Enclosure 2 to PLA-6237

GE-Hitachi Nuclear Energy Americas LLC Report # GE-NE-0000-0061-0595-NP-R1

Susquehanna Replacement Steam Dryer Fatigue Analysis

June 2006

(Non-Proprietary)

GE-Hitachi Nuclear Energy Nuclear Americas

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6705 Vallecitos Road, Sunol CA 94586

Non Proprietary Version

GE-NE-0000-0061-0595-NP-R1
DRF 0000-0061-0582
Class I
June 2007

Engineering Report

Susquehanna Replacement Steam Dryer Fatigue Analysis

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REVISION SUMMARY

Rev	Required Changes to Achieve Revision	
0	None	
1	Section 1	Updated Executive Summary to indicate this revision update purpose.
	Section 2	Expanded discussion on background history
	Section 4.1	Added plate mismatch weld factors to criteria discussion
	Section 6.2	Added discussion describing relationship between Maximum and Nominal stresses and structural uncertainty. Moved table 6.1 to section 6.3.
	Section 6.3	Section replaced with new section. Table 6.1 updated to include information from R0 Table 7.1 for closer reviews of component stresses. Added columns for inclusion of weld factors and resulting stress using weld factors for nominal and maximum stresses
	Section 6.3.1	Renumbered to section 6.5 and expanded discussion for stress evaluation in the dryer skirt
	Section 6.3.2	Renumbered section to 6.4 and expanded section to include Outer Vane Bank End Plates
	Section 7	Paragraph removed and table 7.1 deleted
	Section 7.1	Added new section
	Section 7.2	Added new section
	Sections 7.2.1 through 7.2.7	Added new sections
	Section 8.2	Tables 8.2 and 8.3 updated
	Section 9	Updated conclusions
	Figure 5-14	Revised to show correct constraint locations (lugs)
	Figures 6-2 to 6-21	Revised to show revised analysis results
	Figure 6-22	Added new Figure
	Figures 6-23 and 6-24	Renumbered, previously Figures 6-27 and 6-28 respectively
	Figures 6-25 and 6-26	Added new Figure
	Figures 6-27	Renumbered, previously Figures 6-22 and 6-23 respectively
	Figures 6-32 and 6-33	Added new Figure
	Figures 7-1 to 7-8	Added new Figure

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ACRONYMS AND ABBREVIATIONS

Item	Short Form	Description
1	ACM	Acoustic Circuit Model
2	ASME	American Society of Mechanical Engineers
3	BWR	Boiling Water Reactor
4	CLTP	Currently Licensed Thermal Power
5	EPU	Extended Power Uprate
6	FEA	Finite Element Analysis
7	FEM	Finite Element Model
8	FFT	Fast Fourier Transform
9	FIV	Flow Induced Vibration
10	GE	General Electric
11	GENE	General Electric Nuclear Energy
12	Hz	Hertz
13	IGSCC	Intergranular Stress Corrosion Cracking
14	Mlbm/hr	Millions pounds mass per hour
15	MS	Main Steam
16	MSL	Main Steam Line
17	MW_t	Megawatt Thermal
18	NA	Not Applicable
19	NRC	Nuclear Regulatory Commission
20	OBE	Operational Basis Earthquake
21	OLTP	Original Licensed Thermal Power
22	Pb	Primary Bending Stress
23	Pm	Primary Membrane Stress
24	PPL	Pennsylvania Power & Light
25	PSD	Power Spectral Density
26	psi	Pounds per square inch
27	Ref.	Reference
28	RMS	Root-Mean-Squared
29	RPV	Reactor Pressure Vessel
30	SCF	Stress Concentration Factor
31	SRSS	Square Root Sum of Squares
32	SRV	Safety Relief Valve
33	SSES	Susquehanna Steam Electric Station

1. EXECUTIVE SUMMARY

This report documents the finite element stress analyses of the proposed replacement steam dryer for the Susquehanna Steam Electric Station (SSES). The focus of these analyses is to predict the replacement dryer's susceptibility to fatigue under flow induced vibration (FIV) and mechanically induced vibration loads during normal operation at Extended Power Uprate (EPU) power levels. A detailed finite element model (FEM) is used to perform the structural dynamic analyses. The results of these analyses are used to assess dryer component stresses versus fatigue and ASME design criteria under the operating conditions. This report revision has been updated to show the effects of applying the boundary condition at the correct mounting lug locations.

The fatigue evaluations are performed at steam flow closely matching 113% of the Original Licensed Thermal Power (OLTP) flow conditions. The applied pressure loads were developed by Continuum Dynamics, Inc. (CDI) based on in-plant steam line pressure measurements taken during the spring of 2006. The 113% OLTP analysis is used as the basis for extrapolating the dryer stress to full EPU conditions by using the benchmark study and scaling law previously developed for Susquehanna dryer.

The fatigue evaluation indicates that at full EPU conditions, all dryer components meet the fatigue acceptance criteria with adequate or high margins. The ASME load combination analysis results indicate that the stresses for all structural components are under the allowable ASME Code limits at EPU operating conditions.

Therefore, the fatigue evaluation and ASME load combination analysis demonstrates the acceptability of the Susquehanna replacement steam dryer design at EPU operating conditions.

2. INTRODUCTION AND BACKGROUND

The original Susquehanna steam dryer's structural responses were analyzed for component fatigue evaluation at Extended Power Uprate (EPU) conditions [Reference 1]. The analyses used the steam dryer's finite element model to calculate its transient dynamic responses. The pressure loads used in the analyses were developed by Continuum Dynamics, Inc. (CDI) based on in-plant steam line pressure measurements taken at various power levels during the spring of 2006, which included the Original Licensed Thermal Power (OLTP), the Current Licensed Thermal Power (CLTP), and the 113% OLTP. In addition to these provided nominal loads, the time scale of the loads was stretched by plus and minus 10% respectively to create frequency shift in loads, in order to capture structural uncertainty. In all these transient response analyses, Rayleigh damping equivalent to 1% damping ratio was applied. The maximum stresses of dryer components were searched from all the solutions over the calculated response time histories. Based on a benchmarking analysis of 1985 strain gauge data, a scaling factor was applied to these stresses to include both flow and mechanically induced vibration. Subsequently, a scale factor is then used to extrapolate the stress results of 113% OLTP to EPU conditions, and the resulting stress values were used for component fatigue evaluation.

The results of the analyses on the original Susquehanna dryer indicate that the several dryer components were susceptible for fatigue failure under EPU operating condition. After a comprehensive review of alternative dryer modifications and a review of the operational history of previous dryer modifications, a replacement dryer configuration was proposed to sustain the vibration environment at EPU condition. This replacement dryer concept [[ ]] intending to reduce component stresses and increase fatigue margin. The corresponding structural analyses are performed to predict the dryer's structural responses to the vibration loads and ASME load combination, and to assure the dryer meets the design criteria.

This report documents the fatigue analysis and ASME load combinations of this Susquehanna replacement dryer, and summarizes the predicted component stresses and fatigue margins.

3. MATERIAL PROPERTIES

The dryer assembly is manufactured from Type 304 conforming to the requirements of the material and fabrication specifications. ASME material properties are used [Reference 2]. The applicable properties are shown in Table 3-1.

Table 3-1 Properties of SS304 [Reference 2]

Material / property	Room temperature 70°F	Operating temperature 545°F
SS304		
S_y, Yield strength, psi	30,000	17,000
S_u, Ultimate strength, psi	75,000	63,500
E, Elastic modulus, psi	28,300,000	26,430,000

4. DESIGN CRITERIA

4.1 Fatigue Criteria

The steam dryer fatigue evaluation consists of calculating the alternating stress intensity from FIV and mechanical induced vibration loading at all locations in the steam dryer structure and comparing it with the allowable design fatigue threshold stress intensity. The recommended fatigue threshold stress intensity considered is the ASME Code Curve C value of 13,600 psi. Stresses below the ASME Code Curve C value are assumed to be below the level required to initiate a fatigue crack. The fatigue design criteria for the steam dryer is based on Figure I-9.2.2 of ASME Section III [Reference 3], which provides the fatigue threshold values for use in the evaluation of stainless steels. [[

]]

4.2 ASME Code Criteria for Load Combinations

The ASME Code stress limits used in the evaluation of the Susquehanna dryer are listed in Table 4-1.

Table 4-1 ASME Code Stress Limits [Reference 3]

Service level	Stress category	Core Support Structures Stress limits (NG)	
			Stress Limit (ksi)
Service levels A & B	P_m	S_m	16.9
	$P_m + P_b$	$1.5\ S_m$	25.35
Service levels C	P_m	$1.5\ S_m$	25.35
	$P_m + P_b$	$2.25\ S_m$	38.03
Service level D	P_m	Min ($.7S_u$ or $2.4\ S_m$)	40.56
	$P_m + P_b$	1.5 (P_m Allowable)	60.84

Legend:

P_m: General primary membrane stress intensity
P_b: Primary bending stress intensity
S_m: ASME Code stress intensity limit
S_U: Ultimate strength

Table 4-1 Note: Service Level Limits for Service Levels A, B and C are according to NG-3221 and Appendix F Paragraph F-1331 for Level D. Upset condition stress limits are increased by 10% above the limits shown in this table per NG-3223 (a).

5. DRYER FEA MODEL AND APPLIED LOADS

5.1 Full Dryer Shell Finite Element Model

The proposed replacement dryer configuration only [[

]]

5.2 Dynamic Pressure Loads

The replacement steam dryer FIV response analysis uses loads developed by CDI, which are based upon steam flow conditions representative of 113% OLTP. The loads were derived from in-plant pressure measurements taken on the reactor main steam lines in 2006. [[

]]

The loading time history developed with the CDI acoustic circuit model is used as the nominal load case for the replacement steam dryer FIV analysis. In order to capture structural uncertainties, the time scale of this nominal load is stretched or compressed to create load cases with frequency shifts. In this replacement dryer fatigue analysis, a total of 9 load cases are created and analyzed. These 9 load cases include the nominal, minus10 (-10%), minus7.5 (-7.5%), minus5 (-5%), minus2.5 (-2.5%), plus2.5 (+2.5%), plus5 (+5%), plus7.5 (+7.5%), and plus10 (+10%) load cases.

5.3 Spatial Distribution, Time History and Frequency Contents of the Loads

[[

]]. The spatial distributions of pressure on the dryer at these two instances are shown in Figures 5-16 and 5-17, respectively. The spatial distribution shows that the high pressure occurs near the MSL locations.

The pressure time histories, measured at the two maximum pressure locations on the outer hoods, are shown in Figures 5-18 and 5-19. [[

]] Therefore, a pressure power spectral density (PSD) evaluation is used to describe the frequency contents of the pressure time history. The results of the PSD evaluation for the time histories of Figures 5-18 and 5-19 are shown in Figures 5-20 and 5-21, respectively. [[

]]

5.4 [[ ]] and Extrapolation to EPU

In Reference 1, benchmark comparisons were made between the Susquehanna FEA predictions and in-plant measurements taken during testing in 1985. The benchmark study included comparisons between predicted and measured pressures at the pressure drum and outer hood locations. A more detailed comparison was also made of the predicted strains versus measured strains at specific strain gauge locations. It was concluded that Susquehanna FEA results were under predicted [[ ]] the FEA stress results to match the testing measurements. This approach [[ ]] will be used in the replacement Susquehanna dryer fatigue evaluation.

The FIV analysis for the replacement steam dryer is performed with the loading developed from the Susquehanna in-plant main steam line pressure measurements for power level of 113% OLTP (3721 MWt). The results of the finite element analyses must then be extrapolated to determine the stresses on the dryer at EPU conditions. Dynamic operating measurements are available from three sources for determining the extrapolation to EPU. Reference 1 documented the process of extrapolating the results of 113% OLTP to EPU conditions, which included the use of three data sources: The 1985 in-plant instrumented dryer measurements [Reference 5], the MSL pressure measurements [Reference 7], and SSES-specific scale model testing [Reference 8]. [[

]]

6. VIBRATION ANALYSIS AND PREDICTED COMPONENT STRESSES

6.1 Vibration Analysis Approach

The structural responses of the replacement steam dryer [[

]] Rayleigh damping is used in all of the analyses. Rayleigh damping coefficients [[

]]

6.2 Maximum Stresses, Structural Uncertainty and Design Criteria

Following each of the transient solutions, an ANSYS macro is used to search through all time steps on every component to extract the maximum stress intensity and the corresponding time and location. The element stress values from the shell element top, bottom, and middle surfaces are surveyed. The maximum values of stress intensity on the shell top or bottom are used for fatigue evaluation, and the maximum values of stress intensity on the middle surface are used in the ASME load combination.

Of the 9 load cases, the maximum stress intensity of nominal load is to be used for fatigue margin calculation using the following formula:

$$\text{Fatigue Margin} = \frac{13600}{\text{Stress} \cdot \text{SF}} - 1$$

[[

]]

The difference between the nominal case and the maximum stress of all 9 cases, with weld factors included, is used to evaluate structural uncertainty using the following formula:

$$\text{Structural Uncertainty} = \frac{\text{Maximum Stress}}{\text{Nominal Stress}} - 1$$

The acceptance criteria requires each dryer component to have a fatigue margin greater than its structural uncertainty.

The above methods evaluate the design by nominal load case and take the structural uncertainty into account at the same time. It should be pointed out that if one desires to measure margin by the absolute maximum stress, the relation with the margin by nominal stress and structural uncertainty is as follows: Let M_{Max} be the margin by maximum stress, M_{Nom} be the margin by nominal stress, and μ be the structural uncertainty, then

$$M_{Max} = \frac{M_{Nom} - \mu}{1 + \mu}$$

6.3 Calculated Component Maximum Stress Intensities

Table 6-1 summarizes the component stresses from the 9 load cases. It also shows the weld factors for the location which produced the highest stress in each dryer component for both the nominal and maximum cases. "Structural Uncertainty" is calculated as described in the previous section. Table 6.1 represents a combination of Tables 6.1 and 7.1 in the previous revision of this report. The dryer component stress plots for the nominal case are shown in Figures 6-2 through 6-21.

[[

]]

Table 6-1 Maximum Stress Intensity from Vibration Solution under 113%OLTP Loads

[[

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6.4 [[ ]] Stress Investigations

The maximum stresses surveyed directly from the FIV responses [[

]] Figures 6-22 and 6-23 show the corresponding stress intensity plots. [[

]]

6.5 [[ ]] Stress Prediction

[[

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At these locations, the dryer FE model has introduced simplifications in order to capture the dynamic behavior without complicating the FE model. [[

]]

7. FATIGUE PREDICTION AT EPU CONDITIONS

7.1 Fatigue Calculation with the Refined Stresses

Using the vibration response [[ ]], the Susquehanna replacement dryer's component stresses can now be used for fatigue evaluation. Table 7-1 summarizes the component stresses [[ ]] The fatigue margins are then calculated in comparison to the structural uncertainties. The results indicate that all components meet the design criteria that requests fatigue margin greater than the structural uncertainty. Therefore, this replacement dryer concept is structurally adequate to accommodate the vibration environment at EPU condition. This demonstrates the feasibility of the replacement dryer concept for sustained FIV loading.

7.2 Frequency Content of the Structural Response

In order to understand the structural response in relation to the excitation forces, stress frequency contents are analyzed [[ ]]

7.2.1 Stress Frequency Contents of [[ ]]

[[ ]]

7.2.2 Stress Frequency Contents of [[ ]]

[[ ]]

7.2.3 Stress Frequency Contents of [[ ]]

[[

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7.2.4 Stress Frequency Contents of [[ ]]

[[

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Table 7-1 SSES Dryer Component Fatigue Margin under EPU Condition

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8. ASME LOAD COMBINATIONS

The Susquehanna steam dryer was analyzed for the ASME Code load combinations (primary stresses) shown in Table 8-1. The acceptance criteria used for these evaluations are specified in Section 4.2 and are the same as those used for safety related components. The FIV stresses, where applicable, were added from the existing results obtained for the EPU condition.

8.1 ASME Code Load Combinations

Susquehanna is a "New Loads" plant. The resulting load combinations for each of the service conditions are discussed in Reference 9 and summarized in Table 8-1.

Table 8-1 Susquehanna Units 1 & 2 Steam Dryer Load Combinations

Comb. no	Level	Combination
A-1	Normal	$DW + \Delta P_N + FIV_N$
B-1	Upset	$DW + \Delta P_N + TSV_1 + FIV_N$
B-2	Upset	$DW + \Delta P_N + TSV_2$
B-3	Upset	$DW + \Delta P_U + SRV + FIV_U$
B-4	Upset	$DW + \Delta P_N + OBE + FIV_N$
B-5	Upset	$DW + \Delta P_U + [SRV^2 + OBE^2]^{0.5} + FIV_U$
C-1	Emergency	$DW + \Delta P_E + SRV_{ADS} + FIV_N$
D-1	Faulted	$DW + \Delta P_{F1} + [SRV_{ADS}^2 + SSE^2]^{0.5}$
D-2	Faulted	$DW + \Delta P_N + [AC_1^2 + SSE^2 + FIV_N^2]^{0.5}$
D-3	Faulted	$DW + \Delta P_{F2}$
D-4	Faulted	$DW + \Delta P_N + AC_2 + FIV_N$
D-5	Faulted	$DW + \Delta P_U + [SRV^2 + SSE^2]^{0.5} + FIV_U$

Definition of Load Acronyms:

AC1 = Acoustic load due to Main Steam Line Break (MSLB) outside containment, at the Rated Power and Core Flow (Hi-Power) Condition.

AC2 = Acoustic load due to Main Steam Line Break (MSLB) outside containment, at the Low Power/High Core Flow (Interlock) Condition.

AP = Annulus Pressurization Loads

CHUG = Chugging (LOCA) Loads, Greater of symmetric or asymmetric chugging loads.

DW = Metal Weight + Water Weight.

ΔPn = Differential 'static' Pressure Load during Normal Operation.

Δpu = Differential 'static' Pressure Load during Upset Operation (including the effects of stuck-open relief Valve (SORV) condition).

ΔP_E = Differential 'static' Pressure Load during Emergency Operation (inadvertent actuation of ADS).

ΔP_{F1} = Differential Pressure Load in the Faulted condition, due to Main Steam Line Break outside containment at the Rated Power and Core Flow (Hi-Power) condition.

ΔP_{F2} = Differential Pressure Load in the Faulted condition, due to Main Steam Line Break outside containment at the Low Power/High Core Flow (Interlock) Condition.

FIV_N = Flow Induced Vibration Load during Normal Operation.

FIV_U = Flow Induced Vibration Load during Upset Operation.

JR = Jet Reaction Loads

OBE = Operating Basis Earthquake.

SSE = Safe Shutdown Earthquake.

SRV = Safety Relief Valve Loads (Greater of all SRV or SRV-Asymmetric)

SRV_{ADS}= SRV Loads caused by the "automatic depressurization system"

TSV1 = The Initial Acoustic Component of the Turbine Stop Valve (TSV) Closure Load (Inward load on the outermost hood closest to the nozzle).

TSV2 = The Flow Impingement Component (following the Acoustic phase) of the TSV Closure Load (Inward load on the outermost hood closest to the nozzle).

8.2 ASME Code Load Case Stress Results

The stresses reported from the ANSYS analysis runs are maximum stresses and not general primary membrane or membrane plus bending stresses. Comparing the maximum stresses (rather than primary stresses as it is required by the Code) against the ASME limits (Table 4-1) is a very conservative way of structural components evaluation. However, as it is shown in Table 8-2 and Table 8-3, this conservative qualification has been successful for all the components and load combinations. Table 8-2 and Table 8-3 list the components maximum stresses obtained from the ANSYS analysis.

Table 8-2 and Table 8-3 summarize the ASME load combination analysis results and indicate that the stresses for all structural components are under the allowable ASME Code limits at EPU operating conditions.

Table 8-2 EPU ASME Results for Normal and Upset Conditions: Maximum Stresses

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Table 8-3 EPU ASME Results for Emergency and Faulted Conditions: Maximum Stresses

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9. CONCLUSIONS

Finite element stress analyses were performed for the replacement Susquehanna steam dryer to predict dryer structural responses to the Flow Induced Vibration (FIV) and mechanically induced vibration loads under the Extended Power Uprate (EPU) condition and ASME load combination.

A detailed finite element model is used to perform the structural dynamic analyses. The applied pressure loads were developed by Continuum Dynamics, Inc. (CDI) based on in-plant steam line pressure measurements taken at 113% OLTP power levels during the spring of 2006. The results are used as basis for extrapolating the dryer stresses to full EPU conditions.

The fatigue evaluation indicates that at full EPU conditions, all dryer components meet the fatigue acceptance criteria with adequate or high margins, and the replacement Susquehanna design is structurally adequate to accommodate the vibration environment at EPU condition.

The ASME load combination analysis results indicate that the stresses for all structural components are under the allowable ASME Code limits at EPU operating conditions.

Therefore, the fatigue evaluation and ASME load combination analysis demonstrates the acceptability of the Susquehanna replacement steam dryer design.

10. REFERENCES

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Figure 5-1 Thickness Increase of Susquehanna Replacement Dryer

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Figure 5-2 Susquehanna Dryer Finite Element Model

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Figure 5-3 Section of Water Element

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Figure 5-4 Dryer Top Plate

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Figure 5-5 Trough Thin and Thick Section

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Figure 5-6 Bank Top Plate and Top Side Plate

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Figure 5-7 Inner and Outer Vane Bank Plates

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Figure 5-8 Thin and Thick End Plate

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Figure 5-9 Inner Hood and Outer Hood

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Figure 5-10 Hood Support

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Figure 5-11 Thick and Thin Inlet End Plates

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Figure 5-12 Drain Pipes, Drain Channels, Skirt and Lower Skirt Ring

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Figure 5-13 Vane Banks with Perforated Plates

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Figure 5-14 Susquehanna Dryer FE Model Boundary Conditions

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Figure 5-15 Vane Bundle-Trough Interface Boundary Conditions

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Figure 5-16 Pressure Distribution on 90° Hood at LS547, 113% OLTP Nominal

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Figure 5-17 Pressure Distribution on 270° Hood at LS666, 113% OLTP Nominal

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Figure 5-18 Peak Pressure Time History, 90° Hood

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Figure 5-19 Peak Pressure Time History, 270° Hood

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Figure 5-20 Peak Pressure PSD, 90° Hood

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Figure 5-21 Peak Pressure PSD, 270° Hood

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Figure 6-1 Rayleigh Damping Curve

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Figure 6-2 Dryer Base Plate Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-3 Trough Thin Section Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-4 Trough Thick Section Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-5 Bank Top Plate Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-6 Bank Top Side Plates Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-7 Outer Vane Bank End Plate Max. Stress Intensity, 113%OLTP Nominal

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Figure 6-8 Inner Vane Bank End Plate Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-9 Thin End Plates Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-10 Thick End Plates Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-11 Inner Hood Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-12 Outer Hood Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-13 Hood Support Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-14 Inlet End Plate (Thin) Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-15 Inlet End Plate (Thick) Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-16 Skirt Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-17 Support Ring Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-18 Drain Pipe Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-19 Drain Channel Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-20 Lower Skirt Ring Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-21 Cover Plate Max. Stress Intensity, 113% OLTP Nominal

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Figure 6-22 Outer Vane Bank End Plate Max. Stress Intensity, 113% OLTP Plus7.5

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Figure 6-23 Inner Vane Bank End Plate Max. Stress Intensity, 113% OLTP Minus5

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Figure 6-24 Sketch of the Tie rod and Inner Vane Bank End Plate Joint

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Figure 6-25 Outer Vane Bank End Plate Stress Away from Tie-Rod Joint, 113% OLTP Plus5

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Figure 6-26 Inner Vane Bank End Plate Stress Away from Tie-Rod Joint, 113% OLTP Minus2.5

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Figure 6-27 Skirt Stress Intensity, 113% OLTP Minus7.5

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Figure 6-28 [[ ]]

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Figure 6-29 [[ ]]

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Figure 6-30 [[ ]]

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Figure 6-31 [[ ]]

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Figure 6-32 [[

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Figure 6-33 [[ ]]

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Figure 7-1 Trough Thin Section Stress Time History, 113% OLTP Nominal

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Figure 7-2 Trough Thin Section Stress Waterfall Plot (top) and PSD (bottom), 113% OLTP Nominal

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Figure 7-3 Thick End Plate Stress Time History, 113% OLTP Plus5

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Figure 7-4 Thick End Plate Stress Waterfall Plot (top) and PSD (bottom), 113% OLTP Plus5

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Figure 7-5 Inner Hood Stress Time History, 113% OLTP Minus5

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Figure 7-6 Inner Hood Stress Waterfall Plot (top) and PSD (bottom), 113% OLTP Minus5

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Figure 7-7 Skirt Stress Time History, 113% OLTP Minus2.5

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Figure 7-8 Skirt Stress Waterfall Plot (top) and PSD (bottom), 113% OLTP Minus2.5

Proprietary Information Enclosed

Enclosure 3 to PLA-6237

Comparison Tables
With
"End-To-End" Uncertainties

(Proprietary)

GHNEA PROPRIETARY INFORMATION

Maximum "End-To-End" Stress Intensities From Table 1 Of PLA-6146 (dated 12/26/06)

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	Maximum Stress	Weld Factor (WF)	Stress With WF	Stress With Under Prediction Factor	Stress Scaled To Full EPU	Stress With End to End Uncertainty	Final Margin
Dryer Base Plate	1338	1.8	2408	5226	6010	6058	124%
Trough Thin Section	3181	1	3181	6903	7938	8002	70%
Trough Thick Section	2583	1	2583	5605	6446	6497	109%
Bank Top Plates	2243	1	2243	4867	5597	5642	141%
Bank Top Side Plates	2062	1.4	2887	6264	7204	7262	87%
Outer Vane Bank End Plates	3186	1	3186	6914	7951	8014	70%
Inner Vane Bank End Plates	668	1.8	1202	2609	3001	3025	350%
Thin End Plates	551	1.8	992	2152	2475	2495	445%
Thick End Plates	2647	1.8	4765	10339	11890	11985	13%
Inner Hood	2125	1.8	3825	8300	9545	9622	41%
Outer Hoods	1190	1.8	2142	4648	5345	5388	152%
Hood Supports	1139	1.8	2050	4449	5116	5157	164%
Inlet End Plates (Thin)	1242	1.8	2236	4851	5579	5624	142%
Inlet End Plate (Thick)	1326	1.4	1856	4028	4633	4670	191%
Skirt	2710	1	2710	5881	6763	6817	100%
Dryer Support Ring	704	1.8	1267	2750	3162	3188	327%
Drain Pipes	965	1.8	1737	3769	4335	4369	211%
Drain Channel	2461	1.8	4430	9613	11055	11143	22%
Lower Skirt Ring	285	1.8	513	1113	1280	1290	954%
Cover Plate	925	1.8	1665	3613	4155	4188	225%

{3}]]

GHNEA PROPRIETARY INFORMATION

Revised Maximum Stress Intensities [[With Corrected Support Lug Location

	Maximum Stress	Weld Factor (WF)	Stress With WF	Stress With Under Prediction Factor	Stress Scaled To Full EPU	Stress With End to End Uncertainty	Final Margin
Dryer Base Plate	1376	1.8	2476	5373	6179	6228	118%
Trough Thin Section	2811	1.8	5060	10980	12627	12728	7%
Trough Thick Section	2211	1	2211	4798	5518	5562	145%
Bank Top Plates	2582	1.4	3615	7844	9021	9093	50%
Bank Top Side Plates	2389	1.4	3345	7258	8346	8413	62%
Outer Vane Bank End Plates	1443	1.8	2598	5638	6483	6535	108%
Inner Vane Bank End Plates	617	1.8	1110	2409	2770	2792	387%
Thin End Plates	636	1.8	1144	2482	2855	2878	373%
Thick End Plates	2694	1.8	4849	10522	12101	12197	11%
Inner Hood	2480	1.8	4464	9687	11140	11229	21%
Outer Hoods	1184	1.8	2131	4624	5318	5360	154%
Hood Supports	1137	1.8	2047	4441	5107	5148	164%
Inlet End Plates (Thin)	1277	1.8	2298	4987	5735	5781	135%
Inlet End Plate (Thick)	1392	1.8	2505	5436	6251	6301	116%
Skirt	2339	1.8	4210	9136	10507	10591	28%
Dryer Support Ring	288	1.8	519	1126	1295	1306	942%
Drain Pipes	959	1.8	1726	3745	4307	4342	213%
Drain Channel	1967	1.8	3541	7683	8836	8906	53%
Lower Skirt Ring	338	1.8	609	1322	1520	1532	788%
Cover Plate	947	1.8	1704	3698	4252	4286	217%

{3}]]

Enclosure 4 to PLA-6237

Comparison Tables with "End-to-End" Uncertainties

(Non-Proprietary)

Maximum "End-To-End" Stress Intensities From Table 1 Of PLA-6146 (dated 12/26/06)

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Revised Maximum Stress Intensities [[

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Enclosure 5 to PLA-6237

GE-Hitachi Nuclear Energy Americas, LLC Affidavit For Comparison Tables

GE-Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, James F. Harrison, state as follows:

(1) I am Project Manager, Fuel Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC ("GHNEA"), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in GHNEA letter, GE-SSES-AEP-329, *GHNEA Proprietary Review of Maximum 'End-to-End' Stress Tables, PPL Letter PLA-6237*, dated July 3, 2007. The proprietary information, contained in Enclosure 1 entitled, *GHNEA Proprietary Review of Maximum 'End-to-End' Stress Tables, PPL Letter PLA-6237,* is delineated by a [[dotted underline inside double square brackets.{3}]]. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GHNEA relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GHNEA's competitors without license from GHNEA constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future GHNEA customer-funded development plans and programs, resulting in potential products to GHNEA;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GHNEA, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GHNEA, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GHNEA. Access to such documents within GHNEA is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GHNEA are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains details of steam dryer fatigue analyses of the design of the replacement Susquehanna BWR Steam Dryer. Development of this information and its application for the design, procurement and analyses methodologies and processes for the Steam Dryer Program was achieved at a significant cost to GE, on the order of approximately two million dollars.

The development of the dryer performance evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GHNEA asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GHNEA's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GHNEA's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GHNEA.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GHNEA's competitive advantage will be lost if its competitors are able to use the results of the GHNEA experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GHNEA would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GHNEA of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 3rd day of July 2007.

James F. Harrison

James F. Harrison
Project Manager, Fuel Licensing, Regulatory Affairs
GE-Hitachi Nuclear Energy Americas LLC