, documented in CDI Report 07-27P, confirmed the accuracy of the more efficient modal analysis method.

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[23] PSEG Letter (LR-N07-0330) to NRC dated December 31, 2007, "Response to Request for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML080080579

[24] ADAMS Accession No. ML080080584

[25] CDI Report No. 07-27P, Revision 0 – "Finite Element Modeling Bias and Uncertainty Estimates Derived From the Hope Creek Unit 2 Dryer Shaker Test" ADAMS Accession No. ML080090109

In LR-N08-0033[26], Attachment 3, CDI Report 07-17P, Rev. 4, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model,"[27] PSEG calculates the bias error and uncertainty of the FE stress model by comparing the dynamic simulations of 342 Frequency Response Functions (FRFs) with those measured on the HC2 steam dryer with accelerometers and shakers. The mean damping of the modes measured in the test (**[[ ]]** percent) and documented in Attachment 1, "Response to Request for Additional Information"[28] to LR-N08-0028,[29] was applied to the FE model and the peak simulated and measured responses at frequencies up to 250 Hz were compared. No bias errors were found in the FE model, but an uncertainty of **[[ ]]** percent was computed.

Filtering of 80 Hz Signal: The ACM computes a pressure load at 80 Hz acting on the Hope Creek steam dryer. However, there is no evidence of an 80 Hz peak in the MSL pressure measurements. CDI has identified a large-scale, very weakly damped 'sloshing' mode in their acoustic model for the steam dome as the source of the peak. The mode is excited by any signal (even background white noise) in the MSLs, and is the cause of nearly all of the dryer stresses computed using the ACM and FE model. In LR-N08-0033, Attachment 3, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model," PSEG justifies the filtering of the 80-Hz pressure load. Because there is strong evidence that the 80-Hz load is not real, PSEG took MSL strain gage data at the completion of the most recent refueling outage, with reactor pressure at 920 psig and with minimal steam flow (5-8 percent), and established a 'background noise' level for the ACM loads in the range of 80 ± 5 Hz. The background levels are subtracted from the loads computed at normal CLTP conditions between 75 and 85 Hz, removing about 50 percent of the 80-Hz loading. The NRC staff has reviewed the approach and data, and finds PSEG's assessment and reduction of dryer stresses near the fictitious loading frequencies to be acceptable for the Hope Creek EPU license amendment.

End-to-End Bias Errors and Uncertainties

In LR-N08-0033, Attachment 3, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model," PSEG summarizes all the bias errors and uncertainties to be applied to determine the stress ratios at CLTP. These errors included ACM errors, which are discussed above in this SE. The sources of other bias errors and uncertainties, and their values, include:
(1) **[[**

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[26] PSEG Letter (LR-N08-0033) to NRC dated January 30, 2008, "Responses to Requests for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML080420468
[27] CDI Report 07-17P, Rev. 4, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model" ADAMS Accession No. ML080420472 (Proprietary)
[28] ADAMS Accession No. ML080360470 (Proprietary)
[29] PSEG Letter (LR-N08-0028) to NRC dated January 25, 2008, "Responses to Requests for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML080360467

PSEG asserted that the **[[ ]]** percent uncertainty associated with the shaker tests represents the uncertainty in displacement estimates and, therefore, subsumes the corresponding **[[ ]]** percent bias error resulting from mesh discretization. However, the staff did not agree with PSEG because an uncertainty in displacement calculations cannot subsume a bias error in those calculations. However, this was resolved as discussed below.

PSEG estimates the Hope Creek steam dryer stresses taking into account the end-to-end bias errors and uncertainties (excluding the bias error of **[[ ]]** percent associated with displacement convergence). As discussed, about 50 percent of the 80-Hz load is used in estimating these stresses. The resulting lowest stress ratio at CLTP is 1.63 and is mainly due to dead weight. The resulting lowest alternating stress ratio on the Hope Creek steam dryer is 3.22 and occurs at +7.5 percent-frequency shift.

The lowest alternating stress ratio decreases to 3.10 when the bias error of 3.8 percent associated with displacement convergence is included in the end-to-end bias errors and uncertainties.

<u>Extended Power Uprate Stress Ratios</u>

In LR-N08-0033, Attachment 3, CDI Report No.07-17P, Rev.4, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model,"[30] PSEG estimates the stress ratios under EPU conditions by scaling the CLTP dryer loads to EPU conditions. PSEG employs the pressure test data at CLTP and EPU conditions during the 1/8th scale model test as reported in LR-N07-0122,[31] Attachment 1, "EPU Conditions in the Main Steam Lines at Hope Creek Unit 1:Additional Subscale Four Line Tests - C.D.I. Technical Note No. 07-01."[32] The 1/8th-scale model tests show that a flow-induced resonance in one of the MSL SRVs might occur at EPU conditions. The resonance is not expected to be strong, however, and would be much weaker than those that occurred at QC Units 1 and 2 prior to the installation of ASBs in those units. As shown in Figure 24 of CDI Report No. 07-17P, Rev.4, **[[**

]]. As a result, the minimum stress ratio at EPU is 1.58 and the minimum alternating stress ratio is 2.18 at -7.5 percent frequency shift. The minimum alternating stress ratio decreases to 2.10 to account for the bias error associated with the displacement results as determined from the mesh discretization studies. These stress ratios at EPU show sufficient margin to support the Hope Creek steam dryer for EPU operation. In addition, the comparison between the Hope Creek and QC Unit 2 steam dryer loads at EPU conditions reported in LR-N06-0418,[33] Attachment 1,[34] shows that Hope Creek is a much quieter plant with respect to acoustic resonance, which provides further assurance regarding the integrity of the steam dryer for EPU operation.

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[30] CDI Report 07-17P, Rev. 4, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model" ADAMS Accession No. ML080420472 (Proprietary)
[31] PSEG Letter (LR-07-0122) to NRC dated May 24, 2007, "Supplement to Request for License Amendment - Extended Power Uprate" ADAMS Accession No. ML071630305
[32] ADAMS Accession No. ML071630309 (Proprietary)
[33] PSEG Letter (LR-N06-0418) to NRC dated October 20, 2006, "Supplement to License Amendment Request for Extended Power Uprate" ADAMS Accession No. ML063110164
[34] CDI Technical Memo 06-23P (Proprietary) "Comparison of the Hope Creek and Quad Cities Steam Dryer Loads at EPU Conditions," Revision 0, dated September 2006 ADAMS Accession No. ML063110198

Limit curves

In LR-N07-0171[35], Attachment 6, CDI Technical Note No. 07-29P,[36] PSEG provides the limit curves for Hope Creek EPU power ascension. PSEG has changed its approach for developing the limit curves, but the curves are similar to those developed for Vermont Yankee. The highest alternating stress computed for the Hope Creek steam dryer including the consideration for frequency shift are reported in Attachment 5, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model, (Rev. 1)"[37] to LR-N07-0171. This stress is combined with frequency-dependent bias errors and uncertainties associated with Rev. 4 of the ACM, along with uncertainties associated with the MSL pressure measurements, to compute a minimum (most conservative) alternating stress ratio of 1.86. The square of this stress ratio is multiplied by the existing MSL power spectra at CLTP conditions to generate limit curves for each MSL measurement location. Two sets of curves are generated – one for the ASME Code limit of 13,600 psi, and another for 80 percent of the ASME Code limit. Prior to generating the limit curves, the applicant removed tones at multiples of 60 Hz, and vane passing frequencies at 105 and 106.7 Hz associated with the A and B recirculation pumps (these frequencies do not load the dryer by transmission through acoustic paths).

In LR-N08-0033,[38] Attachment 3, CDI Report No.07-17P, Rev.4, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model," PSEG submitted a revised stress analysis of its dryer, which included additional bias errors and uncertainties associated with the FE model, mesh convergence and frequency resolution. In addition, PSEG has removed about 50 percent of the 80 Hz signal, which represents fictitious loading, from the MSL pressure measurements. The resulting minimum alternating stress ratio is somewhat smaller than 3.22 but greater than the 1.86 ratio mentioned above. Therefore, the limit curves associated with the 1.86 ratio and submitted in LR-N07-0171, Attachment 6, CDI Technical Note No. 07-29P, are bounded by the curves for the final minimum alternating stress ratio at CLTP, and, therefore, are acceptable. Updated limit curves will be provided in accordance with an EPU license condition.

A.2.2 Steam, Feedwater, and Condensate Systems and Components

In Attachment 8, "Flow Induced Vibration," to LR-N06-0286,[39] PSEG provided information regarding its susceptibility review of plant system piping and components that might be affected adversely by flow induced vibration (FIV) under EPU conditions at Hope Creek. The systems that will experience a significant increase in flow during EPU operation are the main steam, FW, extraction steam, moisture separator and FW heater drain lines, and condensate systems. The components that were considered susceptible to FIV in the affected systems include small bore branch line connections and fittings to main headers, main header cantilevered components (e.g., relief valves), rigid connections between a vibrating component and its electrical or pneumatic service (e.g., air lines to air-operated valves), valves and components mounted on vibrating lines, in-line components with flow around or through them, and condensate and FW

[35] PSEG Letter (LR-N07-0171) to NRC dated August 3, 2007, "Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate" ADAMS Accession No. ML072250369
[36] C.D.I. Technical Note No. 07-29P, Revision 0, "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Hope Creek Unit 1," August 2007 ADAMS Accession No. ML0722503770 (Proprietary)
[37] C.D.I. Report 07-17P, Revision 1, "Stress Assessment of Hope Creek Unit 1 Steam Dryer Based on Revision 4 Loads Model" ADAMS Accession No. ML072250375 (Proprietary)
[38] PSEG Letter (LR-N08-0033) to NRC dated January 30, 2008, "Responses to Requests for Additional Information, Request for License Amendment, Extended Power Uprate" ADAMS Accession No. ML080420468
[39] PSEG Letter (LR-N06-0286) to NRC dated September 18, 2006, "Request for License Amendment Extended Power Uprate, Hope Creek Generating Station Facility, Operating License NPF-57, Docket No. 50-354" ADAMS Accession No. ML062680451

pumps. To select components potentially susceptible to FIV damage, PSEG used industry reports of nuclear power plant operating experience, interviews with Hope Creek plant personnel, and walkdowns and drawing reviews of plant systems.

PSEG applied ASME Operation and Maintenance Standards and Guides OM-S/G-1994 Part 3, “Requirements for Preoperational and Initial Start-up Vibration Testing of Nuclear Power Plant Piping System,” in establishing its vibration monitoring program at Hope Creek. Accelerometer instrumentation was installed on the main steam, FW, and recirculation piping inside the drywell and MS and FW piping inside the steam tunnel during the refueling outage in October 2004. Steady state vibration levels for these piping systems were collected during plant operation.

Results of the vibration monitoring program indicated MS and FW piping vibration levels below 0.1 g-rms. None of the MS piping indicated a frequency spike due to dead leg acoustic resonance at 100 percent CLTP. Scale model testing predicted an SRV acoustic resonance at EPU conditions at a frequency of 118 Hz. PSEG is installing instrumentation on the SRV pilot valve assemblies to verify that no significant vibration occurs at EPU conditions.

In response to RAI 14.37 in LR-N07-0099,[40] PSEG provided the results of analyses that were completed following the submittal of their original application dated September 18, 2006. For example, modifications to MS small bore connections were scheduled to improve their vibration resistance. Detailed discussions of the piping vibration evaluations are provided in response to RAIs 14.40 and 14.51 in LR-N07-0099. As discussed in response to RAI 14.48 in LR-N07-0099, thermowells and sample probes do not require modifications to support EPU operation.

In response to RAI 14.39 in LR-N07-0099, PSEG provided additional information on its vibration monitoring program. In addition to the accelerometer locations indicated in Attachment 8 to LR-N06-0286, PSEG will install accelerometers on four SRVs to monitor vibration during power ascension. In response to RAI 14.74 in LR-N07-0171,[41] PSEG reported that an FE model of the SRVs was underway to allow calculating vibration limits for these valves. As discussed in response to RAI 14.82 in LR-N07-0171, the Hope Creek MS SRVs are Target Rock two-stage pilot operated valves with the pilot valve connected more rigidly than the relief valves that were damaged during EPU operation at the QC units. In response to RAI 14.74 in LR-N07-0266 (dated October 10, 2007), PSEG provided additional details on the completion of the SRV FE model. Following installation of the SRV accelerometers in October 2007, SRV vibration baseline data at CLTP conditions were evaluated. In its response to RAI 14.74, PSEG proposed the following license condition regarding vibration acceptance criteria for the SRVs:

> PSEG Nuclear LLC shall provide the Level 1 main steam safety relief valve vibration acceptance criteria to the NRC by facsimile or electronic transmission to the NRC project manager prior to increasing power above 3339 MWt.

The vibration data collected to date at Hope Creek indicate that the vibration levels should not exceed applicable stress limits during EPU operation. PSEG is incorporating the results of its evaluations of vibration data into the Power Ascension Test Plan for Hope Creek.

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[40] PSEG Letter (LR-N07-0099) to NRC dated April 30, 2007, “Response to Request for Additional Information, Request for License Amendment * Extended Power Uprate.” ADAMS Accession No. ML071290559

[41] PSEG Letter (LR-N07-0171) to NRC dated August 3, 2007, “Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate” ADAMS Accession No. ML072250369

The NRC staff finds that the vibration monitoring program for the steam, FW, and condensate systems, and their components, at Hope Creek is consistent with the successful approach recently implemented at other nuclear power plants in support of EPU power ascension. The staff considers that PSEG has applied lessons learned from EPU operating experience at other nuclear power plants in developing the vibration monitoring program at Hope Creek. Therefore, the staff finds the Hope Creek vibration monitoring program with the license condition discussed in this SE to be acceptable. The NRC staff will monitor the licensee's actions during power ascension to confirm that allowable vibration levels are not exceeded.

A.2.3 Power Ascension Test Plan

In Attachment 23, "Power Ascension Test Plan Overview" to the Licensee's application, PSEG provided an overview of the Hope Creek EPU Power Ascension Test Plan (PATP). The three main elements of the PATP are: (1) a slow and deliberate power ascension with defined hold points and durations, allowing time for monitoring and analysis; (2) a detailed power ascension monitoring and analysis program to trend steam dryer and piping system performance; and (3) a long term inspection program to verify steam dryer and piping system performance at EPU conditions. Relevant data and evaluations will be transmitted to the NRC staff during the power ascension. In preparation for power ascension, PSEG will prepare an "Infrequently Performed Test Evolution" (IPTE) document for implementation of the actual power ascension testing evolutions.

For EPU power ascension, PSEG will prepare the EPU startup test procedure to include: (a) stress limit curves to be applied for evaluating steam dryer performance; (b) specific hold points and their duration during EPU power ascension; (c) activities to be accomplished during hold points; (d) plant parameters to be monitored; (e) inspections and walkdowns to be conducted for steam, FW, and condensate systems and components during the hold points; (f) methods to be used to trend plant parameters; (g) acceptance criteria for monitoring and trending plant parameters, and conducting the walkdowns and inspections; (h) actions to be taken if acceptance criteria are not satisfied; and (i) verification of the completion of commitments and planned actions specified in its application and all supplements to the application in support of the EPU license amendment request pertaining to the steam dryer prior to power increase above 3339 MWt. PSEG will submit the flow-induced vibration related portions of the EPU startup test procedure to the NRC, including the methodology for updating the limit curves, prior to initial power ascension above 3339 MWt.

The Hope Creek PATP will provide for power ascension monitoring and analysis to trend steam dryer and critical piping system performance. Under the PATP, power will be increased at a rate of about 1 percent CLTP per hour. Steam line strain gage and accelerometer vibration data will be collected hourly during power ascension. At every 2.5 percent CLTP step, MSL strain gage and accelerometer data, and moisture carryover data, will be evaluated against acceptance criteria. At every 5 percent CLTP plateau, the data will be evaluated against the acceptance criteria, plant walkdowns will be conducted, and information will be forwarded to the NRC. The stress and moisture carryover criteria will have two threshold action levels, where Level 1 requires that power be reduced to a previous acceptable level and Level 2 requires that power be held at that level with a re-evaluation of the data.

Upon completion of the IPTE, PSEG will prepare a report on the performance of the steam dryer and plant systems during the EPU power ascension. The report will include evaluations or corrective actions that were required to obtain satisfactory steam dryer performance. The report will also include relevant data collected at each power step, comparisons to performance criteria (design predictions), and evaluations performed in conjunction with steam dryer structural integrity monitoring. PSEG will forward this report to the NRC.

In response to an NRC staff request, PSEG provided the specific Hope Creek EPU Implementation and Power Ascension Test Plan in Attachment 8[42] to LR-N07-0099.[43] Phase I includes preparation of the Test Plan and procedures, and selection of the test organization. Phase II includes instrument set point changes, pre-outage activities, and implementation of major modifications. Phase III consists of two major phases: startup to CLTP (3,339 MWt), and power ascension from CLTP to the final Target Uprate Power (TPU) of 3,723 MWt (111.5 percent CLTP). Phase IV includes periodic monitoring of moisture carryover, on-going system monitoring activities, and steam dryer and other reactor internals inspections. In addition to monitoring routine operating performance parameters, PSEG will conduct detailed monitoring and analyses to trend the performance of the steam dryer and system piping through MSL strain gages, piping accelerometers, and moisture carryover evaluations.

In response to several RAIs, PSEG provided information in LR-N07-0171[44] on the limit curves for monitoring the MSL strain gage data during the Hope Creek power ascension. In Attachment 6 to LR-N07-0171, PSEG submitted CDI Technical Note No. 07-29P, "Limit Curve Analysis with ACM Rev. 4 for Power Ascension at Hope Creek Unit 1,"[45] which discusses the development of Level 1 and Level 2 limit curves for the Hope Creek power ascension. The Level 1 limit curve was based on maintaining the ASME allowable alternating stress value on the dryer. The Level 2 limit curve was based on maintaining 80 percent of the allowable alternating stress value on the dryer. NRC staff review of this information reveals that the limit curves do not allow significant resonance peaks in the Hope Creek MSLs to occur before reaching the limit curve values.

In RAI 14-103, the NRC staff noted that Attachment 8, "Power Ascension Test Plan," to LR-N07-0099 discussed the Hope Creek PATP and requested that PSEG provide proposed license conditions and commitments regarding potential adverse flow effects for power ascension. The staff suggested that PSEG review the license conditions imposed in the EPU license amendment for the Vermont Yankee nuclear power plant issued on March 2, 2006. In LR-N07-0171, PSEG submitted proposed license conditions that would provide monitoring of plant performance, evaluating plant data, and taking prompt action in response to potential adverse flow effects from EPU operation on plant structures, systems, and components.

As license conditions during EPU power ascension of Hope Creek, PSEG will monitor hourly the MSL strain gage data during power ascension above 3339 MWt for increasing pressure fluctuations in the steam lines. PSEG will hold the facility for 24 hours at 105 percent and 110 percent of 3339 MWt to collect data from the MSL strain gages, conduct plant inspections and walkdowns, and evaluate steam dryer performance based on these data. PSEG will provide the

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[42] "Power Ascension Test Plan" ADAMS Accession No. ML071290574

[43] PSEG Letter (LR-N07-0099) to NRC dated April 30, 2007, "Response to Request for Additional Information, Request for License Amendment * Extended Power Uprate" ADAMS Accession No. ML071290559

[44] PSEG Letter (LR-N07-0171) to NRC dated August 3, 2007, "Response to Request for Additional Information, Request For License Amendment, Extended Power Uprate" ADAMS Accession No. ML072250369

[45] ADAMS Accession No. ML0722503770 (Proprietary)

evaluation to the NRC staff upon completion of the evaluation; and will not increase power above each hold point until 96 hours after the NRC confirms receipt of the evaluation.

If any frequency peak from the MSL strain gage data exceeds a Level 1 limit curve, PSEG will return the facility to a lower power level at which the limit curve is not exceeded. PSEG will resolve the uncertainties in the steam dryer analysis, evaluate the continued structural integrity of the steam dryer, and provide that evaluation to the NRC staff. PSEG will obtain NRC approval of that evaluation prior to further increases in reactor power. In the event that acoustic signals are identified that challenge the limit curves during power ascension, PSEG will evaluate dryer loads and re-establish the limit curves based on the new strain gage data, and perform a frequency-specific assessment of ACM uncertainty at the acoustic signal frequency including application of 65 percent bias error and 10 percent uncertainty to all the SRV acoustic resonances.

PSEG will monitor RPV water level instrumentation and MSL piping accelerometers on an hourly basis during power ascension above 3339 MWt. If resonance frequencies are identified as increasing above nominal levels in proportion to strain gage instrumentation data, PSEG will stop power ascension, evaluate the continued structural integrity of the steam dryer, and provide that evaluation to the NRC staff.

After reaching 111.5 percent and 115 percent of 3339 MWt, PSEG will obtain measurements from the MSL strain gages and establish the steam dryer flow-induced vibration load fatigue margin for the facility, update the dryer stress report, and re-establish the limit curves with the updated ACM load definition, which will be provided to the NRC staff. If an engineering evaluation is required because a Level 1 acceptance criterion is exceeded, PSEG will perform the structural analysis to address frequency uncertainties up to ±10 percent and assure that peak responses that fall within this uncertainty band are addressed.

PSEG will submit a report with the results of the Hope Creek PATP following completion of the power ascension. As part of the post EPU monitoring program, PSEG will monitor plant parameters indicative of degradation of the steam dryer or plant systems during EPU operation. For example, moisture carryover will be monitored with the results reviewed and evaluated. As MSL strain gages and accelerometers remain operable, data collection may be performed during the remainder of the operating cycle following EPU implementation. Steam dryer inspections and monitoring of plant parameters potentially indicative of steam dryer failure will be conducted as recommended in General Electric Service Information Letter 644, “BWR Steam Dryer Integrity,” and Electric Power Research Institute (EPRI) Technical Report 1011463, “BWR Vessel and Internals Project, Steam Dryer Inspection and Flaw Evaluation Guidelines (BWRVIP-139).” The results of the visual inspections of the steam dryer will be reported to the NRC staff within 90 days following startup from the respective refueling outage.

The NRC staff has reviewed the Hope Creek PATP for its ability to provide a slow and deliberate power ascension that allows for monitoring of plant data, evaluating steam dryer and system performance, and taking corrective action in the event that plant data reveal such action is appropriate. Further, the staff compared the proposed license conditions for Hope Creek with those applied to the Vermont Yankee power ascension. The staff finds that the Hope Creek PATP and the applicable license conditions provide an acceptable power ascension process that is consistent with the successful approach employed at Vermont Yankee. The staff has included the license conditions proposed by PSEG with minor adjustments in this SE.

A.3 Conclusion

The NRC staff has reviewed the licensee's evaluations of potential adverse flow effects on the MS, FW, and condensate systems and their components (including the steam dryer) for the operation of Hope Creek at EPU conditions. The staff concludes that the licensee has provided reasonable assurance that the flow-induced effects on the steam dryer and other plant equipment are within the structural limits at CLTP conditions and extrapolated EPU conditions. The staff further concludes that the licensee has demonstrated that the MS, FW, and condensate systems and their components (including the steam dryer) will continue to meet the requirements of GDC 1, 2, 40, and 42 following implementation of the proposed EPU at Hope Creek, subject to the license conditions in this SE. Therefore, the NRC staff concludes that the proposed license amendment to operate Hope Creek at EPU conditions is acceptable with respect to potential adverse flow effects.

A.4 EPU License Conditions on Potential Adverse Flow Effects

See Section 3.3.3.